UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
1201 NE Lloyd Boulevard, Suite 1100
PORTLAND, OREGON 97232-1274

March 29, 2019

Refer to ECO WCRO-2018-00152

Mr. David Mabe
Deputy Regional Director
U.S. Bureau of Reclamation
1150 North Curtis Road, Suite 100
Boise, ID 83706

Mr. Benjamin Zelinsky
Bonneville Power Administration
905 NE 11th Ave
Portland OR 97232-4169

Mr. Tim Dykstra
U.S. Army Corps of Engineers
1201 NE Lloyd Blvd., Suite 400
Portland, OR 97232

Re: Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for the Continued Operation and Maintenance of the Columbia River System

Dear Mr. Mabe, Mr. Zelinsky and Mr. Dykstra:

Thank you for your letter of November 2, 2018, requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for the ongoing operation and maintenance of the Columbia River System (CRS) and associated non-operational measures to offset adverse effects to listed species. The three federal Action Agencies with responsibility for operating the CRS are the Bonneville Power Administration (BPA), the U.S. Army Corps of Engineers (Corps), and the U.S. Bureau of Reclamation (BOR). Thank you, also, for your request for consultation pursuant to the essential fish habitat (EFH) provisions in Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. § 1855(b)).

Your November 2, 2018 request for initiation of consultation noted the Action Agencies were engaged in discussions with regional sovereigns with the goal of developing a spring spill operation that balanced increased spill for listed salmon and steelhead, maintaining power generation during periods of high demand, and increased implementation feasibility for the operation. As a result of those discussions, the Action Agencies, with the states of Oregon and Washington and the Nez Perce Tribe, developed and filed with the court on December 18, 2018, a status report that attached the 2019-2021 Flexible Spill Operations Agreement (*Natl Wildlife Fed'n et al. v. NMFS et al.*, 3:01-CV-00640-SI (D. Or) (ECF 2298)). On December 19, 2018, we received a letter from the Corps stating that the 2019-2021 Flexible Spill Operation Agreement amended sections of the spill and hydropower operations portion of the November 2, 2018 proposed action at the lower Snake River and lower Columbia River projects in 2019 and 2020, and included adaptive management provisions that allow for regional discussions and potential changes in summer spill and fish transport operations in 2020. The agreement did not alter any other aspect of the November 2, 2018 consultation package. Finally, we received a letter from the Corps dated March 8, 2019, on behalf of the Action Agencies which included additions to the proposed action that are intended to benefit salmonids. The proposed action is expected to continue until a new action is adopted through Records of Decision in the ongoing Columbia River System Operations (CRSO) National Environmental Policy Act (NEPA) process.

We appreciate the extensive discussions and informal consultation that informed the development of the final proposed action.

The enclosed document contains a final biological opinion (Opinion) prepared by NMFS pursuant to section 7(a)(2) of the ESA on the effects of the proposed action. In this Opinion, we conclude that the effects of the proposed action are not likely to jeopardize the continued existence Upper Willamette River (UWR) Chinook Salmon, UWR steelhead, eulachon, Lower Columbia River (LCR) Chinook salmon, LCR steelhead, LCR coho salmon, Columbia River chum salmon, Middle Columbia River steelhead, Upper Columbia River (UCR) steelhead, UCR Chinook salmon, Snake River (SR) fall Chinook, SR sockeye salmon, Snake River Basin steelhead, and SR spring/summer Chinook salmon. In this Opinion, we have also determined that the proposed action will not destroy or adversely modify designated critical habitat for the same species. In this Opinion, we also concur with BPA, the Corps, and BOR that the action, as currently proposed, is not likely to adversely affect Southern Resident killer whales and the southern distinct population segment of green sturgeon or their designated critical habitat.

As required by section 7 of the ESA, NMFS provides an incidental take statement (ITS) with the Opinion. The ITS includes reasonable and prudent measures (RPM) NMFS considers necessary or appropriate to minimize the impact of incidental take associated with this action. The take statement sets forth nondiscretionary terms and conditions, including reporting requirements, that the Action Agencies must comply with to carry out the RPMs. Incidental take from actions in compliance with these terms and conditions will be exempt from ESA take prohibitions.

The Opinion includes ESA conservation recommendations that are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02). The conservation measures provided here are intended, in part, to inform the ongoing CRSO NEPA process.

This document also includes the results of our analysis of the action's effects on EFH pursuant to section 305(b) of the MSA, and includes five Conservation Recommendations to avoid, minimize, or otherwise offset potential adverse effects on EFH. Section 305(b)(4)(B) of the MSA requires federal agencies provide a detailed written response to NMFS within 30 days after receiving these recommendations.

Please contact Ritchie Graves, 503-231-6891, Branch Chief, Columbia Hydropower Branch of the Interior Columbia Basin Office in Portland, Oregon (Ritchie.Graves@noaa.gov) if you have any questions concerning this consultation, or if you require additional information.

Sincerely,

Michael P. Tehan
Assistant Regional Administrator
Interior Columbia Basin Office
NOAA Fisheries, West Coast Region

Enclosure

Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response

Continued Operation and Maintenance of the Columbia River System

NMFS Consultation Number: *WCRO*-2018-00152

Action Agenc*ies*: Bonneville Power Administration
U.S. Army Corps' of Engineers
U.S. Bureau of Reclamation

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	Is Action Likely To Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Upper Willamette River Chinook Salmon	Threatened	Yes	No	Yes	No
Upper Willamette River Steelhead	Threatened	Yes	No	Yes	No
Eulachon	Threatened	Yes	No	Yes	No
Lower Columbia River Chinook Salmon	Threatened	Yes	No	Yes	No
Lower Columbia River Steelhead	Threatened	Yes	No	Yes	No
Lower Columbia River Coho Salmon	Threatened	Yes	No	Yes	No
Columbia River Chum Salmon	Threatened	Yes	No	Yes	No
Middle Columbia River Steelhead	Threatened	Yes	No	Yes	No
Upper Columbia River Steelhead	Threatened	Yes	No	Yes	No
Endangered	Threatened	Yes	No	Yes	No
Snake River Fall Chinook	Threatened	Yes	No	Yes	No
Snake River Sockeye Salmon	Threatened	Yes	No	Yes	No
Snake River Steelhead	Endangered	Yes	No	Yes	No

Snake River Spring/Summer Chinook Salmon	Threatened	Yes	No	Yes	No
Green Sturgeon	Threatened	No	N/A	No	N/A
Southern Resident Killer Whale	Threatened	No	N/A	No	N/A

Consultation Conducted By: National Marine Fisheries Service, West Coast Region

Issued By:

Michael P. Tehan
Assistant Regional Administrator
Interior Columbia Basin Office

Date: March 29, 2019

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Abbreviations and Acronyms

Action Agencies	U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, and the Bonneville Power Administration
AEMR	action effectiveness monitoring and research
AMIP	Adaptive Management Implementation Plan
A/P	abundance and productivity
BPA/Bonneville	Bonneville Power Administration
BRT	Biological Review Team (NMFS)
CEERP	Columbia Estuary Ecosystem Restoration Program
CFS	cubic feet per second
CHaMP	Columbia Habitat Monitoring Protocol
CHARTs	Critical habitat analytical review teams (NMFS)
COMPASS model	Comprehensive passage model
Corps	U.S. Army Corps of Engineers
Council	Northwest Power and Conservation Council
CR	Columbia River
CRFMP	Columbia River Fisheries Management Plan
CRITFC	Columbia River Inter-Tribal Fish Commission
CRS	Columbia River System
CSLs	California sea lions
CSS	Comparative Survival Study
CTCR	Confederated Tribes of the Colville Reservation
CWT	coded-wire-tagging
DART	data access in real time
DDT	dichlorodiphenyltrichloroethane
DIP	demographically independent population
DO	dissolved oxygen
DPS	distinct population segment
DQA	Data Quality Act
EFH	essential fish habitat
EIS	environmental impact statement
ENSO	El Niño/Southern Oscillation
EPA	Environmental Protection Agency
ERTG	Expert Regional Technical Group
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FCRPS	Federal Columbia River Power System
FERC	Federal Energy Regulatory Commission
FFDRWG	Fish Facility Design Review Work Group
FOGs	floating orifice gates
FOP	Fish Operations Plan

FPOM	fish passage operations and maintenance
FR	Federal Register
FRM	flood risk management
FSOA	Flexible Spill Operations Agreement
GBT	gas bubble trauma
HCP	habitat conservation plan
HGMP	Hatchery and Genetics Management Plan
HSRG	Hatchery Scientific Review Group
ICTRT	Interior Columbia Technical Recovery Team
IDFG	Idaho Department of Fish and Game
IMW	intensively monitored watershed
IAPMP	Inland Avian Predation Management Plan
ISAB	Independent Scientific Advisory Board
ISEMP	Interior Status and Effectiveness Monitoring Program
ITS	incidental take statement
LCFRB	Lower Columbia Fish Recovery Board
LCR	Lower Columbia River
LCREP	Lower Columbia River Estuary Partnership
LSRB	Lower Snake River Recovery Board
LSRCP	Lower Snake River Compensation Plan
LWD	large woody debris
MAF	million acre-feet
MAT	minimum abundance threshold
MCR	Middle Columbia River
MIP	minimum irrigation pool
MPG	major population group
MOP	minimum operating pool
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NEPA	National Environmental Policy Act
NFH	National Fish Hatchery
NGO	non-governmental organization
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPCC	Northwest Power and Conservation Council
NPEA	Natural Production Emphasis Area
NPMP	Northern Pikeminnow Management Program
NPT	Nez Perce Tribe
NWFSC	Northwest Fisheries Science Center
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
PAHs	polycyclic aromatic hydrocarbons
PBDEs	polybrominated diphenyl ethers

PBF	physical or biological feature
PBT	persistent bioaccumulative toxics
PCBs	polychlorinated biphenyls
PDO	Pacific Decadal Oscillation
PFMC	Pacific Fisheries Management Council
pHOS	proportion of hatchery-origin fish on spawning grounds
PIT	passive integrated transponder
PNI	proportionate natural influence
pNOB	proportion of natural-origin fish in broodstock
QET	quasi-extinction risk threshold
Reclamation/USBR	U.S. Bureau of Reclamation
RIOG	Regional Implementation Oversight Group
RM	river mile
RM&E	research, monitoring, and evaluation
RPA	Reasonable and Prudent Alternative
R/S	returns-per spawner
SARs	smolt-to-adult returns
SCA	Supplemental Comprehensive Analysis
SCT	Systems Configuration Team
S/D	spatial structure and diversity
SLEDs	sea lion excluder devices
SR	Snake River
SRB	Snake River Basin
SRKWs	Southern Resident killer whales
SSL	Steller sea lions
T:B	transport-bypass ratio
TAC	Technical Advisory Committee
TDG	total dissolved gas
TIR	transport in-river ratio
TMDL	total maximum daily load
TMT	technical management team
TRMP	Tribal Resource Management Plan
TRT	technical recovery team
UCR	Upper Columbia River
UCRTT	Upper Columbia Regional Technical Team
UCSRB	Upper Columbia Salmon Recovery Board
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
UWR	Upper Willamette River
VSP	viable salmonid population
WDFW	Washington Department of Fish and Wildlife
WLC-TRT	Willamette/Lower Columbia Technical Recovery Team
WQT	Water Quality Team

1. Introduction

This Introduction provides background on the biological opinion and discusses the related consultation and litigation history. It also describes the proposed federal action and area affected by the action. The information is relevant to the other sections of this document and is incorporated by reference into Sections 2 and 3.

1.1 Background

The National Marine Fisheries Service (NMFS) prepared the biological opinion (opinion) and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 USC 1531 et seq.), and implementing regulations at 50 CFR 402.

We also completed an essential fish habitat (EFH) consultation on the proposed action in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801 et seq.), and implementing regulations at 50 CFR 600.

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (DQA) (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available through the NOAA Repository [https://repository.library.noaa.gov/]. A complete record of this consultation is on file at the NMFS office in Portland, Oregon.

1.2 Consultation History

1.2.1 Consultation Before 2014

Shortly after Snake River spring/summer Chinook salmon, fall Chinook salmon, and sockeye salmon were listed under the Endangered Species Act in the early 1990s, the U.S. Army Corps of Engineers (Corps), U.S. Bureau of Reclamation (Reclamation or USBR), and U.S. Department of Energy ─ Bonneville Power Administration (Bonneville or BPA), collectively referred to as the Action Agencies, began consulting with NMFS on the operation of the federal Columbia River System (CRS[1]).[2] The litigation history related to NMFS' CRS biological opinions since

[1] In earlier biological opinions, the CRS was referred to as the Federal Columbia River Power System or FCRPS.
[2] Biological opinions issued by NMFS related to the operation of the CRS include: (1) 1992 Operation of the FCRPS (April 10, 1992); (2) Operation of the FCRPS January Through April 1993 (February 24, 1993); (3) 1993 Operation of the FCRPS (May 26, 1993); (4) 1994–1998 Operation of the FCRPS (March 16, 1994); (5) Reinitiation of Consultation on 1994–98 Operation of the FCRPS and Juvenile Transportation Program in 1995 and Future Years (March 2, 1995); (6) Supplemental FCRPS Biological Opinion (May 14, 1998) [to consider newly listed steelhead species]; (7) Supplemental Biological Opinion – Bureau of Reclamation Operations and Maintenance of its Projects in the Snake River Basin Above Lower Granite Dam: A Supplement to the Biological Opinion Signed on March 2, 1995, and May 14, 1998 (December 9, 1999) [to consider the USBR's planned operation to comply with the 1995

that time is extensive, and is not repeated here except as necessary to provide context for the current consultation.

On May 5, 2008, following two years of collaboration by NMFS and the Action Agencies with regional states and tribes to develop items to be included in the proposed action, and to clarify policy issues and to reach agreement or narrow areas of disagreement on scientific and technical information, as directed by Judge James Redden's Remand Order, NMFS issued a 2008 biological opinion.[3] The 2008 biological opinion included a Reasonable and Prudent Alternative (RPA) with 73 actions (and many more sub-actions) to be implemented over a 10-year period. In 2009, the newly inaugurated Obama Administration received the Court's permission to review the 2008 biological opinion. The result of this review was a jointly developed Adaptive Management Implementation Plan (AMIP), proposed by the Action Agencies and endorsed by NMFS. On May 20, 2010, NMFS issued a supplemental biological opinion[4], which incorporated and integrated the AMIP with the 2008 biological opinion's RPA. In 2011, the court remanded the 2010 supplemental biological opinion. On remand, the Action Agencies worked with regional implementation partners to identify habitat mitigation projects for the remaining duration of the biological opinion. Further consultation on remand culminated in NMFS' issuance of another supplemental biological opinion[5] on January 17, 2014, which: (1) addressed specific issues raised by Judge Redden (most notably the failure "to identify specific mitigation plans beyond 2013, that are reasonably certain to occur;" (2) considered effects to newly designated critical habitat for eulachon and green sturgeon and to proposed critical habitat for Lower Columbia River coho salmon; and (3) revised the 2008/2010 RPAs to address updated scientific information.

RPA prescription to deliver 427,000 acre-feet of upper Snake River water and the operation of all USBR projects in the Snake River upstream of Lower Granite Dam]; (8) Supplemental Biological Opinion ─ Operation of the Federal Columbia River Power System Including the Juvenile Fish Transportation Program: A Supplement to the Biological Opinions Signed on March 2, 1995, and May 14, 1998, for the Same Projects (February 4, 2000) [to consider six species listed as threatened or endangered in March 1999]; (9) Biological Opinion ─ Reinitiation of Consultation on Operation of the Federal Columbia River Power System, Including the Juvenile Fish Transportation Program, and 19 Bureau of Reclamation Projects in the Columbia Basin (December 21, 2000); and (10) Endangered Species Act ─ Section 7 Consultation Biological Opinion: Consultation on Remand for Operation of the Columbia River Power System and 19 Bureau of Reclamation Projects in the Columbia Basin (Revised and reissued pursuant to court order, NWF v. NMFS, Civ. No. CV 01-640-RE (D. Oregon)) (November 30, 2004).

[3] Endangered Species Act Section 7(a)(2) Consultation Biological Opinion And Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation on Remand for Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(I)(A) Permit for Juvenile Fish Transportation Program (Revised and reissued pursuant to court order, NWF v. NMFS, Civ. No. CV 01-640-RE (D. Oregon)) (May 5, 2008).

[4] Endangered Species Act Section 7(a)(2) Consultation Supplemental Biological Opinion Supplemental Consultation on Remand for Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(I)(A) Permit for Juvenile Fish Transportation Program (May 20, 2010).

[5] Endangered Species Act Section 7(a)(2) Supplemental Biological Opinion: Consultation on Remand for Operation of the Federal Columbia River Power System (January 17, 2014).

1.2.2 2014 Biological Opinion Litigation and Orders

On May 4, 2016, the U.S. District Court for the District of Oregon issued an opinion and order invalidating NMFS' 2008/2014 biological opinion. *Nat'l Wildlife Fed'n v. Nat'l Marine Fisheries Serv.*, 184 F. Supp. 3d 861 (D. Or. 2016). Among other rulings, the summary judgment opinion addressed NMFS' interpretation and application of the substantive standards contained in section 7(a)(2) of the ESA, 16 U.S.C. § 1536(a)(2).

In the 2008/2014 biological opinion, NMFS began with the jeopardy and adverse modification standards and analytical framework adopted in the 2000 Federal Columbia River Power System (FCRPS) biological opinion, and NMFS then addressed the legal deficiencies the court identified in the 2000 biological opinion's standards and analysis. In the 2008/2014 biological opinion, NMFS articulated the standard as involving consideration of "(a) whether the species can be expected to survive with an adequate potential for recovery (e.g., trending toward recovery) under the effects of the action, the effects of the environmental baseline, and any cumulative effects; and (b) whether affected designated critical habitat is likely to remain functional (or retain the ability to become functional) to serve the intended conservation role for the species in the near and long term under the effects of the action, environmental baseline, and any cumulative effects."

Regarding the jeopardy analysis, NMFS' 2008/2014 biological opinion used both qualitative and quantitative population-level analyses that were supplemented by qualitative analyses at the major population group (MPG) and species (Evolutionarily Significant Unit or ESU, or Distinct Population Segment or DPS) level. At the population level, NMFS' analyses considered whether, with the proposed RPA Actions, the populations are expected to replace themselves and grow over time (e.g., population trend metrics over 1.0). Where the evidence showed that the RPA Actions, combined with all other factors affecting the species, are improving the status and trends of enough populations within an MPG and ESU and, thus, contributing to their recovery, NMFS could be assured that the RPA Actions are not, at the same time, jeopardizing the continued existence of the listed species. Our intent in the 2000 and 2008/2014 biological opinions, therefore, was to adopt standards that provided ample assurances the ESA's section 7(a)(2) jeopardy prohibition was not violated. We did not find or conclude that the 2000 or 2008/2014 biological opinion standards and analyses were required by the plain language of the ESA, or our implementing regulations.

On review, the courts overturned NMFS' 2000 and 2008/2014 biological opinions. In 2016, the district court determined that the 2008/2014 biological opinion's standards and analyses were arbitrary and capricious and did not comply with the ESA. The courts thus overturned standards and analyses we developed specifically for the CRS. Rather than continue on this path of developing CRS-specific standards, we return to our usual practice applied in most (if not all) ESA consultations. Specifically, we apply the statutory language and our long-standing interpretations of section 7(a)(2) that are contained in the U.S. Fish and Wildlife Services' (USFWS') joint consultation regulations and preambles to those regulations. We use these standards and long-standing interpretations of the ESA to determine whether the proposed action is likely to jeopardize the continued existence of the listed species.

In applying the ESA and our implementing regulations, we reiterate our long-standing interpretation that section 7(a)(2) does not require that a proposed action result in an improvement to species status, growth rates, or other metrics to demonstrate compliance with section 7(a)(2). A standard requiring an improvement to species status, growth rates, or other metrics would be contrary to the plain language of section 7(a)(2), which only requires agencies to insure that their actions are not likely to jeopardize "the continued existence" of listed species. That standard also would be contrary to our 1986 regulations, which interpret section 7(a)(2) as being violated only where the action causes reductions to the species' "reproduction, numbers, or distribution" to the degree of reducing appreciably the species' likelihood of survival and recovery in the wild. In accord, neither the ESA nor our implementing regulations require that a proposed action or RPA result in populations or species being on a trend toward recovery, or otherwise result in improvements that would ensure survival of a species or improve the potential for recovery.

Regarding the destruction or adverse modification analysis, the 2000 and 2008/2014 biological opinions used standards and analyses in place at the time. Since those biological opinions were issued, NMFS and USFWS have adopted a new regulatory definition of section 7(a)(2)'s destruction or adverse modification mandate. NMFS now uses and relies upon the regulatory definition at 50 C.F.R. 402.02, and not the prior standards used in the 2008/2014 biological opinion that the district court reviewed in its 2016 summary judgement opinion.

1.2.3 2019 Biological Opinion

On November 2, 2018, the Action Agencies requested initiation of formal consultation with NMFS under Section 7 (a)(2) of the ESA, and submitted a consultation package which included a description of the federal action describing how the hydropower system would be operated. That request for initiation of consultation noted the Action Agencies were engaged in discussions with regional sovereigns with the goal of developing a spring spill operation which finds a balance between increased spill for listed salmon and steelhead, maintaining power generation during periods of high demand, and increased implementation feasibility for the operation. As a result of those discussions, the Action Agencies, with the states of Oregon and Washington and the Nez Perce Tribe, developed and filed with the court on December 18th, 2018 a status report that attached the 2019-2021 Flexible Spill Operations Agreement (*Natl Wildlife Fed'n et al. v. NMFS et al.,* ECF 2298). Subsequently, on December 19, 2018, NMFS received a letter from the Corps which states the 2019-2021 Flexible Spill Operation Agreement amends sections of the spill and hydropower operations portion of the previous proposed action at the lower Snake River and lower Columbia River projects in 2019 and 2020, together with a provision calling for cessation of summer transport operations in 2020 with allowance for adaptive management through the regional process. The agreement does not alter any other aspect of the November 2, 2018 consultation package. Finally, NMFS received a letter from the Corps dated March 8, 2019 on behalf of the Action Agencies which included additions to the Proposed Action that are beneficial to salmonids and not intended to alter proposed system operations (Ponganis 2019).

In this consultation, NMFS considers the effects of the Action Agencies' proposed action (the continued operation and maintenance of the Columbia River System of dams; tributary and estuary habitat mitigation programs; conservation and safety net hatchery programs; predator management programs; and research, monitoring, and evaluation [RM&E] programs) on eight species of salmon (ESUs), five species of steelhead (DPSs), and the Southern Distinct Population Segment of Pacific Eulachon and their designated critical habitat. This consultation also considers the Action Agencies' request for NMFS' concurrence on their Not Likely to Adversely Affect determinations for the Southern DPS of North American green sturgeon and the DPS of Southern Resident killer whales (SRKWs). The proposed action is expected to continue until a new action is adopted through Records of Decision in the ongoing Columbia River System Operations National Environmental Policy Act (NEPA) process.

This biological opinion includes both a jeopardy analysis and a destruction or adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of" a listed species, which is "to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02). Under this regulatory definition, the proposed action must not result in an appreciable reduction in the likelihood of survival and recovery. While this analysis must consider the action's effects on both the survival and recovery of the species, NMFS does not interpret the statute or its regulations to require the proposed action to improve or increase the likelihood of survival and recovery, as discussed above. Section 7(a)(2) focuses on the "continued existence" of the species, not an improvement in the likelihood of recovery or the attainment of an improved status, which is addressed through section 4 recovery plans. Nor do we interpret the statute or our regulations to require the development of a tipping point beyond which an action jeopardizes the species or recovery benchmarks to analyze whether there is an appreciable reduction in the likelihood of recovery.[6] Section 7(a)(2) provides NMFS with discretion on how it shall determine whether the statutory prohibition is exceeded, and we have interpreted that statutory language as requiring analysis of whether the action reduces "the reproduction, numbers, or distribution of the species." Similarly, this biological opinion relies upon the regulatory definition of "destruction or adverse modification," which means "a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features." (50 CFR 402.02). Additional description of our analytical approach can be found in Chapter 2.

[6] Our interpretation of what is required by the ESA and our regulations is consistent with, and supported by, the preamble text found at 83 *Fed. Reg.* 35178 (July 25, 2018).

1.3 Proposed Federal Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies (50 CFR 402.02).

This ESA section 7(a)(2) consultation evaluates the effects of an ongoing federal action: the operation, maintenance, and management of the 14 federal dam and reservoir projects in the Columbia River System that are managed as a coordinated system for multiple congressionally authorized public purposes by the Action Agencies (BPA et al. 2018a). The proposed action includes operational measures (e.g., flood risk management, navigation, fish passage, and hydropower generation) and non-operational measures (e.g., support for conservation hatchery programs, predation management, habitat improvement actions, and RM&E programs). The proposed action, including both operational and non-operational measures, is largely consistent with RPA measures stemming from the 2008 biological opinion, as supplemented in 2010 and 2014.

The Corps operates and maintains 12 of the 14 federal Columbia River System projects: Bonneville, The Dalles, John Day, McNary, Ice Harbor, Lower Monumental, Little Goose, Lower Granite, Dworshak, Chief Joseph, Albeni Falls, and Libby Dams. The Corps operates and maintains these projects for flood risk management, navigation, hydropower generation, fish and wildlife conservation, irrigation, recreation, water quality, and municipal and industrial water supply, though not every project is authorized for every one of these purposes.

Reclamation operates and maintains the remaining two of the 14 federal Columbia River System projects: Grand Coulee and Hungry Horse Dams. Reclamation operates these projects to support multiple legally mandated purposes, including irrigation, hydropower generation, flood risk management, navigation, and municipal and industrial water supply.

BPA markets and distributes power generated at these 14 federal projects on the Columbia River and its tributaries. Transmission facilities owned and operated by BPA interconnect and integrate electric power generated at the federal projects to the regional transmission grid.

The Action Agencies also fund or implement substantial mitigation, enhancement, and RM&E programs. These programs include: salmon and steelhead hatchery programs (including kelt reconditioning programs), tributary habitat and estuary habitat restoration programs, predator management programs, and RM&E programs (including fish status monitoring).

This section focuses on those aspects of the proposed action which most affect ESA-listed species considered in this consultation. A more detailed description of the proposed action can be found in the consultation package (BPA et al. 2018a, Chapter 2).

1.3.1 System Operations and Maintenance for Congressionally Authorized Project Purposes

The Action Agencies propose to continue operating and maintaining the 14 federal Columbia River System projects to meet congressionally authorized purposes: flood risk management (FRM), fish and wildlife conservation, power system management, irrigation/water supply, navigation, recreation, system maintenance, water quality, and municipal and industrial water supply, though not every project is authorized for every one of these purposes.

1.3.1.1 Operations for Flood Risk Management

The Action Agencies propose to continue operating the Columbia River System storage projects as a coordinated system to meet regional FRM objectives to protect life and property by minimizing flood consequences or risk of damages, regardless of the conditions presented in any given water year. The coordinated operation resulting from this objective (as conditioned by previous consultations) can best be described in terms of seasonal operations. There is no specific operation for FRM in August.

Fall Operation: September ─ December

Fall operations (September─December period) at specific water storage projects are affected by a variety of factors, but projects are generally operated to reach end-of-December target reservoir elevations to create flood storage space, which usually results in operations to lower (draft) reservoir levels during this period.

Storage Evacuation Operation: January ─ April

During the January─April period, the Columbia River System storage projects operate to the storage reservation diagram (SRD) unique to each dam. The SRDs determine the maximum allowable elevation for each reservoir based on a given water-supply forecast. This can result in a range of outcomes depending upon the official water-supply forecasts prepared for each storage project throughout the Columbia River basin, including The Dalles Dam, within the first 10 days of each month, from January through April. Every year, the federal storage reservoirs are operated to maximize available water for fish during the migration season, while also ensuring that FRM objectives are met.

Refill Operation: May ─ July

During the May─July period, the Columbia River System storage projects are operated to target refill, limited by system and local FRM guidance. The projects on the Columbia River operate together to meet the initial controlled flow (ICF) at The Dalles Dam, while refilling reservoirs during the refill period. The ICF is a calculated flow, used in conjunction with the forecasts and available reservoir storage, to determine when to start refill to ensure a high probability of achieving total refill while managing flood risks. During the refill period, the outflow from the reservoir is kept lower than the inflow to the reservoir, allowing the water level in the reservoir to increase and refill, eventually reaching its targeted refill elevation when the risk of flooding has significantly decreased.

1.3.1.2 Operations for Conservation of Fish and Wildlife

The operation of the 14 Columbia River System projects is managed to benefit ESA-listed anadromous (e.g., salmon and steelhead) and resident species (e.g., Kootenai River white sturgeon, and bull trout), as well as other non-listed species (e.g., salmonids, burbot, and lamprey), while achieving other project purposes.

Storage Project Operations

The Action Agencies manage water and reservoir operations for both anadromous and resident fish using the specific operations described in detail in the 2018 proposed action. These operations consider seasonal spring and summer flow objectives for migrating juvenile salmon and steelhead at several representative locations in the Columbia and Snake Rivers, and fall and winter flows for spawning and incubating chum salmon below Bonneville Dam. While projects vary, in general, this includes the following:

- Operate storage projects to be at their FRM elevation targets in early April (the exact date to be determined during in-season management) to maximize flows for the spring out-migration of juvenile salmon.
- Refill the storage projects by the end of June/early July (exact date to be determined during in-season management) to provide summer flow augmentation consistent with available water supply, spring operations, and FRM requirements.
- Draft storage projects to their August 31 or September 30 elevation targets based on water-supply volume forecast to support summer flow augmentation for juvenile fall Chinook salmon migration.
- Provide fall and winter tailwater elevations/flows to support chum salmon spawning and incubation in the Ives Island area below Bonneville Dam, and to provide access for chum spawning in Hamilton and Hardy Creeks.
- Balance the consideration of these priorities for various listed fish (resident and anadromous).

The Action Agencies also propose to continue to pursue agreement with Canada, through the Columbia River Treaty annual agreements (up to 1.0 million acre-feet (MAF) released within the May─July period) or long-term Non-Treaty Storage Agreements (up to 0.5 MAF released in the spring to benefit juvenile migrants in the lowest 20th percentile of water conditions (Dry Year Strategy), if not used in the prior year.

Run-of-River[7] Spring Fish Passage Spill Operations 2019

The intent of the flexible spring fish passage spill operation is to (1) provide fish benefits (increasing spill levels to improve juvenile passage conditions and survival rates and adult returns), (2) provide federal power system benefits, and (3) provide operational feasibility. As described in the 2019-2021 Flexible Spill Operation Agreement (*Natl Wildlife Fed'n et al. v. NMFS et al.,* ECF 2298)*,* spring spill levels in 2019 will follow the flexible spill concept. Beginning in the spring of 2019, the four lower Snake River dams and the four Columbia River dams will operate up to 120 percent TDG Gas Cap spill for a minimum of sixteen hours per day, and each project may operate under "performance spill" for up to eight hours per day.[8] The eight hours of performance spill maybe split into two separate blocks with one beginning in the AM hours, and one in the PM hours. These performance spill blocks provide more flow through turbine units. Higher powerhouse flow allows for power marketing flexibility and can also work to alleviate passage concerns for adult migrants that can have difficulty passing during high spill at some projects. The Gas Cap spill periods are intended to increase spillway passage and reduce powerhouse encounter rates for downstream migrating juvenile salmonids. Spring spill operations will occur April 3–June 20 at the four lower Snake River projects, and April 10–June 15 at the four lower Columbia River projects. Daily spill caps to meet the 120 percent tailrace target will be coordinated with NMFS and adjusted daily as necessary. Target spill levels for spring 2019 at each project are defined in Table 1.3-1.

[7] Run-of-river hydropower is a type of hydroelectric generation whereby little or no water storage is provided. The power facility is subject to seasonal river flows.
[8] Spilling up to the 120 percent gas cap levels at many projects presumes that the Washington Department of Ecology will approve a proposal to remove the 115 percent forebay gages as points of compliance from the state standard.

Table 1.3-1 Summary of 2019 spring spill levels at lower Snake and Columbia River projects (FOP 2019).

PROJECT	GAS CAP SPILL (16 hours per day)[1, 2, 3, 5]	PERFORMANCE STANDARD SPILL (8 hours per day)[2, 4, 5]
Lower Granite	120% Gas Cap	20 kcfs
Little Goose	120% Gas Cap	30%
Lower Monumental	120% Gas Cap (uniform spill pattern)	30 kcfs (bulk spill pattern)
Ice Harbor	120% Gas Cap	30%
McNary	120% Gas Cap	48%
John Day	120% Gas Cap	32%
The Dalles	120% Gas Cap[6]	40%
Bonneville	120% Gas Cap[7] (no downstream forebay)	100 kcfs

[1]Uncertainty remains about how the system will respond to these new operations, therefore existing adaptive management processes will be employed to help address any unintended consequences that may arise in-season as a result of implementing these proposed spill operations. Additionally, spilling up to the 120 percent gas cap levels at many projects presumes that the Washington Department of Ecology will approve a proposal to remove the 115 percent forebay gages as points of compliance from the state standard.

[2]Spill may be temporarily reduced at any project if necessary to ensure navigation safety or transmission reliability.

[3]120 percent Gas Cap spill is spill to the maximum level that meets, but does not exceed, the TDG criteria allowed under state laws.

[4]Performance standard spill would occur with some flexibility. The 8 hours would be split into two blocks, an a.m. block and a p.m. block. An a.m. block is defined as beginning in the a.m. (but may end in the p.m.) and a p.m. block is defined as beginning in the p.m. Only Little Goose would be set to at least 4 hours in the a.m. (beginning near dawn and not to exceed 5 hours in the a.m.) and no more than 4 hours in the p.m. (generally near dusk) to help with adult passage issues. All other projects could spill up to 5 hours of performance standard spill either in the a.m. or p.m. time period with the remaining hours occurring in the alternate time period (not to exceed 8 hours in a day).

[5]No ponding above current MOP/MIP assumptions: Snake River - MOP 1.5 ft. range to provide 1 ft. of usable space; John Day - MIP 2 ft. range to provide 1.5 ft. of usable space.

[6]Gas cap fish passage spill restricted to spillbays 1-8.

[7]Spill up to the 120% Gas Cap, not to exceed 150 kcfs.

2020 Spring Fish Passage Spill Operations

As described in the 2019-2021 Flexible Spill Operation Agreement, spill operations in the spring of 2020 will incorporate spill up to and including 125 percent TDG for the spring fish passage spill season. The decision to operate up to 125 percent TDG is dependent on the provision of state water quality standards. The Washington Department of Ecology expects to make a decision on the modification up to 125 percent TDG (as read in the tailrace) prior to the beginning of the 2020 spring juvenile fish passage spill season. The Oregon Department of Environmental Quality (ODEQ) will ask the Oregon Environmental Quality Commission (EQC) to consider changing the current standard modification to allow spring juvenile fish passage spill up to 125 percent TDG (as read in the tailrace) at the four Lower Columbia River dams. As described in the agreement, parties will continue in good faith to evaluate the effect of different variables, such as project-specific spill levels and duration (both daily and seasonal), to refine 2020 spring operations, and complete a final specific operations plan by September 1, 2019. If the Parties cannot agree on a refined operation, one of the two representative spring spill operations will be implemented in the 2020 spill season, or until the Parties can agree on refinements. The spring spill operations in 2020 are similar in concept to the 2019 flex spill operation, with the primary difference being the increase to the higher spill caps necessary to achieve up to 125 percent tailrace TDG. This increase in spill cap will result in higher spill levels for 16 hours per day at most dams, however, The Dalles Dam will spill less at 40 percent and John Day Dam will spill either 32 percent or maintain up to 120 percent TDG flexible spill. The reductions in spill at these two projects are intended to meet the power benefit objective of the Flexible Spill Operation Agreement. Spill caps will be limited during low and moderate flows by powerhouse minimum generation requirements at some projects (Table 1.3-2).

Table 1.3-2. Spill operations for spring 2020 as described in the 2019-2021 Flexible Spill Operation Agreement (*Natl Wildlife Fed'n et al. v. NMFS et al*., ECF 2298) with Minimum Generation estimates (which may vary outside these ranges under certain circumstances) assuming priority units (typically unit 1) are available. John Day operation is pending further discussion.

Project	125% TDG Spill (16 hours)	Performance Spill (8 hours)	Minimum Generation (Kcfs)
Lower Granite	125% TDG	20 kcfs	11.8 – 12.9
Little Goose	125% TDG	30%	11.3 – 11.8
Lower Monumental	125% TDG	30 kcfs (bulk)	11.1 – 12.3
Ice Harbor	125% TDG	30%	8.4 – 10.1
McNary	125% TDG	48%	50 – 60
John Day	120% TDG or 32%	32%	50 – 60
The Dalles	40%	40%	50 – 60

Project	125% TDG Spill (16 hours)	Performance Spill (8 hours)	Minimum Generation (Kcfs)
Bonneville	125% TDG	100 kcfs	30 – 40

Summer Fish Passage Spill Operations 2019-2020

Summer spill operations in 2019 will occur June 21–August 31 at the four lower Snake River projects, and June 16–August 31 at the four lower Columbia River projects. Target spill levels for summer 2019 and 2020 at each project are defined in Table 1.3-3. As described in the 2019-2021 Flexible Spill Operation Agreement, spill may be reduced in summer of 2020 in the Snake River if parties to the agreement reach consensus on the preferred operation. The reduction in spill in summer is in response to typically low numbers of juvenile migrants, and the desire to ensure that 2020 spring spill operations meet all three objectives of the Flexible Spill Operation Agreement. The alternative scenario would be to continue with summer spill operations until August 31 (*Natl Wildlife Fed'n et al. v. NMFS et al.,* ECF 2298).

Table 1.3-3. Summary of 2019-2020 summer target spill levels at lower Snake and lower Columbia River projects.

PROJECT	2019-2020 SUMMER SPILL (24 hrs/day)
Lower Granite	18 kcfs
Little Goose	30%
Lower Monumental	17 kcfs
Ice Harbor	30%
McNary	57% (with no spillway weir)
John Day	35%
The Dalles	40%
Bonneville	95 kcfs

Reservoir Operations 2019-2020

The Action Agencies will operate Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams at minimum operating pool (MOP) with a 1.5-foot operating range (to provide 1.0 foot of usable space) from April 3 until small numbers of juvenile migrants are present (approximately September 1) unless adjusted on occasion to meet authorized project purposes, primarily navigation (Table 1.3-4). Except for the John Day Project, the Lower Columbia River projects (Bonneville, The Dalles, and McNary) will be operated at normal operating range for each project. John Day Dam will be operated at minimum irrigation pool (MIP) with a 2-foot range (to provide 1.5 feet of usable space) from April 10 through September 30. Slight deviations from these levels, based on navigation needs may be required on occasion.

Table 1.3-4. Minimum operating pool (MOP), Minimum Irrigation Pool (MIP), and Normal Operating Elevation Range for CRS projects[1].

Project	Normal Operating Elevation Range		1.5-foot MOP/ 2.0-foot MIP Restricted Elevation Range	
	Minimum	Maximum	Minimum	Maximum
Lower Granite[2]	733.0	738.0	733.0	734.5
Little Goose3	633.0	638.0	633.0	634.5
Lower Monumental[3]	537.0	540.0	537.0	538.5
Ice Harbor[3]	437.0	440.0	437.0	438.5
McNary[4]	337.0	340.0	N/A	N/A
John Day[5]	262.0 Nov 1-Dec 31; 262.5 Apr 1-Oct 31	266.5	262.5	264.5
The Dalles[4]	155.0	160.0	N/A	N/A
Bonneville[4]	71.5	76.5	N/A	N/A

[1]MOP elevations provided in feet above mean sea level (NGVD29).

[2]Due to sedimentation near the Port of Clarkston, the Lower Granite pool may require variable MOP operations relative to river flow as needed for navigation as described in the FOP.

[3]Little Goose, Lower Monumental, and Ice Harbor may have adjusted MOP for navigation (Raised MOP or Expanded MOP), as described in the FOP.

[4]McNary, The Dalles, and Bonneville have no MOP or MIP restriction and operate within Normal Elevation Range. Normal operation range differs from minimum and full pool primarily due to **navigation** constraints (Conder 2019a).

[5]The John Day pool normal operating range minimum is increased to 262.5 feet from March 15 through October 31 for irrigation purposes. John Day Dam will be operated at Minimum Irrigation Pool (MIP) 262.5-264.5 feet (2-ft range) from April 10 through September 30.

Transport Operations 2019-2020

The start of juvenile transport operations at Lower Granite, Little Goose, and Lower Monumental dams will target April 24 (collection starting on April 23) as coordinated through the Technical Management Team (TMT) and the Regional Implementation Oversight Group (RIOG), but transport will begin no later than May 1. This is consistent with operations in 2018; prior to 2018, managers typically elected to begin transport May 1. In 2019, transport operations will continue through the end of October at Lower Granite and Little Goose Dams and through the end of September at Lower Monumental Dam, regardless of when spill ends. As part of ongoing discussions between parties of the 2019-2021 *Flexible Spill Operation Agreemen*t, cessation of transport operations in July and parts of June and August of 2020 may occur (Action Agency letter to NMFS dated 12.19.2018). Additionally, allowances for adaptive management through established regional forum processes may lead to further modifications to the transport program.

1.3.1.3 Operations for Power System Management

The Action Agencies propose to continue operating the 14 federal CRS projects to generate electricity to meet regional load (demand). Power will be generated, using any remaining flexibility to manage water flow, and to meet the daily and seasonal demand for electricity.[9] This includes balancing electricity demand and supply, managing the system to address or avoid emergencies, and integrating renewable resources. BPA must also manage and provide operating reserves based on required reserve obligations using dispatchable energy generation[10] to ensure that generation within the balancing authority area matches load at all times and maintains the safety and reliability of the transmission grid. See consultation package Section 2.1.3 for more details.

1.3.1.4 Operations for Irrigation/Water Supply

The Bureau of Reclamation and Corps propose to continue to store and divert water for irrigation and water supply (see consultation package Section 2.1.4 for more details). This includes the operation of the Columbia Basin Project and the mainstem hydrologic effects of several Reclamation irrigation projects that are not coordinated with the Columbia River System (The

[9] The Action Agencies generally prioritize FRM and environmental responsibilities, such as conservation actions for protected fish species, which limits flexibility to meet daily and seasonal demand for electricity.

[10] Dispatchable generation refers to sources of electricity that can be dispatched (generation is increased or decreased) at the request of power grid operators or of the plant owner to meet fluctuations in demand or supply. Often, baseload power plants, such as nuclear or coal, cannot be turned on and off in less than several hours. The time periods in which a dispatchable generation plant may be turned on or off may vary in time frames of seconds, minutes or hours.

Dalles Project; Chief Joseph Dam Project; Umatilla Projects, including Phase I and Phase II; Yakima Project; Deschutes Project; and Crooked River Project are included in this consultation). Depletions from these non-Columbia River System irrigation projects are included in the Columbia River hydrologic models for the Columbia River System.

The Corps manages some CRS reservoir levels to allow for irrigation on private agricultural lands. The Corps' Northwestern Division Reservoir Control Center coordinates and modifies operations to benefit irrigation at both John Day and McNary Projects. The Lower Snake River Project also provides irrigation water by maintaining stabilized reservoir levels that enable the installation and operation of pumping stations.

1.3.1.5 Operations for Navigation

The Action Agencies propose to continue operating the eight mainstem projects for navigation (see consultation package Section 2.1.5 for details). This includes managing reservoir elevations, filling and draining navigation locks, and maintaining navigation locks. Adjustments in spill or reservoir operating ranges may be required at any of the lower Snake or lower Columbia River projects to address navigation safety concerns and to maintain the authorized depth in the federal navigation channel.

1.3.1.6 Operations for Recreation

The Action Agencies propose to continue the operation of the 14 CRS projects to support recreational activities (see consultation package Section 2.1.6 for details). This includes managing reservoir elevation and river flows. Both recurring and one-time requests for special operations to support recreation are considered, within normal operating limits and other project requirements including FRM and fish conservation operations.

1.3.1.7 System Maintenance

The Action Agencies propose to continue to maintain the 14 CRS projects (see consultation package Section 2.1.6 for details). This includes scheduled, or routine, maintenance of fish facilities, spillway components, navigation locks, generating units, and supporting systems to ensure project reliability and to comply with North American Electric Reliability Corporation (NERC)/Western Electricity Coordinating Council (WECC) regulatory requirements.

System maintenance also includes maintenance that is not planned, referred to as unscheduled maintenance. Unscheduled maintenance can occur any time there is a problem or unforeseen maintenance issue or emergency that requires a project feature, such as a generator unit, to be taken offline in order to resolve. Unscheduled maintenance occurring in combination with ongoing scheduled maintenance can significantly reduce the generating capability and hydraulic capacity of the project. The timing, duration, and extent of these events are unforeseeable. These events are coordinated through the appropriate teams under the Regional Forum, such as the Fish Passage Operations and Maintenance (FPOM) coordination team and TMT, to minimize negative effects on fish.

Maintenance that is planned but is not performed at regular intervals (e.g., unit overhauls, major structural modifications, or rehabilitations) is referred to as non-routine maintenance. Non-routine maintenance is not performed at a regular pre-determined frequency, and includes tasks that are more significant in nature than routine scheduled maintenance. Non-routine maintenance examples include power plant modernization and major rehabilitations of CRS project features.

Maintenance also includes measures to reduce or contain the releases of oils and greases from federal dams into the Snake or Columbia Rivers. For equipment in contact with the water, the Corps has developed best management practices to avoid accidental releases and to minimize the adverse effects in the case of an accidental release. The Corps has also begun using, where feasible, "environmentally acceptable lubricant" greases and in some cases has replaced greased equipment with greaseless equipment. The Corps has also developed and are implementing oil accountability plans with enhanced inspection protocols and are reporting annually.

1.3.2 Non-Operational Conservation Measures to Benefit ESA-listed Salmon and Steelhead

In addition to the operational measures described above, the Action Agencies propose to continue non-operational conservation measures to address uncertainty regarding the effects of further increases in spring spill, and to help offset any residual adverse effects of system management. These non-operational measures include support for conservation hatchery programs, predation management, habitat improvement actions in the Columbia River estuary and various tributaries, and kelt reconditioning (see consultation package Section 2.2 for details). The Action Agencies' approach to mitigating the effects of CRS management on ESA-listed salmon and steelhead is consistent with conservation strategies established in regional salmon and steelhead recovery planning processes.

1.3.2.1 Conservation and Safety Net Hatchery Actions

To support ESA-listed salmon and steelhead species affected by CRS management, the Action Agencies will continue to fund the operation and maintenance of safety net and conservation hatchery programs that preserve and rebuild the genetic resources of ESA-listed salmon and steelhead in the Columbia and Snake River basins. The purposes of conservation programs are to rebuild and enhance the naturally reproducing ESA-listed fish in their native habitats using locally adapted broodstock, while maintaining genetic and ecological integrity, and supporting harvest where and when consistent with conservation objectives. Safety net programs are focused on preventing extinction and preserving the unique genetics of a population using captive broodstock to increase the abundance of the species at risk.

Conservation and Safety Net Hatcheries

The conservation and safety net hatcheries, funding for which is included in this proposed action, are listed in Table 2.8 of the consultation package. The operation and maintenance of these programs have undergone separate, program-specific ESA consultations with NMFS (Table 1.3-5). The programs will be operated in accordance with those biological opinions. RM&E relevant to each hatchery program has been incorporated into the relevant hatchery program biological opinion(s). The Action Agencies have also committed to fund hatchery programs with Chinook salmon production levels equal to, or greater than, those previously analyzed by NMFS in the 2008/2014 biological opinions. The Action Agencies propose to continue to discuss broader, basinwide, hatchery monitoring needs as they come up, and to collaborate with NMFS to evaluate ways to support these needs to the extent practicable.

Table 1.3-5. Action agency-funded conservation and safety net hatchery programs included in this consultation.

Species	Hatchery Program	Population	Program Type	Operator	Action Agency Funding Source	Biological Opinion Status	Production level approved in NMFS BiOp
Upper Columbia River spring Chinook	Winthrop NFH spring Chinook Program[1]	Methow spring Chinook	Integrated conservation	USFWS	Reclamation	Final biological opinion 10/13/2016	Up to 400,000 smolts
Upper Columbia River steelhead	Winthrop steelhead Program	Winthrop steelhead	Integrated conservation	USFWS	Reclamation	Final biological opinion 10/10/2017	Up to 200,00 smolts
Upper Columbia River spring Chinook	Chief Joseph Hatchery (CJH) Program/ Winthrop NFH	Okanogan spring Chinook	Isolated conservation (10j)	Colville Tribe/ USFWS	Bonneville/ Reclamation	Final CJH biological opinion 10/27/2014 Final biological opinion WNFH 10/13/16	Up to 200,000 smolts
Snake River spring Chinook	Yankee Fork/Panther Creek spring Chinook	Yankee Fork/Panther Creek	Integrated Recovery	SBT	Bonneville	Final biological opinion 12/26/2017	Up to 1,000,000 smolts; 600k in Yankee Fork and 400k in Panther Creek
Snake River spring Chinook	Johnson Creek spring Chinook	Johnson Creek	Integrated Recovery	NPT	Bonneville	Final biological opinion 11/27/2017	Up to 150,000 smolts

Species	Hatchery Program	Population	Program Type	Operator	Action Agency Funding Source	Biological Opinion Status	Production level approved in NMFS BiOp
Snake River fall Chinook	Nez Perce Tribal Hatchery fall Chinook salmon Program	Clearwater basin	Integrated Recovery	NPT	Bonneville	Final biological opinion 10/9/2012	Up to 1,400,000 yearlings
Snake River sockeye	Snake River Sockeye Salmon Captive Broodstock Program	Redfish Lake	Integrated Recovery	IDFG	Bonneville	Final biological opinion 9/28/2013	Up to 1,000,000 smolts

[1]The Upper Columbia River spring Chinook salmon and steelhead hatchery programs included in this table serve as both conservation programs as well as the Grand Coulee mitigation programs.

Kelt Reconditioning

The Action Agencies propose to continue funding kelt reconditioning in the upper Columbia, mid-Columbia, and the Snake River basins as a conservation tool to enhance abundance and productivity, and minimize loss of genetic and life-history diversity. Reestablishment or enhancement of repeat spawning in listed steelhead populations can improve productivity, diversity, and demographic stability, and is particularly important during times of low steelhead abundance. Since 2008, the Action Agency-funded kelt reconditioning projects have successfully reconditioned and released over 2,500 repeat spawning steelhead in the upper Columbia, mid-Columbia, and Snake River basins (Hatch et al. 2018).

1.3.2.2 Predator Management and Monitoring Actions

The Action Agencies propose to continue actions to reduce the number of ESA-listed salmon and steelhead that are impacted by predators (see consultation package Section 2.2.2 for details):

- Pinniped Management at Bonneville Dam ─
    - Installation of sea-lion excluder gates in ladder entrances,
    - Support for land- and water-based harassment efforts by state and tribal agencies, and
    - Assessment of sea lion abundance, distribution, and predation rates.
- Pikeminnow Predation Management ─
    - Implementation of the Northern Pikeminnow Management Program (NPMP), including the Sport Reward Fishery (May through September) and Dam Angling programs (May through October).
- Avian Predation Management ─
    - Implementation of Inland Avian Predation Management Plan (IAPMP),
    - Implementation of East Sand Island Caspian Tern Management Plan,
    - Implementation of East Sand Island Double-Crested Cormorant Management Plan, and
    - Synthesization of avian predation data collected throughout the planning and implementation of the three avian management plans to assist in assessing the effectiveness of these actions on a basinwide scale.

1.3.2.3 Estuary Habitat Actions

The Action Agencies propose to continue implementing the Columbia Estuary Ecosystem Restoration Program (CEERP) to increase the capacity and quality of estuarine ecosystems, and improve the opportunity for access by juvenile salmonids. This element of the proposed action will mitigate for the effects of flow regulation on floodplain connectivity below Bonneville Dam, and will help address uncertainty related to any residual effects of the proposed action for the hydrosystem, including uncertainty regarding such effects in the face of climate variability (see consultation package Section 2.2.3.1 for details).

The Action Agencies propose to prioritize habitat improvement sites by identifying regions with the greatest potential to benefit yearling and subyearling life-history types of ESA-listed Chinook salmon and steelhead. Examples of potential actions include: reconnecting floodplains, recreating wetland channels, reducing non-native species, and restoring native vegetation. The Action Agencies will continue to use the Expert Regional Technical Group (ERTG) to inform selection and prioritization of biologically effective projects and to review completed projects.

The Action Agencies propose to reconnect an average of 300 acres per year to the tidal regime for the duration of the proposed action. They also propose to continue to coordinate and implement the CEERP restoration and monitoring plans with NMFS, to programmatically evaluate action effectiveness monitoring and research (AEMR) using a three-level, nested, approach,[11] and to improve the estuary habitat program over time as information becomes available that addresses current and future uncertainties. Several efforts are already underway:

- Synthesis Memorandum number 2, a five-year update of the best available scientific information for the lower Columbia River estuary (June 2018);
- Oncor Database, a web-accessible, geospatial database for ecosystem improvement data and associated RM&E;
- ERTG's Landscape Perspectives, providing their recommendations for additional factors that should be part of the site selection process; and
- Implementation Forecasting, an effort to identify the viability of projects that could become restored and contribute to more robust estuary ecosystem, a companion product to the ERTG's Landscape Perspectives project.

The intent of each of the undertakings listed above is to refine and learn a more effective approach to restoring estuary habitat. The Action Agencies describe these proposed endeavors, and their continued on-the-ground habitat improvement, as a commitment and willingness to analyze the outcomes and results of these actions to improve their understanding and the effectiveness of habitat improvement in the estuary.

1.3.2.4 Tributary Habitat Actions

The Action Agencies propose to continue strategic implementation of tributary habitat improvement actions as offsite mitigation to help address uncertainty related to residual adverse

11 The three levels of AEMR move from intensive to extensive, and it is important to note that these levels are nested, that is, Level 1 includes Level 2 and Level 3, and Level 2 includes Level 3: Level 1, "intensive AEMR," examines ecosystem processes and functions, e.g., juvenile salmon species composition, density, diet, and growth, along with structures and controlling factors; Level 2, "core AEMR," assesses core indicators of ecosystem structures and controlling factors such as plant species composition, percent cover, and biomass (Roegner et al. 2009); and, Level 3, "standard AEMR," monitors key controlling factors and other indicators, e.g., photo points, water surface elevation, and salinity.

effects of the proposed action on the listed salmon and steelhead that migrate through the CRS, including uncertainty regarding such effects in the face of climate change (see consultation package Section 2.2.3.2 for details).

Implementation Approach

The Action Agencies commit that their tributary habitat improvement actions will be informed by recovery plans and other best available science, will build adaptively on the science-based strategies and research and monitoring information developed during implementation of tributary habitat improvement actions under the 2008/2014 FCRPS biological opinion, and will maintain the extensive network of collaboration with local experts and implementing partners developed under the 2008 biological opinion.

The Action Agencies will focus implementation of tributary habitat improvement actions on populations that are important to MPGs, including the priority populations identified in the 2008 FCRPS biological opinion, and will continue working with NMFS to refine population priorities. The Action Agencies will prioritize actions based on:

- Geographic location — The Action Agencies will identify watersheds where additional habitat actions offer the greatest potential to contribute to species viability. They also will emphasize non-federal lands, both to complement existing efforts and responsibilities of other federal agencies and to focus on lower gradient, often highly productive habitat; and
- Type of action — The Action Agencies will identify the actions that will be most effective at addressing key limiting factors within priority watersheds.

The overall strategy will be to protect high-quality habitat, improve lower-quality habitat with good potential to become high-quality habitat, and address connectivity and migration concerns, and areas of high fish mortality. Decisions will be based on an understanding of the habitat requirements of the target species and their life-history characteristics; understanding of population-specific limiting factors; development of implementation and prioritization plans; and coordination among stakeholders, landowners, funding and monitoring entities, and implementers.

Actions and Metrics

For the period covered by this consultation, the Action Agencies will complete, or have in process, habitat improvement actions for three MPGs within the Snake River spring/summer Chinook salmon ESU, for two MPGs within the Snake River steelhead DPS, and for Upper Columbia River spring Chinook salmon and Upper Columbia River steelhead. Specific metrics that the Action Agencies have committed to are included in the effects analysis for each of these species.

In addition, the Action Agencies may implement habitat improvement actions for Mid-Columbia River steelhead and for the populations of Columbia River chum, Lower Columbia River (LCR) coho, LCR Chinook, and LCR steelhead that have been affected by CRS management.

Reporting

The Action Agencies will provide NMFS with information to evaluate the tributary habitat improvement program, including inputs for future life-cycle modeling and for evaluation of the program's implementation and effectiveness. Information reported will include:

- Action description (category, rationale, objectives);
- Flow – cubic feet per second or acre-feet increased instream flow acquired;
- Screening – number of screens;
- Access – miles of access;
- Complexity – miles of stream complexity improved;
- Riparian – miles or acres of riparian habitat enhanced;
- Location and extent of action;
- Implementation timing; and
- Target-reach current and post-implementation habitat condition.

The Action Agencies will work with NMFS to refine and improve reporting, and to align the habitat database with reporting needs, where feasible.

Climate Change

Many of the habitat improvement actions planned, designed, funded, and implemented by the Action Agencies will help support resilient habitats and flexibility to adjust to climate change. For example, actions to enhance riparian areas, stream complexity, and stream flow will help to mitigate the effects of warmer summer temperatures, climate-related changes in flow regimes, increased wildfires, changes in flood regimes, and increases in cumulative stress to stream systems.

Research, Monitoring and Evaluation

The Action Agencies intend to implement a tributary habitat RM&E program to assess tributary habitat conditions, limiting factors, and habitat improvement action effectiveness, and address critical uncertainties associated with habitat mitigation actions.

The Action Agencies will develop a newly refined habitat RM&E strategy in collaboration with NMFS and other regional partners within the term covered by this consultation. Purposes of future RM&E will be focused on communicating the status of tributary habitat in the Columbia River basin (habitat and fish status and trends monitoring), documenting habitat actions (implementation and compliance monitoring), guiding future tributary habitat improvement decisions (effectiveness monitoring), and reducing critical uncertainties to assess the benefit of tributary habitat actions to salmonid populations (research).

During the development of this habitat RM&E strategy, the Action Agencies will fund the following tributary habitat RM&E during this consultation period:

- Status and trends of habitat and fish;
- Implementation and compliance monitoring; and
- Effectiveness monitoring –
    - Site-scale effectiveness monitoring,
    - Watershed-scale effectiveness monitoring,
    - Basinwide analyses and summaries, and
    - Research.

Specific tributary-related RM&E programs that the Action Agencies intend to support through the consultation period include: Intensively Monitored Watersheds (IMWs); adaptive management through integration of RM&E, life-cycle models, and implementation of tributary habitat projects; stream temperature and flow monitoring; PIT-tag marking and evaluation of Upper Columbia and Snake River salmon and steelhead; PIT-tag marking and evaluation of juvenile Snake River sockeye salmon; natural abundance monitoring for the Snake River fall Chinook ESU; status and trend monitoring for fish populations in the upper basin; and research and monitoring of nearshore ocean conditions, causal mechanisms and migration/behavior characteristics affecting survival of juvenile salmon.

1.3.2.5 Fish Status Monitoring Actions

The Action Agencies propose to fund the following monitoring and evaluation activities in order to effectively track survival of ESA-listed species affected by Action Agency management:

- PIT-tag marking of Upper Columbia and Snake River stocks to provide ESU-specific estimates of juvenile and adult survival through the federal mainstem dams;
- PIT-tag marking of juvenile Snake River sockeye salmon for specific survival tracking of this ESU from the Stanley Basin to Lower Granite Dam and through the mainstem Columbia River System projects; and
- Implementation of core elements of natural abundance monitoring for the Snake River fall Chinook salmon ESU.

In addition, as noted previously, the Action Agencies will continue fish status and trend monitoring for selected populations in the upper basin. They will also continue ongoing efforts to improve the approach to CRS status monitoring (analytical approaches, tagging needs, methods, and protocols), with a focus on programmatic efficiencies and improved reporting though technology and elimination of duplication. This will be done in collaboration with the state, tribal, and federal fishery agencies and will be coordinated with other status monitoring needs and strategies for the region.

Ongoing support also includes BPA contributions to research involving the effects of nearshore ocean conditions on adult returns, including the causal mechanisms and migration/behavior characteristics affecting survival of juvenile salmon during their first weeks in the ocean.

1.3.3 Reporting, Adaptive Management, and Regional Coordination

The Action Agencies propose to use the best available scientific information to identify and carry out actions that are expected to provide immediate and long-term benefits to listed fish, while continuing to operate for other authorized purposes set forth by Congress. To that end, the Action Agencies propose to coordinate with NMFS and other regional partners to inform and signal appropriate adaptations to changing circumstances (see consultation package Section 2.3 for details).

1.3.3.1 Annual Biological Opinion Implementation Reporting

The Action Agencies propose to report annually to NMFS the following information:

- Configuration or operational changes at the dams;
- Operations for juvenile fish (e.g., the placement of screens, the start and end of spill operations);
- Transport operations (start and end of transport operations, number of fish transported);
- Operations for adult fish;
- Predation management actions;
- Kelt reconditioning actions;
- Results from monitoring operations, such as:
    - Adult fish counts,
    - Pinniped numbers and predation estimates at Bonneville Dam,
    - Juvenile fish in-river system survival estimates,[12] and
    - Adult fish upstream conversion estimates;
- Tributary habitat improvements –

[12] NOAA Fisheries has historically produced estimates of juvenile in-river system survival and adult fish conversion rates. The Action Agencies provide tagged fish, detection capability at dams, and maintain the PITagis database, while NOAA analyzes the data, generates the estimates and delivers them to the Action Agencies for inclusion in annual Biological Opinion reporting. The Action Agencies assume this collaborative arrangement will continue.

  - See the Action Agencies Proposed Action Section 2.2.3.2 for details on tributary habitat improvement reporting; and
- Estuary habitat improvements –
  - Acres of estuary floodplain improved, and
  - Miles of estuary riparian area improved.

1.3.3.2 Adaptive Management and Regional Coordination

The Action Agencies propose to continue to use an adaptive management framework to manage system operations and guide implementation of the additional non-operational measures to benefit ESA-listed salmon and steelhead. The Action Agencies propose to continue to work collaboratively with regional sovereign parties to adaptively manage the implementation of system operations related to fish through various policy and technical teams, collectively referred to as the Regional Forum,[13] and to implement year-round system operations related to fish and adaptively manage operations, as necessary.

1.3.3.3 Contingencies

The 2009 Adaptive Management Implementation Plan included triggers for: (1) unexpected declines in adult abundance and (2) environmental disasters or environmental degradation (either biological or environmental) in combination with preliminary abundance indicators. The Action Agencies propose to work with NMFS and other salmon managers, and will coordinate with other appropriate parties in any regionwide diagnostic effort, such as utilizing life-cycle models if the early warning or significant decline triggers are tripped as defined in the 2014 biological opinion (i.e., five-year abundance trends, rolling four-year averages of abundance, and where those metrics fall relative to particular percentiles).

1.3.4 Interrelated and Interdependent Actions

"Interrelated actions" are those that are part of a larger action and depend on the larger action for their justification. "Interdependent actions" are those that have no independent utility apart from the action under consideration (50 CFR 402.02). The proposed action encompasses a broad-scale program of activities. There are no actions that have been identified as interrelated or interdependent to the proposed action.

1.4 Action Area

"Action area" means all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR 402.02). For this consultation, the action area for all fish species is the mainstem Columbia River, including and downstream of Libby and Hungry Horse Dams and reservoirs (on tributaries in Montana), down to and

[13] This includes the Regional Implementation Oversight Group (RIOG); Technical Management Team (TMT); Systems Configuration Team (SCT); Studies Review Work Group (SRWG); Fish Facility Design Review Work Group (FFDRWG); and Fish Passage Operations and Maintenance (FPOM) coordination team.

including the Columbia River estuary and plume (i.e., nearshore ocean adjacent to the river mouth); the Snake River below the confluence with the Salmon River; and the Clearwater River, including Dworshak Reservoir and downstream of the dam in the North Fork Clearwater River, flowing into the Clearwater River to its confluence with the lower Snake River. It also includes any subbasins that are the focus of the tributary habitat improvement actions that the Action Agencies have proposed to offset any residual adverse effects of system management. Further, the action area extends upstream to all additional spawning and rearing areas that are accessible to ESA-listed salmon and steelhead and that are affected by the CRS action.

The downstream extent of the action area for fish species (the nearshore ocean immediately adjacent to the river mouth) is defined by observed changes in flow attributable to the operation of the CRS.

2. Endangered Species Act

This chapter describes the status of 16 different ESA-listed species and their critical habitats in the action area that could be affected by the proposed action, and describes the environmental baseline. It also provides NMFS' finding regarding the effects of the proposed action, and whether the action is likely to jeopardize the listed species or destroy or adversely modify their critical habitat.

2.1 Analytical Approach

This biological opinion includes both a jeopardy analysis and an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of" a listed species, which is "to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

The biological opinion relies on the regulatory definition of "destruction or adverse modification," which "means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features" (50 CFR 402.02).

The designations of critical habitat for salmon, steelhead, and eulachon use the terms primary constituent elements (PCEs), or essential features, to describe sites and habitat components that are essential for conservation. The latest critical habitat regulations (81 FR 7414) replace those terms with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

We use the following approach to determine whether a proposed action is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Identify the rangewide status of the species and critical habitat.
- Describe the environmental baseline in the action area.
- Analyze the effects of the proposed action on both species and their habitat using an "exposure–response–risk" approach.
- Describe any cumulative effects in the action area.

- Integrate and synthesize the above factors by: (1) Reviewing the status of the species and critical habitat; and (2) adding the effects of the action, the environmental baseline, and cumulative effects to assess the risk that the proposed action poses to species and critical habitat.
- Reach a conclusion about whether the proposed action is expected to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species, or appreciably diminish the value of critical habitat for the conservation of a listed species.
- If necessary, suggest a RPA to the proposed action.

In this opinion, we analyze the effects of the proposed action separately for each species because each is uniquely exposed to the effects of the action, either in terms of life history, run timing, number of dams passed, or location in the Columbia Basin. Thus, when describing the environmental baseline and analyzing the effects of the action for each species, we focus our analysis on that portion of the action area that is most relevant (in terms of exposure and response) for each species.

For Pacific salmon, steelhead, and certain other species, we commonly use four "viable salmonid population" (VSP) criteria (McElhany et al. 2000) to assess the viability of the populations that, together, constitute the species. These four criteria (spatial structure, diversity, abundance, and productivity) encompass the species' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. When these parameters are collectively at appropriate levels, they maintain a population's capacity to adapt to various environmental conditions and allow it to sustain itself in the natural environment.

"Spatial structure" refers both to the spatial distributions of individuals in the population and the processes that generate that distribution. A population's spatial structure depends on habitat quality and spatial configuration, and the dynamics and dispersal characteristics of individuals in the population.

"Diversity" refers to the distribution of traits within and among populations. These range in scale from DNA sequence variation in single genes to complex life-history traits (McElhany et al. 2000).

"Abundance" generally refers to the number of naturally produced adults (i.e., the progeny of naturally spawning parents) in the natural environment (e.g., on spawning grounds).

"Productivity," as applied to viability factors, refers to the entire life cycle (i.e., the number of naturally spawning adults produced per parent). When progeny replace or exceed the number of parents, a population is stable or increasing. When progeny fail to replace the number of parents, the population is declining. McElhany et al. (2000) use the terms "population growth rate" and "productivity" interchangeably when referring to production over the entire life cycle. They also refer to "trend in abundance," which is the manifestation of long-term population growth rate.

For species with multiple populations, once the biological status of a species' populations has been determined, we assess the status of the entire species using criteria for groups of populations, as described in recovery plans and guidance documents from technical recovery teams. Considerations for species viability include having multiple populations that are viable, and ensuring that populations with unique life histories and phenotypes are viable, and that some viable populations are both widespread to avoid concurrent extinctions from mass catastrophes and spatially close to allow functioning as metapopulations (McElhany et al. 2000).

The proposed action is an ongoing action, but is of limited duration because the Action Agencies are developing an Environmental Impact Statement (EIS) in accordance with NEPA that will assess and update the approach for long-term system operations, maintenance, and configuration, as well as evaluate measures to avoid, offset, or minimize impacts to resources affected by the management of the CRS, including ESA-listed species and designated critical habitat. A court order currently requires the Action Agencies to issue Records of Decision on or before September 24, 2021.[14] Based on scoping, the range of alternatives being examined is broad and includes potential large-scale changes in the action. Thus, there is substantial uncertainty regarding what system operations, maintenance, and configuration the Action Agencies will propose at the conclusion of the NEPA process. Likewise, it is unknown what measures intended to avoid, offset, or minimize adverse effects will ultimately be included in the preferred alternative.

Accordingly, our analysis of effects for species and their critical habitat extends from 2019 into the future, but emphasizes the evaluation of effects that are reasonably certain to occur as a result of implementing the proposed action pending completion of the EIS and our issuance of a subsequent biological opinion addressing the effects of the final preferred alternative. To the extent our consideration of potential effects beyond that time period assumes the current proposed action remains in place, it is intended, in part, to inform the evaluation of alternatives in the EIS.

We analyze the effects of the proposed action in the interior Columbia Basin using the COMPASS (Comprehensive Passage Model) model to assess effects on juvenile survival migrating through the lower Snake and Columbia Rivers. The COMPASS model was developed by NMFS' Northwest Fisheries Science Center (NWFSC), and is a tool for comparatively assessing the likely effect of alternative hydropower structures and/or operations on the passage and survival of salmon and steelhead. Information from both PIT tags and acoustic tags were used to calibrate the model.

[14]The Presidential Memorandum on Promoting the Reliable Supply and Delivery of Water in the West, issued on October 19, 2018, required the development of an expedited schedule for completion of the NEPA process. The Council on Environmental Quality has confirmed a revised schedule that calls for completing the Draft EIS in February 2020, the Final EIS in June 2020 and Records of Decision by September 30, 2020. These dates are consistent with, but earlier than, the court-ordered deadlines.

We use the full life-cycle models developed through the NWFSC's Adaptive Management Implementation Plan efforts for 22 of the 31 extant populations in the Upper Columbia spring Chinook salmon and Snake River spring/summer Chinook salmon ESUs to project population abundance and a quasi-extinction risk. The life-cycle models incorporate results from the COMPASS model, and are parameterized to include tributary habitat actions, pinniped predation, and survival in the ocean. The life-cycle models, which are under continuing refinement, represent the best available science and are useful to inform our analyses (ISAB 2006a, 2006b, 2006c, 2008, 2013, 2017).

2.2 Upper Willamette River (UWR) Chinook Salmon

This section applies the analytical framework described in section 2.1 to the UWR Chinook salmon ESU and provides NMFS' finding regarding whether the proposed action is likely to jeopardize the continued existence of UWR Chinook salmon ESU or destroy or adversely modify its critical habitat.

2.2.1 Rangewide Status of the Species and Critical Habitat

The status of UWR Chinook salmon is determined by the level of extinction risk that the listed species faces, based on parameters considered in documents such as the recovery plan, status reviews, and listing decisions. The species status also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. This informs the description of the species' likelihood of both survival and recovery. The condition of critical habitat throughout the designated area is determined by the current function of the essential PBFs that help to form that conservation value.

2.2.1.1 Status of Species

The UWR Chinook salmon (*Oncorhynchus tshawytscha*) ESU is composed of all naturally spawned spring-run Chinook salmon originating from the Clackamas River subbasin and from the Willamette River subbasins upstream of Willamette Falls, as well as five artificial propagation programs (Figure 2.2-1).[15] Seven historical, demographically independent populations have been identified, but significant natural production now occurs only in the Clackamas and McKenzie subbasins. The other naturally spawning populations are small and mostly composed of hatchery-origin fish. NMFS expresses the status of an ESU in terms of the status and extinction risk of its individual populations, relying on McElhaney et al.'s (2000) description of a viable salmonid population. The 2011 Conservation and Recovery Plan for Upper Willamette Chinook salmon and steelhead (ODFW and NMFS 2011) describes the viability criteria in detail, and the parameter values needed for persistence of individual populations and for recovery of the ESU. Though the risk categories for the seven populations range from low to very high, the extinction risk for the ESU overall is high to very high.

Upper Willamette River Chinook salmon were originally listed as threatened on March 24, 1999. That status was affirmed in 2005 and updated on April 14, 2014. Critical habitat was designated in 2005. The recovery plan was completed in 2011 (ODFW and NMFS 2011), and the last five-year status review was completed in 2016 (NMFS 2016a). Table 2.2-1 provides a summary of listing and recovery plan information, status summary, and limiting factors for UWR Chinook

[15] McKenzie River Hatchery Program (Oregon Department of Fish and Wildlife [ODFW] Stock #23), Marion Forks Hatchery/North Fork Santiam River Program (ODFW Stock #21), South Santiam Hatchery Program (ODFW Stock #24) in the South Fork Santiam River and Molalla River, Willamette Hatchery Program (ODFW Stock #22), and Clackamas Hatchery Program (ODFW Stock #19).

salmon. More information can be found in the recovery plan and status review for this species. These documents are available on the NMFS West Coast Region website.[16]

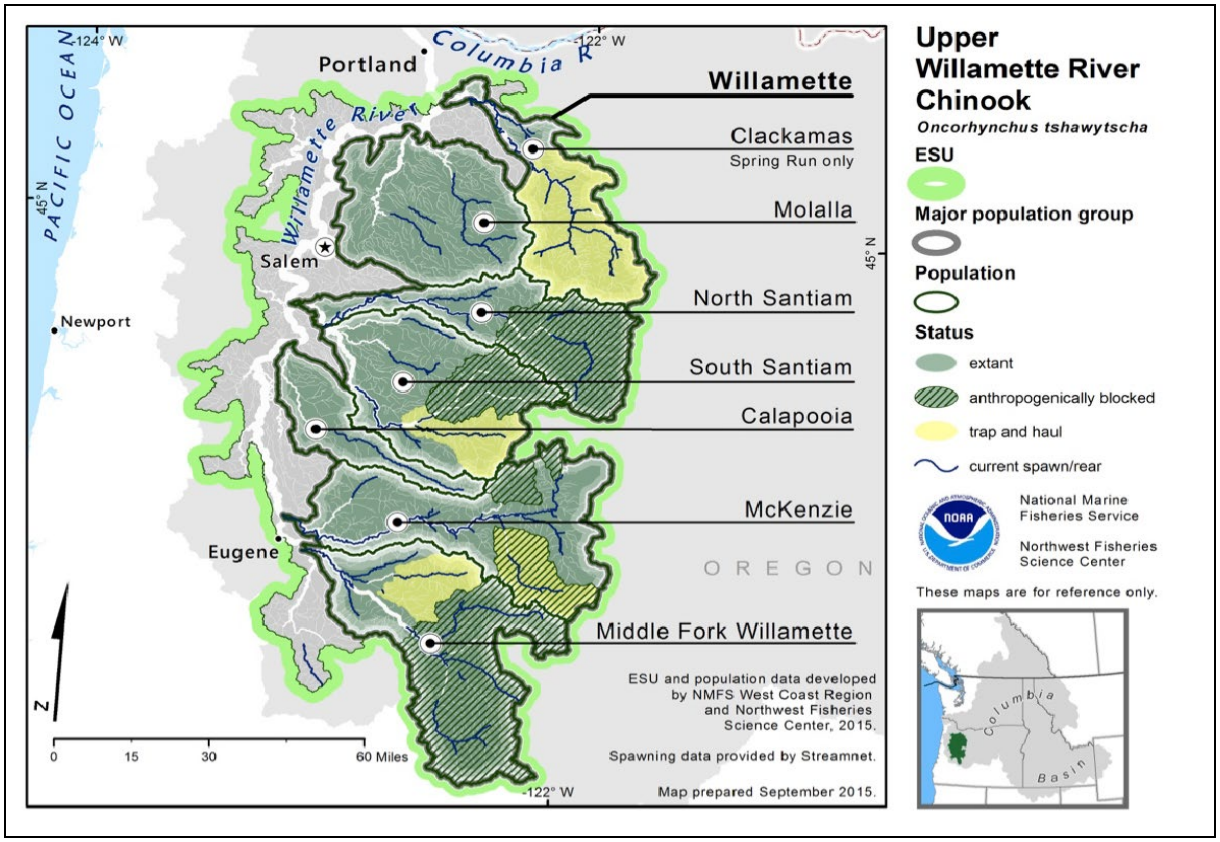


Figure 2.2-1. Map of the Upper Willamette River Chinook salmon ESU's spawning and rearing areas, illustrating populations and major population groups. Source: NWFSC 2015.

Upper Willamette River Chinook salmon differ from other Columbia Basin Chinook salmon according to both genetic and life-history data (Schreck et al. 1986; Utter et al. 1989; Waples et al. 1993; Myers et al. 1998). Recent research has shown that the ESU exhibits several different life-history pathways. Many juveniles from interior spring Chinook salmon populations reach the Willamette mainstem migration corridor as yearlings, but some juveniles found in the lower Willamette River are subyearlings (Friesen et al. 2004). These early subyearling migrants can enter the Willamette mainstem (as fry) as early as May and head to the lower Columbia as early as June (Schroeder et al. 2005). Early subyearling migrants have been captured in the upper estuarine zone of the lower Columbia River, and have also been captured in nearshore ocean samples in June. Fall subyearling migrants usually remain in the Willamette subbasins through their first spring and summer; some spend their first winter in the Willamette River, while others move past Willamette Falls on the lower Willamette River prior to winter, and likely rear in the

[16] Currently these documents can be found within the NMFS West Coast Region website at: http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/salmon_and_steelhead_listings/chinook/upper_willamette_river/upper_willamette_river_chinook.html. Last accessed August 2018.

Columbia River or estuary before entering the ocean as early as March (ODFW and NMFS 2011; Rose 2015).

The recovery plan (ODFW and NMFS 2011) identifies key and secondary limiting factors and threats to UWR Chinook salmon recovery for each population by area and life stage. Access to historical spawning and rearing areas is restricted by large dams in the four historically most-productive tributaries, and is a key limiting factor to recovery. In the absence of effective passage programs, the fish will continue to be confined to more lowland reaches where land development, water temperatures, and water quality are limiting. Pre-spawning mortality levels are generally high in the lower tributary reaches where water temperatures and fish densities are generally the highest (NMFS 2016a). In contrast to most of the other populations in this ESU, McKenzie River Chinook salmon have access to much of their historical spawning habitat, although access to historically high-quality habitat above Cougar Dam (South Fork McKenzie River) is still limited by poor downstream juvenile passage (NMFS 2016a).

Abundance levels for five of the seven demographically independent populations (DIPs) in this ESU remain well below their recovery goals. Of these, the Calapooia River may be functionally extinct, and the Molalla River remains critically low (although perhaps only marginally better than the zero VSP score estimated in the recovery plan). Abundances in the North and South Santiam Rivers have risen since the last review, but still range only in the high hundreds of fish. Improvement in the status of the Middle Fork Willamette River relates solely to the return of natural adults to Fall Creek; however, the capacity of the Fall Creek basin alone is insufficient to achieve the recovery goals for the Middle Fork Willamette River DIP. The Fall Creek program also provides valuable information relevant to the use of reservoir draw-downs as a method of juvenile downstream passage. The proportion of natural-origin spawners has improved in the North and South Santiam basins, but remains well below identified recovery goals. The presence of juvenile (subyearling) Chinook salmon in the Molalla River suggests that there is some limited natural production.

The Clackamas and McKenzie Rivers have previously been viewed as natural population strongholds, but have both experienced declines in abundance. Overall, populations appear to be at either moderate or high risk and there has been likely little net change in the VSP score for the ESU since the last review.

An increase in the number of adult and juvenile salmon predator species (pinnipeds, birds, and fish) in the lower Columbia and lower Willamette Rivers over the past decade have become emerging and serious threats to the recovery of UWR Chinook salmon.

Table 2.2-1. Recent status and limiting factors information for UWR Chinook salmon from the 2016 status review (NWFSC 2015; NMFS 2016a).

Status Summary	Limiting Factors
Seven demographically independent populations of spring-run Chinook salmon have been identified by the Willamette–Lower Columbia Technical Recovery Team for the UWR Chinook salmon ESU (Myers et al. 2006). "(C)" and "(G)" identify Core and Genetic Legacy populations, respectively (Appendix B in WLCTRT 2003). Risk of extinction categories are from McElhany et al. 2007:	• Climate change effects including increased stream temperatures, changes in precipitation/stream flow, and years of low ocean productivity. • Restricted access to historical, and more productive, spawning an rearing habitats due to the presence of large dams in the four historically most-productive tributaries: North Santiam, South Santiam, Middle Fork Willamette and McKenzie. • Poor habitat quality and high pre-spawning mortality in the accessible, lowland reaches where land development, water temperatures, and water quality are limiting.
Clackamas (C) – moderate risk	• Anthropogenic introductions of nonnative species and out-of-ESU races of salmon or steelhead have increased predation on, and competition with, native UWR Chinook salmon.
Molalla – high risk	
North Fork Santiam (C) – very high risk	• Poor downstream juvenile passage from the historically high-qual habitat above Cougar Dam (South Fork McKenzie River).
South Fork Santiam – very high risk Calapooia – very high risk, may be functionally extinct	• An altered seasonal flow regime and Columbia River plume due t water diversions and water management projects.
McKenzie (C, G) – low risk Middle Fork Willamette (C) – very high risk The fraction of hatchery origin fish in all populations remains high. Although there has been an overall decrease in the VSP (Viable Salmonid Population) status of the UWR Chinook salmon ESU since the previous status review, the magnitude has not been sufficient to suggest a change in the risk category. Given current climatic conditions and the prospect of long-term climatic change, in addition to the lack of access to historical headwater spawning habitat, continued pinniped predation, and urban development, the ESU may	• Degraded and lost juvenile rearing habitat, including floodplain connections, velocity refuges, and shallow-water habitat, especial from levees and bank armoring projects and increased developme (especially in areas like the Portland Harbor). • Reduced productivity resulting from sediment and nutrient-relate changes in the estuary. • Human population growth effects, including increased water use, land use, development, and pollution levels. • Higher pinniped predation rates on adults in the estuary and at Willamette Falls. • Continued avian predation on smolts in the Columbia River estua • Continued nonnative fish predation on fry and smolts in the Columbia and Willamette. • A high, but declining, proportion of hatchery-origin fish on spawning grounds (pHOS).

Status Summary	Limiting Factors
experience a greater risk of extinction in the near future (NWFSC 2015; NMFS 2016b).	• Ocean harvest rates of approximately 30%; fishery-related mortalities from ocean salmon fisheries and recreational and commercial gillnet fisheries in the Lower Columbia.

Based on the updated risk assessment in the most recent five-year status review, there are a number of general considerations that affect some or all of the populations. In addition to the prespawning mortalities monitored in the specific population basins, there is a shortfall in abundance between Willamette Falls and east-side tributary census points due to pre-spawning mortality or spawning in the unsurveyed lower reaches of east- or west-side tributaries (Jepson et al. 2013, 2014) where spawning and incubation conditions are less well suited to spring-run Chinook salmon. Radio-tagging results from 2014 suggest that few fish strayed into west-side tributaries (no detections) and relatively fewer fish were unaccounted for between Willamette Falls and the tributaries: 12.9 percent of clipped fish and 5.3 percent of unclipped fish (Jepson et al. 2015). Access to historical spawning and rearing areas is restricted by large dams in the four historically most productive tributaries, and in the absence of effective passage, programs will continue to be confined to more lowland reaches where land development, water temperatures, and water quality may be limiting. Pre-spawning mortality levels are generally high in the lower tributary reaches where water temperatures and fish densities are generally the highest. Areas immediately downstream of high-head dams may also be subject to high levels of total dissolved gas (TDG, expressed as a percent of saturation). While the relationship between TDG levels and mortality is related to a complex interaction of fish species, age, depth, and history of exposure (Beeman and Maule 2006), the relative risks are quite high in some reaches. For example, natural-origin Chinook salmon and steelhead are passed above the barrier dam at the Minto fish facility into a short reach immediately below the Detroit/Big Cliff Dam complex. At certain times of the year, water spilled over Detroit and Big Cliff Dams on the North Santiam River has the potential to produce high levels of TDG, which could affect a significant portion of the incubating embryos, instream juveniles, and adults in the basin, although the effect of this impact has not been quantified (NWFSC 2015).

The apparent decline in the status of the McKenzie River DIP in the last ten years is a source of concern given that this population was previously seen as a stronghold of natural production in the ESU. In contrast to most of the other populations in this ESU, McKenzie River Chinook salmon have access to much of their historical spawning habitat, although access to historically high-quality habitat above Cougar Dam (South Fork McKenzie River) is still limited by poor downstream juvenile passage. Additionally, the installation of a temperature control structure in Cougar Dam in 2008 was thought to benefit downstream spawning and rearing success. Similarly, natural-origin returns to the Clackamas River have remained flat, despite adults having access to much of their historical spawning habitat. Although returning adults have access to most of the Calapooia and Molalla River basins, habitat conditions are such that the productivity of these systems is very low. Natural-origin spawners in the Middle Fork Willamette River in the last ten years consisted solely of adults returning to Fall Creek. While these fish contribute to the DIP and ESU, at best the contribution will be minor. Finally, improvements were noted in the North and South Santiam DIPs. The increase in abundance in both DIPs was in contrast to the other DIPs and the counts at Willamette Falls. While spring-run Chinook salmon in the South Santiam DIP have access to some of their historical spawning habitat, natural-origin spawners in the North Santiam DIP are still confined to below Detroit Dam and subject to relatively high pre-spawning mortality rates (NWFSC 2015).

Although there has likely been an overall decrease in the VSP status of the UWR Chinook salmon ESU since the last review, the magnitude of this change is not sufficient to suggest a change in risk category. Given current climatic conditions and the prospect of long-term climatic change, the inability of many populations to access historical headwater spawning and rearing areas may put this ESU at greater risk in the near future (NWFSC 2015). Further, recent observations of coastal ocean conditions suggest that the 2015-17 outmigrant year classes experienced below average ocean survival, which predicts a corresponding drop in adult returns through 2019 (Werner et al. 2017).

2.2.1.2 Status of Critical Habitat

This section describes the status of designated critical habitat affected by the proposed action by examining the condition and trends of the PBFs of that habitat throughout the designated area. These features are essential to the conservation of the ESA-listed species, because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration, and/or foraging). Table 2.2-2 summarizes status information for designated critical habitat for UWR Chinook salmon based on the detailed information on the status of critical habitat provided in the recovery plan for the species and the recent status review (ODFW and NMFS 2011; NMFS 2016a). UWR Chinook salmon critical habitat is within the Willamette/Lower Columbia River recovery domain.

Anthropogenic effects on habitat in the Willamette River basin, particularly the major water storage and hydroelectric projects, have significantly reduced access to spawning habitat in the four most historically productive basins. Other factors affecting the condition of designated, critical habitat for UWR Chinook salmon and the essential PBFs include:

- Increases in water use and storage; destructive land use activities;
- Urban development and other effects related to human population growth (primarily in the Willamette basin, but also in the Columbia Basin and estuary);
- Degraded freshwater habitat, especially floodplain connectivity and function, channel structure and complexity, and riparian areas and large wood recruitment as a result of cumulative impacts of agriculture, forestry, and development; and
- Degraded water quality and altered water temperatures as a result of both tributary dams and the cumulative impacts of agriculture, forestry, and urban development.

All of these factors have reduced the quality of many remaining habitat areas by weakening important watershed processes and the functions that sustained them.

Table 2.2-2. Critical habitat, designation date, Federal Register citation, and status summary for UWR Chinook salmon critical habitat.

Designation Date and Federal Register Citation	Critical Habitat Status Summary
9/02/05 **70 FR 52630**	Critical habitat encompasses 10 subbasins in Oregon containing 60 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most HUC5 watersheds with essential PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005a). However, most of these watersheds have some, or high, potential for improvement. Of these 60, 19 watersheds received a low rating, 18 received a medium rating, and 23 received a high rating of conservation value to the ESU. The lower Willamette/Columbia River rearing/migration corridor is considered to have a high conservation value and is the only habitat area designated in one of the high-value watersheds identified above. This corridor connects every population with the ocean and is used by rearing/migrating juveniles and migrating adults. The Columbia River estuary is a unique and essential area for juveniles and adults making the physiological transition between life in freshwater and marine habitats. 1,472 miles of stream are designated critical habitat.

2.2.1.3 Climate Change Implications for UWR Chinook Salmon and Critical Habitat

One factor affecting the rangewide status of UWR Chinook salmon and aquatic habitat is climate change. The U.S. Global Change Research Program (USGCRP), mandated by Congress in the Global Change Research Act of 1990, reports average warming of about 1.3ºF from 1895 to 2011. As the climate changes, air temperatures in the Pacific Northwest are expected to increase 4 to 13°F by the end of the century, with the largest increases expected in the summer (Mantua et al. 2009; Mote et al. 2014). Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004; Scheuerell and Williams 2005; Zabel et al. 2006; ISAB 2007). According to the ISAB, these effects pose the following impacts into the future:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a smaller snowpack, watersheds will see their runoff diminished earlier in the season, resulting in lower stream flows in the June through September period. River

flows in general and peak river flows are likely to increase during the winter due to more precipitation falling as rain rather than snow.

- Water temperatures are expected to rise, especially during the summer months when lower stream flows co-occur with warmer air temperatures.

The proposed action is only expected to be implemented in the interim time period between 2019 and completion of the NEPA process; however, the effects of the implementation of the proposed action will extend many years (e.g., maturation of estuary habitat projects). Thus, both natural climate variation and climate change are relevant to our analysis.

Likely changes in temperature, precipitation, wind patterns, and sea-level height have implications for the survival of UWR Chinook salmon in both its freshwater and marine habitats. As the climate changes, air temperatures in the Pacific Northwest are expected to increase 4 to 13°F by the end of the century (Mantua et al. 2009; Mote et al. 2014). While total precipitation changes are uncertain, increasing air temperature will result in more precipitation falling as rain rather than snow in watersheds across the basin (NMFS 2017a). In general, these changes in air temperatures, river temperatures, and river flows are expected to cause changes in salmon distribution, behavior, growth, and survival, although the magnitude of these changes remains unclear. In coastal areas, projections indicate an increase of 1–4 feet of global sea-level rise by the end of the century. This sea-level rise and storm surge pose a risk to infrastructure, and coastal wetlands and tide flats are likely to erode or be lost as a result of seawater inundation (Mote et al. 2014). Ocean acidification is also expected to negatively impact Pacific salmon and organisms within their marine food webs.

Climate change would affect UWR Chinook salmon and critical habitat in the following ways: (1) warmer stream temperatures could increase pre-spawning mortality and cause changes in growth, development rates, and disease resistance; (2) changes in flow regimes (larger winter floods and lower flows in the summer and fall) could reduce overwintering habitat for juveniles, reduce egg and juvenile survival, reduce spawning habitat access/availability, and alter spawning run timing; (3) timing of smolt migration may change due to a modified timing of the spring freshet; (4) changing ocean conditions and marine food webs could affect ocean survival and growth; and (5) predicted sea-level rise could cause significant reductions in rearing habitat in some Pacific Northwest coastal areas (Glick et al. 2007).

2.2.2 Environmental Baseline

The environmental baseline includes the past and present impacts of all federal, state, or private actions and other human activities in an action area; the anticipated impacts of all proposed federal projects in an action area that have already undergone formal or early section 7 consultation; and the expected impacts of state or private actions that are contemporaneous with the consultation in process.

For UWR Chinook salmon, we focus the description of the environmental baseline on that portion of the action area where UWR Chinook salmon juveniles and adults are exposed to the effects of the proposed action.

To determine the upstream extent of UWR Chinook salmon distribution in the Columbia River, and thus the potential for exposure to the effects of the proposed action, we reviewed UWR Chinook salmon PIT detections at Bonneville Dam over the past ten years (2008–18). A total of three adults were detected at Bonneville Dam during this time, two in 2017 and one in 2016. No detections were observed at The Dalles or McNary Dams. Thus, the upper extent of UWR Chinook salmon exposure to the effects of the proposed action is primarily the confluence of the Willamette River with the Columbia (DART 2019a). The downstream extent of the effects of the action (changes in flow) is the plume.[17] Therefore, we focus our analysis on the area from the Willamette River confluence to the plume, and include the mouths of tributaries to the Columbia River in this reach to the extent that they are affected by flow management in the Columbia River. We also include Bonneville Pool downstream to the confluence with the Willamette because of the few fish observed passing through Bonneville Dam (adult strays)

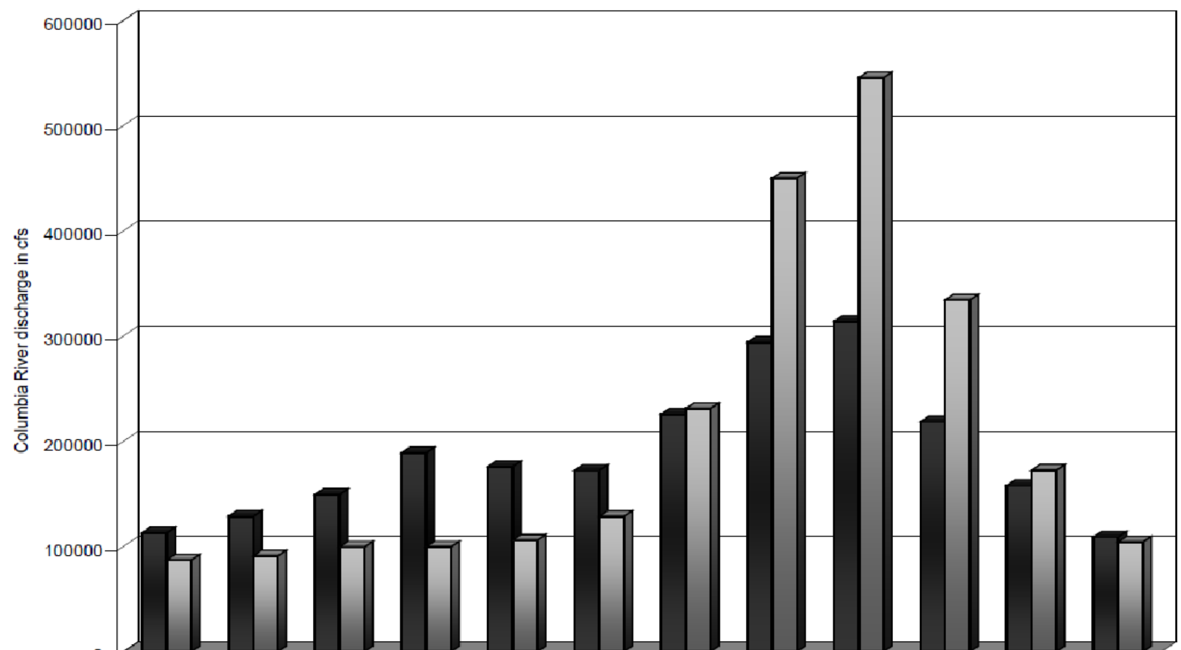
2.2.2.1 Mainstem Habitat

On the mainstem of the Columbia River, hydropower projects (including the CRS), water storage projects (including reservoirs in Canada operated under the Columbia River Treaty), and the withdrawal of water for irrigation and urban uses have significantly degraded salmon and steelhead habitats (Bottom et al. 2005; Fresh et al. 2005; NMFS 2013). The volume of water discharged by the Columbia River varies seasonally according to runoff, snowmelt, and hydropower demands. Mean annual discharge is estimated to be 265 kcfs, but may range from lows of 71–106 kcfs to highs of 530 kcfs (Hamilton 1990; Prahl et al. 1998; NMFS 1998; USACE 1999). Naturally occurring maximum flows on the river would occur in May, June, and July as a result of snowmelt in the headwater regions. Minimum flows would occur from September to March, with periodic peaks due to heavy winter rains (Holton 1984). Interannual variability in stream flow is strongly correlated with two recurrent climate phenomena, the El Niño/Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO; Newman et al. 2016).

Water storage projects (dams and reservoirs) and water management activities have reduced flows between Bonneville Dam and the mouth of the Columbia River compared to natural flows in the late spring and summer months; on average, this reduction can range from nearly 15 kcfs in August to over 230 kcfs in May (see Figure 2.2-2). Recognizing that the flow versus survival relationships for some interior basin ESUs/DPSs displayed a plateau over a wide range of flows but declined markedly as flows dropped below some threshold (NMFS 1995b, 1998), NMFS and

[17] The Columbia River plume is defined as those waters contiguous to the mouth of the Columbia River having salinity less than 32.5 percent (Park 1966). Historically, the outflow from the Columbia River was viewed as a freshwater plume oriented southwest over the Oregon shelf during summer and north or northwest over the Washington shelf during winter. However, more recent data show that the plume extends in both directions and is frequently present up to 100 miles north of the river mouth from spring to fall (Hickey et al. 2005).

the CRS Action Agencies have attempted to manage Columbia and Snake River water resources to maintain seasonal flows above threshold objectives given the amount of runoff in a given year. These flow objectives have guided preseason reservoir planning and in-season flow management. Nonetheless, since the development of the hydrosystem, average monthly flows at Bonneville Dam have been substantially lower during May–July and higher in October–March than an unregulated system. Reduced flows have increased travel times during outmigration for juvenile salmonids and reduced access to high-quality estuarine habitats during spring through early summer.



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Current	113017	128641	149403	189076	175921	172150	225689	293948	313930	218523	157935	109020
Natural	87115	91029	99387	99496	106033	128580	231047	450040	545561	334238	172430	104310

Figure 2.2-2. Comparison of monthly discharge (flow) in the Columbia River between current conditions (black) and normative flows (gray). These data show that pre-development flows were lower in the winter and higher in the spring and early summer months.

The series of dams and reservoirs have also blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is only one-third of nineteenth-century levels (Simenstad et al. 1982 and 1990; Sherwood et al. 1990; Weitkamp 1994; NRC 1996; NMFS 2008a). Similarly, Bottom et al. (2005) estimated that the delivery of suspended sediment to the lower river and estuary has been reduced by about 60 percent (as measured at Vancouver, Washington). This reduction has altered the development of habitat along the margins of the river.

Industrial harbor and port development are also significant influences on the lower Willamette and lower Columbia Rivers (Bottom et al. 2005; Fresh et al. 2005; NMFS 2013a). Since 1878, the Corps has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the lower Willamette River as a navigation channel. Originally dredged to a 20-foot minimum depth, the federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The navigation channel supports many ports on both sides of the river, resulting in several thousand commercial ships traversing the river every year. The dredging, along with diking, draining, and placing of fill material in wetlands and shallow habitat, also disconnects the river from its floodplain, resulting in the loss of shallow-water rearing habitat and the ecosystem functions that floodplains provide (e.g., supply of prey, refuge from high flows, and temperature refugia; Bottom et al. 2005).

The most extensive urban development in the lower Columbia River subbasin has occurred in the Portland/Vancouver area. Common water-quality issues, both in areas with urban development and areas with rural residential septic systems, include warmer water temperatures, lowered dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff (LCREP 2007).

2.2.2.2 Passage Survival

With the exception of an extremely limited number of adult strays detected at Bonneville Dam, none of the populations in this ESU pass any of the mainstem CRS projects.

2.2.2.3 Water Quality

Water quality in the action area is impaired. Common toxic contaminants found in the Columbia River system include polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), polybrominated diphenyl ethers (PBDEs, or flame retardants), dichlorodiphenyltrichloroethane (DDT) and other legacy pesticides, current use pesticides, pharmaceuticals and personal care products, and trace elements (LCREP 2007). The LCREP 2007 report noted widespread presence of PCBs and PAHs, both geographically and in the food web. Urban and industrial portions of the lower river contribute significantly to contaminant levels in juvenile salmon; juvenile salmon are absorbing toxic contaminants during their time rearing and feeding in the lower Columbia River (LCREP 2007). Likewise, juvenile salmon accumulate DDT in their tissues and are exposed to estrogen-like compounds in the lower river, likely associated with pharmaceuticals and personal care products. Concentrations of copper are present at levels that could interfere with crucial salmon behaviors. Small releases of materials such as lubricants occur during dam operation and maintenance and contribute to background exposure to contaminants in the Columbia River.

Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute municipal and industrial waste discharges to the lower Columbia River. Industrial and municipal wastes from the Portland/Vancouver metro areas, including the superfund-designated reach in the lower Willamette River, also contribute to degraded water quality in the lower Columbia River. Mining areas scattered around the basin deliver higher background concentrations of metals. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river.

Outside of urban areas, the majority of residences and businesses rely on septic systems. Common water-quality issues associated with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff. Under these environmental conditions, fish in the action area are stressed. Stress may lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival).

Water temperatures in the Columbia River are a concern; because of temperature standard exceedances, the Columbia River is included on the Clean Water Act §303(d) list of impaired waters established by Oregon and Washington. Temperature conditions in the Columbia River basin are affected by many factors, including:

- Natural variation in weather and river flow;
- Construction of the dam and reservoir system (the large surface areas of reservoirs and resulting slower river velocities contribute to warmer late summer/fall water temperatures);
- Increased temperatures of tributaries due to water withdrawn for irrigated agriculture, and due to grazing and logging;
- Point-source discharges such as cities and industries; and
- Climate change.

The Environmental Protection Agency (EPA) is working with federal and state agencies, the tribes, and other stakeholders to develop water-quality improvement plans (total maximum daily loads) for temperature in the Columbia River and lower Snake River. As part of the 2015 biological opinion on EPA's approval of water-quality standards, including temperature (NMFS 2015a), EPA committed to work with federal, state, and tribal agencies to identify and protect thermal refugia and thermal diversity in the lower Columbia River and its tributaries.

Comparisons of long-term temperature monitoring in the migration corridor before and after impoundment reveal a change in the thermal regime of the Snake and Columbia Rivers. Using historical flows and environmental records for the 35-year period 1960–95, Perkins and Richmond (2001) compared water temperature records in the lower Snake River with and without the lower Snake River dams and found three notable differences between the current versus unimpounded river:

- Maximum summer water temperature has been slightly reduced;
- Water temperature variability has decreased; and
- Post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall, a phenomenon termed thermal inertia.

These hydrosystem effects (influenced by the temperatures of tributary streams entering the Snake and Columbia Rivers both upstream of, within, and downstream of the mainstem dams) continue downstream and influence temperature conditions in the lower Columbia River. At a macro scale, water temperature affects salmonid distribution, behavior, and physiology (Groot and Margolis 1991); at a finer scale, temperature influences migration swim speed of salmonids (Salinger and Anderson 2006), timing of river entry (Peery et al. 2003), susceptibility to disease and predation (Groot and Margolis 1991), and, at temperature extremes, survival.

Another feature of water quality that affects mainstem water quality and habitat is total dissolved gas (TDG, expressed as a percent of saturation). To facilitate the downstream movement of juvenile salmonids, Oregon and Washington regulatory agencies issue criteria adjustments for TDG as measured in the forebay and tailrace (NMFS 1995a). Specifically, water that passes over the spillway at a mainstem dam can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated TDG conditions can cause gas bubble trauma (GBT) in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). Historically, TDG supersaturation was a major contributor to juvenile salmon mortality; to reduce TDG supersaturation, the Corps installed spillway improvements, typically “flip lips” to create a hydraulic jump and deflect water upwards, at each mainstem dam except The Dalles Dam. Biological monitoring shows that the incidence of GBT in both migrating smolts and adults remains between 1 and 2 percent when TDG concentrations in the upper water column do not exceed 120 percent of saturation in CRS project tailraces. When those levels are exceeded, there is a corresponding increase in the incidence of signs of GBT symptoms. Fish migrating at depth avoid exposure to the higher TDG levels due to pressure compensation mechanisms (Weitkamp et al. 2003). For the 2018 spill season, the Action Agencies targeted the 115/120 TDG levels with the goal of improving juvenile passage survival.

2.2.2.4 Tributary Habitat

Information about the species’ status in the tributary portion of its life cycle and condition of critical habitat can be found in Section 2.2.1 (Rangewide Status). Tributary habitat occupied by UWR Chinook salmon is not exposed to the effects of the proposed action.

2.2.2.5 Estuary Habitat

The estuary provides important migratory and rearing habitat for UWR Chinook salmon populations. Since the late 1800s, 68–70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening combined with flow regulation and other modifications (Kukulka and Jay 2003; Bottom et al. 2005; Marcoe and Pilson 2017). Disconnection of tidal wetlands and floodplains has eliminated much of the historical rearing habitat for subyearling Chinook salmon and reduced the production of wetland macrodetritus supporting salmonid food webs (Simenstad et al. 1990; Maier and Simenstad 2009), both for smaller juveniles in shallow water and for larger juveniles migrating in the mainstem (ERTG 2018).

Ford (2011) describes both yearling and subyearling emigrants from this ESU. Some juveniles grow quickly in the lower reaches of their spawning tributaries and the mainstem Willamette River and migrate to the estuary as subyearlings. These fish have been captured in shallow-water habitats along the floodplain and within mainstem islands in the lower Columbia River, with some residing over winter (Johnson et al. 2015).

Because juvenile UWR Chinook salmon spend a significant amount of time in the estuary (Hanson et al. 2015; Johnson et al. 2015; Rose 2015; Kidd et al. 2018), improved connectivity of floodplain habitat for feeding and growth likely contributes to survival when smolts first enter the ocean. Although yearlings do not use the low-velocity, shallow-water habitats to the same extent as subyearlings, improved opportunities for feeding likely improve survival to the early ocean life stage as well. Restoration actions in the estuary, such as those highlighted in the 2016 five-year review have improved access and connectivity to habitat in the estuary (NMFS 2016a).

2.2.2.6 Hatcheries

Salmon and steelhead smolt hatchery releases throughout the Columbia Basin have likely reduced the productivity of natural populations via density-dependence, predation, and increased competition for limited resources (LCREP 2011; NMFS 2017a). NMFS directs federal funding to many of the hatchery programs in the Lower Columbia through the Mitchell Act. NMFS completed a biological opinion on its funding of the Mitchell Act program in 2017 (NMFS 2017a). As a result of this consultation, several reform measures will be implemented that will reduce the effects of hatchery supplementation on natural-origin populations. These measures include changing broodstock management to better align hatchery broodstocks with the diversity of natural-origin population, and reducing the genetic and ecological risk by modifying the number of hatchery fish produced and released. The reduction in the number of hatchery fish released over the last ten years will likely reduce the effects of hatcheries on Upper Willamette River natural-origin Chinook salmon in the lower Columbia River (NMFS 2017a).

2.2.2.7 Recent Ocean and Lower River Harvest

Ocean fishery impacts on UWR spring Chinook salmon are typically in the range of 10–15 percent under current agreements in the Pacific Salmon Treaty. The anticipated harvest rate on UWR spring Chinook salmon in the proposed mainstem Columbia River fisheries in 2018-2027 ranges from 5-11 percent, and will not exceed an overall combined harvest rate of 15 percent from all freshwater fisheries combined. The 2018 Agreement proposes to continue adhering to these limits for harvest effect to UWR Chinook salmon (NMFS 2018a). Harvest rates in freshwater fisheries have averaged 9.5 percent since 2008 (TAC 2017; NMFS 2018a) while in-ocean fisheries have averaged 9.5 percent since 2009 (PSC CTC 2017).

2.2.2.8 Predation

The existence of dams and reservoirs around the Columbia Basin also blocks sediment transport. Total sediment discharge into the estuary and Columbia River plume is about one-third of nineteenth-century levels (NMFS 2008a). This reduces turbidity in the lower river, especially during spring, which is likely to make juvenile outmigrants more vulnerable to visual predators like piscivorous birds and fishes.

2.2.2.8.1 Avian Predation

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, are having a significant impact on the survival of juvenile salmonids (including UWR Chinook salmon) in the Columbia River. Caspian terns (*Hydropogne caspia*) on Rice Island, an artificial dredged-material disposal island in the estuary, consumed about 5.4-14.2 million juveniles per year in 1997 and 1998, or 5-15 percent of all the smolts reaching the estuary (Roby et al. 2017). Efforts began in 1999 to relocate the tern colony 13 miles closer to the ocean at East Sand Island where the tern diet would diversify to include marine forage fish. During 2001-15, estimated consumption by terns on East Sand Island averaged 5.1 million smolts per year, about a 59 percent reduction compared to when the colony was on Rice Island.

Management efforts are ongoing to further reduce salmonid consumption by terns in the lower Columbia River and similar efforts are in progress to reduce the nesting population of double-crested cormorants (*Phalacrocorax auritus*) in the estuary. Based on PIT-tag recoveries at East Sand Island, average annual tern and cormorant predation rates for UWR Chinook salmon were about 2.5 and 1.3 percent, respectively, before efforts to manage these colonies (Evans et al. 2018a). Predation rates on UWR Chinook salmon for East Sand Island terns have since decreased to 1.0 percent, but in 2017 this improvement was offset to an unknown degree by terns roosting farther upstream on Rice Island (Evans et al. 2018a). Due to failures of the cormorant colony in 2016 and 2017 (Appendix C), there are no estimates of predation rates since management of that colony began. In addition, substantial numbers of cormorants have relocated to the Astoria-Megler Bridge (preliminary report of 1,737 birds in 2018) and hundreds more are observed on the Longview Bridge, navigation aids, and transmission towers in the lower river (Anchor QEA et al. 2017). Smolts may constitute a larger proportion of the diet of cormorants nesting at these sites than if the birds were foraging from East Sand Island. Thus, the success of the East Sand Island tern and cormorant management plans at meeting their underlying goals of reducing salmonid predation is uncertain at this time.

2.2.2.8.2 Piscivorous Fish Predation

Native pikeminnow are significant predators of juvenile salmonids in the Columbia River basin, followed by nonnative smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011, 2015). Before the start of the NPMP in 1990, this species was estimated to eat about 8 percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River basin each year. Williams et al. (2017) compared current estimates of northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent.

However, the NPMP fishery incidentally catches salmon and steelhead. On average, 43 adult Chinook salmon, including jacks, and 67 juveniles were killed and/or handled each year in the Sport Reward Fishery during 2013-17. The fishery is conducted over a much larger area than that occupied by UWR Chinook salmon, but small numbers of these fish could have been from this ESU.

Juvenile salmonids are also consumed by nonnative fishes including walleye, smallmouth bass, and channel catfish. Both the Oregon and Washington Departments of Fish and Wildlife have removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids.

2.2.2.8.3 Pinniped Predation

California (*Zalophus californianus*) and Steller sea lions (*Eumetopias jubatus*) aggregate each spring at the base of Bonneville Dam (and below Willamette Falls on the lower Willamette River), where they feed on adult salmon and steelhead. In 2016, the Corps documented the second-largest number of pinnipeds at Bonneville Dam and the second-largest estimate of salmonid predation since observations began in 2002—9,525 fish, or 5.8 percent of adult salmonid passage between January 1st and May 31st (USACE 2017). In addition, numbers of Steller sea lions have been increasing between August and December in recent years (from an average of three per day in October 2011 to 22 per day in 2015; Madson et al. 2017). Recent declines in pup production and survival suggest the population may have stopped growing.

NMFS' NWFSC began studying the losses of adult spring- and summer-run Chinook salmon to sea lions between the mouth of the Columbia River and Bonneville Dam in 2010. Average annual survival through this reach has ranged from 58 to 91 percent, generally decreasing through 2015 (M. Rub, NWFSC, pers. comm., 2017). Preliminary estimates indicate that survival was higher during 2016. Up to 50 percent of the mortality of adult spring- and summer-run Chinook salmon destined for tributaries above Bonneville Dam occurred within the 10-mile reach just below the dam.

Adult UWR Chinook salmon are also vulnerable to predation throughout the lower Columbia River. This vulnerability is primarily for spring-run populations that migrate during May and June when pinniped abundance is highest. Under an authorization under the Marine Mammal Protection Act, management agencies have implemented numerous measures to reduce predation at Bonneville Dam and Astoria, from hazing to removal. From 2008–17, a total of 15 California sea lions at Bonneville Dam were captured and placed in captivity (Brown et al. 2017). During that same period, 163 California sea lions were euthanized at Bonneville Dam and five at Astoria (Brown et al. 2017). An authorization to lethally remove sea lions has been issued for Willamette Falls and the trapping and removal activities have begun.

2.2.2.8.4 Compensatory Effects and Predation on Salmonid Populations

An estimate of the effect of a predator population on adult returns to Bonneville Dam (e.g., the effect of smolt consumption by northern pikeminnow or Caspian terns) has the potential to be erroneous if it does not consider whether other factors intervene to compensate for the change in mortality (ISAB 2016). The primary mechanisms for compensatory effects are: (1) increased fish survival due to reduced densities in later life stages, (2) selective predation based on fish size and condition, and (3) predator switching from one prey species to another. Compensatory effects are difficult to quantify because they can occur later in the life cycle and can vary over time; efforts are currently underway to better understand compensatory effects (Haeseker 2015; Evans et al. 2018b).

2.2.2.9 Research and Monitoring Activities

The primary effects of past and ongoing CRS-related RM&E programs on UWR Chinook salmon are associated with the capturing and handling of fish. The RM&E program is a collaborative, regionally coordinated approach to fish and habitat status monitoring, action effectiveness research, critical uncertainty research, and data management. The information derived from the program facilitates effective adaptive management through better understanding the effects of the ongoing CRS action. Capturing, handling, and releasing fish generally leads to stress and other sublethal effects, but fish sometimes die from such treatment. The mechanisms by which these activities affect fish have been well documented and are detailed in Section 8.1.4 of the 2008 biological opinion. Some RM&E actions also involve sacrificial sampling of fish. We estimated the number of UWR Chinook salmon that have been handled each year during the implementation of RM&E under the 2008 RPA as the average annual take reported for 2013-2017:

- No UWR Chinook salmon were handled or killed during activities associated with the Smolt Monitoring Program and the Comparative Survival Study (CSS).
- No UWR Chinook salmon were handled or killed during activities associated with the Interior Status and Effectiveness Monitoring Program (ISEMP).
- Estimates for UWR Chinook salmon handling and mortality for all other RM&E programs show: (1) 19 hatchery and 16 wild adults handled; (2) one hatchery and one wild adult died; (3) 19 hatchery and 16 wild juveniles handled; and (4) one hatchery and two wild juveniles died.

The combined take (i.e., handling, including injury, and incidental mortality) associated with these elements of the RM&E program has, on average, affected less than 1 percent of the wild (i.e., natural origin) adult returns or juvenile production for the UWR Chinook salmon ESU (Bellerud 2018). This relatively small effect is deemed worthwhile because it allows the Action Agencies and NMFS to evaluate the effects of CRS operations, including modifications to facilities, operations, and mitigation actions.

In addition, northern pikeminnow are tagged as part of the Sport Reward Fishery and their rate of recapture is used to calculate exploitation rates. Northern pikeminnow are collected for tagging using boat electrofishing in select reaches of the Columbia River. During 2017, boat electrofishing operations in the Columbia River extended upstream from RM 47 (near Clatskanie, Oregon) to RM 394 (Priest Rapids Dam), and in the Snake River from RM 10 (Ice Harbor Dam) to RM 41 (Lower Monumental Dam) and from RM 70 (Little Goose Dam) to RM 156 (upstream of Lower Granite Dam). Researchers conducted four sampling events consisting of 15 minutes of boat electrofishing effort in shallow water within each 0.6-mile reach during April-July.

A side effect of the electrofishing effort is that salmon and steelhead may be exposed to the electrofishing field, with the potential for injury, stress, and fatigue and even cardiac or respiratory failure (Snyder 2003). Some adult and juvenile UWR Chinook salmon are likely to be present in shallow shoreline areas during the April-July time period. Most sampling occurs in darkness (1800-0500 hours) and in turbid water, they cannot monitor the fate of all affected fish. Operators shut off the electrical field if salmonids are seen and because most stunned fish quickly recover and swim away, they cannot be identified to species (i.e., Chinook, coho, chum, or sockeye salmon or steelhead). Barr (2018) reported encountering an annual average of 891 adult and 60,312 juvenile salmonids in the lower Columbia River each year during 2013-17 electrofishing operations based on visual estimation methods. It is likely that some of these were UWR Chinook salmon.

2.2.2.10 Critical Habitat

The environmental baseline for the physical and biological features (PBFs) for UWR Chinook salmon critical habitat are reflected in the same impacts discussed above (e.g., mainstem flows, passage, water quality, predation) and summarized here in Table 2.2-3. Restoration activities addressing access to the historical estuarine floodplain are improving the baseline condition for that PBF; however, more restoration is needed before the PBFs can fully support the conservation of UWR Chinook salmon.

Table 2.2-3. Physical and biological features (PBFs) of designated critical habitat for UWR Chinook salmon.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBF in the Action Area
Freshwater spawning	Substrate, adequate water quality and water quantity	Concerns about access to spawning sites, substrate quality, water quality
Freshwater rearing	Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility, water quality, forage, and natural cover	Concerns about access to rearing sites, availability of complex habitat, water quantity and water quality
Freshwater migration corridors	Free of obstruction and excessive predation, adequate water quality and quantity, and natural cover	Concerns about increased opportunities for predators, especially birds and pinnipeds (construction of dredge-material islands in the lower river and other human-built structures used by terns and cormorants for nesting)

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBF in the Action Area
Estuarine areas	Free of obstruction and excessive predation with water quality, quantity, and salinity, natural cover, juvenile and adult forage	Diking off areas of the estuary floodplain (land use), combined with reduced peak spring flows (water diversions and water storage and hydroelectric projects), have reduced access to floodplain habitat for rearing and prey production
Nearshore marine areas[1]	Free of obstruction and excessive predation with water quality, quantity, and forage	Concerns about increased opportunities for pinniped predators, adequate forage

[1] Designated area includes only the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

The CRS Action Agencies and other federal and nonfederal entities have taken actions in recent years to improve the functioning of some of these PBFs of critical habitat. For stream-type juveniles, projects that have protected or restored riparian areas and breached or lowered dikes and levees in the estuary have improved the functioning of the juvenile migration corridor. For subyearling smolts, restoration projects in the estuary are improving the functioning of areas used for growth and development.

2.2.2.11 Future Anticipated Impacts of Completed Consultations

The environmental baseline also includes the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, including the consultation on the operation and maintenance of the Bureau of Reclamation's upper Snake River projects. The 2016 five-year review evaluated new information regarding the status and trends of UWR Chinook salmon, including recent biological opinions issued for UWR Chinook salmon and key emergent or ongoing habitat concerns (NMFS 2016a). Since the beginning of 2015 through 2017, we completed 456 formal consultations (130 in 2015, 150 in 2016, and 176 in 2017) that addressed effects to UWR Chinook salmon.[18] These numbers do not include the many projects implemented under programmatic consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed salmonids. Some of the completed consultations are large (large action area, multiple species), such as the Mitchell Act consultation and the consultation on the 2018–27 *U.S. v. Oregon* Management Agreement. Many of the completed actions are for a single activity within a single subbasin.

Some current and proposed restoration projects will improve access to blocked habitat and riparian condition, and increase channel complexity and instream flows. For example, under BPA's Habitat Improvement Programmatic consultation, BPA implemented 29 projects in the

[18] PCTS data query, July 31, 2018.

Columbia Basin that improved fish passage in 2017, and 99 projects that involved river, stream, floodplain, and wetland restoration; some of these projects are likely to benefit UWR Chinook salmon. These projects will benefit the viability of the affected populations by improving abundance, productivity, and spatial structure. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more, and typically less, than a few weeks).

Other types of federal projects, including grazing allotments, dock and pier construction, and bank stabilization, will be neutral or have short- or even long-term adverse effects on viability. All of these actions have undergone section 7 consultation, and the actions[19] were found to meet the ESA standards for avoiding jeopardy. Similarly, future federal restoration projects will improve the functioning of the PBFs' safe passage, spawning gravel, substrate, water quantity, water quality, cover/shelter, food, and riparian vegetation. Projects implemented for other purposes will be neutral or have short- or even long-term adverse effects on some of these same PBFs. However, all of these actions[20] have undergone section 7 consultation and were found to meet the ESA standards for avoiding adverse modification of critical habitat.

2.2.2.12 Summary

The factors described above have negatively affected the abundance, productivity, diversity, and spatial structure of UWR Chinook salmon populations. The small net improvement in floodplain connectivity achieved through the CRS estuary habitat program and efforts to improve hatchery practices and lower harvest rates are positive signs, but other stressors are likely to continue. NMFS (2016a) identified past land development, habitat degradation, and predation, in combination with the potential effects of climate change, as likely to present a continuing strong negative influence into the foreseeable future.

The habitat within the action area does not fully support the conservation value of designated critical habitat for UWR Chinook salmon as described above. The PBFs essential for the conservation of UWR Chinook salmon, that occur within the area affected by the proposed action include freshwater rearing areas, freshwater migration corridors, estuarine rearing areas, and nearshore marine areas (at the mouth of the Columbia River).

The CRS Action Agencies and other federal and nonfederal entities have taken actions in recent years to improve the functioning of some of the PBFs of critical habitat. For stream-type juveniles, projects that have protected or restored riparian areas and breached or lowered dikes and levees in the estuary have improved the functioning of the juvenile migration corridor. For subyearling smolts, restoration projects in the estuary are improving the functioning of areas used for growth and development; these projects have high conservation value for this ESU. However, other factors that have negative effects on these PBFs are expected to continue into the future.

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[19] Or their RPA.
[20] Including any RPAs.

2.2.3 Effects of the Action

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

The proposed action is an ongoing action that has been modified over time to reflect capital improvements, as well as changes in operation based on existing conditions and improved information on how CRS operations affect UWR Chinook salmon and other listed species and their critical habitats. The current proposed action includes operational measures (e.g., flood risk management, navigation, fish passage, and hydropower generation) and non-operational measures (e.g., support for conservation hatchery programs, predation management, habitat improvement actions) that will be implemented beginning in 2019. The proposed action, however, is of limited duration. The Action Agencies are developing an EIS in accordance with NEPA that will assess and update the approach for long-term system operations, maintenance, and configuration as well as evaluate measures to avoid, offset, or minimize impacts to resources affected by the management of the CRS, including ESA-listed species and designated critical habitat. A court order currently requires the Action Agencies to issue Records of Decision on or before September 24, 2021.[21] Based on scoping, the range of alternatives being examined is broad and includes potential large-scale changes in the action. Thus, there is substantial uncertainty regarding what system operations, maintenance, and configuration the Action Agencies will propose at the conclusion of the NEPA process. Likewise, it is unknown what measures intended to avoid, offset, or minimize adverse effects will ultimately be included in the final preferred alternative.

Accordingly, our analysis of effects for UWR Chinook salmon and their critical habitat extends from 2019 into the future, but emphasizes the evaluation of effects that are reasonably certain to occur as a result of implementing the proposed action (pending completion of the EIS and our issuance of a subsequent biological opinion addressing the effects of the final preferred alternative). To the extent our consideration of potential effects beyond that time period assumes the current proposed action remains in place, it is intended, in part, to inform the evaluation of alternatives in the EIS.

The Action Agencies will operate the run-of-river lower Columbia River projects (McNary, John Day, The Dalles, and Bonneville Dams) in accordance with the annual Water Management Plan and Fish Passage Plan (including all appendices). These projects are operated for multiple

[21] The Presidential Memorandum on Promoting the Reliable Supply and Delivery of Water in the West, issued on October 19, 2018, required the development of an expedited schedule for completion of the NEPA process. The Council on Environmental Quality has confirmed a revised schedule that calls for completing the Draft EIS in February 2020, the Final EIS in June 2020 and Records of Decision by September 30, 2020. These dates are consistent with, but earlier than, the court-ordered deadlines.

purposes, including fish and wildlife conservation, irrigation, navigation, power, recreation, and, in the case of John Day Dam, limited flood risk management.

The effects of the proposed action are generally consistent with the effects caused by a continuation of the CRS operations, as described in the environmental baseline section (including effects caused by facility maintenance and hatchery activities), with the exception of the addition of the flexible spill operation. A small number of adult UWR Chinook salmon may be exposed to elevated TDG (from increased spill) if they move upstream past the mouth of the Willamette River. The other operational changes are not anticipated to alter the effects to UWR Chinook salmon because no fish in the ESU will be exposed to the effects of those changes.

2.2.3.1 Effects to Species

Both juvenile and adult UWR Chinook salmon from all populations will be exposed to the continuing effects of the action in the mainstem Columbia River from the Willamette River confluence downstream to the plume.

2.2.3.1.1 Hydrosystem Operation

For UWR Chinook salmon, the effects of the proposed hydrosystem operations are essentially a continuation of the effects of recent hydrosystem operations described in the environmental baseline (resulting from implementation of the 2008 biological opinion reasonable and prudent alternative hydro actions) with the addition of the proposed increase in spill. During periods of increased spill each spring, elevated TDG levels will extend for at least 35 miles downstream of Bonneville Dam (Camas-Washougal gauge). A small number of adult UWR Chinook salmon may be exposed to these conditions upstream of the mouth of the Willamette River. To the extent adult individuals stray and move further upstream in the Columbia River, exposure will be increased. There will be no exposure to elevated TDG levels associated with periods of increased spring spill levels for juveniles migrating and rearing in the Columbia River downstream of the Willamette River confluence because TDG effects will dissipate by the time the flows reach the Willamette confluence.

The effects of continuing the CRS operations will include greater than natural flows in the action area during the months of October through March, when UWR Chinook salmon fall migrants are likely present in the Columbia mainstem and estuary. The continued changes in flow may alter the fitness of some individual fish (faster migration to the estuary) but we do not expect increased mortality from these changes. Similarly, UWR Chinook salmon will not be exposed to the proposed changes in the hydrosystem operations (increases spill, MOP, transportation of juveniles) and continued maintenance operation of the facilities.

2.2.3.1.2 Predator Management and Monitoring Actions

The Action Agencies propose continued implementation of the Caspian Tern Nesting Habitat Management Plan (USACE 2015a) and the Double-crested Cormorant Management Plan (USACE 2015b). Tern habitat on East Sand Island will be maintained at no less than one acre for the period covered by this interim consultation. Management actions for cormorants will be limited to passive dissuasion and hazing, although limited egg take (up to 500 eggs) may be requested from USFWS in an annual depredation permit application to preclude cormorants from nesting in new or different areas on East Sand Island. These ongoing actions have the potential to improve the viability of the UWR Chinook salmon populations by increasing the survival of outmigrating juveniles as they move through the estuary. However, the dispersal of double-crested cormorants from East Sand Island to nest sites on the Astoria-Megler Bridge in recent years and observations of thousands of Caspian terns roosting on Rice Island indicate that the numbers of avian predators in the estuary and their effects on the viability of salmonids, such as UWR Chinook salmon, are in flux. Because the Action Agencies propose to continue maintaining the reduced amounts of nesting habitat achieved for terns and cormorants on East Sand Island (BPA et al. 2018a), we expect that any reduced predation rates achieved for UWR Chinook salmon under the 2008 FCRPS biological opinion and associated RPA will continue during the interim period.

The Action Agencies propose to synthesize colony size and predation rate data collected under the tern and cormorant colony management plans. The intent of the synthesis report is to provide the Action Agencies, cooperating agencies, and NMFS with a summary of predation by piscivorous waterbirds on ESA-listed salmonids in the Columbia River basin before, during, and after the management actions in order to assess their effectiveness on a basinwide scale. This review will help the Action Agencies prioritize any efforts to take place during this interim period, or to be discussed as future mitigation measures in the CRS Operations NEPA document.

The pikeminnow predation management program includes the Sport Reward Fishery and Dam Angling programs, which will continue as part of the proposed action. The first is implemented in the lower Columbia River, including the estuary. This fishery removes approximately 10–20 percent of predatory-sized pikeminnow per year and is open from May through September, when juveniles can be rearing in mainstem habitats. We expect that the Sport Reward Fishery will continue to improve the survival of juvenile UWR Chinook salmon that are rearing and migrating through the lower Columbia River. We estimate that numbers of Chinook salmon, including UWR Chinook salmon, handled and/or killed in the Sport Reward Fishery will be no more than 100 adults (including jacks) and 200 juveniles per year, system-wide, during the interim period. These numbers are reasonable based on highest anticipated take in any one year. The Dam Angling Program is conducted at The Dalles and John Day Dams and dam anglers are unlikely to encounter any UWR Chinook salmon. Except for a very few individuals, UWR Chinook salmon will not be exposed to activities associated with pinniped predation management because these activities occur in proximity of Bonneville Dam.

2.2.3.1.3 Habitat Actions

The tributary habitat improvements will not target any tributaries that provide habitat for UWR Chinook salmon and, thus, will not affect this ESU.

The Action Agencies have committed to continuing to implement the CEERP to increase the capacity and quality of estuarine ecosystems and improve access for juvenile salmonids. The Action Agencies will continue to emphasize reconnection of floodplain areas in tidally influenced waters of the lower Columbia River and estuary, primarily through modifying levees. Additional actions at habitat improvement sites will include recreating historical channel networks, reducing the presence of nonnative species, and revegetating habitat improvement sites with native vegetation to ensure a site's resiliency. These projects are expected to provide direct and indirect benefits (i.e., increased food availability) to UWR Chinook salmon as they migrate and rear in the estuary. The subyearling life-history type spends longer in the estuary (several weeks to months) and, therefore, is more likely to benefit from additional growth in the estuary compared to yearling migrants.

NMFS supports the ISAB's assessment that it is difficult to reliably quantify the survival benefits of estuary habitat restoration, but agrees that the Action Agencies' assessment method, including review by the ERTG, is useful to prioritize projects.[22] The Action Agencies' proposed action includes a commitment to reconnect an average of 300 acres of floodplain per year to the mainstem, a goal that they have a record of achieving in 2008-17 (BPA et al. 2018b). The habitat's conservation value is likely to improve as more habitat gets reconnected, and the benefits are likely to accrue as the habitat patches get larger (Spiesman et al. 2018). While juvenile UWR Chinook salmon have been observed using reconnected habitats (Johnson et al. 2018), we agree that a link to survival benefits has not been demonstrated. However, it is our professional opinion that these habitats provide important resting and feeding areas for subyearling UWR Chinook salmon, and are likely to provide important prey items to yearling UWR Chinook salmon in the mainstem. It is also likely that these benefits will increase as restored habitat area accrues over time and habitat quality matures.

2.2.3.1.4 Research and Monitoring Activities

The Action Agencies' RM&E program will be similar to the current program, or will be implemented at a reduced scale. Thus, the level of injury and mortality discussed in the Environmental Baseline, primarily from the capturing and handling of fish, is likely to continue at a similar or reduced level. We estimate based on past reporting that, on average, the following numbers of UWR Chinook salmon will be affected each year during the interim period:

- No UWR Chinook salmon will be handled or killed during activities associated with the Smolt Monitoring Program and the CSS.
- No UWR Chinook salmon will handled or killed during activities associated with the Fish Status Monitoring.

[22] As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss with ERTG and regional partners relevant climate change science in an effort to understand whether their planned estuary projects are resilient to climate change (i.e., sea-level rise, temperatures, and mainstem flow levels). In addition, the Action Agencies' annual update of their restoration and monitoring plans for the estuary will document any needed adjustments in design, location, or other elements of a given project to address climate change impacts, both during and beyond the interim period.

- Projected estimates of UWR Chinook salmon handling and mortality for all other RM&E programs include: (1) 174 hatchery and 149 wild adults handled; (2) two hatchery and one wild adult killed; (3) 29,910 hatchery and 14,213 wild juveniles handled; and (4) 299 hatchery and 142 wild juveniles killed.

The combined observed mortality associated with these elements of the RM&E program will, on average, affect less than 1 percent of the wild (i.e., natural origin) adult returns or juvenile production for the UWR Chinook salmon ESU (Bellerud 2018). Although we estimate that 2.35 percent of the wild adults and 1.11 percent of the wild juvenile production will be handled each year, on average, we expect that only up to one percent of these will die after release (i.e., 0.02 percent of adults and 0.01 percent of juveniles handled). This relatively small effect is deemed worthwhile because it will allow the Action Agencies and NMFS to continue to evaluate the effects of CRS operations, including modifications to facilities, operations, and mitigation actions.

Electrofishing operations for the NPMP during the interim period are expected to continue at the same level of effort as in recent years (four 15-minute sampling events per 0.6-mile reach between RM 47 near Clatskanie, Oregon, and the confluence with the Willamette River during April-July; a total of 550 hours system-wide). Some adult and juvenile UWR Chinook salmon are likely to be present in shallow shoreline areas during electrofishing activities and may be stunned and even killed. However, because the operator releases the electrical field as soon as salmonids are observed, and most of these fish quickly recover and swim away, we are unable to use observations from past operations to estimate the number of fish from this ESU that will be affected. Information obtained through electrofishing supports management of the NPMP, which is reported to have reduced salmonid predation by about 30 percent (Williams et al. 2017). This level of take is anticipated to occur for the duration of this proposed action, pending completion of the NEPA process.

2.2.3.2 Effects to Critical Habitat

Implementation of the proposed action will affect the volume and timing of flow in the Columbia River, which has the potential to alter habitat in the Columbia River mainstem and estuary for all populations. The proposed action will also improve rearing habitat in the estuary. The PBFs that could be affected by the proposed action are described in Table 2.2-4.

Table 2.2-4. Effects of the proposed action on the physical and biological features (PBFs) essential for the conservation of the ESU.

PBF	Effect of the Proposed Action
Freshwater spawning and rearing	Freshwater spawning and rearing habitats are not exposed to the effects of the proposed action.
Freshwater migration corridors and estuarine areas	Sediment will continue to accumulate behind CRS dams, reducing turbidity during the spring smolt outmigration, which could make juveniles more vulnerable to visual predation. This PBF will continue to improve with the proposed reconnection of an average of 300 acres of floodplain habitat per year during the interim period. Because estuary bird colonies and predation rates are in flux, it is not clear whether continued tern and cormorant colony management is likely to reduce avian predation (i.e., meet the management plan goals). Any reduced predation rates achieved under the 2008 biological opinion and associated RPA will continue during the interim period.
Nearshore marine areas	Nearshore marine habitats are not exposed to the effects of the proposed action.

2.2.4 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation (50 CFR 402.02). Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Nonfederal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. These projects also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth management programs (planning and regulation), various stream and riparian habitat projects, watershed planning and implementation, acquisition of water rights for instream purposes and sensitive areas, instream flow rules, stormwater and discharge regulation, total maximum daily load (TMDL) implementation to achieve water-quality standards, hydraulic project permitting, and increased spill and bypass operations at hydropower facilities. NMFS determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. These activities are likely to have beneficial cumulative effects that will significantly improve conditions for the salmon and steelhead, including UWR Chinook salmon.

NMFS also noted that some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects are activities that occurred in the recent past and were included in the Environmental Baseline. Some of these activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the action area, nonfederal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. All of these activities can contaminate local or larger areas with hydrocarbon-based materials. Continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations.

Overall, we anticipate that projects to restore and protect habitat, restore access to and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area.

2.2.5 Integration and Synthesis

In this section, we add the effects of the action (Section 2.2.3) to the environmental baseline (Section 2.2.2) and the cumulative effects (Section 2.2.4), taking into account the status of the species and critical habitat (Sections 2.2.1.1 and 2.2.1.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat for the conservation of the species.

2.2.5.1 Species

NMFS' recent status review affirmed UWR Chinook salmon as threatened; there has been an overall decrease in the VSP status of the ESU but the magnitude of this change is not sufficient to suggest a change in risk category. This ESU is comprised of one MPG (Willamette) with seven populations. Abundance levels for five of the populations remain well below their recovery goals. Of these, the Calapooia River may be functionally extinct and the Molalla River remains critically low. Abundances in the North and South Santiam Rivers have risen since the last review, but still range only in the high hundreds of fish. The Clackamas and McKenzie Rivers have previously been viewed as natural population strongholds, but have both experienced declines. In contrast to most of the other populations in this ESU, McKenzie River Chinook salmon have access to much of their historical spawning habitat, although access to historically high-quality habitat above Cougar Dam is still limited by poor downstream juvenile passage (NMFS 2016a). Overall, populations appear to be at either moderate or high risk (NWFSC 2015).

UWR Chinook salmon are only marginally affected by the effects of the proposed action. No effects are expected to their spawning and rearing habitat (all in the Willamette River watershed). Both adults and juvenile UWR Chinook salmon are exposed to changes in flow (continued operations) as they migrate through the lower Columbia River and the estuary. A very few individual adult UWR Chinook salmon stray during their upstream migration and pass through Bonneville Dam.

For UWR Chinook salmon, the effects of the proposed hydrosystem operations are essentially a continuation of the effects of recent hydrosystem operations described in the environmental baseline. This includes greater than natural flows in the action area during the months of October through March when UWR Chinook salmon fall migrants are likely present in the Columbia River mainstem and estuary. The continued changes in flow are not expected to affect the abundance, productivity, or spatial structure and diversity of any of the UWR Chinook salmon populations because the sublethal effects to individual fish are relatively small and are unlikely to affect reproduction or numbers at the scale of populations.

The increase in spring spill proposed by the Action Agencies is not expected to affect UWR Chinook salmon at the population or ESU scale because exposure to increased levels of TDG is limited to a few individual adults that move upstream in the Columbia River from the mouth of the Willamette River.

The other proposed changes to CRS operations are not anticipated to negatively affect UWR Chinook salmon survival. In particular, the changes in usable forebay ranges (MOP 1.5-foot range) at the Lower Snake River reservoirs and the change in operating range at the John Day forebay (MIP 2-foot range) will result in inconsequential variations in the timing and amount of flow in the lower Columbia River.

The Action Agencies will continue to fund predator control activities, estuary habitat improvements, and modify operations to improve survival. The efficacy of the avian predation program is currently in flux; the Action Agencies, NMFS and other stakeholders have a plan to develop a better approach to avian predation management basinwide.

As a general matter, the effects of the proposed action are very similar to a short-term continuation of the same effects caused by the current operations and maintenance of the CRS (including the RM&E program), as well as the associated measures implemented to avoid, minimize or offset adverse effects. Therefore, we do not anticipate large changes in mortality caused by the CRS or substantial new risks to UWR Chinook salmon or their habitat, and we do not expect considerable changes in the effects on reproduction, numbers, or distribution.

However, we do anticipate additional improvements in habitat conditions in the estuary that will accrue over time.

The environmental baseline includes the past and present impacts of hydropower operations, changes in tributary and mainstem habitat (both beneficial and adverse), harvest, and hatcheries on UWR Chinook salmon. The baseline provides important context for assessing the effects of the action described above.

Regarding changes in hatchery effects to the UWR Chinook salmon ESU, in 2017, NMFS completed a biological opinion on its funding of the Mitchell Act program (NMFS 2017a). As a result, several additional reform measures have been implemented, including changes in broodstock management to better align hatchery broodstocks with the diversity of the natural-origin populations and modifications to the number of hatchery fish produced and released in certain programs, along with the installation of new seasonal weirs. The production level changes will reduce the pHOS and reduce genetic and ecological risk. Improvements in hatchery management are likely to support improvements in the viability of UWR Chinook salmon populations in the foreseeable future.

NMFS also recently completed a biological opinion on the 2018-2027 *U.S. v. Oregon* Management Agreement, which provides a framework for managing salmon and steelhead fisheries and hatchery programs in much of the Columbia River basin. Ocean fishery impacts on UWR Chinook salmon are typically in the range of 10-15 percent under current agreements in the Pacific Salmon Treaty. Chinook salmon fishery impacts in all freshwater fisheries are limited to less than 15 percent under current ESA authorizations, although current impacts are typically in the range of 8-12 percent. The biological opinion concluded that the effects of harvest on LCR Chinook salmon, when considering the current reliance on hatchery programs, will allow gains in VSP scores to continue to accrue.

Tributary habitat for UWR Chinook salmon is not anticipated to be affected by the proposed action.

Proposed estuary habitat improvements will benefit UWR Chinook salmon. Restoration actions in the estuary, such as those highlighted in the latest five-year review (including those completed by the Action Agencies), have improved access and connectivity to habitat in the estuary (NMFS 2016a). These restoration actions will continue, and are expected to result in benefits to UWR Chinook salmon over the long term.

The status of UWR Chinook salmon is also likely to be affected by climate change. Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycle. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater and changes to food webs in freshwater, estuarine and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management actions may help alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations, increased riparian vegetation to control water temperatures, etc.).

Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life-history types that will be successful in the future are neither static nor predictable. Therefore, maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the UWR Chinook salmon ESU. Because of its location in the lower Columbia River basin, the ESU is likely to be more affected by climate related effects in the estuary for fall-run subyearlings, and in tributary streams (altered seasonal flows and temperatures) for spring-run populations. Emerging research using complex life-cycle modeling indicates a potentially strong link between sea surface temperature (SST) and survival of Snake River spring/summer Chinook salmon populations. However, the apparent link between SST and survival is presumably caused by food web interactions, relationships which could be disrupted by major transformations of community dynamics as well as ocean acidification and other factors under a changing climate. The degree to which SST is linked to survival of UWR Chinook and how that relationship interacts with other variables throughout the UWR Chinook life cycle will likely be an important area of future research.

When evaluating the effects of the action, those effects must be taken together with the effects on UWR Chinook of future state or private activities, not involving federal activities that are reasonably certain to occur within the action area. NMFS anticipates that human development activities will continue to have adverse effects on UWR Chinook salmon in the action area. Many of these activities and their effects occurred in the recent past and were included in the environmental baseline but are also reasonably certain to occur in the future. Within the action area, non-federal actions are likely to include activities associated with human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Habitat restoration efforts led by state and local agencies, tribes, environmental organizations, and local communities are likely to continue. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives that, in some cases, are identified through ESA recovery plans. Larger, more regionwide, restoration and conservation efforts are either underway or planned throughout the Columbia River basin. These state and private actions have helped restore habitat, improve fish passage, and reduce pollution. While these efforts are reasonably certain to continue to occur, funding levels may vary on an annual basis.

The recovery plan (ODFW and NMFS 2011) identifies key and secondary limiting factors and threats to UWR Chinook recovery for each population by area and life stage. Access to historical spawning and rearing areas is restricted by large dams in the four historically most-productive

Willamette River tributaries, and is a key limiting factor to recovery. In the absence of effective passage programs, the fish will continue to be confined to more lowland reaches where land development, water temperatures, and water quality are limiting factors. Pre-spawning mortality levels are generally high in the lower tributary reaches where water temperatures and fish densities are generally the highest (NMFS 2016a). The recovery plan was finalized in 2011 and identifies recovery actions to be implemented, generally over a 25-year period. Effective implementation requires that the recovery efforts of diverse private, local, state, tribal, and federal parties across two states be coordinated at multiple levels. The proposed action will not result in reductions to UWR Chinook salmon reproduction, numbers, or distribution that would impede the ability to successfully carry out the identified recovery measures and actions over the time frames considered in the recovery plan.

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, and considering the interim nature of the proposed action, it is NMFS' biological opinion that the proposed action is not likely to reduce appreciably the likelihood of both survival and recovery of UWR Chinook salmon.

2.2.5.2 Critical Habitat

Critical habitat for UWR Chinook salmon encompasses ten subbasins in Oregon and Washington containing 60 occupied watersheds, as well as the lower Willamette/Columbia River rearing/migration corridor. Most watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005a, 2013a). However, most of these watersheds have some, or high potential for improvement. Similar to the discussion above for species, the status of critical habitat is likely to be affected by climate change with predicted rising temperatures and alterations in stream flow patterns. Past and future modifications to the major water storage and hydroelectric projects in the Willamette River basin, improved access to historical spawning habitat, and habitat restoration efforts will help ameliorate those effects to critical habitat.

The environmental baseline includes a broad range of past and present actions and activities that have affected the conservation value of critical habitat for UWR Chinook. These include the effects of hydropower and water storage in the Willamette River basin, changes in tributary and mainstem habitat (both positive and negative) on freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine areas, and nearshore marine areas. Changes to land use and development activities remain a concern; these include activities that affect the quality and accessibility of habitats and habitat-forming processes, such as riparian condition and floodplain function as well as water quality (NMFS 2016a). Reduced or lost habitat complexity, connectivity, quantity, and quality in the Columbia River mainstem and the estuary remain areas of concern. Toxic contamination and urban and industrial development in the lower Willamette and Columbia Rivers are also a concern, particularly for fry migrants that spend many months rearing in the estuary.

Despite a long-term trend in degradation of these habitats, there have been localized improvements in their conservation value through the combined efforts of federal, state, and local agencies; tribes; and other stakeholders. A number of restorations have been implemented in freshwater and estuary habitat in the action area; a number of these funded through the CRS program. The estuary program will continue to fund habitat improvement actions in the estuary that will likely contribute to improved rearing and migratory habitat. Despite significant losses to predators in the migration corridor, the combined efforts of multiple parties has reduced the effect of predation, and the action agencies propose to continue predator management activities.

The adverse downstream effects associated with CRS flood control management operations (altered flow regime, lost and degraded habitat conditions in the mainstem Columbia River) will continue with the proposed action. Conversely, the proposed action will continue to improve the functioning of many of the PBFs; for example, reducing predation by pinnipeds and northern pikeminnows will continue to improve safe passage for juveniles and reduce the risk to this PBF. The estuary habitat restoration program will reconnect floodplains and provide additional feeding and rearing areas at the project scale; these benefits will accrue at the designation scale over time and will contribute to the conservation value of habitat in the lower Columbia estuary.

Considering the ongoing and future effects of the environmental baseline and cumulative effects, and in light of the status of critical habitat and the interim nature of the proposed action, the proposed action will not appreciably reduce the value of designated critical habitat for the conservation of UWR Chinook.

2.2.6 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of UWR Chinook salmon or destroy or adversely modify its designated critical habitat.

2.3 Upper Willamette River (UWR) Steelhead

This section applies the analytical framework described in section 2.1 to UWR steelhead DPS and provides NMFS' finding regarding whether the proposed action is likely to jeopardize the continued existence of the UWR steelhead DPS or destroy or adversely modify its critical habitat.

2.3.1 Rangewide Status of the Species and Critical Habitat

The status of UWR steelhead is determined by the level of extinction risk that the listed species faces, based on parameters considered in documents such as the recovery plan, status reviews, and listing decisions. The species status also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. This informs the description of the species' likelihood of both survival and recovery. The condition of critical habitat throughout the designated area is determined by the current function of the essential PBFs that help to form that conservation value.

2.3.1.1 Status of Species

The UWR steelhead DPS includes all naturally spawned anadromous, winter-run *Onocorhynchus mykiss* originating below natural and manmade impassable barriers from the Willamette River and its tributaries upstream of Willamette Falls to, and including, the Calapooia River (Figure 2.3-1). There is only one major population group in this DPS, comprised of four historical populations (Myers et al. 2006); all four populations remain extant and produce moderate numbers of natural-origin steelhead each year. Winter steelhead hatchery releases within the boundary of the UWR steelhead DPS ended in 1999; however, there is still a substantial hatchery program for nonnative summer steelhead.

UWR steelhead were first listed as threatened in 1999, reaffirmed in 2006, and updated in 2014 (79 FR 20802). McElhany et al. (2007) found that the overall extinction risk for this DPS is moderate. The most recent ESA five-year status review noted that the declines in abundance noted during the previous five-year status review (Ford 2011) continued through the period 2010–15 (NWFSC 2015). The most recent status update (NWFSC 2015) determined that there has been no change in the biological risk category since the last reviews of these populations.

The Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead (2011) identifies key and secondary limiting factors and threats to UWR steelhead recovery for each population by area and life stage. Key limiting factors are associated with hydropower and flood management dams, including irrigation withdrawals, as well as the effects of land management practices within the Willamette subbasins, and some genetic introgression with an out-of-basin hatchery stock.

Table 2.6-1 provides a summary of status and limiting factors for UWR steelhead. More information can be found in the recovery plan and status review for this species. These documents are available on the NMFS West Coast Region website.[23]

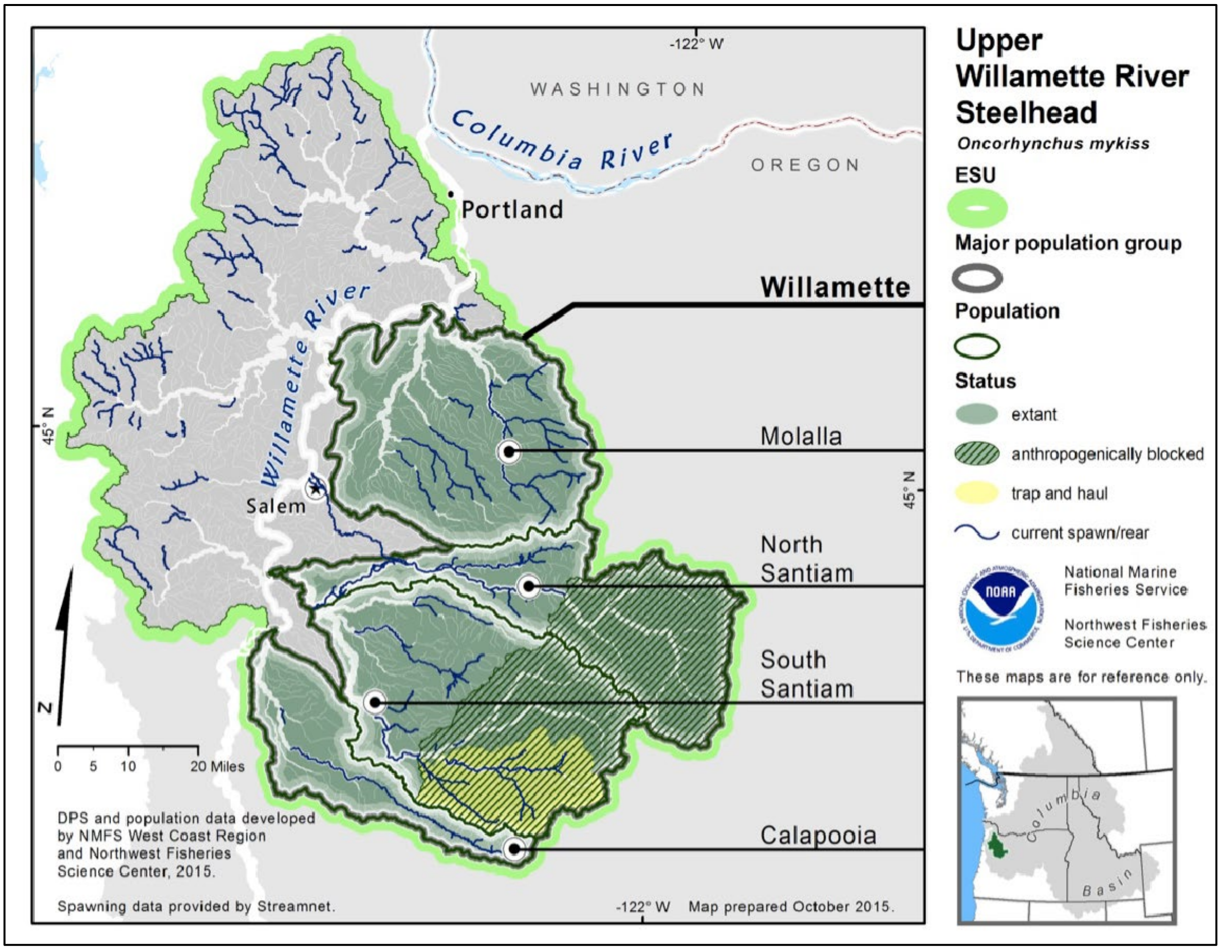


Figure 2.3-1. Map of the Upper Willamette River winter steelhead DPS spawning and rearing areas, illustrating the four populations within the one major population group.

Before the construction of a fish ladder at Willamette Falls in the early 1900s, flow conditions allowed steelhead to ascend Willamette Falls only during the late winter and spring. Presently, the majority of the UWR winter steelhead run return to freshwater from January through April, pass Willamette Falls from mid-February to mid-May, and spawn from March through June (with peak spawning in late April and early May). UWR steelhead currently exhibit a stream-type life history with individuals exhibiting yearling life-history strategy. Juvenile steelhead rear in headwater tributaries and upper portions of the subbasins from one to four years (average of two years), then, as smoltification occurs in April through May, they migrate downstream

[23] Currently these documents can be found within the NMFS West Coast Region website at: http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/salmon_and_steelhead_listings/steelhead/upper_willamette_river/upper_willamette_river_steelhead.html. Last accessed August 2018.

through the mainstem Willamette and Columbia River estuaries and into the ocean. The downstream migration speed depends on factors including river flow, temperature, turbidity, and others, with the quickest migration occurring with high river flows. UWR steelhead can forage in the ocean for one to two years (average of two years) and during this time period are thought to migrate north to waters off Canada and Alaska and into the North Pacific, including the Alaska Gyre (Myers et al. 2006).

There is no directed fishery for winter steelhead in the upper Willamette River, and they are the only life history displayed by natural steelhead in this area. Due to differences in return timing between native winter steelhead, introduced hatchery-origin summer steelhead, and hatchery-origin spring Chinook salmon, the encounter rates for winter steelhead in the recreational fishery are thought to be low. Sport fishery mortality rates were estimated at 0 to 3 percent (Ford 2011). There is additional incidental mortality in the commercial net fisheries for hatchery Chinook salmon and steelhead in the Lower Columbia River. Tribal fisheries occur above Bonneville Dam and do not impact UWR steelhead (NWFSC 2015).

Winter steelhead hatchery programs were terminated in the late 1990s. Currently, the only steelhead programs in the upper Willamette River release Skamania Hatchery-origin summer steelhead, though this program is not part of the DPS. Annual total releases have been relatively stable at around 600,000 fish from 2009 to 2014, although the distribution has changed, with fewer fish being released in the North Santiam River and corresponding increases in the South Santiam and Middle Fork Willamette Rivers to maintain the release level of about 600,000 fish. However, there has been some concern regarding the effect of introduced summer steelhead on native late-winter steelhead. There is some overlap in the spawn timing for summer- and late-winter steelhead, and genetic analysis has identified approximately 10 percent of the juvenile steelhead sampled at Willamette Falls and in the Santiam Basin (Johnson et al. 2013; NWFSC 2015) as hybrids of summer and winter steelhead.

The presence of hatchery-reared and feral hatchery-origin fish in the upper Willamette River basin may also affect the growth and survival of juvenile late-winter steelhead. In the North and South Santiam Rivers, juveniles are largely confined, by dams, below much of their historical spawning and rearing habitat. Releases of large numbers of hatchery-origin summer steelhead may temporarily exceed rearing capacities and displace winter juvenile steelhead.

Piscivorous birds, including Caspian terns and cormorants, and fishes, including northern pikeminnow, take significant numbers of juvenile steelhead. Steelhead smolts are especially vulnerable to Caspian tern predation (Evans et al. 2018a). Pikeminnow are significant predators of yearling juvenile migrants in the Willamette and Columbia Rivers (Friesen and Ward 1999).

In addition, UWR steelhead adults are subject to pinniped predation when they return to freshwater as adults (Brown et al. 2017). The magnitude of pinniped predation for UWR steelhead in the estuary is not known, though the presence of California sea lions and Steller sea lions at the Astoria Mooring Basin has been increasing over the past few years. Similarly, the number of sea lions observed at Willamette Falls has also been increasing. Data collected by the

Oregon Department of Fish and Wildlife observers at Willamette Falls estimates that California sea lions predated on adult UWR steelhead in 2018, and Steller sea lions predated on additional UWR steelhead adults in the same year. A population viability analysis conducted by the Oregon Department of Fish and Wildlife estimated probabilities of quasi-extinction for each UWR steelhead population over a 100-year period under four different levels of pinniped predation: no sea lions, and number of sea lions observed at Willamette Falls in 2015, 2016, and 2017. The Calapooia population had more than a 99 percent chance of quasi-extinction even without the presence of any sea lions. The North Santiam and South Santiam populations had at least a 60 percent chance of becoming quasi-extinct over the next 100 years under 2017 (highest) sea lion predation rates, but the chance was greatly reduced under other sea lion presence scenarios. The Molalla population only had a 21 percent probability of quasi-extinction, even under the 2017 (worst) scenario.

Table 2.3-1. Listing classification and date, recovery plan reference, most recent status review, status summary, and limiting factors for UWR steelhead considered in this opinion.

Status Summary	Limiting Factors
This DPS has four demographically independent populations. The 2011 recovery plan (ODFW and NMFS 2011) determined three populations to be at low risk of extinction (Molalla, North Santiam, South Santiam) and one at moderate risk (Calapooia). Since then, the DPS continues to demonstrate the overall low abundance pattern that was of concern during the last status review. The causes of these declines are not well understood, although much accessible habitat is degraded and under continued development pressure. The elimination of winter-run hatchery releases in the basin reduces hatchery threats, but nonnative summer steelhead hatchery releases are still a concern for species diversity and a source of competition for the DPS. Since 2011, it has been determined that all four populations may be at moderate risk of extinction (Ford 2011).	● Climate change effects, including increased stream temperatures, changes in precipitation/streamflow, and years of low ocean productivity. ● Ongoing development of low-elevation freshwater habitats in private ownership, which further contributes to: – Degraded freshwater habitat, – Degraded water quality, – Lower instream flows in summer and early fall, and – Increased disease incidence. ● Reduced peak flows and altered flows in Willamette mainstem and North and South Santiam Rivers due to hydropower/flood management system. ● Reduced access to spawning and rearing habitats due to impaired adult and juvenile passage at North and South Santiam dams. ● Interbreeding and competition with nonnative summer steelhead hatchery releases and residualized winter steelhead. ● Predation on returning adults by pinnipeds at the Willamette Falls Dam and in the Columbia estuary. ● Predation on juveniles by birds (Columbia estuary) and nonnative fish in Columbia estuary and Willamette River. ● Altered estuarine food web and impaired growth and survival due to reduced inputs of microdetritus.

Status Summary	Limiting Factors
	● An altered seasonal flow regime and Columbia River plume due to water diversions and water management projects. ● Urban growth and port development effects on estuarine habitat, including reduced water quality/increased levels of toxins and pollutants, including legacy contaminants.

2.3.1.2 Status of Critical Habitat

This section describes the status of designated critical habitat by examining the condition and trends of the PBFs of that habitat throughout the designated area. These features are essential to the conservation of the ESA-listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration, and foraging). Table 2.3-2 summarizes status information for designated critical habitat for UWR steelhead based on the detailed information on the status of critical habitat provided in the recovery plan for the species and the most recent status review (ODFW and NMFS 2011; NWFSC 2015). UWR steelhead critical habitat is within the Willamette/Lower Columbia River recovery domain.

The status of critical habitat is discussed in more detail in the Environmental Baseline, Section 2.3.2 below. We reviewed the status of designated critical habitat by examining the condition and trends of PBFs throughout the range of UWR steelhead, which include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine areas, and nearshore marine areas. Removal of multiple barriers has improved access and allowed the restoration of hydrological processes that may improve downstream habitat conditions. However, the value of PBFs remains impaired by tributary barriers and access to spawning habitat, loss of habitat complexity, toxics and water-quality issues, and concerns about predation during migration.

Table 2.3-2. Critical habitat, designation date, Federal Register citation, and status summary for UWR steelhead critical habitat.

Designation Date and Federal Register Citation	Critical Habitat Status Summary
9/02/05 **70 FR 52630**	Critical habitat encompasses seven subbasins in Oregon containing 38 occupied watersheds, as well as the lower Willamette/Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for steelhead are in fair-to-poor or fair-to-good condition (NMFS 2008a). NMFS rated conservation value of HUC5 watersheds as high for 15 watersheds, medium for 6 watersheds, and low for 17 watersheds, and also possibly high for 5 additional watersheds that were not included in the assessed total due to blocked adult passage. The lower Willamette/Columbia River rearing/migration corridor is considered to have a high conservation value and is the only habitat area designated in one of the high-value watersheds identified above. This corridor connects every population with the ocean and is used by rearing/migrating juveniles and migrating adults. The Columbia River estuary is a unique and essential area for juveniles and adults making the physiological transition between life in freshwater and marine habitats.

2.3.1.3 Climate Change Implications for UWR Steelhead and Critical Habitat

One factor affecting the rangewide status of UWR steelhead and aquatic habitat is climate change. The U.S. Global Change Research Program (USGCRP), mandated by Congress in the Global Change Research Act of 1990, reports average warming of about 1.3ºF from 1895 to 2011. As the climate changes, air temperatures in the Pacific Northwest are expected to increase 4 to 13°F by the end of the century, with the largest increases expected in the summer (Mantua et al. 2009; Mote et al. 2014). Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004; Scheuerell and Williams 2005; Zabel et al. 2006; ISAB 2007). According to the ISAB, these effects pose the following impacts into the future:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a smaller snowpack, watersheds will see their runoff diminished earlier in the season, resulting in lower stream flows in the June through September period. River flows in general and peak river flows are likely to increase during the winter due to more precipitation falling as rain rather than snow.

- Water temperatures are expected to rise, especially during the summer months when lower stream flows co-occur with warmer air temperatures.

The proposed action is only expected to be implemented in the interim time period between 2019 and completion of the NEPA process; however, the effects of the implementation of the proposed action will extend many years (e.g., maturation of estuary habitat projects). Thus, both natural climate variation and climate change are relevant to our analysis.

Likely changes in temperature, precipitation, wind patterns, and sea-level height have implications for the survival of UWR steelhead in both freshwater and marine habitats. As the climate changes, air temperatures in the Pacific Northwest are expected to increase 4 to 13°F by the end of the century (Mantua et al. 2009; Mote et al. 2014). While total precipitation changes are uncertain, increasing air temperature will result in more precipitation falling as rain rather than snow in watersheds across the basin (NMFS 2017a). In general, these changes in air temperatures, river temperatures, and river flows are expected to cause changes in salmon distribution, behavior, growth, and survival, although the magnitude of these changes remains unclear. In coastal areas, projections indicate an increase of 1–4 feet of global sea-level rise by the end of the century; sea-level rise and storm surge pose a risk to infrastructure and coastal wetlands, and tide flats are likely to erode or be lost as a result of seawater inundation (Mote et al. 2014). Ocean acidification is also expected to negatively impact Pacific salmon and organisms within their marine food webs.

Climate change would affect UWR steelhead in the following ways: (1) warmer stream temperatures could cause changes in growth and development rates and disease resistance; (2) changes in flow regimes (larger winter floods and lower flows in the summer and fall) could reduce egg and juvenile survival, and alter outmigration and spawning run timing; and (3) changing ocean conditions and marine food webs could affect ocean survival and growth.

2.3.2 Environmental Baseline

The environmental baseline includes the past and present impacts of all federal, state, or private actions and other human activities in an action area; the anticipated impacts of all proposed federal projects in an action area that have already undergone formal or early section 7 consultation; and the expected impacts of state or private actions that are contemporaneous with the consultation in process.

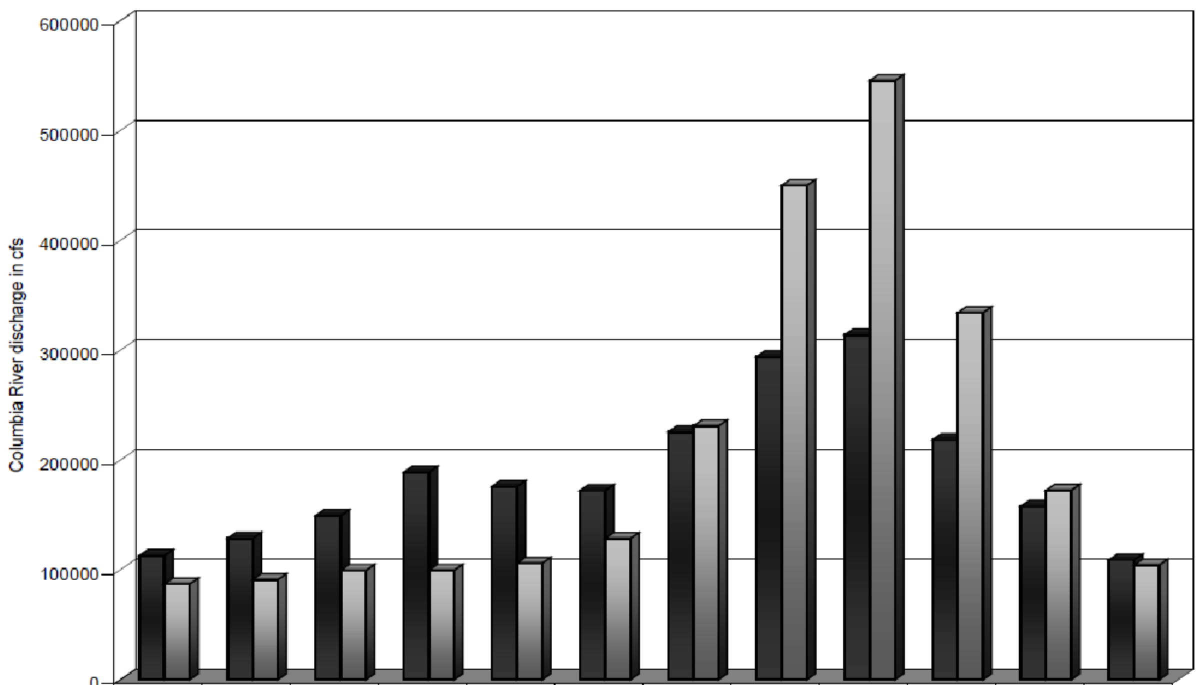
For UWR steelhead, we focus the description of the environmental baseline on that portion of the action area where UWR steelhead juveniles and adults are exposed to the effects of the proposed action. Most juvenile and adult UWR migrate between spawning and rearing habitat in the Willamette River basin directly to the ocean via the lower Columbia River and the ocean. To ascertain whether any adult UWR steelhead overshoot the Willamette River and continue upstream to Bonneville Dam, we examined PIT detections at Bonneville Dam. Four UWR steelhead were observed swimming upstream through Bonneville Dam in 2016. Thus, the upper extent of the UWR steelhead distribution is Bonneville Pool.

The proposed action does not affect fish or habitat in the Willamette River and is not included in our analysis for UWR steelhead. Thus, our analysis focuses primarily on the area from the Willamette River confluence to the plume, including the mouths of tributaries to the Columbia River in this reach to the extent that they are affected by flow management in the Columbia River. For the purposes of this consultation, UWR steelhead (juveniles and adults) are exposed to the effects of the proposed action from Bonneville Pool downstream to the Columbia River plume.

2.3.2.1 Mainstem Habitat

On the mainstem of the Columbia River, hydropower projects (including the CRS), water storage projects (including reservoirs in Canada operated under the Columbia River Treaty), and the withdrawal of water for irrigation and urban uses have significantly degraded salmon and steelhead habitats (Bottom et al. 2005; Fresh et al. 2005; NMFS 2013a). The volume of water discharged by the Columbia River varies seasonally according to runoff, snowmelt, and hydropower demands. Mean annual discharge is estimated to be 265 kcfs, but may range from lows of 71–106 kcfs to highs of 530 kcfs (Hamilton 1990; Prahl et al. 1998; NMFS 1998; USACE 1999). Naturally occurring maximum flows on the river would occur in May, June, and July as a result of snowmelt in the headwater regions. Minimum flows would occur from September to March, with periodic peaks due to heavy winter rains (Holton 1984). Interannual variability in stream flow is strongly correlated with two recurrent climate phenomena, the ENSO and the PDO (Newman et al. 2016).

Water storage projects (dams and reservoirs) and water management activities have reduced flows between Bonneville Dam and the mouth of the Columbia River compared to natural flows in the late spring and summer months; on average, this reduction can range from nearly 15 kcfs in August to over 230 kcfs in May (see Figure 2.3-2). Recognizing that the flow versus survival relationships for some interior basin ESUs/DPSs displayed a plateau over a wide range of flows but declined markedly as flows dropped below some threshold (NMFS 1995b, 1998), NMFS and the CRS Action Agencies have attempted to manage Columbia and Snake River water resources to maintain seasonal flows above threshold objectives given the amount of runoff in a given year. This has been accomplished by avoiding excessive drafts going into spring to minimize the flow reductions needed to refill the reservoirs and by drafting the storage reservoirs during summer to augment flows. These flow objectives have guided preseason reservoir planning and in-season flow management. Nonetheless, since the development of the hydrosystem, average monthly flows at Bonneville Dam have been substantially lower during May–July and higher in October–March than an unregulated system. Reduced flows have increased travel times during outmigration for juvenile salmonids and reduced access to high-quality estuarine habitats during spring through early summer.



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Current	113017	128641	149403	189076	175921	172150	225689	293948	313930	218523	157935	109020
Natural	87115	91029	99387	99496	106033	128580	231047	450040	545561	334238	172430	104310

Figure 2.3-2. Comparison of monthly discharge (flow) in the Columbia River between current conditions (black) and normative flows (gray). These data show that pre-development flows were lower in the winter and higher in the spring and early-summer months.

The series of dams and reservoirs have also blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is only one-third of nineteenth-century levels (Simenstad et al. 1982, 1990; Sherwood et al. 1990; Weitkamp 1994; NRC 1996; NMFS 2008a). Similarly, Bottom et al. (2005) estimated that the delivery of suspended sediment to the lower river and estuary has been reduced by about 60 percent (as measured at Vancouver, Washington). This reduction has altered the development of habitat along the margins of the river.

Industrial harbor and port development are also significant influences on the lower Willamette and lower Columbia Rivers (Bottom et al. 2005; Fresh et al. 2005; NMFS 2013a). Since 1878, the Army Corps of Engineers has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the lower Willamette River as a navigation channel. Originally dredged to a 20-foot minimum depth, the federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The navigation channel supports many ports on both sides of the river, resulting in several thousand commercial ships traversing the river every year. The dredging, along with diking, draining, and placing of fill material in wetlands and shallow habitat, also disconnects the river from its floodplain, resulting in the loss of shallow-water rearing habitat and the ecosystem functions that floodplains provide (e.g., supply of prey, refuge from high flows, temperature refugia; Bottom et al. 2005).

The most extensive urban development in the lower Columbia River subbasin has occurred in the Portland/Vancouver area. Common water-quality issues, both in areas with urban development and areas with rural residential septic systems, include warmer water temperatures, lowered dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff (LCREP 2007).

2.3.2.2 Passage Survival

With the exception of an extremely limited number of adult strays detected at Bonneville Dam, none of the populations in this DPS pass any of the mainstem CRS projects.

2.3.2.3 Water Quality

Water quality in the action area is impaired. Common toxic contaminants found in the Columbia River system include PCBs, PAHs, PBDEs, DDT and other legacy pesticides, current use pesticides, pharmaceuticals and personal care products, and trace elements (LCREP 2007). The LCREP report noted widespread presence of PCBs and PAHs, both geographically and in the food web. Urban and industrial portions of the lower river contribute significantly to contaminant levels in juvenile salmon; juvenile salmon are absorbing toxic contaminants during their time rearing and feeding in the lower Columbia River (LCREP 2007). Likewise, juvenile salmonids accumulate DDT in their tissues and are exposed to estrogen-like compounds in the lower river, likely associated with pharmaceuticals and personal care products. Concentrations of copper are present at levels that could interfere with crucial salmon and steelhead behaviors. Small releases of materials such as lubricants occur during dam operation and maintenance and contribute to background exposure to contaminants in the Columbia River.

Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute municipal and industrial waste discharges to the lower Columbia River. Industrial and municipal wastes from the Portland/Vancouver metro areas, including the superfund-designated reach in the lower Willamette River, also contribute to degraded water quality in the lower Columbia River. Mining areas scattered around the basin deliver higher background concentrations of metals. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river.

Outside of urban areas, the majority of residences and businesses rely on septic systems. Common water-quality issues associated with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff. Under these environmental conditions, fish in the action area are stressed. Stress may lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival).

Water temperatures in the Columbia River are a concern; because of temperature standard exceedances, the Columbia River is included on the Clean Water Act §303(d) list of impaired waters established by Oregon and Washington. Temperature conditions in the Columbia River basin are affected by many factors, including:

- Natural variation in weather and river flow;
- Construction of the dam and reservoir system (the large surface areas of reservoirs and resulting slower river velocities contribute to warmer late summer/fall water temperatures);
- Increased temperatures of tributaries due to water withdrawn for irrigated agriculture, and due to grazing and logging;
- Point-source thermal discharges from cities and industries; and
- Climate change.

The EPA is working with federal and state agencies, the tribes, and other stakeholders to develop water-quality improvement plans (total maximum daily loads) for temperature in the Columbia River and lower Snake River. As part of the 2015 biological opinion on EPA's approval of water-quality standards, including temperature (NMFS 2015a), EPA committed to work with federal, state, and tribal agencies to identify and protect thermal refugia and thermal diversity in the lower Columbia River and its tributaries.

Comparisons of long-term temperature monitoring in the migration corridor before and after impoundment reveal a change in the thermal regime of the Snake and Columbia Rivers. Using historical flows and environmental records for the 35-year period 1960–95, Perkins and Richmond (2001) compared water temperature records in the lower Snake River with and without the lower Snake River dams and found three notable differences between the current versus unimpounded river:

- Maximum summer water temperature has been slightly reduced,
- Water temperature variability has decreased, and
- Post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall, a phenomenon termed thermal inertia.

These hydrosystem effects (influenced by the temperatures of tributary streams entering the Snake and Columbia Rivers both upstream of, within, and downstream of the mainstem dams) continue downstream and influence temperature conditions in the lower Columbia River. At a macro scale, water temperature affects salmonid distribution, behavior, and physiology (Groot and Margolis 1991); at a finer scale, temperature influences migration swim speed of salmonids (Salinger and Anderson 2006), timing of river entry (Peery et al. 2003), susceptibility to disease and predation (Groot and Margolis 1991), and, at temperature extremes, survival.

2.3.2.4 Tributary Habitat

Tributaries occupied by this species are not affected by the proposed action. Information about the species' status in the tributary portion of its life cycle can be found in Section 2.3.1 (Rangewide Status).

2.3.2.5 Estuary Habitat

The estuary provides important migration habitat for UWR steelhead populations. Since the late 1800s, 68–70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, shoreline development, flow regulation, and other modifications (Kukulka and Jay 2003; Bottom et al. 2005; Marcoe and Pilson 2017). Disconnection of tidal wetlands and floodplains has reduced the production of wetland macrodetritus supporting salmonid food webs (Simenstad et al. 1990; Maier and Simenstad 2009), both in shallow water and for larger juveniles migrating in the mainstem (ERTG 2018).

Restoration actions in the estuary such as those highlighted in the latest five-year review (NMFS 2016) have improved connectivity with and prey flux from the floodplain to the mainstem (PNNL and NMFS 2018). From 2004 through 2017, restoration sponsors implemented 58 projects including dike and levee breaching or lowering, tide gate removal, and tide gate upgrades that reconnected 5,412 acres of historical tidal floodplain habitat to the mainstem. This represents a 2.5 percent net increase in the connectivity of habitats that produce prey consumed by juvenile steelhead, including fish from the UWR steelhead DPS (Johnson et al 2018; PNNL and NMFS 2018). Although yearling steelhead do not enter and reside in these areas to the same extent as subyearling Chinook migrants, improved opportunities for feeding on commonly consumed prey that drift into the mainstem are likely to contribute to survival at ocean entry.

2.3.2.6 Hatcheries

Winter steelhead hatchery programs were terminated in the late 1990s. Currently, the only steelhead programs in the upper Willamette River release Skamania Hatchery-origin summer steelhead, though this program is not part of the DPS. Annual total releases have been relatively stable at around 600,000 fish from 2009 to 2014, although the distribution has changed, with fewer fish being released in the North Santiam River and corresponding increases in the South Santiam and Middle Fork Willamette Rivers to maintain the release level of about 600,000 fish. However, there has been some concern regarding the effect of introduced summer steelhead on native late-winter steelhead. There is some overlap in the spawn timing for summer- and late-winter steelhead, and genetic analysis has identified approximately 10 percent of the juvenile steelhead sampled at Willamette Falls and in the Santiam River basin (Johnson et al. 2013; NWFSC 2015) as hybrids of summer and winter steelhead.

The presence of hatchery-reared and feral hatchery-origin fish in the upper Willamette River basin may also affect the growth and survival of juvenile late-winter steelhead. In the North and South Santiam Rivers, juveniles are largely confined by dams below much of their historical spawning and rearing habitat. Releases of large numbers of hatchery-origin summer steelhead may temporarily exceed rearing capacities and displace winter juvenile steelhead.

2.3.2.7 Recent Ocean and Lower River Harvest

There is no directed fishery for winter steelhead in the upper Willamette River, and they are the only life history displayed by natural steelhead in this area. Due to differences in return timing between native winter steelhead, introduced hatchery-origin summer steelhead, and hatchery-origin spring Chinook salmon, the encounter rates for winter steelhead in the recreational fishery are thought to be low. Sport fishery mortality rates were estimated at 0 to 3 percent (Ford 2011). There is additional incidental mortality in the commercial net fisheries for hatchery Chinook salmon and steelhead in the lower Columbia River (total freshwater harvest is estimated to be about 9.5 percent). Tribal fisheries occur above Bonneville Dam and do not impact UWR steelhead (NWFSC 2015).

2.3.2.8 Predation

The existence of dams and reservoirs around the Columbia Basin also blocks sediment transport. Total sediment discharge into the estuary and Columbia River plume is about one-third of nineteenth-century levels (NMFS 2008a). This reduces turbidity in the lower river, especially during spring, which is likely to make juvenile outmigrants more vulnerable to visual predators like piscivorous birds and fishes.

2.3.2.8.1 Avian Predation

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, are having a significant impact on the survival of juvenile salmonids (including UWR steelhead) in the Columbia River. Caspian terns on Rice Island, an artificial dredged-material disposal island in the estuary, consumed about 5.4-14.2 million juveniles per year in 1997 and 1998, or 5-15 percent of all the smolts reaching the estuary (Roby et al. 2017). Efforts began in 1999 to relocate the tern colony 13 miles closer to the ocean at East Sand Island where the tern diet would diversify to include marine forage fish. During 2001-15, estimated consumption by terns on East Sand Island averaged 5.1 million smolts per year, about a 59 percent reduction compared to when the colony was on Rice Island. Management efforts are ongoing to further reduce salmonid consumption by terns in the lower Columbia River and similar efforts are in progress to reduce the nesting population of double-crested cormorants in the estuary.

Researchers have not estimated predation rates for UWR steelhead because these fish are not PIT tagged. However, based on detection rates for fish from interior Columbia Basin steelhead DPSs at the East Sand Island colonies, steelhead are more vulnerable to avian predation than Chinook salmon (Evans et al. 2018), possibly because they are more surface-oriented (Beeman and Maule 2006). Predation rates by East Sand Island terns on steelhead from interior DPSs ranged from about 15-22 percent per year before the management plans were implemented, but have dropped to about 9 percent per year for each DPS (Evans et al. 2018a). Predation rates by East Sand Island cormorants on interior steelhead, pre-management, ranged from about 5-9 percent per year. Due to failures of the cormorant colony in 2016 and 2017 (Appendix C), there are no estimates of predation rates since management of that colony began. In addition, substantial numbers of cormorants have relocated to the Astoria-Megler Bridge (preliminary report of 1,737 in 2018) and hundreds more are observed on the Longview Bridge, navigation aids, and transmission towers in the lower river (Anchor QEA et al. 2017). Smolts may constitute a larger proportion of the diet of cormorants nesting at these sites than if the birds were foraging from East Sand Island. Thus, the success of the East Sand Island tern and cormorant management plans at meeting their underlying goals of reducing salmonid predation is uncertain at this time.

2.3.2.8.2 Piscivorous Fish Predation

Native pikeminnow are significant predators of juvenile salmonids in the Columbia River basin, followed by nonnative smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011, 2015). Before the start of the NPMP in 1990, this species was estimated to eat about eight percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River basin each year. Williams et al. (2017) compared current estimates of northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. On average, 37 adult steelhead and 217 juveniles were killed and/or handled each year in the Sport Reward Fishery during 2013-17. The fishery is conducted over a much larger area than that occupied by UWR steelhead, but small numbers of these fish could have been from this DPS.

2.3.2.8.3 Pinniped Predation

California and Steller sea lions prey on adult steelhead throughout the lower Columbia River. The population size of California sea lions has shown a steady increase from lows in the mid-1970s to levels in 2014 above maximum net productivity level (Lakke et al. 2018). Recent declines in pup production and survival suggest the population may have stopped growing. This vulnerability is primarily for spring-run populations such as those from the UWR steelhead DPS, which migrate during spring when the pinnipeds' abundance is highest. Under an authorization under the Marine Mammal Protection Act, management agencies have implemented numerous measures to reduce predation at Bonneville Dam and Astoria, from hazing to removal. From 2008–17, 15 California sea lions at Bonneville Dam were captured and placed in captivity (Brown et al. 2017). During that same period, 163 California sea lions were euthanized at Bonneville Dam and five at Astoria (Brown et al. 2017). An authorization to lethally remove sea lions has been issued for Willamette Falls and the trapping and removal activities have begun.

2.3.2.8.4 Compensatory Effects and Predation on Salmonid Populations

An estimate of the effect of a predator population on adult returns to Bonneville Dam (e.g., the effect of smolt consumption by northern pikeminnow or Caspian terns) has the potential to be erroneous if it does not consider whether other factors intervene to compensate for the change in mortality (ISAB 2016). The primary mechanisms for compensatory effects are: (1) increased fish survival due to reduced densities in later life stages, (2) selective predation based on fish size and condition, and (3) predator switching from one prey species to another. Compensatory effects are difficult to quantify because they can occur later in the life cycle and can vary over time; efforts are currently underway to better understand compensatory effects (Haeseker 2015; Evans et al. 2018b).

2.3.2.9 Research and Monitoring Activities

The primary effects of past and ongoing CRS-related RM&E programs on UWR steelhead are associated with the capturing and handling of fish. The RM&E program is a collaborative, regionally coordinated approach to fish and habitat status monitoring, action effectiveness research, critical uncertainty research, and data management. The information derived from the program facilitates effective adaptive management through better understanding the effects of the ongoing CRS action. Capturing, handling, and releasing fish generally leads to stress and other sublethal effects, but fish sometimes die from such treatment. The mechanisms by which these activities affect fish have been well documented and are detailed in Section 8.1.4 of the 2008 biological opinion. Some RM&E actions also involve sacrificial sampling of fish. We estimated the number of UWR steelhead that have been handled each year during the implementation of RM&E under the 2008 RPA as the average annual take reported for 2013-2017:

- No UWR steelhead were handled or killed during activities associated with the Smolt Monitoring Program or the CSS.
- No UWR steelhead were handled or killed during activities associated with the ISEMP.
- Estimates for UWR steelhead handling and mortality for all other RM&E programs show: (1) one hatchery and one wild adult handled; (2) no hatchery or wild adults died; (3) no hatchery and one wild juvenile handled; and (4) no hatchery or wild juveniles died.

The combined take (i.e., handling, including injury, and incidental mortality) associated with these elements of the RM&E program has, on average, affected less than one percent of the wild (i.e., natural origin) adult returns or juvenile production for the UWR steelhead DPS (Bellerud 2018). This relatively small effect is deemed worthwhile because it allows the Action Agencies and NMFS to evaluate the effects of CRS operations, including modifications to facilities, operations, and mitigation actions.

In addition, northern pikeminnow are tagged as part of the Sport Reward Fishery and their rate of recapture is used to calculate exploitation rates. Northern pikeminnow are collected for tagging using boat electrofishing in select reaches of the Columbia River. During 2017, boat electrofishing operations in the Columbia River extended upstream from RM 47 (near Clatskanie, Oregon) to RM 394 (Priest Rapids Dam), and in the Snake River from RM 10 (Ice Harbor Dam) to RM 41 (Lower Monumental Dam) and from RM 70 (Little Goose Dam) to RM 156 (upstream of Lower Granite Dam). Researchers conducted four sampling events consisting of 15 minutes of boat electrofishing effort in shallow water within each 0.6-mile reach during April-July.

A side effect of the electrofishing effort is that salmon and steelhead may be exposed to the electrofishing field, with the potential for injury, stress, and fatigue and even cardiac or respiratory failure (Snyder 2003). Some adult and juvenile UWR steelhead are likely to be present in shallow shoreline areas during the April-July time period. Most sampling occurs in darkness (1800-0500 hours). Operators shut off the electrical field if salmonids are seen and because most stunned fish quickly recover and swim away, they cannot be identified to species (i.e., Chinook, coho, chum, or sockeye salmon or steelhead). Barr (2018) reported encountering an annual average of 891 adult and 60,312 juvenile salmonids in the lower Columbia River each year during 2013-17 electrofishing operations based on visual estimation methods. It is likely that some of these were UWR steelhead.

2.3.2.10 Critical Habitat

The environmental baseline for UWR steelhead critical habitat is reflected in the same impacts discussed above (e.g., mainstem flows, passage, water quality, and predation) and summarized here in Table 2.3-3. Water quality is a concern for all PBFs. Restoration activities addressing access to the historical estuarine floodplain are improving the baseline condition for that PBF; however, more restoration is needed before the PBFs can fully support the conservation of UWR steelhead.

Table 2.3-3. Physical and biological features (PBFs) of designated critical habitat for UWR steelhead.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBF
Freshwater spawning	Substrate, adequate water quality and water quantity	Concerns about access to spawning sites, substrate quality, water quality
Freshwater rearing sites	Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility, water quality, forage, and natural cover.	Concerns about water quantity, temperature, access to rearing habitat, lack of complex rearing habitat
Freshwater migration corridors	Free of obstruction and excessive predation, adequate water quality and quantity, and natural cover.	Concerns about increased opportunities for predators, especially birds and pinnipeds (construction of dredge-material islands in the lower river and other human-built structures used by terns and cormorants for nesting).
Estuarine areas	Free of obstruction and excessive predation with water quality,	Diking off areas of the estuary floodplain (land use), combined with reduced peak spring flows (water diversions

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBF
	quantity, and salinity, natural cover, juvenile and adult forage.	and water storage and hydroelectric projects) have reduced access to floodplain habitat for rearing and prey production.
Nearshore marine areas	Free of obstruction and excessive predation with water quality, quantity, and forage.	Concerns about increased opportunities for pinniped predators, adequate forage.

2.3.2.11 Future Anticipated Impacts of Completed Federal Formal Consultations

The environmental baseline includes the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, including the consultation on the operation and maintenance of the Bureau of Reclamation's upper Snake River projects. The 2016 five-year review evaluated new information regarding the status and trends of UWR steelhead, including recent biological opinions issued for UWR steelhead and key emergent or ongoing habitat concerns (NMFS 2016a). Since the beginning of 2015 through 2017, we completed 435 formal consultations (142 in 2015, 136 in 2016, and 157 in 2017) that addressed effects to UWR steelhead.[24] These numbers do not include the many projects implemented under programmatic consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed salmonids. Some of the completed consultations are large (large action area, multiple species), such as the Mitchell Act consultation and the consultation on the 2018–27 *U.S. v. Oregon* Management Agreement. Many of the completed actions are for a single activity within a single subbasin.

Some current and proposed restoration projects will improve access to blocked habitat and riparian condition outside of the action area, and increase channel complexity and instream flows throughout the Columbia Basin. For example, under BPA's Habitat Improvement Programmatic consultation, BPA implemented 29 projects in the Columbia Basin that improved fish passage in 2017, and 99 projects that involved river, stream, floodplain, and wetland restoration. These projects will benefit the viability of the affected populations by improving abundance, productivity, and spatial structure. Some of these projects, especially projects in the estuary, are likely to provide beneficial effects for UWR steelhead. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more, and typically less, than a few weeks).

Other types of federal projects, including grazing allotments, dock and pier construction, and bank stabilization will be neutral or have short- or even long-term adverse effects on viability.

[24] PCTS data query, July 31, 2018.

All of these actions have undergone section 7 consultation and the actions[25] were found to meet the ESA standards for avoiding jeopardy.

Similarly, future federal restoration projects will improve the functioning of the PBFs safe passage, spawning gravel, substrate, water quantity, water quality, cover/shelter, food, and riparian vegetation. Projects in the Willamette River basin or in the estuary are most likely to benefit critical habitat for UWR steelhead. Projects implemented for other purposes will be neutral or have short- or even long-term adverse effects on some of these same PBFs. However, all of these actions,[26] have undergone section 7 consultation and were found to meet the ESA standards for avoiding adverse modification of critical habitat.

2.3.2.12 Summary

The factors described above have negatively affected the abundance, productivity, diversity, and spatial structure of UWR steelhead populations. The small net improvement in floodplain connectivity achieved through the CRS estuary habitat program and efforts to improve hatchery practices and lower harvest rates are positive signs, but other stressors are likely to continue. NMFS (2016a) identified past land development, habitat degradation, and predation, in combination with the potential effects of climate change, as likely to present a continuing strong negative influence into the foreseeable future.

Likewise, the habitat within the action area does not fully support the conservation value of designated critical habitat for UWR steelhead, as described above. The PBFs essential for the conservation of UWR steelhead that occur within the area affected by the proposed action include freshwater migration corridors, estuarine rearing areas, and nearshore marine areas (at the mouth of the Columbia River).

The CRS Action Agencies and other federal and nonfederal entities have taken actions in recent years to improve the functioning of some of the PBFs of critical habitat. For stream-type juveniles, projects that have protected or restored riparian areas and breached or lowered dikes and levees in the estuary have improved the functioning of the juvenile migration corridor. For subyearling smolts, restoration projects in the estuary are improving the functioning of areas used for growth and development. However, other factors that have negative effects on these PBFs are expected to continue into the future.

2.3.3 Effects of the Action

Under the ESA, “effects of the action” means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR

[25] Or the RPA to the actions.
[26] Including any RPA.

402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

The proposed action is an ongoing action that has been modified over time to reflect capital improvements, as well as changes in operation based on existing conditions and improved information on how CRS operations affect UWR steelhead and other listed species and their critical habitats. The current proposed action includes operational measures (e.g., flood risk management, navigation, fish passage, and hydropower generation) and non-operational measures (e.g., support for conservation hatchery programs, predation management, habitat improvement actions) that will be implemented beginning in 2019. The proposed action, however, is of limited duration. The Action Agencies are developing an EIS in accordance with NEPA that will assess and update the approach for long-term system operations, maintenance, and configuration as well as evaluate measures to avoid, offset, or minimize impacts to resources affected by the management of the CRS, including ESA-listed species and designated critical habitat. A court order currently requires the Action Agencies to issue Records of Decision on or before September 24, 2021.[27] Based on scoping, the range of alternatives being examined is broad and includes potential large-scale changes in the action. Thus, there is substantial uncertainty regarding what system operations, maintenance, and configuration the Action Agencies will propose at the conclusion of the NEPA process. Likewise, it is unknown what measures intended to avoid, offset, or minimize adverse effects will ultimately be included in the final preferred alternative.

The Action Agencies will operate the run-of-river lower Columbia River projects (McNary, John Day, The Dalles, and Bonneville Dams) in accordance with the annual Water Management Plan and Fish Passage Plan (including all appendices). These projects are operated for multiple purposes, including fish and wildlife conservation, irrigation, navigation, power, recreation, and, in the case of John Day Dam, limited flood risk management.

The effects of the proposed action are generally consistent with the effects caused by a continuation of the CRS operations as described in the environmental baseline section (including effects caused by facility maintenance and hatchery activities), with the exception of the addition of the flexible spill operation. It is unlikely that any UWR steelhead will be exposed to elevated TDG levels (from the increased spill) upstream of the mouth of the Willamette River. The other operational changes are not anticipated to alter the effects to UWR steelhead because no fish in the DPS will be exposed to the effects of those changes.

[27] The Presidential Memorandum on Promoting the Reliable Supply and Delivery of Water in the West, issued on October 19, 2018, required the development of an expedited schedule for completion of the NEPA process. The Council on Environmental Quality has confirmed a revised schedule that calls for completing the Draft EIS in February 2020, the Final EIS in June 2020 and Records of Decision by September 30, 2020. These dates are consistent with, but earlier than, the court-ordered deadlines.

2.3.3.1 Effects to Species

Both juvenile and adult UWR steelhead from all populations will be exposed to the continuing effects of the action in the mainstem Columbia River from the Willamette River confluence downstream to the plume.

2.3.3.1.1 Hydrosystem Operation

The effects of the proposed action are essentially a short-term continuation of the effects from recent hydrosystem operations as described in the Environmental Baseline section above, with the addition of the proposed increase in spring spill. During periods of increased spill each spring, elevated TDG levels will extend for at least 35 miles downstream of Bonneville Dam (Camas-Washougal gage). It is highly unlikely that UWR steelhead will be exposed to elevated TDG levels associated with the proposed increase in spring spill. A small number of adult UWR steelhead may be exposed to these conditions upstream of the mouth of the Willamette River. To the extent adult individuals stray and move further upstream in the Columbia River through Bonneville Dam, exposure to project effects will increase. There will be no exposure to elevated TDG levels associated with periods of increased spring spill levels for juveniles migrating and rearing in the Columbia River downstream of the Willamette River confluence because TDG effects will dissipate by the time the flows reach the Willamette confluence.

The effects of continuing the CRS operations will include greater than natural flows in the action area during the months of October through March, when UWR steelhead migrants are likely present in the Columbia mainstem and estuary. The continued changes in flow may alter the fitness of some individual fish (faster migration to the estuary) but we do not expect increased mortality from these changes. Similarly, UWR Chinook salmon will not be exposed to the proposed changes in the hydrosystem operations (increases spill, MOP, transportation of juveniles) and continued maintenance operation of the facilities.

2.3.3.1.2 Predator Management and Monitoring Actions

The Action Agencies propose continued implementation of the Caspian Tern Nesting Habitat Management Plan (USACE 2015a) and the Double-crested Cormorant Management Plan (USACE 2015b). Tern habitat on East Sand Island will continue to be maintained at no less than one acre. Management actions for cormorants nesting on East Sand Island will be limited to passive dissuasion and hazing. Limited egg take (up to 500 eggs) may be requested from USFWS in an annual depredation permit application, to preclude cormorants from nesting in new or different areas on East Sand Island. These ongoing actions have the potential to improve the viability of the UWR steelhead DPS by increasing the survival of outmigrating juveniles as they move through the estuary. However, the dispersal of double-crested cormorants from East Sand Island to nest sites on the Astoria-Megler Bridge in recent years, and observations of thousands of Caspian terns roosting on Rice Island, indicate that the numbers of avian predators in the estuary and their effects on the viability of salmonids, such as UWR steelhead, are still in flux. Because the Action Agencies propose to continue maintaining the reduced amounts of nesting habitat achieved for terns and cormorants on East Sand Island (BPA et al. 2018a), we expect that any reduced predation rates achieved for UWR steelhead under the 2008 FCRPS biological opinion and associated RPA will continue during the interim period.

The Action Agencies propose to synthesize avian colony size and predation rate data collected under the tern and cormorant colony management plans. The intent of the synthesis report is to provide the Action Agencies, Cooperating Agencies, and NMFS with a summary of predation by piscivorous waterbirds on ESA-listed salmonids in the Columbia River basin before, during, and after the management actions in order to assess their effectiveness on a basinwide scale. This review will help the Action Agencies prioritize any efforts to take place during this interim period, or to be discussed as future mitigation measures in the CRS Operations NEPA document.

The pikeminnow predation management program includes the Sport Reward Fishery and Dam Angling programs, which will continue as part of the proposed action. The first is implemented in the lower Columbia River including the estuary. This fishery removes approximately 10–20 percent of predatory-sized pikeminnow per year and is open from May through September, when juveniles can be rearing in mainstem habitats. We expect that the Sport Reward Fishery will continue to improve the survival of juveniles that are rearing and migrating through the lower Columbia River. We estimate that the numbers of steelhead, including UWR steelhead, handled and/or killed in the Sport Reward Fishery will be no more than 100 adults and 600 juveniles per year, system-wide, during the interim period. The Dam Angling Program is conducted at The Dalles and John Day Dams and dam anglers are unlikely to encounter any UWR steelhead.

2.3.3.1.3 Habitat Actions

The tributary habitat improvements will not target any tributaries that provide habitat for UWR steelhead, and, thus, will not affect this DPS.

The Action Agencies have committed to continue to implement the CEERP to increase the capacity and quality of estuarine ecosystems and improve access for juvenile salmonids. The Action Agencies will continue to emphasize reconnection of floodplain areas in tidally influenced waters of the lower Columbia River and estuary, primarily through modifying levees. Additional actions at habitat improvement sites will include recreating historical channel networks, reducing the presence of nonnative species, and revegetating habitat improvement sites with native vegetation to ensure a site's resiliency. These projects are expected to provide increased food availability to UWR steelhead as they migrate through the estuary.

NMFS supports the ISAB's assessment finding that it is difficult to reliably quantify the survival benefits of estuary habitat restoration, and agrees that the Action Agencies' assessment methodology, including review by the ERTG,[28] is useful to prioritize projects. The Action

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[28] As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss with ERTG and regional partners relevant climate change science in an effort to understand whether their planned estuary projects are resilient to climate change (i.e., sea level rise, temperatures, and mainstem flow levels). In addition, the Action Agencies' annual update of their restoration and monitoring plans for the estuary will document any needed adjustments in design, location, or other elements of a given project to address climate change impacts, both during and beyond the interim period.

Agencies' proposed action includes a commitment to continuing to reconnect an average of 300 acres of floodplain per year to the mainstem, a goal that they have a record of achieving in 2008-17 (BPA et al. 2018b). Thus, the estuary program will provide benefits (flux of insect and amphipod prey to the mainstem migration corridor) to juvenile UWR steelhead migrating through the estuary. The habitat's conservation value is likely to improve as more habitat gets reconnected, and the benefits are likely to accrue as the habitat patches get larger (Spiesman et al. 2018). These habitats provide important prey items for yearling steelhead in the mainstem (Johnson et al. 2018). It is also likely that these benefits will increase as restored habitat area accrues over time and habitat quality matures.

2.3.3.1.4 Research and Monitoring Activities

The Action Agencies' RM&E program will be similar to the current program, or will be implemented at a reduced scale. Thus, the level of injury and mortality discussed in the Environmental Baseline, primarily from the capturing and handling of fish, is likely to continue at a similar or reduced level. We estimate that, on average, the following numbers of UWR steelhead will be affected each year during the interim period:

- No UWR steelhead will be handled or killed during activities associated with the Smolt Monitoring Program and the CSS.
- No UWR steelhead will handled or killed during activities associated with Fish Status Monitoring.
- Projected estimates of UWR steelhead handling and mortality for all other RM&E programs include: (1) 73 hatchery and 62 wild adults handled; (2) one hatchery and one wild adult killed; (3) 923 hatchery and 1,323 wild juveniles handled; and (4) nine hatchery and 13 wild juveniles killed.

The combined observed mortality associated with these elements of the RM&E program will, on average, affect less than 1 percent of the wild (i.e., natural origin) adult returns or juvenile production for the UWR steelhead DPS (Bellerud 2018). Although we estimate that 3.29 percent of the wild adults will, on average, be handled each year, we expect that only up to one percent of these will die after release (i.e., 0.03 percent of those handled). This relatively small effect is deemed worthwhile because it will allow the Action Agencies and NMFS to continue to evaluate the effects of CRS operations, including modifications to facilities, operations, and mitigation actions.

Electrofishing operations for the NPMP during the interim period are expected to continue at the same level of effort as in recent years (four 15-minute sampling events per 0.6-mile reach between RM 47 near Clatskanie, Oregon, and the confluence with the Willamette River during April-July; a total of 550 hours system-wide). Some adult and juvenile UWR steelhead are likely to be present in shallow shoreline areas during electrofishing activities and may be stunned and even killed. However, because the operator releases the electrical field as soon as salmonids are observed, and most of these fish quickly recover and swim away, we are unable to use observations from past operations to estimate the number of fish from this DPS that will be affected. Information obtained through electrofishing supports management of the NPMP, which is reported to have reduced salmonid predation by about 30 percent (Williams et al. 2017). This level of take is anticipated to occur for the duration of this proposed action, pending completion of the NEPA process.

2.3.3.2 Effects to Critical Habitat

Implementation of the proposed action will continue to affect the volume and timing of flow in the Columbia River, which has the potential to alter habitat in the Columbia River mainstem and estuary for all populations. The proposed action will also improve rearing habitat in the estuary. The PBFs that could be affected by the proposed action are described in Table 2.3-4.

Table 2.3-4. Effects of the proposed action on the physical and biological features (PBFs) essential for the conservation for the DPS.

PBF	Effect of the Proposed Action
Freshwater migration corridors and estuarine areas	Sediment will continue to accumulate behind CRS dams, reducing turbidity in the migration corridor during the spring outmigration, which could make juveniles more vulnerable to predators. This PBF will continue to improve with the reconnection of an average of 300 acres of floodplain habitat per year during the interim period (prey production and flux to the mainstem). Because estuary bird colonies and predation rates are in flux, it is not clear whether continued tern and cormorant colony management is likely to reduce avian predation (i.e., meet the management plan goals). Any reduced predation rates achieved under the 2008 biological opinion and associated RPA will continue during the interim period.

2.3.4 Cumulative Effects

“Cumulative effects” are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation (50 CFR 402.02). Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Nonfederal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem functions or species-specific conservation objectives. These projects address the protection of adequately functioning habitat and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. These projects also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth management programs (planning and regulation), various stream and riparian habitat projects, watershed planning and implementation, acquisition of water rights for instream purposes and sensitive areas, instream flow rules, stormwater and discharge regulation, TMDL implementation to achieve water-quality standards, hydraulic project permitting, and increased spill and bypass operations at hydropower facilities. NMFS has determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. These activities are likely to have beneficial cumulative effects that will significantly improve conditions for the salmon and steelhead, including UWR steelhead.

NMFS also noted that some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects are activities that occurred in the recent past and were included in the environmental baseline. Some of these activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the action area, nonfederal actions are likely to include activities associated with human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. All of these activities can contaminate local or larger areas with hydrocarbon-based materials. Continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations.

Overall, we anticipate that projects to restore and protect habitat, restore access to and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area.

2.3.5 Integration and Synthesis

In this section, we add the effects of the action (Section 2.3.3) to the environmental baseline (Section 2.3.2) and the cumulative effects (Section 2.3.4), taking into account the status of the species and critical habitat (Sections 2.3.1.1 and 2.3.1.2), to formulate the agency’s biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat for the conservation of the species.

2.3.5.1 Species

NMFS' recent status review describes UWR steelhead as threatened but expressed concern about abundance levels that continued to decline through the period 2010-15 (NWFSC 2015). Before the construction of a fish ladder at Willamette Falls in the early 1900s, flow conditions allowed steelhead to ascend Willamette Falls only during the late winter and spring. Presently, the majority of the UWR winter steelhead run return to freshwater from January through April. This DPS is a single MPG (Willamette) with four independent populations. The cause for declines in the four populations is not well understood, although much accessible habitat is degraded and under continued development pressure. The elimination of winter-run hatchery releases in the basin reduces hatchery threats, but nonnative summer steelhead hatchery releases are still a concern for species diversity, and a source of competition for the DPS. The DPS is at moderate risk of extinction.

The effects of CRS operations on UWR steelhead are limited to effects on estuarine migration and habitat conditions in the lower Columbia River. These effects are likely to reduce the survival of juvenile UWR steelhead as they move through the lower Columbia River. As no populations pass through any of the CRS dams, no individuals of any of the four UWR steelhead populations will be exposed to the increase in spring spill or elevated TDG levels.

The other proposed changes to CRS operations are not anticipated to negatively affect UWR steelhead survival. In particular, the changes in usable forebay ranges (MOP 1.5-foot range) at the Lower Snake River reservoirs and the change in operating range at the John Day forebay (MIP 2-foot range) will result in inconsequential variations in the timing and amount of flow in the lower Columbia River.

The Action Agencies will continue to fund predator-control activities and estuary habitat improvements. The implementation of the CRS mitigation and enhancement programs will continue to reduce long-term impacts and continue to allow for improvement in the status for the four populations that migrate through the lower Columbia River. The estuary program is anticipated to improve habitat conditions and contribute to improved survival and productivity for all populations as restored habitat area accrues over time and habitat quality matures. The efficacy of the avian predation program is currently in flux; the Action Agencies, NMFS and other stakeholders have a plan to develop a better approach to avian predation management basinwide. Because the Action Agencies propose to continue maintaining the reduced amounts of nesting habitat achieved for terns and cormorants on East Sand Island (BPA et al. 2018a), we expect that any reduced predation rates achieved for UWR steelhead under the 2008 FCRPS biological opinion and associated RPA will continue during the interim period.

As a general matter, the effects of the proposed action are very similar to a short-term continuation of the same effects caused by the current operations and maintenance of the CRS (including the RM&E program), as well as the associated measures implemented to avoid, minimize, or offset adverse effects. Therefore, we do not anticipate large changes in mortality caused by the CRS or substantial new risks to UWR steelhead or their habitat, and we do not expect considerable changes in the effects on reproduction, numbers, or distribution. However, we do anticipate additional improvements in habitat conditions in the estuary that will accrue over time.

The environmental baseline includes the past and present impacts of hydropower operations, changes in tributary and mainstem habitat (both beneficial and adverse), harvest, and hatcheries on UWR steelhead. The baseline provides important context for assessing the effects of the action described above.

The presence of hatchery-reared and feral hatchery-origin fish in the upper Willamette River basin may affect the growth and survival of juvenile late-winter steelhead. In the North and South Santiam Rivers, juveniles are largely confined, by dams, below much of their historical spawning and rearing habitat. Releases of large numbers of hatchery-origin summer steelhead may temporarily exceed rearing capacities and displace winter juvenile steelhead.

There is no directed fishery for winter steelhead in the upper Willamette River, and they are the only life history displayed by natural steelhead in this area. Due to differences in return timing between native winter steelhead, introduced hatchery-origin summer steelhead, and hatchery-origin spring Chinook salmon, the encounter rates for winter steelhead in the recreational fishery are thought to be low (estimated to be at 0 to 3 percent; Ford 2011).

Tributary habitat for this DPS is outside the area affected by the proposed action.

The status of UWR steelhead is also likely to be affected by climate change. Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycle. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater and changes to food webs in freshwater, estuarine and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management actions may help alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations, increased riparian vegetation to control water temperatures, etc.).

Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life-history types that will be successful in the future are neither static nor predictable. Therefore, maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the UWR steelhead DPS. Because of its location in the lower Columbia River basin, the DPS is likely to be more affected by climate related effects in the estuary and in tributary streams (altered seasonal flows and temperatures). Emerging research using complex life-cycle modeling indicates a potentially strong link between SST and survival of Snake River spring/summer

Chinook populations. However, the apparent link between SST and survival is presumably caused by food web interactions, relationships which could be disrupted by major transformations of community dynamics as well as ocean acidification and other factors under a changing climate. The degree to which SST is linked to survival of UWR steelhead, and how that relationship interacts with other variables throughout the UWR steelhead life cycle, will likely be an important area of future research.

When evaluating the effects of the action, those effects must be taken together with the effects on UWR steelhead of future state or private activities, not involving federal activities that are reasonably certain to occur within the action area. NMFS anticipates that human development activities will continue to have adverse effects on UWR steelhead in the action area. Many of these activities and their effects occurred in the recent past and were included in the environmental baseline but are also reasonably certain to occur in the future. Within the action area, nonfederal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Habitat restoration efforts led by state and local agencies, tribes, environmental organizations, and local communities are likely to continue. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives that, in some cases, are identified through ESA recovery plans. Larger, more regionwide, restoration and conservation efforts are either underway or planned throughout the Columbia River basin. These state and private actions have helped restore habitat, improve fish passage, and reduce pollution. While these efforts are reasonably certain to continue to occur, funding levels may vary on an annual basis.

The recovery plan (ODFW and NMFS 2011) identifies key and secondary limiting factors and threats to UWR steelhead. Key limiting factors are associated with Willamette River basin hydropower and flood management dams, including irrigation withdrawals, as well as the effects of land management practices within Willamette subbasins, and some genetic introgression with an out-of-basin hatchery stock. The recovery plan, finalized in 2011, identifies recovery actions to be implemented, generally over a 25-year period, as specified in the management unit plans and estuary recovery plan module. Effective implementation requires that the recovery efforts of diverse private, local, state, tribal, and federal parties across two states be coordinated at multiple levels. The proposed action will not result in reductions to UWR steelhead reproduction, numbers, or distribution that would impede the ability to successfully carry out the identified recovery measures and actions over the time frames considered in the recovery plan.

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, cumulative effects, and considering the interim nature of the proposed action, it is NMFS' biological opinion that the proposed action is not likely to reduce appreciably the likelihood of both survival and recovery of UWR steelhead.

2.3.5.2 Critical Habitat

Critical habitat for UWR steelhead encompasses seven subbasins in Oregon containing 38 occupied watersheds, as well as the lower Willamette/Columbia River rearing/migration corridor. Most watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2008a, 2013a). However, most of these watersheds have some, or high potential for improvement. Similar to the discussion above for species, the status of critical habitat is likely to be affected by climate change with predicted rising temperatures and alterations in stream flow patterns. Past and future modifications to the major water storage and hydroelectric projects in the Willamette River basin, improved access to historical spawning habitat, and habitat restoration efforts will help ameliorate those effects to critical habitat.

The environmental baseline includes a broad range of past and present actions and activities that have affected the conservation value of critical habitat for UWR steelhead. These include the effects of hydropower and water storage in the Willamette River basin, changes in tributary and mainstem habitat (both positive and negative) on freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine areas, and nearshore marine areas. These also include effects from hatcheries. Changes to land use and development activities remain a concern; these activities affect the quality and accessibility of habitats and habitat-forming processes such as riparian condition and floodplain function as well as water quality (NMFS 2016a). Reduced or lost habitat complexity, connectivity, quantity, and quality in the Columbia River mainstem and the estuary remain areas of concern. Toxic contamination and urban and industrial development in the Lower Willamette and Columbia Rivers are also a concern, particularly for fry migrants that spend many months rearing in the estuary.

Despite a long-term trend in degradation of these habitats, there have been localized improvements in their conservation value through the combined efforts of federal, state, and local agencies; tribes; and other stakeholders. A number of restoration actions have been implemented in freshwater and estuary habitat in the action area; a number of these funded through the CRS program. The estuary program will continue to fund habitat improvement actions in the estuary that will likely contribute to improved rearing and migratory habitat. Despite significant losses to predators in the migration corridor, the combined efforts of multiple parties has reduced the effect of predation, and the action agencies propose to continue predator management activities.

The adverse downstream effects associated with CRS flood control management operations (altered flow regime, lost and degraded habitat conditions in the mainstem Columbia River) will continue with the proposed action. Conversely, the proposed action will continue to improve the functioning of many of the PBFs; for example, reducing predation by pinnipeds and northern pikeminnows will continue to improve safe passage for juveniles and reduce the risk to this PBF. The estuary habitat restoration program will reconnect floodplains and provide additional feeding and rearing areas at the project scale; these benefits will accrue at the designation scale over time and will contribute to the conservation value of habitat in the lower Columbia estuary.

Considering the ongoing and future effects of the environmental baseline and cumulative effects, and in light of the status of critical habitat, the proposed action will not appreciably reduce the value of designated critical habitat for the conservation of UWR steelhead.

2.3.6 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of UWR steelhead or destroy or adversely modify its designated critical habitat.

2.4 Eulachon

This section applies the analytical framework described in section 2.1 to the Southern DPS of eulachon and provides NMFS' finding regarding whether the proposed action is likely to jeopardize the continued existence of the Southern DPS of eulachon or destroy or adversely modify its critical habitat.

2.4.1 Rangewide Status of the Species and Critical Habitat

The status of the Southern Distinct Population Segment of eulachon *(Thaleichthiys pacificus),* hereafter simply referred to as eulachon, is determined by the level of extinction risk that the listed species faces, based on parameters considered in the species' recovery plan, status reviews, listing decisions, and other documents. This informs the description of the species' likelihood of both survival and recovery. The condition of critical habitat throughout the designated area is determined by the current function of the essential PBFs that help to support that conservation value.

2.4.1.1 Status of Species

Eulachon in the listed southern DPS are primarily a marine pelagic species that spawn in the lower reaches of coastal rivers and whose primary prey is plankton (Gustafson et al. 2010). They are typically found in near-benthic habitats in open marine waters of the continental shelf between 66 and 400 feet in depth (Hay and McCarter 2000).

The southern DPS of eulachon comprises fish that spawn in rivers south of the Nass River in British Columbia to, and including, the Mad River in California. Four subpopulations[29]—the Klamath River, the Columbia River, the Fraser River, and the British Columbia coastal rivers—are considered in NMFS' recovery plan as a minimum set of "populations" that are needed to meet biologically based (abundance, productivity, spatial distribution, and genetic and life-history diversity) and threats-based delisting criteria (NMFS 2017b).

Presently, most eulachon production south of the U.S.–Canada border originates in the Columbia Basin, including the Columbia, Cowlitz, Grays, Kalama, Lewis, and Sandy Rivers (Gustafson et al. 2010). Historically, eulachon were occasionally reported to spawn in tributaries as far upstream as the Hood River (Oregon) and the Klickitat River (Washington) (NMFS 2017b). Since Bonneville Dam was completed in 1937, there have been occasional observations of

[29] There are many "populations" of eulachon within the range of the species. For their threats analysis, the Biological Review Team (BRT) did not include all known or possible eulachon spawning areas. As such, the BRT partitioned the southern DPS of eulachon into geographic areas, i.e., subareas/subpopulations, for their threats assessment. Thus, the subpopulation structure used by the BRT leaves out some "populations" within the DPS (e.g., Elwha River, Naselle River, Umpqua River, and Smith River) that we now know may have (or have had) some important contribution to the overall productivity, spatial distribution, and genetic and life-history diversity of the species (NMFS 2017b). At present, it is not known whether eulachon are one large metapopulation or comprise multiple demographically independent populations.

eulachon at, or even above (passing through the ship locks), the dam in years when eulachon were highly abundant (NMFS 2017b).

Starting in 1994, the southern DPS of eulachon experienced an abrupt decline in abundance throughout its range. Eulachon abundance in monitored rivers improved in the 2013–15 return years, but recent poor conditions in the northeastern Pacific Ocean appear to have driven sharp declines in the river systems in 2016 and 2017. However, ocean surveys conducted by NMFS in May 2018 found substantially higher catches of juvenile Chinook and coho salmon than observed during the poor ocean condition years (2013–17), indicating that overall ocean conditions may be improving. While there is no similar specific correlation between ocean condition metrics tracked by NMFS and eulachon abundance to date, it is likely that ocean conditions that are favorable for other native species would also benefit eulachon.

NMFS listed the southern DPS of eulachon as threatened under the ESA in 2010, reaffirming this conclusion in its 2016 five-year status review (NMFS 2016b). NMFS designated critical habitat for eulachon under the ESA in 2011 (76 FR 65324), and completed the recovery plan in 2017 (NMFS 2017b). Table 2.4-1 provides a summary of listing and recovery plan information, status summary, and threats for eulachon. More information can be found in the recovery plan and status review for this species (NMFS 2016b, 2017b). These documents are available on the NMFS West Coast Region website.[30]

No reliable fishery-independent, historical abundance estimates exist for eulachon. From 2000 to 2017, spawning stock biomass estimates in the Columbia River ranged from a low of about 780 thousand fish in 2005 to a high of nearly 186 million fish in 2014. Spawning stock biomass estimates in the Fraser River (1995–2017) ranged from a low of from about 110 to 150 thousand fish in 2010 to a high of about 42 to 56 million fish in 1996. Fishery-independent estimates are not available for the Klamath River or British Columbia coastal rivers (NMFS 2017b).

The Biological Review Team (BRT) rated climate change impacts on ocean conditions as the highest threat to the persistence of eulachon subpopulations, followed by bycatch in coastal shrimp fisheries, which is likely reduced in recent years due to the adoption of lights and excluder devices developed specifically to reduce eulachon bycatch. Dams and water diversions, climate change impacts on freshwater habitat, predation, water quality, shoreline construction, and dredging were all rated as moderate impacts for at least one subpopulation (NMFS 2017b).

[30] http://www.westcoast.fisheries.noaa.gov/protected_species/eulachon/pacific_eulachon.html. Last accessed August 2018.

Table 2.4-1. Listing classification and date, recovery plan reference, most recent status review, status summary, and threats for eulachon.

Status Summary	Threats (BRT Ratings)
The southern DPS of eulachon comprises fish that spawn in rivers south of the Nass River in British Columbia to, and including, the Mad River in California. Four "subpopulations" are considered in NMFS' recovery plan as a minimum set of "populations" that are needed to meet biologically based and threats-based delisting criteria: the Klamath River, the Columbia River, the Fraser River, and the British Columbia coastal rivers. Starting in 1994, there was an abrupt decline in the abundance of eulachon returning to all subpopulations, including the Columbia River. Despite a brief period of improved returns in 2001–03, the returns and associated commercial landings were at low levels from the mid-1990s through the 2000s. Eulachon abundance in monitored rivers has improved substantially in the 2010s, and was relatively high in the 2013–15 return years, before declining in 2016 and 2017, most likely due to recent poor ocean conditions. Low returns are expected in the near term. Initial indications from monitoring in 2018 are that ocean conditions appear to be improving for salmonids, which may also indicate generally improving conditions for eulachon.	• High: climate change impacts on ocean conditions • High–Moderate: ocean fisheries bycatch • Moderate: climate change impacts on freshwater habitat • Moderate: predation • Moderate–Low: water quality • Moderate–Very Low: dams and water diversions • Moderate–Very Low: shoreline construction • Moderate–Very Low: dredging

2.4.1.2 Status of Critical Habitat

This section describes the status of designated critical habitat affected by the proposed action by examining the condition and trends of the essential PBFs of that habitat throughout the designated areas. These features are essential to the conservation of the ESA-listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration, and foraging). Table 2.4-2 summarizes designated critical habitat based on the detailed information on the status of critical habitat throughout the designation area provided in the recovery plan for the species (NMFS 2017).

Physical or biological features essential to the conservation of the southern DPS fall into three major categories reflecting key life-history phases of eulachon:

- Freshwater spawning and incubation sites with water flow, quality, and temperature conditions and substrate supporting spawning and incubation, and with migratory access for adults and juveniles. These features are essential to conservation because without them, the species cannot successfully spawn and produce offspring.

- Freshwater and estuarine migration corridors associated with spawning and incubation sites that are free of obstruction and with water flow, quality, and temperature conditions supporting larval and adult mobility, and with abundant prey items supporting larval feeding after the yolk sac is depleted. These features are essential to conservation because they allow adult fish to swim upstream to reach spawning areas, and they allow larval fish to proceed downstream and reach the ocean.
- Nearshore and offshore marine foraging habitat with water quality and available prey, supporting juveniles and adult survival. Eulachon prey on a wide variety of species, including crustaceans such as copepods and euphausiids (Hay and McCarter 2000; WDFW and ODFW 2001), unidentified malacostracans (Sturdevant 1999), cumaceans (Smith and Saalfeld 1955), mysids, barnacle larvae, and worm larvae (WDFW and ODFW 2001). These features are essential to conservation because they allow juvenile fish to survive, grow, and reach maturity, and they allow adult fish to survive and return to freshwater systems to spawn.

Table 2.4-2. Critical habitat, designation date, Federal Register citation, and status summary for eulachon critical habitat.

Designation Date and Federal Register Citation	Critical Habitat Status Summary
10/20/2011 **76 FR 65324**	Critical habitat encompasses 16 rivers (up to the ordinary high water line/bankfull elevation in streams and tidally influenced areas in estuaries) in California, Oregon, and Washington: Mad River, CA; Redwood Creek, CA; Klamath River, CA, Umpqua River, OR; Tenmile Creek, OR; Sandy River, OR; Columbia River, OR and WA (up to Bonneville Dam); Grays River, WA; Skamolawa Creek, WA; Elochoman River, WA; Cowlitz River, WA; Toutle River, WA; Kalama River, WA; Lewis River, WA (up to Merwin Dam); Quinault River, WA; and Elwha River, WA; excepting Indian lands of the following federally recognized tribes in the same states (Resighini Rancheria, CA; Yurok Tribe, CA; Quinault Tribe, WA; and Lower Elwha Tribe, WA). Compared to historical conditions, most watersheds with PBFs for eulachon are currently degraded, at least to some extent, by human activities, climate change impacts to the ocean and freshwater habitat, urbanization and rural residential development, transportation corridors, industry, predation (by nonindigenous species), water quality, dams and water diversions, shoreline construction (e.g., pile dikes, jetties, bank armoring, and levies), and dredging (NMFS 2017b).

2.4.1.3 Climate Change Implications for Eulachon and Critical Habitat

One factor affecting eulachon and its critical habitat is climate change. In 2010, the BRT concluded that climate change is one of the major threats to this DPS (NMFS 2016b). The BRT ranked climate change impacts on ocean conditions as the most serious threat to persistence of eulachon, and scored climate change impacts on freshwater habitat and eulachon bycatch as moderate to high risk in all subareas of the DPS. The 2010 BRT noted concern that climate change may have contributed to a mismatch between timing of ocean entry of eulachon larvae and availability of crucial prey species. However, the ability of the Columbia River eulachon stock to respond rapidly to the good ocean conditions of the late 1999 to early 2002 period illustrated the species' resiliency, and the 2010 BRT viewed this resiliency as providing the species with a buffer against future environmental perturbations.

The climate we experience is a combination of natural variability and long-term change. Climate change is not detectable day-to-day or year-to-year. It is detectable in the long-term trends in daily and annual temperatures (Link et al. 2015). These long-term changes in the Earth's climate system pose challenges for the management of anadromous fish. Information on the impacts of both climate variability and change on eulachon is very important to developing effective management approaches across multiple time scales. Although the proposed action is only expected to be implemented in the interim time period between 2019 and completion of the NEPA process, the effects of the implementation of the proposed action will extend many years (e.g., maturation of estuary habitat projects). Thus, both natural climate variation and climate change are relevant to our analysis.

Climate change impacts on ocean conditions (i.e., as measured by large-scale spatial and temporal shifts in oceanic-atmospheric patterns in the northeastern Pacific Ocean associated with both natural climate variability and anthropogenic-forced climate change) are likely the principal threat to eulachon, as ocean condition is the one phenomenon that correlates with the recent species-wide declines in abundance. While the specific characteristics that provide favorable marine conditions for eulachon in the northeastern Pacific Ocean are unknown, available information suggests that there is a link between the PDO (Gustafson et al. 2010) and other marine indices, such as the ENSO, the Oceanic Niño Index (ONI), and the Northern Oscillation Index (NOI), and eulachon survival, abundance, and recruitment potential. One hypothesis is that cool-phase PDO cycles are associated with greater primary and secondary productivity in the northern California Current (Figure 2.4-1) that provides abundant food resources for multiple age classes, especially larval eulachon entering the marine environment.

Likely changes in temperature, precipitation, wind patterns, and sea-level height have profound implications for survival of eulachon in both their freshwater and marine habitats. Recent descriptions of expected changes in Pacific Northwest climate that are relevant to eulachon include Elsner et al. (2009), Mantua et al. (2009), Mote and Salathe (2009), Salathe et al. (2009), and Gustafson et al. (2010). Reviews of the effects of climate change in the Columbia River basin include ISAB (2007), Hixon et al. (2010), Dalton et al. (2013), and NMFS (2014).

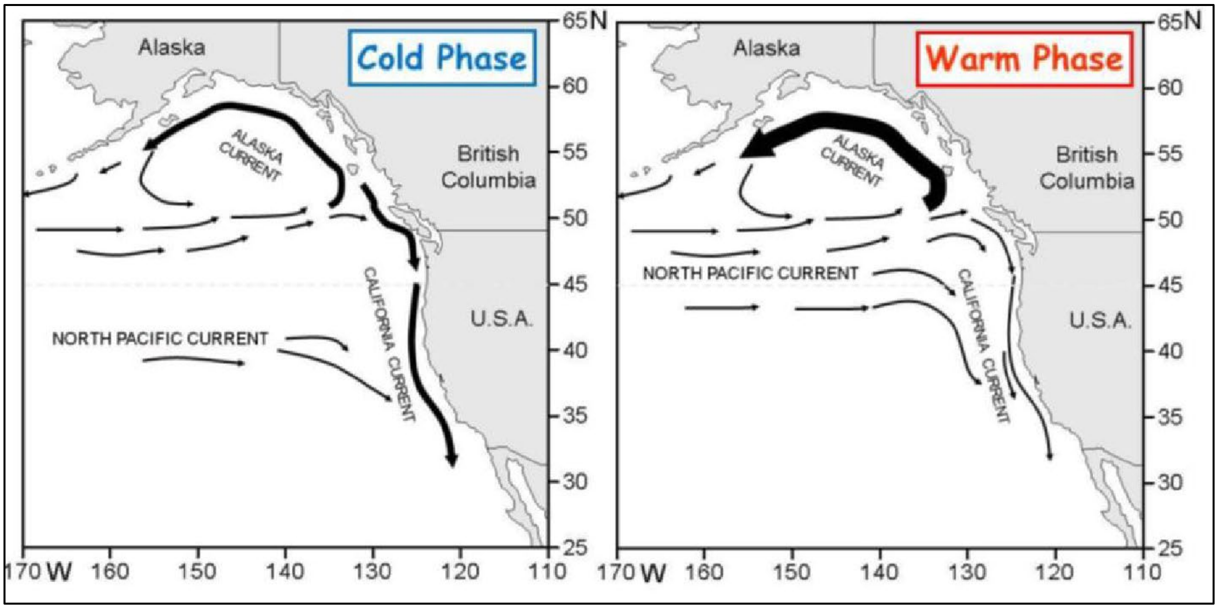

Figure 2.4-1. A working hypothesis on how changes in the Pacific Decadal Oscillation affect productivity in the northern California Current. Source: Peterson et al. 2013.

The following is a summary of expected climate change-related effects on eulachon and their habitats derived from the above sources.

2.4.1.3.1 Freshwater Environments

Climate records show that the Pacific Northwest has warmed about 0.13°F since 1900, or about 50 percent more than the global average warming over the same period (Dalton et al. 2013). The warming rate for the Pacific Northwest over the next century is projected to be in the range of 0.2°F to 1.1°F per decade. While total precipitation changes are predicted to be minor (+1 to 2 percent), increasing air temperature will alter the snow pack, streamflow timing and volume, and water temperature in the Columbia Basin. Climate scientists predict the following physical changes to rivers and streams in the Columbia River basin:

- Warmer temperatures will result in more precipitation falling as rain rather than snow, and snow pack will diminish, water temperatures will increase, and stream flow volume and timing will be altered.

2.4.1.3.2 Estuarine and Plume Environments

Climate change will also affect eulachon in the estuarine and plume environments. In the estuary, eulachon would be primarily affected by increased water temperatures, flow-related changes, altered phytoplankton and zooplankton prey, and increased predation. Eulachon may be affected by habitat changes in the plume environment due to flow- or sediment-related changes; however, use of plume habitat by eulachon remains poorly understood. Effects of climate change on eulachon in the estuary and plume may include:

- Higher winter freshwater flows and higher sea levels may increase sediment deposition in the plume, possibly reducing the quality of rearing habitat;
- Lower freshwater flows in late spring and summer may lead to upstream extension of the salt wedge, possibly influencing the distribution of eulachon prey and predators; and
- Increased temperature of freshwater inflows and seasonal expansion of freshwater habitats may extend the range of nonnative, warm-water species that are normally found only in freshwater.

In all of these cases, the specific effects on eulachon abundance, productivity, spatial distribution, and diversity are poorly understood.

2.4.1.3.3 Marine Environments

Effects of climate change in marine environments include increases in ocean temperature, stratification of the water column, and ocean acidification, and changes in intensity and timing of coastal upwelling. Hypotheses differ regarding whether coastal upwelling will decrease or intensify, but even if it intensifies, the increased stratification of the water column may reduce the ability of upwelling to bring nutrient-rich water to the surface. Climate models also indicate that future conditions in the North Pacific region will trend toward conditions that are typical of the warm phases of the PDO, but the models in general do not reliably reproduce the oscillation patterns. Hypoxic conditions observed along the continental shelf in recent years appear to be related to shifts in upwelling and wind patterns that may be related to climate change.

Climate-related changes in the marine environment are expected to alter primary and secondary productivity, the structure of marine communities, and, in turn, the growth, productivity, and survival of eulachon, although the degree of impact on eulachon is currently poorly understood. Earlier peak spring freshwater flows can decrease the incubation period and lead to reduced larval survival, which when coupled with altered upwelling may result in reduced marine survival rates.

Ocean warming may also change migration patterns, thus increasing distances to feeding areas and reducing eulachon survival. Rising atmospheric carbon dioxide concentrations drive changes in seawater chemistry, increasing the acidification of seawater and thus reducing the availability of carbonate for shell-forming invertebrates. This process of acidification is under way. It has been well documented along the Pacific coast of the United States, and is predicted to accelerate with increasing greenhouse gas emissions. Ocean acidification has the potential to reduce survival of many marine organisms, including eulachon. However, because there is currently a paucity of research directly related to the effects of ocean acidification on fish and their prey, potential effects are uncertain. Laboratory studies on prey taxa have generally indicated negative effects of increased acidification, but how this translates to the population dynamics of eulachon prey and the survival of eulachon is uncertain.

The risk to eulachon from climate change effects in marine environments is high, but there is also a high level of uncertainty regarding the severity of potential impacts. The relative impact to recovery is ranked high.

2.4.2 Environmental Baseline

The environmental baseline includes the past and present impacts of all federal, state, or private actions and other human activities in an action area, the anticipated impacts of all proposed federal projects in an action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process.

For eulachon, we focus our description of the environmental baseline on that portion of the action area where eulachon are exposed to the effects of the proposed action.

The Columbia River and its tributaries support the largest eulachon run in the world (Hay et al. 2002). Eulachon use the mainstem Columbia River within the action area to migrate to spawning grounds as adults and to emigrate from freshwater into marine waters as larvae. Large spawning aggregations of eulachon have been observed in the mainstem Columbia River and in the Cowlitz, Lewis, Sandy (Graig and Hacker 1940), Grays (Smith and Saalfeld 1955), Kalama (DeLacy and Batts 1963), and Elochoman Rivers, and in Skamokawa Creek (WDFW and ODFW 2001). Smith and Sallfeld (1955) stated that eulachon were reported to spawn up to the Hood River on the Oregon side of the Columbia River before the construction of Bonneville Dam (1938), but were not known to ascend beyond Cascade Rapids until 1896 when the locks and canal were built for steamboat passage. The upstream extent of eulachon distribution is Bonneville Pool, and they travel downstream to the plume.

Eulachon use the mainstem Columbia River within the action area for:

- Migrating to spawning grounds as adults. Migrations are associated with higher tides and water temperatures ranging from 40 to 50°F and can occur as early as November or as late as June, with peak spawning typically occurring sometime between January through March.
- Spawning, incubation, and rearing. The great majority of adults are semelparous and spawn only once; eggs are fertilized and drift downstream, adhering to sand and small gravels, hatching in 3–8 weeks depending on water temperatures. Larvae are transported to estuaries, where they forage on small prey items.
- Migrating downstream to the ocean as juveniles. After rearing for an unknown amount of time, eulachon move to the ocean where they generally remain for 2–5 years before returning to spawn (NMFS 2014, 2017b).

2.4.2.1 Mainstem Habitat

The series of dams and reservoirs in the Columbia River basin have blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is only one-third of nineteenth-century levels (Simenstad et al. 1982 and 1990; Sherwood et al. 1990; Weitkamp 1994; NRC 1996; NMFS 2008a). Similarly, Bottom et al. (2005) estimated that the delivery of suspended sediment to the lower river and estuary has been reduced by about 60 percent (as measured at Vancouver, Washington). This reduction has altered the development of habitat along the margins of the river.

Alterations to the natural sediment transport regime have also reduced turbidity levels during the spring freshet (May and June). To the extent juvenile or adult eulachon are present in those months, decreased turbidity could negatively affect survival in the estuary and plume because of improved success of visual predators.

Water management and hydroelectric developments have altered natural flow regimes (generally increasing winter flows from November through March and reducing peak spring flows in May and June) and water temperatures (generally increasing minimum winter temperatures and decreasing spring temperatures; NMFS 2008a). While the effects of water management operations throughout the basin are substantial, it is unknown if these alterations in flow or temperature have positive, neutral, or negative effects on eulachon spawning, incubation, and rearing (NMFS 2014). However, it seems most likely that, to the extent there are adverse effects, they would affect larval eulachon migrating through the estuary and into the ocean in May or June, when flows (and turbidity) are substantially diminished compared to historical conditions.

Implementation of the RPAs in the 2008 FCRPS biological opinion, as amended in 2010 and supplemented in 2014 (minimized flood control drafts, “dry-year” operations, etc.), have incrementally made the seasonal flow regime during the winter and spring more like those occurring before the construction of large storage facilities in the 1960s and 1970s. Assuming eulachon were adapted to historic flow conditions, these changes would be expected to have a small but positive effect on migration conditions for eulachon larvae and adults in the mainstem Columbia River, estuary, and plume compared to past decades.

Eulachon only encounter one mainstem dam in the CRS: Bonneville Dam. When adult eulachon do reach the tailrace of Bonneville Dam (potentially associated with years of high abundance), few are able to pass upstream via either the adult fishways designed for salmon and steelhead or through the locks. Some of those that do pass likely “fall back” downstream through turbines or juvenile bypass systems, where they can be injured or killed. If spawning occurs upstream of Bonneville Dam, eulachon larvae would likely be affected by habitat inundation, reduced water velocities, altered fish community structure, and physical features of dams such as turbines or screens that could injure or kill drifting larvae.

In 1953, eulachon were observed spawning in Tanner Creek on the Oregon side of the Columbia River near the base of Bonneville Dam. As described in the 2014 FCRPS supplemental biological opinion and by the Pacific States Marine Fisheries Commission (2014), the Corps has reported the following observations of adult eulachon in the smolt monitoring facility on the upstream side of Bonneville Dam:

- 1988 – 8,200 adults,
- 2003 – two adults,
- 2005 – five adults, and
- 2014 – 455 adults.

No eulachon have been reported at Bonneville Dam since the 2014 observations. However, applying the hourly sampling rates to the 8,200 adults observed in 1988, suggests a maximum fallback rate of about 95,500 adults through the bypass system in any given year.

Eulachon in Bonneville Reservoir and for at least 35 miles downstream of Bonneville Dam (Camas-Washougal gage) are also exposed to elevated levels of TDG, caused primarily by juvenile fish passage spill (beginning in April) or spill resulting from lack-of-load situations (year-round, but most common during spring). Exposure to elevated TDG is not a big concern for adults because very few adults are around during the high spill period, as spawning is mostly completed by March. Given that the fertilized eggs adhere to the coarse substrates at the bottom of the river and that larval densities have been observed in higher abundance in mid- and bottom water samples in the Columbia River (Howell et al. 2001), the deleterious effects of concentrated TDG are likely reduced due to depth compensation. Once spawning has occurred, the larvae are flushed rapidly to the ocean, further minimizing exposure time to increased TDG. Finally, even though eulachon have been observed migrating up the Columbia River as far as Bonneville Dam, eggs have been collected and spawning presumed from RM 35 up to RM 73 in the mainstem Columbia River (NMFS 2010a) and individuals are thought to migrate this far upstream only when the run size is extremely large. Therefore, in most years, the percentage of the run potentially exposed to elevated TDG levels is expected to be very small.

Industrial harbor and port development are also significant influences on the lower Willamette and lower Columbia Rivers (Bottom et al. 2005; Fresh et al. 2005; NMFS 2013a). Since 1878, the Corps has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and Oregon's Willamette River as a navigation channel. The federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The lower Columbia River supports five ports on the Washington State side: Kalama, Longview, Skamania County, Woodland, and Vancouver. In addition to loss of riparian habitat and disruption of benthic habitat due to dredging, high levels of several sediment chemicals that are harmful to fish at certain concentrations, such as arsenic and PAHs, have been identified in lower Columbia River watersheds in the vicinity of the ports and associated industrial facilities. Small releases of materials such as lubricants occur during dam operation and maintenance and contribute to background exposure to contaminants in the Columbia River. These factors could negatively affect embryonic development, growth rates, and egg, larval, and adult survival rates and are rated a moderate risk in the most recent five-year review (NMFS 2016b).

The most extensive urban development in the lower Columbia River subbasin has occurred in the Portland/Vancouver area. Outside of this urban area, the majority of residences and businesses rely on septic systems. Common water-quality issues with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff. Under these environmental conditions, fish in the action area are stressed. Stress is likely to lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival). Given that eulachon are present only in the winter and spring months, some of these factors (e.g., warmer temperatures and lower dissolved oxygen) are not likely to meaningfully affect them. The effect of contaminants (e.g., increased bacteria, pesticides, and urban runoff) on eulachon is unknown, but likely to have at least some small negative effect to those individuals (adults, eggs, or larvae) exposed to these substances.

Since the late 1800s, 68–70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, shoreline development, flow regulation, and other modifications (Kukulka and Jay 2003; Bottom et al. 2005; Marcoe and Pilson 2017). Disconnection of tidal wetlands and floodplains has reduced the production of wetland macrodetritus and flux to the mainstem during peak spring flows. Recent efforts to reconnect portions of the historical floodplain (Johnson et al. 2018) are expected to improve material fluxes between terrestrial and wetland areas and the mainstem and thus to better support phytoplankton production in the lower river. Phytoplankton is the primary food resource for eulachon larvae in the estuary and plume. Larval eulachon are small and have little to no ability to direct their movement in a large river. They appear to drift passively and rapidly, feeding as they drift downstream (McCarter and Hay 2003). Thus, while shorelines have been substantially impacted, it is not clear that these shallow-water areas are important for larval eulachon.

Changes in the seasonal hydrograph as a result of water use and reservoir storage have also altered habitat-forming processes, including the size of the plume compared to historical conditions. As noted previously, compared to previous decades, the effects on winter and spring flows (when eulachon are present) have likely been somewhat lessened under the operations stemming from the 2008 FCRPS biological opinion. However, no hypotheses have been advanced that would link these changes to the viability of Southern DPS eulachon.

2.4.2.2 Fish Passage

Adult eulachon occasionally reach Bonneville Dam, which blocks or impedes and delays their migration. Some still pass upstream, and those that “fall back” are likely negatively affected by dam structures. If they spawn successfully, the resulting eulachon larvae would likely be negatively affected by the reservoir and dam structures (e.g., turbines, screens, etc.). Recent structures and operations to improve passage conditions for juvenile salmonids (e.g., Powerhouse

2 corner collector and spring spill program) would likely reduce these effects when these systems are operating. Eulachon (primarily eggs and larvae) are exposed to elevated (higher than 110 percent) levels of TDG in Bonneville pool and for approximately 35 miles downstream of Bonneville Dam starting in April. The effect on egg and larvae survival is discussed above.

While estimates of adult abundance have varied dramatically in the past 20 years, high abundance years (like those observed from 2011 to 2015 from a mix of flow types) indicate that eulachon are able to successfully spawn, incubate, rear, and migrate through the lower Columbia River, estuary, and plume.

2.4.2.3 Predation

Researchers studying Caspian terns at East Sand Island saw terns carrying fresh adult eulachon back to the colony in late April, 2014 (Roby 2018). Fork lengths of fish that terns dropped measured 198 and 218 mm, respectively. As measured by catches in the recreational fishery, the 2014 eulachon run was relatively large in the Columbia River and somewhat late so that this species was available during the nesting season. Eulachon were not identified as tern prey in other years indicating that avian predation on adults is not a risk factor at the DPS level.

Sea lions and harbor seals are known predators of adult eulachon. The abundance of harbor seals in the Columbia River has been relatively consistent since the late 1980s (NMFS 2014). Since the mid-2000s, California and Steller sea lions are much more abundant in the lower Columbia River than for prior decades (NMFS 2014, 2016b). As a result, increased predation on adult eulachon is likely and is expected to continue for the foreseeable future. The magnitude of the proportional impact is likely relatively small, and would vary inversely with the abundance of adult eulachon.

The NPMP includes the Sport Reward Fishery and Dam Angling Program. Continuation of the program will result in the ongoing removal of predaceous northern pikeminnow within Bonneville Reservoir and the lower Columbia River estuary. While the potential benefit of this program for eulachon has never been assessed, northern pikeminnow are generalist predators that are likely to consume eulachon adults, eggs, and larvae when they are available. No incidental catch of eulachon was reported for the Sport Reward Fishery or Dam Angling Program during 2013-17 (Williams 2013, 2014; Williams et al. 2015, 2016, 2017).

2.4.2.4 Hatcheries

Eulachon may be impacted by hatchery fish through competition for space, and possibly predation on eulachon by salmon and steelhead juveniles. Predation by hatchery salmon and steelhead juveniles on newly hatched juvenile eulachon is assumed to occur if hatchery salmonid juveniles overlap with juvenile eulachon emigrating from tributary basins. The actual level of predation and the effects of that predation on eulachon are unknown, and were not considered substantive compared to other factors identified as limiting the recovery of eulachon in the Columbia River (Gustafson et al. 2010).

In *U.S. v. Oregon* NMFS (2018a) stated that releases of hatchery salmon and steelhead under the proposed action are not expected to overlap with emerging eulachon juveniles in the lower Columbia River because the emergence and outmigration of juvenile eulachon generally occurs in January through March, before hatchery juveniles reach the lower mainstem Columbia River in April and May. Predation by juvenile salmonids, if it occurs at all, would be limited by the small size and transparency of the emergent eulachon fry, the distribution of eulachon fry in the water column, and the rapid emigration of eulachon juveniles from the lower Columbia River (Gustafson et al. 2010). For these same reasons, competition would not be expected.

2.4.2.5 Harvest

Since 1988, the states of Washington and Oregon have maintained a commercial and recreational fishery for eulachon. In the commercial fishery, eulachon were caught using small-mesh gillnets (i.e., <2 inches) and small mesh dipnets (although small trawl gear is legal, it is rarely used). However, in 2010, following the listing of eulachon under the ESA, the states of Washington and Oregon permanently closed the commercial and recreational eulachon fishery.

In 2014, the states of Washington and Oregon adopted a limited-opportunity recreational and commercial fishery on eulachon in the Columbia River as well as the Cowlitz and Sandy Rivers; this fishery required using the small mesh fishing gear (TAC 2017). Salmon fisheries in the Columbia River use nets with large mesh sizes (i.e., >4.25 inches at all times), and hook-and-line gear designed to catch the much larger salmon species. Encounters of eulachon in salmon fisheries would be extremely unlikely given the general differences in temporal distribution and gear characteristics (TAC 2017). NMFS is not aware of any record of eulachon caught in either commercial or recreational salmon fisheries operated in the Columbia River. NMFS' recovery plan for this DPS of eulachon lists the level of threat for fisheries in the Columbia River as "low" (NMFS 2017b). Given all of the above, it is extremely unlikely that eulachon will be caught or otherwise affected by the fisheries.

2.4.2.6 Research and Monitoring Activities

The primary effects of the past and ongoing CRS-related RM&E programs on eulachon are associated with the capturing and handling of adult fish. The RM&E program is a collaborative, regionally coordinated approach to fish and habitat status monitoring, action effectiveness research, critical uncertainty research, and data management. The information derived from the program facilitates effective adaptive management through better understanding the effects of the ongoing CRS action. Capturing, handling, and releasing fish generally leads to stress and other sublethal effects, but fish sometimes die from such treatment. Some RM&E actions also involve sacrificial sampling of fish. We estimated the number of adult eulachon that have been handled each year during the implementation of RM&E under the 2008 RPA as the average annual take reported for 2013-2017:

- 455 adult eulachon were handled by the Smolt Monitoring Program; none were killed.

- One adult and 22 juvenile eulachon were reported handled and none were killed during other RM&E activities (e.g., towing a midwater trawl with a PIT-tag detector in place of a cod end, or beach seining for salmon).

The combined take (i.e., handling, including injury) associated with these elements of the RM&E program has, on average, affected much less than 1 percent of the adults in the Southern DPS of eulachon (average run estimate of over 93 million during 2013-17; Bellerud 2018). This relatively small effect is deemed worthwhile because it allows the Action Agencies and NMFS to evaluate the effects of CRS operations, including modifications to facilities, operations, and mitigation actions.

Eulachon are not encountered during April-July electrofishing operations conducted under the NPMP because they are not in the lower Columbia River during that time period.

2.4.2.7 Critical Habitat

The environmental baseline for the PBFs for eulachon critical habitat is reflected in the same impacts discussed above (e.g., mainstem flows, water quality, and predation) and summarized in Table 2.4-3. Restoration activities addressing access to the historical estuarine floodplain are improving the baseline condition for that PBF; however, more restoration is needed before the PBFs can fully support the conservation of eulachon.

Table 2.4-3. Physical and biological features (PBFs) of designated critical habitat for eulachon.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBF
Freshwater spawning and incubation sites	Water flow, quality, and temperature conditions and substrate supporting spawning and incubation, and with migratory access for adults and juveniles.	Concerns about water temperature, climate change, and adequate food supply.
Freshwater and estuarine migration corridors	Free of obstruction and with water flow, quality, and temperature conditions supporting larval and adult mobility, and with abundant prey items supporting larval feeding after the yolk sac is depleted.	Concerns about increased opportunities for predators, especially birds and pinnipeds (construction of dredge-material islands in the lower river and other human-built structures used by terns and cormorants for nesting). Diking off areas of the estuary floodplain (land use), combined with reduced peak spring flows (water diversions and water storage and hydroelectric projects), have reduced access to floodplain habitat for rearing and prey production.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBF
Nearshore and offshore marine foraging habitat	Water quality and available prey, supporting juveniles and adult survival. Eulachon prey on a wide variety of species including crustaceans such as copepods and euphausiids (Hay and McCarter 2000; WDFW and ODFW 2001), unidentified malacostracans (Sturdevant 1999), cumaceans (Smith and Saalfeld 1955), mysids, barnacle larvae, and worm larvae (WDFW and ODFW 2001).	Concerns about climate change.

The CRS Action Agencies and other federal and nonfederal entities have taken actions in recent years to improve the functioning of some of these PBFs of critical habitat. Projects that have protected or restored riparian areas and breached or lowered dikes and levees in the estuary have improved the functioning of the migration corridor. Restoration projects in the estuary are improving the functioning of areas used for growth and development.

2.4.2.8 Future Anticipated Impacts of Completed Consultations

The environmental baseline also includes the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, including the consultation on the operation and maintenance of the Bureau of Reclamation's upper Snake River projects. The 2016 five-year review evaluated new information regarding the status and trends of eulachon, including recent biological opinions issued for eulachon and key emergent or ongoing habitat concerns (NMFS 2016b). Since the beginning of 2015 through 2017, we completed 118 formal consultations (26 in 2015, 23 in 2016, and 69 in 2017) that addressed effects to eulachon.[31] These numbers do not include the many projects implemented under programmatic consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed salmonids. Some of the completed consultations are large (large action area, multiple species), such as the Mitchell Act consultation and the consultation on the 2018–27 *U.S. v. Oregon* Management Agreement. Many of the completed actions are for a single activity within a single subbasin.

Some current and proposed restoration projects will improve access to blocked habitat and riparian condition, and increase channel complexity and instream flows. For example, under

[31] PCTS data query, July 31, 2018.

BPA's Habitat Improvement Programmatic consultation, BPA implemented 29 projects in the Columbia Basin that improved fish passage in 2017, and 99 projects that involved river, stream, floodplain, and wetland restoration. These projects will benefit the viability of salmon and steelhead populations by improving abundance, productivity, and spatial structure. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more, and typically less, than a few weeks). However, it is rare for these projects to specifically target habitats important for eulachon spawning and incubation.

Other types of federal projects, including grazing allotments, dock and pier construction, and bank stabilization will be neutral or have short- or even long-term adverse effects on viability. All of these actions have undergone section 7 consultation and the actions[32] were found to meet the ESA standards for avoiding jeopardy.

Similarly, future federal restoration projects will improve the functioning of the PBFs safe passage, spawning gravel, substrate, water quantity, water quality, cover/shelter, food, and riparian vegetation for Pacific salmon and steelhead. Projects implemented for other purposes will be neutral or have short- or even long-term adverse effects on some of these same PBFs. Again, these actions rarely target habitats important to eulachon. All of these actions[33] have undergone section 7 consultation and were found to meet the ESA standards for avoiding adverse modification of critical habitat.

2.4.3 Effects of the Action

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

The proposed action is an ongoing action that has been modified over time to reflect capital improvements, as well as changes in operation based on existing conditions and improved information on how CRS operations affect eulachon and other listed species and their critical habitats. The current proposed action includes operational measures (e.g., flood risk management, navigation, fish passage, and hydropower generation) and non-operational measures (e.g., support for conservation hatchery programs, predation management, habitat improvement actions) that will be implemented beginning in 2019.

The effects of the proposed action are generally consistent with the effects caused by a short-term continuation of the recent CRS operations as described in the environmental baseline section, with the exception of the addition of the proposed increase in spring spill.

[32] Or any RPAs.
[33] Including any RPAs.

2.4.3.1 Effects to Species

Eulachon adults, eggs, and larvae have the potential to be exposed to effects of the proposed action, including flow management and floodplain reconnection in the mainstem Columbia River from Bonneville Reservoir and Dam downstream to the Columbia River plume. In some years (potentially associated with larger spawning runs), some fraction of eulachon spawners will be affected by Bonneville Dam and its impoundment; passage upstream of the dam can be impeded or delayed by the presence of the dam.

2.4.3.1.1 Hydrosystem Operation

The effects of the continued operation of the CRS (system-wide water management operations) are essentially a continuation of the effects of recent system operations described in the baseline section above with the addition of the proposed increase in spring spill at the eight run-of-river dams. The continued effects include reduced sediment transport, altered hydrograph, altered water temperature regime, and impaired passage above Bonneville Dam. Fish passage studies have not evaluated the specific effects of Bonneville Dam fish passage improvements for juvenile salmonids on eulachon. However, to the extent eulachon adults and larvae are present upstream of the project, recent passage improvements at Bonneville Dam[34] will continue under the proposed action and will likely continue to improve the survival of adults "falling back" at the dam and of larvae migrating/drifting downstream.

During periods of increased spring spill between April 10–June 15 resulting from the proposed flexible spring spill operation, eulachon could be affected in the following ways: (1) potential for increased fallback of adults that succeed in passing Bonneville Dam via the adult salmon ladders or navigation locks; and (2) both larvae and adults within Bonneville Reservoir and for approximately 35 miles downstream of Bonneville Dam will be exposed to increased levels of TDG.

Higher spill is correlated with fallback behavior at Bonneville Dam for adult Chinook salmon and steelhead. Given their much smaller size, it is likely that adult eulachon would be less able to avoid increased flows to the spillway in comparison to adult salmon and steelhead. Given the lack of survival estimates for eulachon (adult) through any passage route at Bonneville Dam, it is unclear whether the changes in operations would positively, neutrally, or negatively affect the survival of eulachon. Similarly, there is little evidence to suggest how, or to what extent, increased TDG levels above levels evaluated in the baseline section would affect eulachon survival in the vicinity of Bonneville Dam. Further, the peak of the adult spawning run is typically over by the end of March, and the impact to the fraction of drifting larvae exposed to further elevated TDG levels may be ameliorated by depth compensation, indicating that the spill program would not be an important risk factor at the individual scale. However, while the extent that larvae may be impacted by elevated TDG immediately below Bonneville Dam is not known,

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[34] These include the installation of minimum gap runners at Bonneville PH1 and the FGE improvements at PH2 and improvements to sluiceway fish guidance system (efficiency and conveyance) at PH1.

we believe that most eulachon spawning takes place in tributary rivers, such as the Lewis River, and thus would not be exposed to the elevated TDG levels.

2.4.3.1.2 Predator Management

The Corps and BPA support land- and water-based sea lion harassment efforts from the area downstream of Bonneville Dam. However, given the inconsistent presence of adult eulachon at Bonneville Dam, these efforts likely have little effect on survival of eulachon. Sea lion exclusion devices in the adult fishway entrances should not affect the ability of eulachon to enter the fishways when they are present.

The Action Agencies propose continued implementation of the Caspian Tern Nesting Habitat Management Plan (USACE 2015a) and the Double-crested Cormorant Management Plan (USACE 2015b). However, observations of terns (or cormorants) eating eulachon are rare, and it is unlikely that these colony management actions will improve the survival of adults at the population scale.

2.4.3.1.3 Habitat Actions

The Action Agencies have not proposed to improve spawning and incubation habitat used by eulachon on tributaries to the lower Columbia River.

The Action Agencies will continue to implement the CEERP to increase the capacity and quality of estuarine ecosystems by continuing to reconnect roughly 300 acres of the historical floodplain per year to the tidal regime, a goal that they have a record of achieving in 2008-17 (BPA et al. 2018b). These projects, though not targeting eulachon habitat, are likely to improve material fluxes to the mainstem and thus to better support the production of phytoplankton, the primary food source for larval eulachon, in the lower river. These benefits will increase as restored habitat area accrues over time and habitat quality matures.

2.4.3.1.4 Research and Monitoring Activities

The Action Agencies' RM&E program will be similar to the current program, or will be implemented at a reduced scale. Thus, the level of injury and mortality discussed in the environmental baseline, primarily from the capture and handling of adult eulachon, is likely to continue at a similar or reduced level. However, because eulachon numbers in the lower Columbia River vary so widely from year to year, we estimate that, on average, the following number of eulachon will be affected each year during the interim period:

- Up to 1,000 adult eulachon will be handled and zero will be killed during activities associated with the Smolt Monitoring Program and CSS; no juvenile eulachon will be handled or killed.
- Up to 1,000 adult eulachon will be handled and zero will be killed during other RM&E activities (e.g., towing a midwater trawl with a PIT-tag detector in place of a cod end, or beach seining for salmon). No juvenile eulachon will be handled or killed.

The combined observed mortality associated with these elements of the RM&E program will, on average, affect less than one percent of the adult eulachon run and an unknown, but likely very small proportion of the outmigrating juveniles in any given year (Bellerud 2018). This relatively small effect is deemed worthwhile because it will allow the Action Agencies and NMFS to continue to evaluate the effects of CRS operations including modifications to facilities, operations, and mitigation actions.

Eulachon are not expected to be encountered during April-July electrofishing operations conducted under the NPMP because they are not in the lower Columbia River during that time period.

2.4.3.2 Effects to Critical Habitat

The PBFs of freshwater spawning and incubation sites, freshwater and estuarine migration corridors, and nearshore foraging sites are essential for conservation because eulachon cannot successfully spawn and produce offspring without this habitat; the habitat allows adult fish to swim upstream to reach spawning areas, allows juvenile fish to proceed downstream to reach the ocean, and provides abundant forage species and suitable water quality. The Columbia River is a significant portion of the critical habitat for this DPS.

The proposed action will affect the PBFs of eulachon critical habitat. These effects are described in Table 2.4-4. The implementation of the flexible spring spill operation will increase spill levels up to the state TDG limit up to 150 kcfs in the tailrace of Bonneville Dam for the spring spill period April 10–June 15 each year. In addition to the effects already considered, this action has the potential to increase the exposure of eulachon adults, eggs, and larvae to elevated TDG in Bonneville Reservoir and for at least 35 miles below Bonneville Dam. However, we do not know if the TDG levels likely to result from increased spill resulting from the flexible spring spill operation will substantively affect the PBFs that support eulachon spawning and incubation. Most spawning will be complete before the onset of spring spill. Increased TDG associated with the flexible spill operation will temporarily diminish the value of any incubation sites in lower the Columbia River near Bonneville Dam.

Table 2.4-4. Physical and biological features (PBFs) of designated critical habitat for eulachon.

Physical and Biological Feature (PBF)	Effects of the Proposed Action
Freshwater spawning and incubation sites	We do not know if the TDG resulting from increased spill will substantively reduce the conservation value of the PBFs that support eulachon spawning and incubation. Flows in the spring will increase after April. Most spawning will be completed by that time. Increased TDG may temporarily diminish the value of any incubation sites within about 35 miles of Bonneville Dam; however, we believe most spawning sites are in tributary rivers such as the Lewis River, which will not be affected CRS operations.

Physical and Biological Feature (PBF)	Effects of the Proposed Action
	We do not expect many adult eulachon to experience elevated TDG. The increased spill will not begin at Bonneville Dam until April 10th.
Freshwater and estuarine migration corridors	Habitat in the estuary will be improved at the local scale by the proposed restoration activities. These will improve opportunities for forage and water quality.

2.4.4 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation (50 CFR 402.02). Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Nonfederal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat and mainstem habitat for eulachon. These projects also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth management programs (planning and regulation), various stream and riparian habitat projects, watershed planning and implementation, acquisition of water rights for instream purposes and sensitive areas, instream flow rules, stormwater and discharge regulation, TMDL implementation to achieve water-quality standards, hydraulic project permitting, and increased spill and bypass operations at hydropower facilities. NMFS has determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. These activities are likely to have beneficial cumulative effects that will improve conditions for eulachon.

NMFS has also noted that some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects are activities that occurred in the recent past and were included in the environmental baseline. Some of these activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if

authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the action area, nonfederal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations.

Overall, we anticipate that projects to restore and protect habitat will result in a beneficial effect on eulachon compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on eulachon in the action area.

2.4.5 Integration and Synthesis

In this section, we add the effects of the action (Section 2.4.3) to the environmental baseline (Section 2.4.2) and the cumulative effects (Section 2.4.4), taking into account the status of the species and critical habitat (Sections 2.4.5.1 and 2.4.5.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat for the conservation of the species.

2.4.5.1 Species

Starting in 1994, there was an abrupt decline in the abundance of eulachon returning to all subpopulations, including the Columbia River. Despite a brief period of improved returns in 2001-03, the returns and associated commercial landings were at low levels from the mid-1990s through the 2000s. Eulachon abundance improved substantially in the 2010s, and was relatively high in the 2013-15 return years, before declining in 2016 and 2017, most likely due to recent ocean conditions. Low returns are expected to persist for the near term, but may respond positively to recent improvements in ocean conditions.

The effects of CRS operations on populations originating in subbasins downstream of Bonneville Dam are limited to the effects of flow management and marginally increased exposure to higher TDG levels during migration and rearing in the Columbia River, including the estuary. Reduced flows from May through July will be an ongoing effect of CRS operations as proposed. While the overall effects on adults and larvae are unknown, most could be negative for those eulachon larvae migrating/drifting through the estuary and plume in May and June. Other impacts, such as alterations in sediment transport and elevated water temperatures downstream in late summer and fall, may also affect the southern DPS of eulachon, but we have no data to quantify the magnitude or scale of those impacts.

For adults that reach Bonneville Dam in high-abundance years, this project remains a substantial barrier to upstream migration to a small number of tributaries where spawning historically may have occurred. While many individual adults (and their surviving progeny) may be affected, reduced survival of adults (upstream passage and fallback) or their progeny are likely not substantially limiting the abundance and productivity in subpopulations in the Columbia River.

The flexible spring spill operation proposed by the Action Agencies is expected to reduce powerhouse passage rates for downstream migrating juvenile salmon and steelhead. The CSS hypothesizes that increased spill could substantially reduce latent mortality of juvenile yearling Chinook and steelhead moving downstream through the mainstem dams. The potential for effects to eulachon are not known. Both larvae and adult in Bonneville Reservoir and for approximately 35 miles downstream of the dam may be exposed to increased levels of TDG. However, the peak of adult spawning run is typically over by the end of March, and the impact to the fraction of drifting larvae exposed to elevated TDG should be small. We do not believe the spill program will be an important risk factor for the southern DPS of eulachon

The other proposed changes to CRS operations are not anticipated to negatively affect eulachon survival. In particular, the changes in usable forebay ranges (MOP 1.5-foot range) at the Lower Snake River reservoirs and the change in operating range at the John Day forebay (MIP 2-foot range) will result in inconsequential variations in the timing and amount of flow in the lower Columbia River.

The Action Agencies will continue to fund predator control activities and estuary habitat improvements, and modify operations to improve salmon survival. The implementation of the CRS mitigation and enhancement programs will continue to reduce long-term impacts and may support a small improvement in the status for eulachon. The pikeminnow program will likely provide some small productivity benefit at the population scale (predation by sea lions and birds is thought to be rare). The estuary program is anticipated to improve the productivity of phytoplankton in the lower river, the primary food source for larval eulachon.

As a general matter, the effects of the proposed action are very similar to a short-term continuation of the same effects caused by the current operations and maintenance of the CRS, as well as the associated measures implemented to avoid, minimize or offset adverse effects. Therefore, we do not anticipate large changes in mortality caused by the CRS or substantial new risks to the southern DPS of eulachon or their habitat, and we do not expect considerable changes in the effects on reproduction, numbers, or distribution. However, we do anticipate additional improvements in habitat conditions in the estuary that will accrue over time.

The environmental baseline includes the past and present impacts of hydropower, changes in tributary and mainstem habitat (both beneficial and adverse), harvest, and hatcheries on eulachon. Ocean conditions and climate are important factors for eulachon viability. The baseline provides important context for assessing the effects of the action described above.

In the opinion for the 2018-2027 *U.S. v. Oregon* Management Agreement (NMFS 2018a), which provides a framework for managing salmon and steelhead fisheries and hatchery programs in much of the Columbia River basin, NMFS concluded that releases of hatchery salmon and steelhead are not expected to overlap with emerging eulachon juveniles in the lower Columbia River because the emergence and outmigration of juvenile eulachon generally occurs in January through March, before hatchery juveniles reach the lower mainstem Columbia River in April and May. Since 2014, Washington and Oregon have adopted limited-opportunity recreational and commercial fishery on eulachon in the Columbia River and the Cowlitz and Sandy Rivers (TAC 2017). Encounters of eulachon in Columbia River salmon fisheries would be extremely unlikely given the differences in temporal distribution and gear characteristics. The recovery plan rates the level of threat for fisheries in the Columbia River as low (NMFS 2017b).

Climate change impacts on ocean conditions are rated as the highest threat to the persistence of eulachon subpopulations, followed by bycatch in offshore shrimp fisheries (NMFS 2017b). Dams and water diversions, climate change impacts on freshwater habitat, predation, water quality, shoreline construction, and dredging were all rated as moderate impacts. Habitat in the action area is degraded by numerous human activities: the development and operation of water storage and diversion facilities and mainstem hydroelectric facilities, shoreline development, rural development, urbanization, dredging and toxic contamination.

The status of eulachon is likely to be affected by climate change. Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycles. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater, and changes to food webs in freshwater, estuarine, and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management actions may help alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations, increased riparian vegetation to control water temperatures, etc.).

Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life-history types that will be successful in the future are neither static nor predictable. Therefore, maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including eulachon. Emerging research using complex life-cycle modeling indicates a potentially strong link between SST and survival of Snake River spring/summer Chinook populations. However, the apparent link between SST and survival is presumably caused by food web interactions, relationships which could be disrupted by major transformations of community dynamics, as well as ocean acidification and other factors under a changing climate. The degree to which SST is linked to survival of eulachon, and how that relationship interacts with other variables throughout the eulachon life cycle, will likely be an important area of future research.

When evaluating the effects of the action, those effects must be taken together with the effects on eulachon of future state or private activities, not involving federal activities that are reasonably certain to occur within the action area. NMFS anticipates that human development activities will continue to have adverse effects on eulachon in the action area. Many of these activities and their effects occurred in the recent past and were included in the environmental baseline but are also reasonably certain to occur in the future. Within the action area, nonfederal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Habitat restoration efforts lead by state and local agencies, tribes, environmental organizations, and local communities are likely to continue. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives that, in some cases, are identified through ESA recovery plans. Larger, more regionwide, restoration and conservation efforts are either underway or planned throughout the Columbia River basin. These state and private actions have helped restore habitat, improve fish passage, and reduce pollution. While these efforts are reasonably certain to continue to occur, funding levels may vary on an annual basis.

Eulachon abundance appears strongly related to ocean conditions, and thus this species is considered extremely vulnerable to climate change. The recovery plan (NMFS 2017b) identifies recovery actions to be implemented, including estuary and freshwater habitat actions and changes to the shrimp fishery. Effective implementation requires that the recovery efforts of diverse private, local, state, tribal, and federal parties across two states be coordinated at multiple levels. The proposed action will not result in reductions to eulachon reproduction, numbers, or distribution that would impede the ability to successfully carry out the identified recovery measures and actions over the time frames considered in the recovery plan.

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, cumulative effects, and considering the interim nature of the proposed action, it is NMFS' biological opinion that the proposed action is not likely to reduce appreciably the likelihood of both survival and recovery of the southern DPS eulachon.

2.4.5.2 Critical Habitat

Critical habitat for the southern DPS of eulachon encompasses 16 rivers in California, Oregon, and Washington. This includes the lower Columbia River and nearshore and offshore marine foraging habitat with water quality and prey that support juvenile and adult survival. Similar to the discussion above for species, the status of critical habitat is likely to be affected by climate change with predicted rising temperatures and alterations in stream flow patterns and habitat quality.

The environmental baseline includes a broad range of past and present actions and activities that have affected the conservation value of critical habitat for eulachon. These include the effects of hydropower, changes in tributary and mainstem habitat (both positive and negative) on freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine areas, and nearshore marine areas. Despite a long-term trend in degradation of these habitats, there have been localized improvements in their conservation value through the combined efforts of federal, state, and local agencies; tribes; and other stakeholders. Restoration activities addressing access to the historical estuarine floodplain are improving the baseline condition for the spawning and incubation PBF.

Continued operation of the CRS will impact the timing of flows in the lower Columbia River. Increased levels of TDG during the spring spill period will increase TDG levels within Bonneville Dam's reservoir and for at least 35 miles downstream. However, we do not know if the proposed increase in spill and TDG will have substantive negative effects on the PBFs that support eulachon spawning and incubation because most spawning will be complete before the onset of spring spill. Increased flows could also diminish the value of incubation sites in the lower Columbia River. The estuary habitat restoration program will reconnect floodplains and provide additional forage and water quality at the project scale; these benefits will accrue at the designation scale over time.

Considering the ongoing and future effects of the environmental baseline and cumulative effects and in light of the status of critical habitat, the proposed action will not appreciably reduce the value of designated critical habitat for the conservation of eulachon.

2.4.6 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of eulachon or destroy or adversely modify its designated critical habitat.

2.5 Lower Columbia River (LCR) Chinook Salmon

This section applies the analytical framework described in section 2.1 to the LCR Chinook salmon ESU and provides NMFS' finding regarding whether the proposed action is likely to jeopardize the continued existence of the LCR Chinook salmon ESU or destroy or adversely modify its critical habitat.

2.5.1 Rangewide Status of the Species and Critical Habitat

The status of LCR Chinook salmon is determined by the level of extinction risk that the listed species faces, based on parameters considered in documents such as the recovery plan, status reviews, and listing decisions. The species status also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. This informs the description of the species' current likelihood of both survival and recovery. The condition of critical habitat throughout the designated area is determined by the current function of the PBFs that help to form that conservation value.

2.5.1.1 Status of Species

The LCR Chinook salmon ESU includes all naturally spawned populations from the mouth of the Columbia River upstream to and including the White Salmon River in Washington and the Hood River in Oregon. This ESU also includes the Willamette River upstream to Willamette Falls (exclusive of spring-run Chinook salmon in the Clackamas River), and 15 artificial propagation programs.[35] The ESU spans three distinct ecological regions (Coast, Cascade, and Gorge) and includes three distinct life-history types (spring-run, fall-run, and late-fall-run). Major population groups are defined by the combinations of ecological region and life-history type that existed historically: Cascade spring, Gorge spring, Coast fall, Cascade fall, Gorge fall, and Cascade late-fall.[36] LCR Chinook salmon were listed in 1999 as threatened, and this listing determination was reaffirmed in 2005. The recovery plan was completed in 2013 (NMFS 2013a), and the most recent status review was completed in 2015 (NWFSC 2015; Table 2.5-1). More

[35] Big Creek Tule Fall Chinook, Astoria High School (Salmon and Trout Enhancement Program also known as STEP implemented by the Oregon Department of Fish and Wildlife), Tule Fall Chinook, Warrenton High School (STEP), Tule Fall Chinook, Cowlitz Tule Fall Chinook Salmon Program, North Fork Toutle Tule Fall Chinook, Kalama Tule Fall Chinook, Washougal River Tule Fall Chinook, Spring Creek National Fish Hatchery (NFH) Tule Chinook, Cowlitz spring Chinook salmon (two programs), Friends of Cowlitz spring Chinook, Kalama River Spring Chinook, Lewis River Spring Chinook, Fish First Spring Chinook, and Sandy River Hatchery Spring Chinook salmon (ODFW stock #11).

[36] The Willamette–Lower Columbia Technical Recovery Team used the term "strata" to refer to these population groupings, which are significant in identifying delisting criteria. The strata are analogous to the "major population groups" defined by the Interior Columbia Technical Recovery Team. For consistency, we use the term major population group throughout this biological opinion.

information can be found in the recovery plan and status review for this species. These documents are available on the NMFS West Coast Region website.37

Table 2.5-1. Status summary and limiting factors for LCR Chinook salmon.

Status Summary	Limiting Factors
This ESU comprises 32 independent populations. Twenty-seven populations are at very high risk, two populations are at high risk, one population is at moderate risk, and two populations are at very low risk. Overall, there was little change since the last status review in 2015 in the biological status of this ESU, although there are some positive trends. Increases in abundance were noted in about 70% of the fall-run populations, and decreases in hatchery contributions were noted for several populations. Relative to baseline VSP levels identified in the recovery plan, there has been an overall improvement in the status of a number of fall-run populations, although most are still far from the recovery plan goals.	• Reduced access to spawning and rearing habitat • Hatchery-related effects • Harvest-related effects on fall Chinook salmon • An altered flow regime • Reduced access to off-channel rearing habitat • Reduced productivity resulting from sediment- and nutrient-related changes in the estuary • Contaminants

LCR spring Chinook salmon populations are stream-type, while LCR early-fall and late-fall Chinook salmon populations are ocean-type. Stream-type populations have a longer freshwater residency, perform extensive offshore migrations, and are most commonly found in headwater streams of large river systems. Ocean-type populations are more commonly found in coastal streams and typically migrate to sea within the first three months of life. Other life history differences among run types include the timing of spawning, incubation, emergence in freshwater, migration to the ocean, maturation, and return to freshwater. This life-history diversity allows different runs of Chinook salmon to use streams as small as 10 feet wide and rivers as large as the mainstem Columbia (NMFS 2013a). Stream characteristics determine the distribution of run types among LCR streams. Depending on run type, juvenile LCR Chinook salmon may rear for a few months to a year or more in freshwater streams, rivers, or the estuary before migrating to the ocean in spring, summer, or fall.

Limiting factors for LCR Chinook salmon include concerns about adverse effects to diversity and productivity as a result of high proportions of hatchery-origin spawners in select basins. Degraded habitat conditions are an additional concern, particularly with regard to tributary channel complexity, side channel and floodplain connectivity, water quality, and hydrologic

[37] Currently these documents can be found within the NMFS West Coast Region website at: http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/salmon_and_steelhead_listings/chinook/lower_columbia_river/lower_columbia_river_chinook.html. Last accessed August 2018.

patterns that are legacy effects of urbanization, agriculture, timber practices, and toxic contamination from exposure to emerging and legacy chemicals. Improved ocean fisheries management and implementation of selective freshwater fisheries continue to reduce harvest impacts, with the exception of the bright fall-run component of the LCR Chinook salmon ESU, where harvest rates were up to 40 to 65 percent in recent years, equivalent to the harvest rates of the early 1980s (NMFS 2016c).

Pinniped numbers have increased in the Columbia River basin, which has led to an increase in predation on LCR Chinook salmon. More than 40,000 fish from listed and unlisted salmon and steelhead stocks have been consumed by California sea lions in the vicinity of Bonneville Dam from 2002 through 2014 (Stansell et al. 2014). Most, but not all, California sea lions leave Bonneville Dam by the end of May, there are a handful that have taken residence in the area between Bonneville Dam forebay and The Dalles Dam. Steller sea lions are not as abundant as California sea lions in the Columbia River, although in 2012, more Steller sea lions than California sea lions were seen at Bonneville Dam and consumed high numbers of salmonids. The risk to LCR Chinook salmon has not been quantified, but we can make inferences based on studies looking at predation rates for all ESUs and run timing of the LCR Chinook salmon populations. The spring-run stocks are at greatest risk, because their run timing coincides with the period of greatest density of pinnipeds in the river and below Bonneville Dam (discussed further in the Environmental Baseline). The absolute number of animals preying upon salmon and steelhead throughout the lower Columbia River and Willamette River is not known.

A variety of nonindigenous fishes in the Lower Columbia River recovery domain affect salmon and their ecosystems. A number of studies have concluded that many established nonindigenous species (e.g., smallmouth bass, channel catfish, and American shad) pose a threat to the recovery of ESA-listed Pacific salmon, including LCR Chinook salmon. Threats are not restricted to direct predation; nonindigenous species compete directly and indirectly for resources, significantly altering food webs and trophic structure and potentially altering evolutionary trajectories (Sanderson et al. 2009; NMFS 2010).

The recovery plan for LCR Chinook salmon identifies ESU- and MPG-level biological recovery criteria, and within each MPG, it also identifies specific population-level goals consistent with the MPG-level criteria (Table 2.5-2; NMFS 2013a). For populations with a spring-run life-history type, the LCR Chinook salmon recovery plan identifies the goals of restoring the Cascade and Gorge MPGs to a high probability of persistence or to a probability of persistence consistent with their historical condition.[38] Very large improvements will be needed in most populations to achieve ESA recovery, although less or very little improvement is needed for some populations (Figures 2.5-1 and 2.5-2). Almost every population is greatly affected by the loss and degradation of tributary habitat, and five populations have experienced significant loss of spatial structure as a result of tributary dams that block access to spawning habitats. These impacts are comparable to or even greater than those associated with other factors that negatively affect

[38] The historical role of the Gorge spring and Gorge fall MPGs is unclear and warrants further investigation (NMFS 2013a).

tributary habitat. Accordingly, for most populations with a spring-run life-history type, the greatest gains are expected from tributary habitat and tributary dam passage improvements (combined with hatchery reintroduction programs). For most LCR Chinook spring-run salmon populations, the recovery plan also targets significant reductions in hatchery-related impacts. Achieving recovery will also require improvements in predation management and estuary habitat impacts.

Table 2.5-2. LCR Chinook salmon major population groups (MPGs), run timing, populations, and scores for the key viable salmonid population (VSP) elements (abundance/productivity[A/P], spatial structure, and diversity) used to determine overall net persistence probability of the population (NWFSC 2015). Persistence probability ratings and key element scores range from very low (VL) to low (L), moderate (M), high (H), and very high (VH). The five populations that spawn upstream of Bonneville Dam are highlighted in gray.

MPG		Population	A/P	Spatial Structure	Diversity	Overall Persistence Probability
Ecological Subregion	**Run Timing**					
Cascade	Spring	Upper Cowlitz (WA)	VL	L	M	VL
		Cispus (WA)	VL	L	M	VL
		Tilton (WA)	VL	VL	VL	VL
		Toutle (WA)	VL	H	L	VL
		Kalama (WA)	VL	H	L	VL
		NF Lewis (WA)	VL	L	M	VL
		Sandy (OR)	M	M	M	M
	Fall	Lower Cowlitz (WA)	VL	H	M	VL
		Upper Cowlitz (WA)	VL	VL	M	VL
		Toutle	VL	H	M	VL
		Coweeman (WA)	L	H	H	L
		Kalama (WA)	VL	H	M	VL
		Lewis (WA)	VL	H	H	VL
		Salmon Creek (WA)	VL	H	M	VL
		Clackamas (OR)	VL	VH	L	VL
		Sandy (OR)	VL	M	L	VL
		Washougal (WA)	VL	H	M	VL
	Late-fall	NF Lewis (WA)	VH	H	H	VH
		Sandy (OR)	VH	M	M	H
	Spring	White Salmon (WA)	VL	VL	VL	VL

MPG		Population	A/P	Spatial Structure	Diversity	Overall Persistence Probability
Ecological Subregion	Run Timing					
Columbia Gorge		Hood (OR)	VL	VH	VL	VL
	Fall	Lower Gorge (WA & OR)	VL	M	L	VL
		Upper Gorge (WA & OR)	VL	M	L	VL
		White Salmon (WA)	VL	L	L	VL
		Hood (OR)	VL	VH	L	VL
Coast Range	Fall	Youngs Bay (OR)	L	VH	L	L
		Grays/Chinook (WA)	VL	H	VL	VL
		Big Creek (OR)	VL	H	L	VL
		Elochoman/Skamokawa (WA)	VL	H	L	VL
		Clatskanie OR)	VL	VH	L	VL
		Mill/Abernathy/Germany (WA)	VL	H	L	VL
		Scappoose (OR)	L	H	L	L

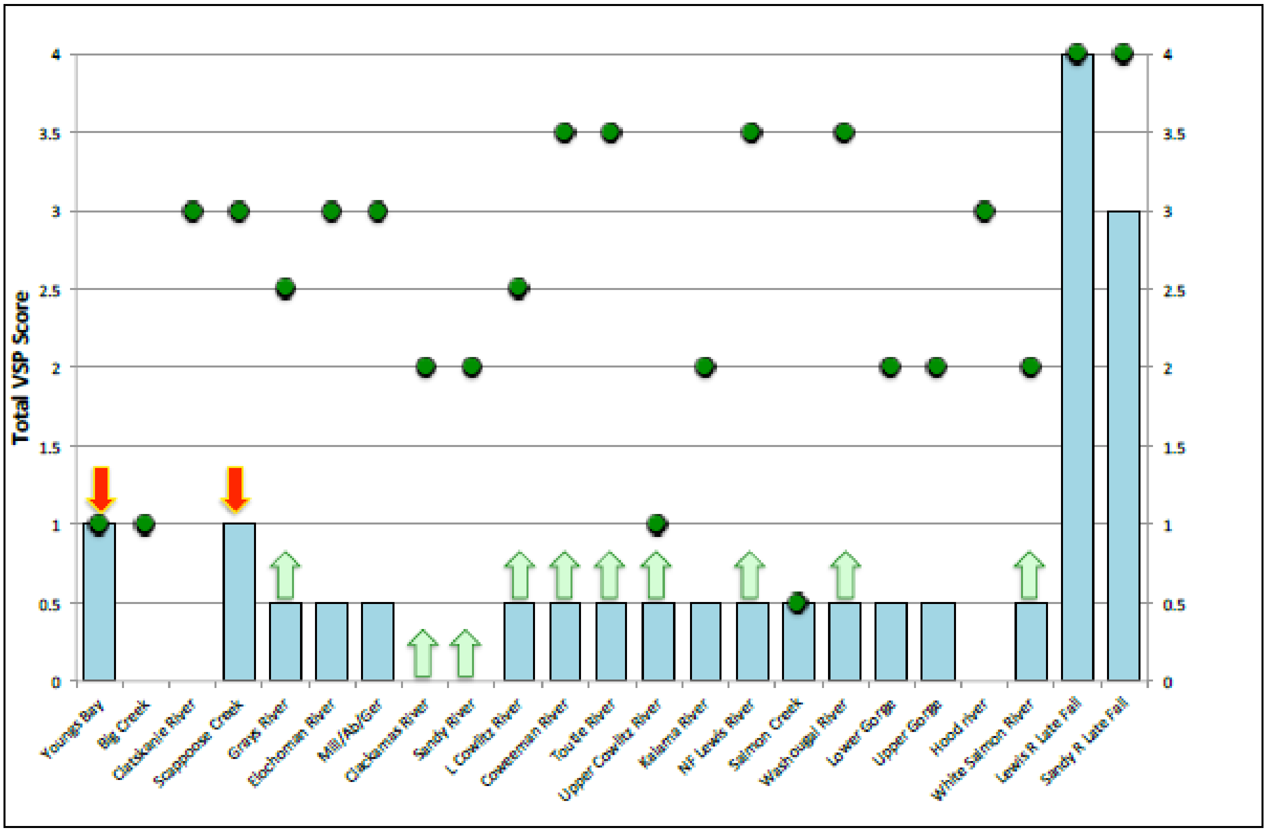


Figure 2.5-1. VSP status of fall-run and late-fall-run, demographically independent populations in the Lower Columbia River Chinook salmon ESU. Bars indicate the initial viable salmonid population (VSP) status (as identified in the recovery plan; NMFS 2013a); green circles indicate the recovery goals. Arrows indicate the general direction, but not the magnitude, of any VSP score based on new data reviewed in NWFSC 2016. VSP scores represent a combined assessment of population abundance and productivity, spatial structure, and diversity (McElhany et al. 2006). A VSP score of 3.0 represents a population with a 5% risk of extinction within a 100-year period.

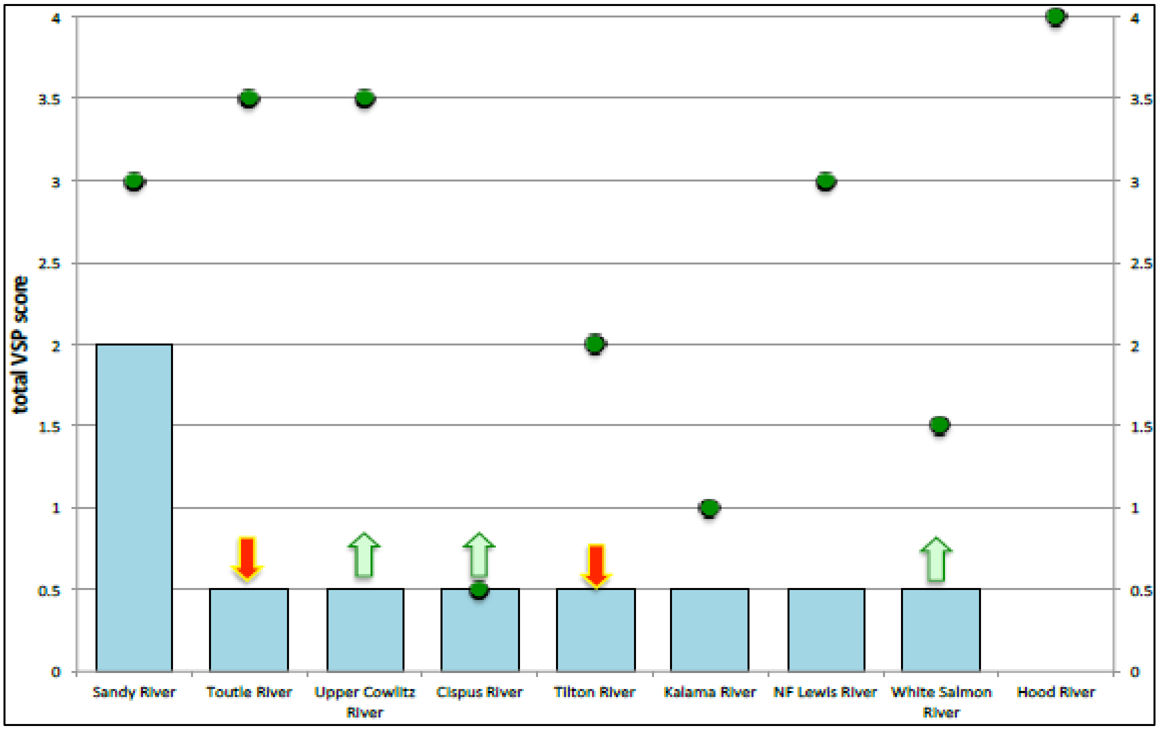


Figure 2.5-2. VSP status of spring-run, demographically independent populations in the Lower Columbia River Chinook salmon ESU. Bars indicate the initial viable salmonid population (VSP) status (as identified in the recovery plan; NMFS 2013a); green circles indicate the recovery goals. Arrows indicate the direction, but not the magnitude, of the VSP score change based on new data reviewed in NWFSC (2015). VSP scores represent a combined assessment of population abundance and productivity, spatial structure, and diversity (McElhany et al. 2006). A VSP score of 3.0 represents a population with a 5% risk of extinction within a 100-year period.

Similar to spring-run populations, for fall-run populations, the LCR Chinook salmon recovery plan identifies the goals of restoring the Coast, Cascade, and Gorge MPGs to a high probability of persistence or to a probability of persistence consistent with their historical condition. Very large improvements are needed for most populations with a fall-run life-history type to achieve LCR Chinook salmon recovery, although some populations require less improvement. For the populations in the Coast and Cascade MPGs, the recovery plan targets most improvements to be achieved by protecting and restoring tributary and estuarine habitat and by reducing impacts of hatcheries and harvest. In the Gorge MPG, the recovery plan also contemplates reductions in the impacts of hydropower effects to tributary passage and habitat. Some of those effects have been addressed by the recent removal of four dams.[39]

For populations with a late-fall-run life-history type, the LCR Chinook salmon recovery plan identifies the goals of maintaining the North Fork Lewis and Sandy populations, which are comparatively healthy, together with improving the probability of persistence (based on the four VSP parameters) of the Sandy population from its current status of "high" to "very high." Improving the status of the Sandy population depends largely on harvest and hatchery changes.

[39] Five populations in this MPG are or were affected by dam passage issues at Bonneville. Marmot and Little Sandy dams in the Sandy River basin were removed in 2017; Powerdale Dam, on the Hood River, was removed in 2010; and Condit Dam on the White Salmon River was breached in October 2011 and completely removed in 2012.

Habitat improvements to the Columbia River estuary and tributary spawning areas are also necessary.

Out of the 32 populations that make up this ESU, the two late-fall bright runs—the North Fork Lewis and Sandy—are considered viable. Most populations (26 out of 32) have a very low probability of persistence over the next 100 years (and some are extirpated or nearly so; NMFS 2016). Five of the six strata fall significantly short of the Willamette/Lower Columbia Technical Recovery Team (WLC–TRT) criteria for viability; one stratum, Cascade late-fall, meets the WLC–TRT criteria for viability (NMFS 2013a, 2016c).

Abundance and productivity (A/P) ratings for LCR Chinook salmon populations are currently low to very low for most populations, except for spring Chinook salmon in the Sandy River (moderate) and late-fall Chinook salmon in North Fork Lewis and Sandy Rivers (very high for both; Table 2.5-1, Figures 2.5-1 and 2.5-2; NMFS 2013a). For some of these populations with low or very low A/P ratings, low abundance of natural-origin spawners (100 fish or fewer) has increased genetic and demographic risks. Other LCR Chinook salmon populations have higher total abundance, but several of these also have high proportions of hatchery-origin spawners. For tule fall Chinook salmon populations, poor data quality prevents precise quantification of population abundance and productivity; data quality has been poor because of inadequate spawning surveys and the presence of unmarked hatchery-origin spawners (NWFSC 2015).

Examination of the extinction risk ratings for all four VSP parameters, including spatial structure and diversity attributes, for natural populations of LCR Chinook salmon in Oregon (Ford 2011) indicate low to moderate spatial structure risk for most populations, but high diversity risk for all but two populations: the Sandy River bright and spring Chinook salmon populations. The assessments of spatial structure and diversity are combined with those of abundance and productivity to give an assessment of the overall status of LCR Chinook salmon natural populations in Oregon. Risk is characterized as high or very high for all populations except the Sandy River late-fall and spring populations. Relative to baseline VSP levels identified in the recovery plan (NMFS 2013a), there has been an overall improvement in the status of a number of fall-run populations, although most are still far from the recovery plan goals (NWFSC 2015).

Similarly, the most recent ESA five-year status review for LCR Chinook salmon noted that although there are some positive trends, the majority of the populations in this ESU remain at high risk, with low natural-origin abundance levels. Hatchery contributions remain high for a number of populations. While overall hatchery production has been reduced slightly, hatchery-produced fish still represent a majority of fish returning to the ESU.

The effects of harvest as a limiting factor began to decline even before the LCR Chinook salmon were listed in 1999. The exploitation rate for LCR spring Chinook salmon averaged 51 percent from 1980 to 1991 and 31 percent thereafter (NMFS 2018a). Reductions occurred in both ocean and inriver fisheries. Exploitation rates on LCR fall Chinook salmon declined from 1983 to 1993, but still averaged 69 percent during that time frame. From 1994 to 2006, the exploitation rate averaged 41 percent (NMFS 2018a). Harvest has been reduced in recent years as a consequence of NMFS ESA-related guidance. In 2001, fisheries were subject to a total exploitation rate limit of 65 percent. From 2002 to 2006, fisheries were managed subject to a limit of 49 percent. The limit was reduced further to 42 percent in 2007, 41 percent in 2008, 38 percent in 2010, and, since 2012, LCR fall Chinook salmon have been managed to an exploitation rate limit that varies from 30 to 41 percent depending on abundance, in line with the recovery plan (NMFS 2018a).

There have been a number of notable efforts to restore migratory access to areas upstream of dams; dam removals (i.e., Condit Dam, Marmot Dam, and Powerdale Dam) not only improve/provide access, but allow the restoration of hydrological processes that may improve downstream habitat conditions. However, until efforts to improve juvenile passage systems in the Cowlitz and Lewis rivers bear fruition,[40] it is unlikely that there will be significant improvements in the status of LCR spring-run Chinook salmon populations. In addition, the development of suitable habitat is limited by restrictions associated with the built human environment; in many locations, existing development such as dikes, docks, and ports inhibits the development of suitable habitat. Finally, observations of coastal ocean conditions suggest that the 2015–17 outmigrant year classes experienced below-average ocean survival, with a corresponding drop in adult returns expected through 2019 (NWFSC 2015, 2017; Werner et al. 2017). Thus, despite efforts to address key threats, continued land development and habitat degradation, in combination with the potential effects of climate change, will present a continuing negative influence into the foreseeable future for LCR Chinook salmon.

2.5.1.2 Status of Critical Habitat

This section describes the status of designated critical habitat affected by the proposed action by examining the condition and trends of the PBFs of that habitat throughout the designated area. These features are essential to the conservation of the ESA-listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration, and foraging). Table 2.5-3 summarizes status information for designated critical habitat for LCR Chinook salmon based on the detailed information on the status of critical habitat provided in the recovery plan for the species (NMFS 2013a). LCR Chinook salmon critical habitat is within the Willamette/Lower Columbia River recovery domain.

[40] Passage improvements include the development of complex, connected habitat in reaches where dams have recently been removed, and removal of additional culverts or dams to provide access to spawning and rearing habitat (NMFS 2016c).

Table 2.5-3. Critical habitat, designation date, Federal Register citation, and status summary for LCR Chinook salmon critical habitat.

Designation Date and Federal Register Citation	Critical Habitat Status Summary
9/02/05 **70 FR 52630**	Critical habitat encompasses ten subbasins in Oregon and Washington containing 47 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005a; NMFS 2013a). However, most of these watersheds have some, or high, potential for improvement. We rated the conservation value of HUC5 watersheds as high for 30 watersheds, medium for 13 watersheds, and low for four watersheds.

The status of critical habitat is discussed in more detail in the Environmental Baseline section, below. We reviewed the status of designated critical habitat by examining the condition and trends of PBFs throughout the range of LCR Chinook salmon. The PBFs for LCR Chinook salmon critical habitat include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine areas, and nearshore marine areas. Removal of multiple barriers has improved access and allowed the restoration of hydrological processes that may improve downstream habitat conditions. However, the value of PBFs remains impaired by tributary barriers, loss of habitat complexity, toxics and water-quality issues, concerns about predation during migration, and inundation of spawning sites by Bonneville Pool.

2.5.1.3 Climate Change Implications for LCR Chinook Salmon and Critical Habitat

One factor affecting the rangewide status of MCR steelhead and aquatic habitat is climate change. The U.S. Global Change Research Program (USGCRP), mandated by Congress in the Global Change Research Act of 1990, reports average warming of about 1.3ºF from 1895 to 2011. As the climate changes, air temperatures in the Pacific Northwest are expected to increase 4 to 13°F by the end of the century, with the largest increases expected in the summer (Mantua et al. 2009; Mote et al. 2014). Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004; Scheuerell and Williams 2005; Zabel et al. 2006; ISAB 2007). According to the ISAB, these effects pose the following impacts into the future:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a smaller snowpack, watersheds will see their runoff diminished earlier in the season, resulting in lower stream flows in the June through September period. River flows in general and peak river flows are likely to increase during the winter due to more precipitation falling as rain rather than snow.

- Water temperatures are expected to rise, especially during the summer months when lower stream flows co-occur with warmer air temperatures.

The proposed action is only expected to be implemented in the interim time period between 2019 and the completion of the NEPA process; however, the effects of the proposed action will extend many years (e.g., maturation of estuary habitat projects). Thus, both natural climate variation and climate change are relevant to our analysis.

Likely changes in temperature, precipitation, wind patterns, and sea-level height have implications for survival and recovery of LCR Chinook salmon in both its freshwater and marine habitats and the PBFs of its critical habitat. As the climate changes, air temperatures in the Pacific Northwest are expected to increase 4 to 13°F by the end of the century, with the largest increases expected in the summer (Mantua et al. 2009; Mote et al. 2014). While total precipitation changes are uncertain, increasing air temperature will result in more precipitation falling as rain rather than snow in watersheds across the basin (NMFS 2017a). In general, these changes in air temperatures, river temperatures, and river flows are expected to cause changes in salmon distribution, behavior, growth, and survival, although the magnitude of these changes remains unclear. In coastal areas, projections indicate an increase of 1–4 feet of global sea-level rise by the end of the century; sea-level rise and storm surge pose a risk to infrastructure and coastal wetlands, and tide flats are likely to erode or be lost as a result of seawater inundation (Mote et al. 2014). Ocean acidification is also expected to negatively impact Pacific salmon and organisms within their marine food webs.

There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management of these factors may help further alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations, management of flows through the mainstem dams to address temperature concerns, etc.). Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life-history types that will be successful in the future are neither static nor predictable, so maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the LCR Chinook salmon ESU.

Climate change would affect LCR Chinook salmon and critical habitat through physical and chemical changes to their habitats (e.g., increased water temperature, decreased ocean pH, changes in the timing and volume of stream flow). The physical and chemical changes can result in biological impacts such as, but not limited to, reduced ocean survival, changes in growth and development, changes in run timing, and spawning timing (Link et al. 2015). These biological changes can result in changes in species productivity and abundance, distribution, food web structure, community structure, invasive species impacts, and biodiversity and resilience (Link et al. 2015). Because of the location of the ESU in the lower Columbia River basin, the ESU is likely to be more affected by climate-related effects in the estuary, and spring-run populations may be subject to additional effects from climate change to the stream ecosystems (changes in flow timing).

Emerging research using complex life-cycle modeling indicates a potentially strong link between SST and survival of Snake River spring/summer Chinook salmon populations. However, the apparent link between SST and survival is presumably caused by food web interactions, relationships which could be disrupted by major transformations of community dynamics as well as ocean acidification and other factors under a changing climate. The degree to which SST is linked to survival of LCR Chinook salmon and how that relationship interacts with other variables throughout the LCR Chinook salmon life cycle will likely be an important area of future research.

2.5.2 Environmental Baseline

The environmental baseline includes the past and present impacts of all federal, state, or private actions and other human activities in an action area, the anticipated impacts of all proposed federal projects in an action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process.

For LCR Chinook salmon, we focus our description of the environmental baseline on where LCR Chinook salmon juveniles and adults are exposed to the effects of the proposed action. We also consider the broader action area, including tributary habitat, because these areas are important context for understanding the effects of the proposed action.

To determine the upstream extent of LCR Chinook salmon distribution and thus exposure, we reviewed adult LCR Chinook salmon PIT detections at Bonneville Dam (2008–17) and The Dalles Dam (2013–17). PIT detections are an indication of presence/absence, though not absolute abundance, because the proportion of the population that is tagged varies from year-to-year and is not known. A total of 38 adults were detected at Bonneville Dam across the five years, with a range of zero fish in 2008 to 21 fish in 2016. For the five years where data were available, a total of five fish overshot The Dalles Dam (range 0–2 each year).[41] No detections were observed in the mouth of the Deschutes River or at McNary Dam. The downstream extent of the effects of the action, based on observed changes in flow, is the plume.[42] Therefore, the area where LCR Chinook salmon experience the greatest exposure to the effects of the proposed

[41] Tributary overshoot occurs when adult salmonids homing to natal sites continue upstream past the mouth of their natal stream (Richins and Skalski 2018).
[42] The Columbia River plume is defined as those waters contiguous to the mouth of the Columbia River having salinity less than 32.5 percent (Park 1966). Historically, the outflow from the Columbia River was viewed as a freshwater plume oriented southwest over the Oregon shelf during summer and north or northwest over the Washington shelf during winter. However, more recent data show that the plume extends in both directions and is frequently present up to 100 miles north of the river mouth from spring to fall (Hickey et al. 2005).

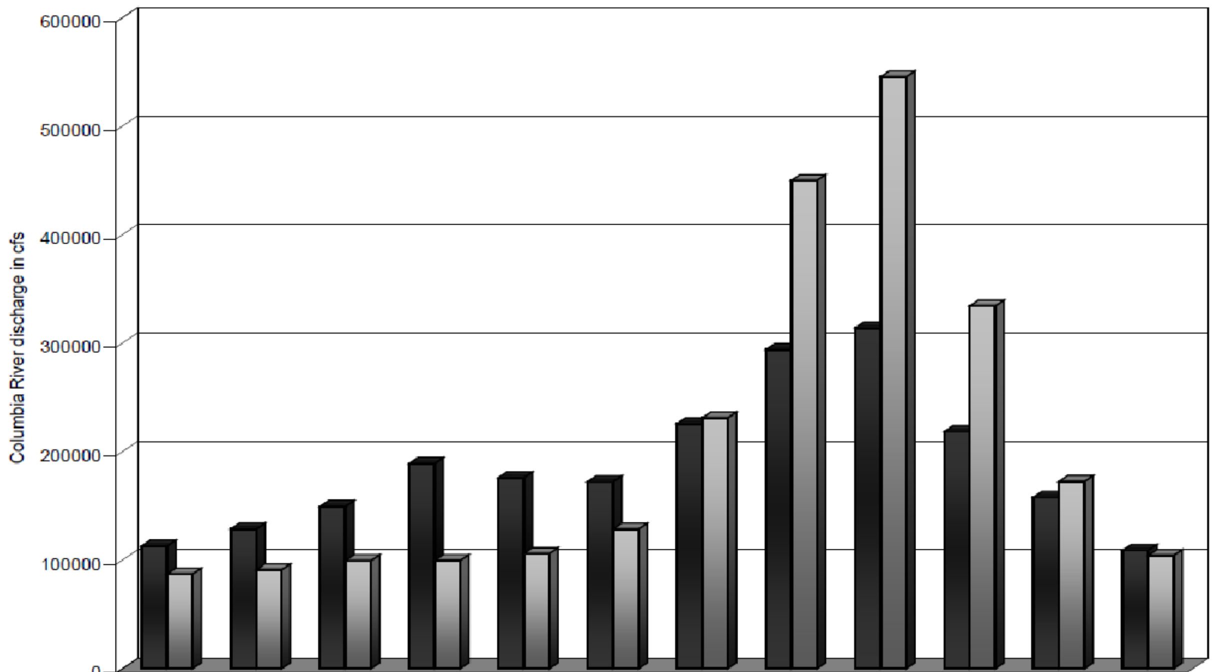
action is the Columbia River from the head of McNary pool to the plume, and tributary confluences in this reach to the extent that they are affected by flow management and habitat mitigation actions in the Columbia River.[43]

2.5.2.1 Mainstem Habitat

On the mainstem of the Columbia River, hydropower projects (including the CRS), water storage projects (including reservoirs in Canada operated under the Columbia River Treaty), and the withdrawal of water for irrigation and urban uses have significantly degraded salmon and steelhead habitats (Bottom et al. 2005; Fresh et al. 2005; NMFS 2013a). The volume of water discharged by the Columbia River varies seasonally according to runoff, snowmelt, and hydropower demands. Mean annual discharge is estimated to be 265 kcfs, but may range from lows of 71–106 kcfs to highs of 530 kcfs (Hamilton 1990; NMFS 1998; Prahl et al. 1998; USACE 1999). Naturally occurring maximum flows on the river would occur in May, June, and July as a result of snowmelt in the headwater regions. Minimum flows would occur from September to March, with periodic peaks due to heavy winter rains (Holton 1984). Interannual variability in stream flow is strongly correlated with two recurrent climate phenomena, the ENSO and the PDO (Newman et al. 2016).

Water storage projects (dams and reservoirs) and water management activities have reduced flows between Bonneville and the mouth of the Columbia River compared to natural flows in the late spring and summer months; on average, this reduction can range from nearly 15 kcfs in August to over 230 kcfs in May (see Figure 2.5-3). Recognizing that the flow versus survival relationships for some interior basin ESUs/DPSs displayed a plateau over a wide range of flows but declined markedly as flows dropped below some threshold (NMFS 1995b, 1998), NMFS and the CRS Action Agencies have attempted to manage Columbia and Snake River water resources to maintain seasonal flows above threshold objectives given the amount of runoff in a given year. This has been accomplished by avoiding excessive drafts going into spring to minimize the flow reductions needed to refill the reservoirs and by drafting the storage reservoirs during summer to augment flows. These flow objectives have guided preseason reservoir planning and in-season flow management. Nonetheless, since the development of the hydrosystem, average monthly flows at Bonneville Dam have been substantially lower during May–July and higher in October–March than an unregulated system. Reduced flows have increased travel times during outmigration for juvenile salmonids and reduced access to high-quality estuarine habitats during spring through early summer.

[43] At this time, the Action Agencies have not proposed mitigation habitat actions in the tributaries of LCR Chinook.



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Current	113017	128641	149403	189076	175921	172150	225689	293948	313930	218523	157935	109020
Natural	87115	91029	99387	99496	106033	128580	231047	450040	545561	334238	172430	104310

Figure 2.5-3. Comparison of monthly discharge (flow) in the Columbia River between current conditions (black) and normative flows (gray). These data show that pre-development flows were lower in the winter and higher in the spring and early summer months.

The series of dams and reservoirs have also blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is only one-third of nineteenth-century levels (Simenstad et al. 1982 and 1990; Sherwood et al. 1990; Weitkamp 1994; NRC 1996; NMFS 2008a). Similarly, Bottom et al. (2005) estimated that the delivery of suspended sediment to the lower river and estuary has been reduced by about 60 percent (as measured at Vancouver, Washington). This reduction has altered the development of habitat along the margins of the river.

Industrial harbor and port development are also significant influences on the lower Willamette and lower Columbia Rivers (Bottom et al. 2005; Fresh et al. 2005; NMFS 2013a). Since 1878, the Army Corps of Engineers has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the lower Willamette River as a navigation channel. Originally dredged to a 20-foot minimum depth, the federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The navigation channel supports many ports on both sides of the river, resulting in several thousand commercial ships traversing the river every year. The dredging, along with diking, draining, and fill material placed in wetlands and shallow habitat, disconnects the river from its floodplain, resulting in the loss of shallow-water rearing habitat and the ecosystem functions that floodplains provide (e.g., supply of prey, refuge from high flows, temperature refugia; Bottom et al. 2005).

The most extensive urban development in the lower Columbia River subbasin has occurred in the Portland/Vancouver area. Common water-quality issues both in areas with urban development and areas with rural residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff (LCREP 2007).

2.5.2.2 Passage Survival

Only five of 32 populations in this ESU are affected by passage conditions at Bonneville Dam and, to a lesser extent, The Dalles Dam: Upper Gorge Fall Run, White Salmon Fall Run, Hood River Fall Run, White Salmon Spring Run, and Hood River Spring Run Chinook salmon. The survival of downstream migrants has improved in recent years due to the construction of the Bonneville Corner Collector and juvenile bypass system at Powerhouse 2, and increases in the percent of flow approaching the dam that goes over the spillway.[44] Both of these measures reduce travel time and the likelihood of turbine passage for juvenile migrants (Ploskey et al. 2012). However, the likelihood that adult Chinook salmon ascending the fish ladder will fall back below the dam increases with percent spill (Boggs et al. 2004).

Early studies found that 11 to 15 percent of juvenile Chinook salmon passing through the turbines at Bonneville Dam died (Bell et al. 1967, as cited in Whitney et al. 1997). Work was done to improve the facility for downstream juvenile passage; recent research from 2010 and 2011 found passage route survival estimates ranged from 93.5 percent (spillway in 2010) to 99.4 percent (Powerhouse 2 corner collector in 2011; Ploskey et al. 2012). Passage survival estimates incorporate passage under general operations and typical maintenance (e.g., screen blockages/cleaning) conditions.

2.5.2.3 Water Quality

Water quality in the action area is impaired. Common toxic contaminants found in the Columbia River system include PCBs, PAHs, PBDEs, DDT and other legacy pesticides, current use pesticides, pharmaceuticals and personal care products, and trace elements (LCREP 2007). The LCREP report noted widespread presence of PCBs and PAHs, both geographically and in the food web. Urban and industrial portions of the lower river contribute significantly to contaminant levels in juvenile salmon; juvenile salmon are absorbing toxic contaminants during their time rearing and feeding in the lower Columbia River (LCREP 2007). Likewise, juvenile salmon are accumulating DDT in their tissues and are exposed to estrogen-like compounds in the lower

[44] At Bonneville Dam, juvenile spring Chinook survival rates through the various passage routes under tested operational conditions are generally: turbines and spillway < PH1 surface passage route (sluiceway) < PH2 juvenile bypass system and surface passage route (corner collector). Increasing spill would be expected to decrease travel time to the extent fish are moved from turbine units to the spillway, but could decrease direct survival rates to the extent fish are moved from surface passage routes or the juvenile bypass system. A reduction in direct survival will not have a negative effect on the ESU if reduced powerhouse passage results in reduced delayed mortality as predicted by CSS (2017).

river, likely associated with pharmaceuticals and personal care products. Concentrations of copper are present at levels that could interfere with crucial salmon behaviors.

Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute municipal and industrial waste discharges to the lower Columbia River. Industrial and municipal wastes from the Portland/Vancouver metro areas, including the superfund-designated reach in the lower Willamette River, also contribute to degraded water quality in the lower Columbia River. Mining areas scattered around the basin deliver higher background concentrations of metals. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river. Small releases of materials such as lubricants occur during dam operation and maintenance and contribute to background exposure to contaminants in the Columbia River.

Outside of urban areas, the majority of residences and businesses rely on septic systems. Common water-quality issues with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff. Under these environmental conditions, fish in the action area are stressed. Stress may lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival).

Water temperatures in the Columbia River are a concern. Because of temperature standard exceedances, the Columbia River is included on the Clean Water Act §303(d) list of impaired waters established by Oregon and Washington. Temperature conditions in the Columbia River basin are affected by many factors, including:

- Natural variation in weather and river flow;
- Construction of the dam and reservoir system (the large surface areas of reservoirs and resulting slower river velocities contribute to warmer late summer/fall water temperatures);
- Increased temperatures of tributaries due to water withdrawals for irrigated agriculture, and due to grazing and logging;
- Point-source thermal discharges from cities and industries; and
- Climate change.

The EPA is working with federal and state agencies, the tribes, and other stakeholders to develop water-quality improvement plans (total maximum daily loads) for temperature in the Columbia River and lower Snake River. As part of the 2015 biological opinion on EPA's approval of water-quality standards, including temperature (NMFS 2015a), EPA committed to work with federal, state, and tribal agencies to identify and protect thermal refugia and thermal diversity in the lower Columbia River and its tributaries.

Comparisons of long-term temperature monitoring in the migration corridor before and after impoundment reveal a change in the thermal regime of the Snake and Columbia Rivers. Using historical flows and environmental records for the 35-year period 1960–95, Perkins and Richmond (2001) compared water-temperature records in the Lower Snake River with and without the lower Snake River dams and found three notable differences between the current versus unimpounded river:

- Maximum summer water temperature has been slightly reduced;
- Water temperature variability has decreased; and
- Post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall, a phenomenon termed thermal inertia.

These hydrosystem effects (influenced by the temperatures of tributary streams entering the Snake and Columbia Rivers both upstream of, within, and downstream of the mainstem dams) continue downstream and influence temperature conditions in the lower Columbia River. At a macro scale, water temperature affects salmonid distribution, behavior, and physiology (Groot and Margolis 1991); at a finer scale, temperature influences migration swim speed of salmonids (Salinger and Anderson 2006), timing of river entry (Peery et al. 2003), susceptibility to disease and predation (Groot and Margolis 1991), and, at temperature extremes, survival.

Another feature of water quality that affects mainstem water quality and habitat conditions is TDG. To facilitate the downstream movement of juvenile salmonids, Oregon and Washington regulatory agencies issue criteria adjustments for TDG as measured in the forebay and tailrace (NMFS 1995b). Specifically, water that passes over the spillway at a mainstem dam can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). Historically, TDG supersaturation was a major contributor to juvenile salmon mortality; to reduce TDG supersaturation, the Corps installed spillway improvements, typically “flip lips” to create a hydraulic jump and deflect water upwards, at each mainstem dam except The Dalles Dam. Biological monitoring shows that the incidence of GBT in both migrating smolts and adults remains between 1–2 percent when TDG concentrations in the upper water column do not exceed 120 percent of saturation in CRS project tailraces. When those levels are exceeded, there is a corresponding increase in the incidence of signs of GBT symptoms measured in the bypass system. Fish migrating at depth avoid exposure to the higher TDG levels due to pressure compensation mechanisms (Weitkamp et al. 2003). For the 2018 spill season, the Action Agencies targeted the 115/120 TDG with the goal of improving juvenile passage survival.

2.5.2.4 Tributary Habitat

Tributary habitat conditions throughout the LCR Chinook salmon ESU have been significantly degraded by an array of land uses, including urbanization, agriculture, forest management, transportation networks, and gravel mining. These land uses have blocked access to historically productive habitats, simplified stream and side channels, degraded floodplain connectivity and function, increased delivery of fine sediment to streams, and degraded riparian conditions (contributing to stream channel simplification, reduced bank stability, increased sediment load, and elevated water temperatures; NMFS 2013a; NWFSC 2015). In addition, tributary dams blocked access to core spawning areas for spring Chinook salmon populations, although several dams licensed by the Federal Energy Regulatory Commission (Marmot and Little Sandy Dams on the Sandy River, Condit Dam on the White Salmon River, and Powerdale Dam on the Hood River) were removed in recent years. When Bonneville Dam was completed in 1938, the reservoir behind the dam inundated considerable portions of historical spawning habitat at the mouths of tributaries for the Upper Gorge and White Salmon fall Chinook salmon populations (NMFS 2013a).

Numerous tributary habitat protection and restoration efforts have been implemented in recent years through the efforts of local recovery planning groups, federal and state agencies, tribal governments, local governments, conservation groups, private landowners, and other entities. These efforts have led to some local improvements in tributary habitat conditions. However, degraded habitat conditions, particularly with regard to channel complexity, floodplain connectivity, water-quality and hydrologic patterns, and toxic contamination, continue to negatively affect the abundance, productivity, spatial structure, and diversity of LCR Chinook salmon populations. Continued land development and habitat degradation, in combination with the potential effects of climate change, may present a continuing strong negative influence into the foreseeable future (NWFSC 2015).

2.5.2.5 Estuary Habitat

The estuary provides important migratory and rearing habitat for LCR Chinook salmon populations. Since the late 1800s, 68–70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening combined with flow regulation and other modifications (Kukulka and Jay 2003; Bottom et al. 2005; Marcoe and Pilson 2017). Disconnection of tidal wetlands and floodplains has eliminated much of the historical rearing habitat for subyearling Chinook salmon and reduced the production of wetland macrodetritus supporting salmonid food webs (Simenstad et al. 1990; Maier and Simenstad 2009), both in shallow water and for larger juveniles migrating in the mainstem (ERTG 2018).

Restoration actions in the estuary, such as those highlighted in the latest five-year review, have improved access and connectivity to floodplain habitat (NWFSC 2015). From 2004 through 2017, restoration sponsors implemented 58 projects, including dike and levee breaching or lowering, tide-gate removal, and tide-gate upgrades that reconnected 5,412 acres of historical tidal floodplain habitat to the mainstem. This represents a 2.5 percent net increase in the connectivity of habitats used extensively by subyearling Chinook salmon, including fish from the LCR ESU (Johnson et al. 2018; PNNL and NMFS 2018). Although yearling Chinook salmon migrants are less likely to enter and rear in these areas, improved opportunities for feeding on commonly consumed prey (chironomid insects and corophiid amphipods; PNNL and NMFS 2018) that drift into the mainstem are likely to contribute to survival at ocean entry.

2.5.2.6 Hatcheries

Hatchery production for LCR Chinook salmon has reduced the diversity and productivity of natural populations throughout the ESU. NMFS directs federal funding to many of the hatchery programs that affect the LCR Chinook salmon ESU through the Mitchell Act. NMFS completed a biological opinion on its funding of the Mitchell Act program in 2017 (NMFS 2017a). As a result, several new hatchery reform measures have been or will be implemented as described below. The implementation of these reform measures is expected to improve the status of the ESU.

- Changes in broodstock management to better align hatchery broodstocks with the diversity of the natural-origin populations that could be potentially affected by the hatchery programs.
- Modifications to the number of hatchery fish produced and released in certain programs, along with the installation of six new seasonal weirs in some tributaries, will reduce the number of hatchery-origin fish spawning naturally, which has posed both a genetic and ecological risk. The production-level changes will reduce the pHOS[45] as described in Table 2.5-4, and reduce genetic and ecological risk.
- Upgrades to hatchery facilities to bring water-intake screens into compliance with new standards that ensure they minimize adverse impacts to ESA-listed fish.
- Even with these improvements, hatchery production will continue to limit the diversity and productivity of natural production of LCR Chinook salmon. In addition, LCR Chinook salmon are affected by hatchery production of salmon and steelhead from other ESUs and DPSs. Hatchery programs were designed to conserve vital genetic resources and to supplement harvest levels to compensate for losses throughout the life cycle. Some scientists suspect that closely spaced releases of hatchery fish from all Columbia Basin hatcheries may lead to increased competition with natural-origin fish for food and habitat space in the estuary. NMFS (2006) and the Lower Columbia Fish Recovery Board (LCFRB 2010) identified competition for food and space among hatchery-origin and natural-origin juveniles in the estuary as a critical uncertainty. ODFW (2010) acknowledged this uncertainty, but listed competition for food and space as a secondary limiting factor for juveniles of all populations.

[45] Percent hatchery fish on the spawning grounds.

Table 2.5-4. Expected genetic effect levels on LCR Chinook salmon populations potentially affected by Mitchell Act-funded hatchery programs. Expected pHOS levels are based on a four-year average. Primary populations are targeted for viability, meaning high or very high persistence probability. Contributing populations are targeted for some improvement in status so that the MPG-wide average viability is 2.25 or higher.

Major Population Group	Population	Recovery Designation	Recent Average pHOS (2010–15)	Expected pHOS levels once Mitchell Act reforms are fully implemented
Coast	Elochoman/Skamokawa	Primary	79%	≤50%
	Mill/Germany/Abernathy	Primary	89%	≤50%
	Grays/Chinook	Contributing	73%	≤50%
Cascade	Coweeman	Primary	15%	≤10%
	Lower Cowlitz	Contributing	27%	≤30%
	Toutle	Primary	64%	≤30%
	Kalama (fall)	Contributing	84%	≤10%
	Kalama (spring	Contributing	~0%	≤10%
	Lewis	Primary	34%	≤10%
	Washougal	Primary	65%	≤30%

2.5.2.7 Recent Ocean and Lower River Harvest

In February 2018, NMFS signed the 2018–27 *U.S. v. Oregon* Management Agreement, which provides a framework for managing salmon and steelhead fisheries and hatchery programs in much of the Columbia River basin. The decision was based on both our recently completed Final EIS and the associated biological opinion (NMFS 2018a). As a result, fisheries affecting LCR Chinook salmon in the 2018–27 *U.S. v. Oregon* Management Agreement are aligned with the recovery strategies in the recovery plan (NMFS 2013a).

Mark-selective fisheries are used below Bonneville Dam to limit impacts to natural-origin spring Chinook salmon. Impacts to the spring populations in the ESU in the winter, spring, and summer seasons are low, with an expected harvest rate ranging from 0.2–2.0 percent.

Three of the spring Chinook salmon populations in the Cascade MPG are supported by associated hatchery programs, since dams currently block passage to most, if not all, of their historic spawning and rearing habitat. Therefore, the genetic legacies of the Upper Cowlitz, Tilton, and Lewis populations in the Cascade Spring MPG are still housed in hatchery programs. In 2018, NMFS concluded that it is appropriate that harvest be managed to ensure that hatchery escapement goals are met, thus protecting what remains of the genetic legacy of the ESU (NMFS 2018a). This approach is consistent with the recovery plan that expects comprehensive solutions for populations with multiple issues, such as spawning access, hatcheries, and harvest (NMFS 2013a). In the Gorge MPG, the biological opinion indicated the proposed tributary harvest rates may not be consistent with achieving recovery goals once populations are reintroduced, habitat improvements are made, and the populations are no longer reliant on hatcheries for their continued survival. However, given the current reliance on the hatchery supplementation program for Hood River spring Chinook salmon and the lack of harvest on the currently extirpated White Salmon population, NMFS concluded that the proposed fisheries are adequately protective of the Gorge Spring MPG populations (NMFS 2018a).

LCR fall-run (tule)[46] Chinook salmon are managed subject to an abundance rate schedule for a total escapement rate that ranges from 30 to 41 percent. The harvest schedule applies to all ocean and inriver fisheries below Bonneville Dam. In 2018, we acknowledge this as a conscientious approach which ensures the gains that have been made in VSP scores in the past few years continue to accrue.

Similarly, by continuing to limit inriver fisheries to an escapement goal of 5,700 spawners for the North Fork Lewis population, the principal indicator stock for management for the bright component of the ESU, we expect to retain the VSP scores indicating an improved viability over the next ten years and into the foreseeable future. The escapements have averaged 12,400 over the last ten years, exceeding both the maximum sustained yield escapement goal and the delisting abundance goal for the North Fork Lewis population.

LCR spring Chinook salmon are caught incidentally in ocean fisheries, primarily off the Washington coast and as far north as Alaska. In spring season fisheries, they are caught in the Columbia River mainstem and tributaries. Exploitation rates[47] have declined, with rates for the Cowlitz spring population declining to 27 percent since 2005.

LCR fall-run (tule) Chinook salmon are caught in ocean fisheries off the coasts of Oregon, Washington, and British Columbia. In fall fisheries, they are caught in the Columbia River mainstem and tributaries. Since 2012, they have been managed subject to an abundance rate schedule for a total exploitation rate that ranges from 30 to 41 percent. Recent exploitation rates have been highly variable, but have averaged 37.2 percent since 2008.

[46] Historically, the Oregon portion of the ESU contained 12 populations: nine fall run Chinook (tule); 1 late fall run Chinook (brights); and 2 spring run Chinook. Only two of these populations show substantial natural production.
[47] Exploitation rate is the proportion of the total return of adult salmon in a given year that die as a result of fishing activity.

While exploitation rates have also declined for the North Fork Lewis bright population, averaging 43 percent since 2000, the goal for harvest management is 5,700 escapements.[48] This goal is based on estimates of the escapement needed to achieve maximum sustained yield. Thus, even though harvest loss is high for this population, harvest actions continue to pass more fish through the fisheries than the delisting abundance goal would require.

Unauthorized harvest also contributes to the loss of fish that occurs during upstream migration, but while we are collectively able to estimate with substantial accuracy what the total adult survival rates are, we are still not able to apportion the mortality individually to the contributing factors. However, we continue to measure and account for loss in Bonneville Reservoir and incorporate its effect in the environmental baseline.

2.5.2.8 Predation

The existence of dams and reservoirs around the Columbia Basin also blocks sediment transport. Total sediment discharge into the estuary and Columbia River plume is about one-third of nineteenth-century levels (NMFS 2008a). This reduces turbidity in the lower river, especially during spring, which is likely to make juvenile outmigrants more vulnerable to visual predators like piscivorous birds and fishes.

2.5.2.8.1 Avian Predation

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, are having a significant impact on the survival of juvenile salmonids (including LCR Chinook salmon) in the Columbia River. Caspian terns on Rice Island, an artificial dredged-material disposal island in the estuary, consumed about 5.4-14.2 million juveniles per year in 1997 and 1998, or 5-15 percent of all the smolts reaching the estuary (Roby et al. 2017). Efforts began in 1999 to relocate the tern colony 13 miles closer to the ocean at East Sand Island where the tern diet would diversify to include marine forage fish. During 2001-15, estimated consumption by terns on East Sand Island averaged 5.1 million smolts per year, about a 59 percent reduction compared to when the colony was on Rice Island. Management efforts are ongoing to further reduce salmonid consumption by terns in the lower Columbia River and similar efforts are in progress to reduce the nesting population of double-crested cormorants in the estuary.

In an effort to estimate predation rates on LCR Chinook salmon by birds nesting in the lower river, Sebring et al. (2010) released a total of 12,116 PIT-tagged subyearling smolts from several lower Columbia River hatcheries. Based on recoveries of these tags at East Sand Island, predation rates averaged 4.4 percent for Caspian terns and 18.0 percent for double-crested cormorants in 2009. Lyons et al. (2014) modeled an overall average predation rate for East Sand Island cormorants on juvenile LCR fall-run Chinook salmon of 24 percent by adjusting the predation rates for fish originating above Bonneville Dam for the higher availability of fish from lower Columbia River hatcheries. Both of these estimates were made before the Corps reduced the size of the tern colony to one acre or began to implement the Double-crested Cormorant

[48] The number of salmon returning to the spawning grounds.

Management Plan. The researchers have not estimated predation rates for this ESU in recent years, but in 2017 any improvement in Caspian tern predation rates was offset to an unknown degree by about 1,000 terns roosting or trying to nest on Rice Island. In addition, substantial numbers of cormorants have relocated to the Astoria-Megler Bridge (preliminary report of 1,737 in 2018) and hundreds more are observed on the Longview Bridge, navigation aids, and transmission towers in the lower river (Anchor QEA et al. 2017). Smolts may constitute a larger proportion of the diet of cormorants nesting at these sites than if the birds were foraging from East Sand Island. Thus, the success of the East Sand Island tern and cormorant management plans at meeting their underlying goals of reducing salmonid predation is uncertain at this time.

In the hydrosystem reach, the Action Agencies have employed wire arrays, pyrotechnics, water cannons, and other measures, including limited lethal take at project tailraces in the lower Columbia River. These measures have been shown to reduce predation rates on juvenile salmonids at John Day and The Dalles Dams, and may have had similar effects at Bonneville Dam (Zorich et al. 2012).

2.5.2.8.2 Piscivorous Fish Predation

Native pikeminnow are significant predators of juvenile salmonids in the Columbia River basin, followed by nonnative smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011, 2015). Before the start of the NPMP in 1990, this species was estimated to eat about eight percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River basin each year. Williams et al. (2017) compared current estimates of northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. On average, 43 adult Chinook salmon, including jacks, and 67 juveniles were killed and/or handled each year in the Sport Reward Fishery during 2013-17. The fishery is conducted over a much larger area than that occupied by LCR Chinook salmon, but small numbers of these fish could have been from this ESU.

The Action Agencies also conduct a Dam Angling Program at The Dalles and John Day Dams. Anglers caught an average of one adult and zero juvenile Chinook salmon per year during 2013-2017 (Williams 2013, 2014; Williams et al. 2015, 2016, 2017). Some of these may have been LCR Chinook salmon.

2.5.2.8.3 Pinniped Predation

California and Steller sea lions aggregate each spring at the base of Bonneville Dam (and below Willamette Falls on the lower Willamette River), where they feed on adult salmon and steelhead. In 2016, the Corps documented the second-largest number of pinnipeds at Bonneville Dam and the second-largest estimate of salmonid predation since observations began in 2002: 9,525 fish, or 5.8 percent of adult salmonid passage between January 1st and May 31st (USACE 2017). In addition, numbers of Steller sea lions have been increasing between August and December in recent years (from an average of three per day in October 2011 to 22 per day in 2015; Madson et al. 2017) and are assumed to intercept adult Snake River fall-run Chinook salmon as well as spring- and summer-run fish from the Upper Columbia and Snake River ESUs. Recent declines in pup production and survival suggest the population may have stopped growing.

NMFS' NWFSC began studying the losses of adult spring- and summer-run Chinook salmon to sea lions between the mouth of the river and Bonneville Dam in 2010. Average annual survival through this reach has ranged from 58 percent to 91 percent, generally decreasing through 2015 (M. Rub, NWFSC, pers. comm., 2017). Preliminary estimates indicate that survival was higher during 2016. Up to 50 percent of the mortality of adult spring- and summer-run Chinook salmon destined for tributaries above Bonneville occurred within the 10-mile reach just below the dam.

Adult LCR Chinook salmon are also vulnerable to predation throughout the lower Columbia River. This vulnerability is primarily for the nine spring-run populations that migrate during May and June, when the pinnipeds' abundance is highest. Under an authorization under the Marine Mammal Protection Act, management agencies have implemented numerous measures to reduce predation at Bonneville Dam and Astoria, from hazing to removal. From 2008 through 2017, 15 California sea lions at Bonneville Dam were captured and placed in captivity (Brown et al. 2017). During that same period, 163 California sea lions were euthanized at Bonneville Dam and five at Astoria (Brown et al. 2017).

2.5.2.8.4 Compensatory Effects and Predation on Salmonid Populations

An estimate of the effect of a predator population on adult returns to Bonneville Dam (e.g., the effect of smolt consumption by northern pikeminnow or Caspian terns) has the potential to be erroneous if it does not consider whether other factors intervene to compensate for the change in mortality (ISAB 2016). The primary mechanisms for compensatory effects are: (1) increased fish survival due to reduced densities in later life stages, (2) selective predation based on fish size and condition, and (3) predators switching from one prey species to another. Compensatory effects are difficult to quantify because they can occur later in the life cycle and can vary over time; efforts are currently underway to better understand compensatory effects (Haeseker 2015; Evans et al. 2018b).

2.5.2.9 Research and Monitoring Activities

The primary effects of the past and ongoing CRS-related RM&E programs on LCR Chinook salmon are associated with the capturing and handling of fish. The RM&E program is a collaborative, regionally coordinated approach to fish and habitat status monitoring, action effectiveness research, critical uncertainty research, and data management. The information derived from the program facilitates effective adaptive management through better understanding the effects of the ongoing CRS action. Capturing, handling, and releasing fish generally leads to stress and other sublethal effects, but fish sometimes die from such treatment. The mechanisms by which these activities affect fish have been well documented and are detailed in Section 8.1.4 of the 2008 biological opinion. Some RM&E actions also involve sacrificial sampling of fish. We estimated the number of LCR Chinook salmon that have been handled each year during the implementation of RM&E under the 2008 RPA as the average annual take reported for 2013-2017:

- Average annual estimates for handling and mortality of LCR Chinook salmon associated with the Smolt Monitoring Program and the CSS was limited to 2,667 hatchery and 829 wild juveniles handled (none died).
- The estimated handling and mortality of LCR Chinook salmon associated with the ISEMP was limited to 1,682 wild juveniles handled and eight wild juveniles died.
- Estimates for LCR Chinook salmon handling and mortality for all other RM&E programs: (1) 20 hatchery and 15 wild adults handled; (2) one hatchery and one wild adult died; (3) 2,295 hatchery and 1,256 wild juveniles handled; and (4) 141 hatchery and 17 wild juveniles died.

The combined take (i.e., handling, including injury, and incidental mortality) associated with these elements of the RM&E program has, on average, affected less than 1 percent of the wild (i.e., natural origin) adult returns or juvenile production for the LCR Chinook salmon ESU (Bellerud 2018). This relatively small effect is deemed worthwhile because it allows the Action Agencies and NMFS to evaluate the effects of CRS operations, including modifications to facilities, operations, and mitigation actions.

In addition, northern pikeminnow are tagged as part of the Sport Reward Fishery and their rate of recapture is used to calculate exploitation rates. Northern pikeminnow are collected for tagging using boat electrofishing in select reaches of the Columbia River. During 2017, northern boat electrofishing operations in the Columbia River extended upstream from RM 47 (near Clatskanie, Oregon) to RM 394 (Priest Rapids Dam), and in the Snake River from RM 10 (Ice Harbor Dam) to RM 41 (Lower Monumental Dam) and from RM 70 (Little Goose Dam) to RM 156 (upstream of Lower Granite Dam). Researchers conducted four sampling events consisting of 15 minutes of boat electrofishing effort in shallow water within each 0.6-mile reach during April-July.

A side effect of the electrofishing effort is that salmon and steelhead may be exposed to the electrofishing field, with the potential for injury, stress, and fatigue and even cardiac or respiratory failure (Snyder 2003). Some adult and juvenile LCR Chinook salmon are likely to be present in shallow shoreline areas during the April-July time period. Most sampling occurs in darkness (1800-0500 hours). Operators shut off the electrical field if salmonids are seen and because most stunned fish quickly recover and swim away, they cannot be identified to species (i.e., Chinook, coho, chum, or sockeye salmon or steelhead). Barr (2018) reported encountering an annual average of 891 adult and 60,312 juvenile salmonids in the lower Columbia River each year during 2013-17 electrofishing operations based on visual estimation methods. It is likely that some of these were LCR Chinook salmon.

2.5.2.10 Critical Habitat

The environmental baseline for the PBFs for LCR Chinook salmon critical habitat are reflected in the same impacts discussed above (e.g., mainstem flows, passage, water quality, predation) and summarized here in Table 2.5-5. Tributary barriers are a concern for freshwater spawning sites, freshwater rearing sites, and migration corridors. Water quality is a concern for all PBFs. Restoration activities addressing migration barriers and water quality have improved the baseline condition for PBFs; however, more restoration is needed before the PBFs can fully support the conservation of LCR Chinook salmon.

Table 2.5-5. Physical and biological features (PBFs) of designated critical habitat for LCR Chinook salmon.

Physical and Biological Feature (PBF)	**Components of the PBF**	**Principal Factors affecting Environmental Baseline Condition of the PBF**
Freshwater spawning sites	Water quantity and quality and substrate to support spawning, incubation, and larval development	● Tributary barriers (culverts, dams, water withdrawals) ● Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) ● Loss of wetland and side channel connectivity (urban and rural development, forest and agricultural practices, channel manipulations) ● Excessive sediment in spawning gravel (forest and agricultural practices) ● Elevated water temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices ● Inundation of spawning sites under Bonneville Reservoir (hydrosystem development)
Freshwater rearing sites	Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility, water quality and forage, and natural cover	● Tributary barriers (culverts, dams, water withdrawals) ● Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) ● Loss of wetland and side channel connectivity (urban and rural development, forest and agricultural practices, channel manipulations) ● Excessive sediment in spawning gravel (forest and agricultural practices) ● Elevated water temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices)

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBF
Freshwater migration corridors	Free of obstruction and excessive predation, adequate water quality and quantity, and natural cover	● Delay and mortality of some juveniles and adults ● Concerns about increased opportunities for predators, especially birds and pinnipeds (construction of dredge-material islands in the lower river and other human-built structures used by terns and cormorants for nesting, constricted passage opportunities for adult Chinook salmon in the Bonneville tailrace)
Estuarine areas	Free of obstruction and excessive predation with water quality, quantity, and salinity, natural cover, juvenile and adult forage	● Diking off areas of the estuary floodplain (land use), combined with reduced peak spring flows (water diversions and water storage and hydroelectric projects) have reduced access to floodplain habitat for rearing and prey production
Nearshore marine areas[1]	Free of obstruction and excessive predation with water quality, quantity, and forage	● Concerns about increased opportunities for pinniped predators, adequate forage

[1] Designated area includes only the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

2.5.2.11 Anticipated Impacts of Completed Consultations

The environmental baseline also includes the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, including the consultation on the operation and maintenance of the Bureau of Reclamation's upper Snake River projects. The 2016 five-year review evaluated new information regarding the status and trends of LCR Chinook salmon, including recent biological opinions issued for the LCR Chinook salmon and key emergent or ongoing habitat concerns (NMFS 2016c). Since the beginning of 2015 through 2017, we completed 487 formal consultations (131 in 2015, 148 in 2016, and 202 in 2017) that addressed effects to LCR Chinook salmon.[49] These numbers do not include the many projects implemented under programmatic consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed salmonids. Some of the completed consultations are large (large action area, multiple species), such as the Mitchell Act consultation and the consultation on the 2018–27 *U.S. v. Oregon* Management Agreement. Many of the completed actions are for a single activity within a single subbasin.

Some current and proposed restoration projects will improve access to blocked habitat and riparian condition, and increase channel complexity and instream flows. For example, under

[49] PCTS data query, July 31, 2018.

BPA's Habitat Improvement Programmatic consultation, BPA implemented 29 projects in the Columbia Basin that improved fish passage in 2017, and 99 projects that involved river, stream, floodplain, and wetland restoration. These projects may benefit the viability of the affected populations by improving abundance, productivity, and spatial structure. Some restoration actions may have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (typically less than a few weeks).

Other types of federal projects, including grazing allotments, dock and pier construction, and bank stabilization, will be neutral or have short- or even long-term adverse effects. All of these actions have undergone section 7 consultation and the actions or the RPA were found to meet the ESA standards for avoiding jeopardy.

Similarly, future federal restoration projects that have already undergone consultation will improve the functioning of the PBFs safe passage, spawning gravel, substrate, water quantity, water quality, cover/shelter, food, and riparian vegetation. Projects implemented for other purposes will be neutral or have short- or even long-term adverse effects on some of these same PBFs. However, all of these actions, including any RPAs, have undergone section 7 consultation and were found to meet the ESA standards for avoiding adverse modification of critical habitat.

2.5.2.12 Summary

The factors described above have negatively affected the abundance, productivity, diversity, and spatial structure of LCR Chinook salmon populations. Recent improvements in passage conditions at Bonneville Dam and at tributary barriers, the small net improvement in floodplain connectivity achieved through the CRS estuary habitat program, and efforts to improve hatchery practices and lower harvest rates are positive signs, but other stressors are likely to continue. NMFS (2016c) identified past land development, habitat degradation, and predation, in combination with the potential effects of climate change, as likely to present a continuing strong negative influence into the foreseeable future.

Likewise, the environmental baseline within the action area does not fully support the conservation value of designated critical habitat for LCR Chinook salmon as described above. The PBFs essential for the conservation of LCR Chinook salmon include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine rearing areas, and nearshore marine areas (at the mouth of the Columbia River).

The CRS Action Agencies and other federal and nonfederal entities have taken actions in recent years to improve the functioning of some of these PBFs of critical habitat. Recent surface passage improvements are expected to reduce delay and mortality of juvenile Chinook salmon at Bonneville Dam. For stream-type juveniles, projects that have protected or restored riparian areas and breached or lowered dikes and levees in the estuary have improved the functioning of the juvenile migration corridor. For subyearling smolts, restoration projects in the estuary are improving the functioning of areas used for growth and development. However, other factors that have negative effects on these PBFs are expected to continue into the future.

2.5.3 Effects of the Action

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

The proposed action is an ongoing action that has been modified over time to reflect capital improvements, as well as changes in operation based on existing conditions and improved information on how CRS operations affect LCR Chinook salmon and other listed species and their critical habitats. The current proposed action includes operational measures (e.g., flood risk management, navigation, fish passage, and hydropower generation) and non-operational measures (e.g., support for conservation hatchery programs, predation management, habitat improvement actions) that will be implemented beginning in 2019. The proposed action, however, is of limited duration. The Action Agencies are developing an EIS in accordance with NEPA that will assess and update the approach for long-term system operations, maintenance, and configuration as well as evaluate measures to avoid, offset, or minimize impacts to resources affected by the management of the CRS, including ESA-listed species and designated critical habitat. A court order currently requires the Action Agencies to issue Records of Decision on or before September 24, 2021.[50] Based on scoping, the range of alternatives being examined is broad and includes potential large-scale changes in the action. Thus, there is substantial uncertainty regarding what system operations, maintenance, and configuration the Action Agencies will propose at the conclusion of the NEPA process. Likewise, it is unknown what measures intended to avoid, offset, or minimize adverse effects will ultimately be included in the final preferred alternative.

As described in Section 2.1 above, our analysis of effects for LCR Chinook salmon extends from 2019 into the future, but emphasizes the evaluation of effects that are reasonably certain to occur as a result of implementing the proposed action pending completion of the EIS and our issuance of a subsequent biological opinion addressing the effects of the final preferred alternative. To the extent our consideration of potential effects beyond that time period assumes the current proposed action remains in place, it is intended, in part, to inform the evaluation of alternatives in the EIS.

The Action Agencies will operate the run-of-river lower Columbia River projects (McNary, John Day, The Dalles, and Bonneville Dams) in accordance with the annual Water Management Plan and Fish Passage Plan (including all appendices). These projects are operated for multiple

[50] The Presidential Memorandum on Promoting the Reliable Supply and Delivery of Water in the West, issued on October 19, 2018, required the development of an expedited schedule for completion of the NEPA process. The Council on Environmental Quality has confirmed a revised schedule that calls for completing the Draft EIS in February 2020, the Final EIS in June 2020 and Records of Decision by September 30, 2020. These dates are consistent with, but earlier than, the court-ordered deadlines.

purposes, including fish and wildlife conservation, irrigation, navigation, power, recreation, and, in the case of John Day Dam, limited flood risk management.

The effects of the proposed action to LCR Chinook are generally consistent with the effects caused by a continuation of the CRS operations as described in the environmental baseline section, with the exception of the addition of the flexible spring spill operation, which is expected to alter conditions for the five LCR Chinook salmon populations migrating upstream of Bonneville Dam. The other operational changes are not anticipated to alter the effects to LCR Chinook salmon because no fish in the ESU will be exposed to the effects of those changes.

2.5.3.1 Effects to Species

Both juvenile and adult LCR Chinook salmon from all 32 populations will be exposed to the continuing effects of the action in the mainstem Columbia River. For the five populations that migrate above Bonneville Dam (Upper Gorge Fall Run, White Salmon Fall Run, Hood River Fall Run, White Salmon Spring Run, and Hood River Spring Run), they will also be exposed to the habitat effects described above, as well as to changes in spring operations at The Dalles and Bonneville Dams that will increase spring spill levels as a result of the flexible spring spill operation.

2.5.3.1.1 Hydrosystem Operation

For LCR Chinook salmon, the effects of operating the hydrosystem as proposed will be essentially a short-term continuation of the recent hydrosystem effects described in the environmental baseline (resulting from implementation of the 2008 biological opinion's reasonable and prudent alternative hydrosystem actions), with the addition of the flexible spring spill operation. This includes recent passage improvements that have further improved the survival of yearling (spring) and subyearling (fall) Chinook salmon that pass through Bonneville Dam (Upper Gorge Fall Run, White Salmon Fall Run, White Salmon Spring Run, Hood River Fall Run, and Hood River Spring Run populations). These include improvements to the sluiceway (fish guidance efficiency and survival) at Powerhouse 1, installation of minimum gap runner turbines at Powerhouse 1 (survival), and improvements to the screens and turbine unit operations at Powerhouse 2 (survival). Ploskey et al. (2011) and Skalski et al. (2012) estimated juvenile dam passage survival for yearling Chinook salmon to be 95.2 percent (SE = 0.4 percent) in 2010 in a single release study, and 96.0 percent (SE = 1.8 percent) in 2011 in a virtual paired release study, respectively. Based on PIT-tag detections of Snake River spring/summer and fall Chinook salmon at Bonneville Dam, and later redetected at upstream dams, we estimate upstream survival rates of 98.6 and 96.9 percent for adult spring- and fall-run Chinook salmon, respectively. We believe direct survival for both juvenile and adult LCR Chinook salmon passing Bonneville Dam will be similar to those described in the environmental baseline during the performance level spring spill condition.

During periods of increased spring spill, the effects to LCR Chinook salmon include: (1) potential for increased fallback of adults for the two spring-run populations that spawn upstream of Bonneville Dam (White Salmon Spring Run and Hood River Spring Run);[51] (2) juveniles from those populations that migrate downstream from April 10 to June 15 will be more likely to pass through the spillway and less likely to pass through the Powerhouse 2 turbines, juvenile bypass system, or corner collector or Powerhouse 1; and (3) exposure to increased levels of TDG (up to 120 or 125 percent depending on short term modification of water quality criteria) as a result of the flexible spring spill operation l in Bonneville pool and downstream of the dam for at least 35 miles.

High spill is correlated with fallback behavior at Bonneville Dam for Chinook salmon, which can increase the risk of injury and fatigue (Boggs et al. 2004). This would most likely affect the two populations of LCR Chinook salmon (White Salmon Spring Run and Hood River Spring Run) that migrate upstream of Bonneville Dam during the spring, or those individual fish overshooting nearby tributaries from other populations. Similarly, because smolt survival rates are lower through the spillway at Bonneville Dam than through several other routes of passage, increased passage rates through the spillway, in comparison to the juvenile bypass system or corner collector at Powerhouse 2, for example (Ploskey et al. 2012), will likely result in slightly decreased survival rates compared to recent operations. The Fish Passage Center, citing the CSS, hypothesizes that increased spill will substantially reduce latent mortality of populations moving downstream through the mainstem dams (CSS 2017).

Compared to the environmental baseline,[52] increased spill levels from April 10 to June 15 will increase the exposure of adult spring migrating adults and smolts to higher concentrations of TDG from the Bonneville pool downstream to at least 35 miles below Bonneville Dam. The increased exposure will likely affect the five populations within the Bonneville Reservoir and those populations most proximal to Bonneville Dam, though increased TDG levels can be measured for at least 35 miles downstream of the dam. Exposure to elevated TDG (up to 125 percent) levels as a result of increased juvenile fish passage spill may affect individual smolts, but should have little, if any, substantive effect on juveniles migrating swiftly past Bonneville Dam and its tailrace because of the brevity of exposure. Adults could be exposed for hours or days to elevated TDG levels as they seek out fishway entrances in the tailrace of Bonneville Dam. However, the potential impacts of exposure up to 120 to 125 percent TDG levels will likely be very limited due to depth compensation.

The other proposed changes to CRS operations are not anticipated to negatively affect LCR Chinook salmon survival. In particular, the changes in usable forebay ranges (MOP 1.5-foot range) at the Lower Snake River reservoirs and the change in operating range at the John Day forebay (MIP 2-foot range) will result in inconsequential variations in the timing and amount of flow in the lower Columbia River.

[51] Adults from the three fall-run populations that migrate above Bonneville Dam will not be in the river during the flexible spring spill operation.
[52] The hydro action under the environmental baseline targeted 100 kcfs spill from 2008–17. In 2018, spill levels were increased to the Gas Cap limit (up to 120 percent TDG in the tailrace of Bonneville Dam).

2.5.3.1.2 Predator Management and Monitoring Actions

The Corps' program to install and operate sea lion excluder gates at Bonneville Dam will continue[53] and will likely positively affect the five populations that pass upstream of Bonneville Dam. Likewise, the Corps' and BPA's support of land- and water-based sea lion harassment and removal efforts from the area downstream of Bonneville are likely to substantially reduce adult mortality of spring-run populations (compared to if these actions were not taken).

The pikeminnow predation management program includes the Sport Reward Fishery and Dam Angling programs, which will continue as part of the proposed action. The first is implemented in the Columbia River, including the estuary. This fishery removes approximately 10–20 percent of predatory-sized pikeminnow per year and is open from May through September, when juvenile Chinook can be rearing and migrating in mainstem habitats. We expect that this ongoing measure will continue the 30 percent reduction in predation rates achieved under the 2008 RPA. We estimate that numbers of Chinook salmon, including some from the LCR Chinook salmon ESU, handled and/or killed in the Sport Reward Fishery will be no more than 100 adults (including jacks) and 200 juveniles per year during the interim period.

The Action Agencies will also continue to implement the Northern Pikeminnow Dam Angling Program at The Dalles and John Day Dams, as described under the environmental baseline. These ongoing measures will continue the reduction in predation rates achieved under the 2008 RPA. We estimate that no more than ten adult (including jacks) and 20 juvenile Chinook salmon, including LCR Chinook salmon, will be caught in the Dam Angling Program per year during the interim period.

The Action Agencies propose to continue implementation of the Caspian Tern Nesting Habitat Management Plan (USACE 2015a) and the Double-crested Cormorant Management Plan (USACE 2015b). As discussed in the Environmental Baseline section, it is difficult to quantify an increased survival because of observations of birds relocating to other sites in the estuary and year-to-year variation in bird population size. Because the Action Agencies propose to continue maintaining the reduced amounts of nesting habitat achieved for terns and cormorants on East Sand Island (BPA et al. 2018a), we expect that any reduced predation rates achieved for LCR Chinook salmon under the 2008 FCRPS biological opinion and associated RPA will continue during the interim period. The Action Agencies will also continue to implement, and improve as needed, the avian predation deterrence measures at the tailrace of Bonneville Dam, which address another source of juvenile LCR Chinook salmon mortality.

The Action Agencies propose to synthesize avian colony size and predation rate data collected under the tern and cormorant colony management plans. The intent of the synthesis report is to provide the Action Agencies, Cooperating Agencies, and NMFS with a summary of predation by piscivorous waterbirds on ESA-listed salmonids in the Columbia River basin before, during, and after the management actions, in order to assess their effectiveness on a basinwide scale. This

[53] The excluder gates are removed and reinstalled seasonally based on the presence of sea lions.

review will help the Action Agencies prioritize any efforts to take place during this interim period or to be discussed as future mitigation measures in the CRS Operations NEPA document.

2.5.3.1.3 Habitat Actions

For those lower Columbia populations that have been negatively affected by the CRS, the Action Agencies will provide funding and/or technical assistance for tributary habitat improvement actions consistent with basinwide criteria for prioritizing actions, including recovery plan priorities, as funding allows. If implemented, and if implemented in a manner consistent with scientifically sound identification and prioritization of limiting factors and geographic locations, such actions could provide benefits to the targeted populations. However, because the Action Agencies have not proposed a commitment to implement tributary habitat improvement actions for LCR Chinook salmon as part of this proposed action, or proposed them in a manner where we could meaningfully assess the effects (e.g., committing to achieve specific amounts or types of restoration), we are not considering the benefits of potential projects in our analysis.

The Action Agencies have committed to continue to implement the CEERP to increase the capacity and quality of estuarine ecosystems and improve access for juvenile salmonids. The Action Agencies will continue to emphasize reconnection of floodplain areas in tidally influenced waters of the lower Columbia River and estuary, primarily through modifying levees. Additional actions at habitat improvement sites will include recreating historical channel networks, reducing the presence of nonnative species, and revegetating habitat improvement sites with native vegetation to ensure a site's resiliency. These projects are expected to provide direct (onsite) and indirect (increased transfer of insect and amphipod prey to the mainstem migration corridor) benefits to LCR Chinook salmon as they rear in and migrate through the estuary. The subyearling life-history type, which dominates this ESU, spends longer in the estuary (several weeks to several months) and thus is likely to benefit more than spring-run populations, which chiefly produce yearling outmigrants.

NMFS agrees with the ISAB's assessment findings that it is difficult to reliably quantify the survival benefits of estuary habitat restoration, but the Action Agencies' assessment method, including review by the ERTG,[54] is useful to prioritize projects. The Action Agencies' proposed action includes a commitment to reconnect an average of 300 acres of floodplain per year to the mainstem, a goal that they have a record of achieving in 2008-17 (BPA et al. 2018b). The habitat's conservation value is likely to improve as more habitat gets reconnected, and the benefits are likely to accrue as the habitat patches get larger (Spiesman et al. 2018). While juvenile LCR Chinook salmon have been observed using reconnected habitats (Johnson et al. 2018), we agree that a link to survival benefits has not been demonstrated. However, it is our

[54] As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss with ERTG and regional partners relevant climate change science in an effort to understand whether their planned estuary projects are resilient to climate change (i.e., sea level rise, temperatures, and mainstem flow levels). In addition, the Action Agencies' annual update of their restoration and monitoring plans for the estuary will document any needed adjustments in design, location, or other elements of a given project to address climate change impacts, both during and beyond the interim period.

opinion that these habitats provide important resting and feeding areas for subyearling LCR Chinook salmon, and are likely to provide important prey items to yearling LCR Chinook salmon in the mainstem. It is also likely that as restored habitat area accrues over time and as habitat quality matures, the improved habitat will improve juvenile survival, even if that improvement cannot be quantified because of the complexity of habitat use by salmon and the variety of factors throughout their life cycle that contribute to survival.

2.5.3.1.4 Research and Monitoring Activities

The Action Agencies' RM&E program will be similar to the current program, or will be implemented at a reduced scale. Thus, the level of injury and mortality discussed in the Environmental Baseline, primarily from the capturing and handling of fish, is likely to continue at a similar or reduced level. We estimate that, on average, the following numbers of LCR Chinook salmon will be affected each year during the interim period:

- Projected estimates of LCR Chinook salmon handling and mortality during activities associated with the Smolt Monitoring Program and the CSS: (1) zero hatchery or wild adults handled or killed; (3) 9,039 hatchery and zero wild juveniles handled; and (4) zero hatchery and 896 wild juveniles killed.
- Projected estimates of LCR Chinook salmon handling and mortality during activities associated with Fish Status Monitoring: (1) zero hatchery or wild adults handled; and (2) zero hatchery or wild adults killed.
- Projected estimates of LCR Chinook salmon handling and mortality for all other RM&E programs: (1) 868 hatchery and 47 wild adults handled; (2) nine hatchery and one wild adult killed; (3) 99,937 hatchery and 114,575 wild juveniles handled; and (4) 999 hatchery and 1,146 wild juveniles killed.

The combined observed mortality associated with these elements of the RM&E program will, on average, affect less than 1 percent of the wild (i.e., natural origin) adult returns or juvenile production for the LCR Chinook salmon ESU (Bellerud 2018). Although we estimate that 1.02 percent of the wild juvenile production will be handled each year, we expect that only up to one percent of these will die after release (i.e., 0.01 percent of those handled). This relatively small effect is deemed worthwhile because it will allow the Action Agencies and NMFS to continue to evaluate the effects of CRS operations including modifications to facilities, operations, and mitigation actions.

Electrofishing operations for the NPMP during the interim period are expected to continue at the same level of effort as in recent years (four 15-minute sampling events per 0.6-mile reach between RM 47 and The Dalles Dam during April-July; a total of 550 hours system-wide). Some adult and juvenile LCR Chinook salmon are likely to be present in shallow shoreline areas during electrofishing activities and may be stunned and even killed. However, because the operator releases the electrical field as soon as salmonids are observed and most of these fish quickly recover and swim away, we are unable to use observations from past operations to estimate the number of fish from this ESU that will be affected. Information obtained through electrofishing supports management of the NPMP, which is reported to have reduced salmonid predation by about 30 percent (Williams et al. 2017). This level of take is anticipated to occur for the duration of this proposed action, pending completion of the NEPA process.

2.5.3.2 Effects to Critical Habitat

Implementation of the proposed action is likely to affect passage at Bonneville Dam for five of the 32 historical populations (i.e., Upper Gorge Fall Run, White Salmon Fall Run, Hood River Fall Run, White Salmon Spring Run, and Hood River Spring Run). Implementation will also affect the volume and timing of flow in the Columbia River, which has the potential to alter habitat in the Columbia River mainstem and estuary. The PBFs that could be affected by the proposed action are described in Table 2.5-6.

Table 2.5-6. Effects of the proposed action on the physical and biological features (PBFs) essential for the conservation for the ESU.

Physical and Biological Feature (PBF)	Effects of the Proposed Action
Freshwater spawning sites	The proposed action will continue the inundation of spawning habitat for fall-run Chinook salmon in the lower reaches of the tributaries to the Bonneville Pool. We do not know how much habitat was inundated when the dam was constructed and the pool filled; the inundation cannot be alleviated by project operation unless the reservoir was drawn down to near the original river level.
Freshwater migration corridors	Increased levels of total dissolved gas (TDG; water quality) in the gorge area during spring spill up to 120-125 percent could affect the conservation value of habitat within Bonneville reservoir and at least 35 miles downstream. This behavioral mechanisms to avoid elevated TDG (i.e., by migrating deeper in the water column). Sediment will continue to accumulate behind CRS dams, reducing turbidity in the migration corridor during the spring smolt outmigration, which could affect the safe passage PBF by increasing the risk of predation. The migration corridor is affected by passage at Bonneville Dam for the five populations that pass the dam. Passage conditions for adult survival (increased fallback) could be negatively affected, resulting in reduced conservation value of this PBF. Passage conditions for juvenile survival may also be affected (juvenile survival is higher in the bypass system and corner collector, next highest in the spillway, and lowest through the turbine units). Any reduced predation rates achieved under the 2008 biological opinion and associated RPA will continue during the interim period.

Physical and Biological Feature (PBF)	Effects of the Proposed Action
Estuarine areas	This PBF will continue to improve with the proposed reconnection of an average of 300 acres of floodplain habitat per year during implementation of this proposed action. Because estuary bird colonies and predation rates are in flux, it is not clear whether the continued tern and cormorant colony management is likely to continue any existing survival benefits; thus, we expect this PBF to remain unchanged.

2.5.4 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation (50 CFR 402.02). Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Nonfederal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. These projects also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth management programs (planning and regulation); a variety of stream and riparian habitat projects; watershed planning and implementation; acquisition of water rights for instream purposes and sensitive areas; instream flow rules; stormwater and discharge regulation; TMDL implementation to achieve water-quality standards; hydraulic project permitting; and increased spill and bypass operations at hydropower facilities. NMFS determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. These activities are likely to have beneficial cumulative effects that will significantly improve conditions for salmon and steelhead, including LCR Chinook salmon.

NMFS also noted that some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects are activities that occurred in the recent past and were included in the environmental baseline. Some of these activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if

authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the action area, nonfederal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations.

Overall, we anticipate that projects to restore and protect habitat, restore access to and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area.

2.5.5 Integration and Synthesis

In this section, we add the effects of the action (Section 2.5.3) to the environmental baseline (Section 2.5.2) and the cumulative effects (Section 2.5.4), taking into account the status of the species and critical habitat (Sections 2.5.1.1 and 2.5.1.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat for the conservation of the species.

2.5.5.1 Species

NMFS' recent status review affirmed LCR Chinook salmon as threatened but identified some positive trends in LCR Chinook salmon status (NWFSC 2015). For example, increases in abundance were observed in about 70 percent of the fall-run populations, and decreases in the hatchery contribution were noted for several populations. The improved fall-run VSP parameters reflect both changes in biological status and improved monitoring. However, the spring-run populations in particular continue to have low natural-origin abundance levels (NWFSC 2015). Hatchery contributions also remain high for a number of populations, especially in the Coast Fall MPG. Restoration of migratory access and hydrological processes to tributary spawning habitat (e.g. removal of Condit Dam, Marmot Dam and Powerdale Dam) have likely been responsible for recent increases in productivity of the affected populations.

The effects of CRS operations on populations originating in subbasins downstream of Bonneville Dam (27 out of 32 populations) are limited to the effects of flow management and marginally increased exposure to higher TDG levels during migration and rearing in the Columbia River, including the estuary. Reduced flows from May through July will be an ongoing effect of CRS operations as proposed, which will continue to increase travel times during outmigration for juvenile salmonids (including LCR Chinook salmon) and reduce access to high quality estuarine habitats during spring through early summer. These alterations impair sediment transport, influence habitat-forming processes, reduce access to peripheral habitat, and change food webs. Moreover, the large reservoirs associated with mainstem dams contribute to elevated water temperatures downstream in late summer and fall. These effects likely reduce the survival of juvenile LCR Chinook salmon as they move through the lower Columbia River, although we are not able to quantify the magnitude or scale of those impacts.

Out of 32 LCR Chinook salmon populations, operation of the CRS will continue to reduce survival for five populations (two spring-run populations and three fall-run populations) that are affected by upstream and downstream passage at Bonneville Dam. However, the White Salmon and Upper Gorge fall-run populations showed stable or improving VSP scores according to the latest status review. Similarly, the White Salmon spring-run population demonstrated an improving VSP score. The Hood River spring and fall-run populations lacked sufficient data to fully evaluate their status. The survival of downstream migrants has improved in recent years due to the construction of the Bonneville Corner Collector and juvenile bypass system at Powerhouse 2, and increases in the percent of flow approaching the dam that goes over the spillway. Both of these measures reduce travel time and the likelihood of turbine passage for juvenile migrants (Ploskey et al. 2012). We anticipate that dam passage survival rates of 93-95 percent (depending on passage route) are likely to continue as a result of the proposed operations, but as described below, changes to spring spill could potentially alter the proportion of LCR Chinook salmon subjected to the various passage routes.

The flexible spring spill operation proposed by the Action Agencies could provide potential benefits to LCR Chinook. The CSS hypothesizes that increased spill could substantially reduce latent mortality of juvenile yearling Chinook salmon moving downstream through the mainstem dams. If this were to occur for LCR Chinook salmon, SARs would also be improved. On the other hand, the improvement would be limited to the two populations (White Salmon Spring Run and Hood River Spring Run) that pass above Bonneville Dam and migrate during the spring, and the hypothesized benefit would generally be less than what may occur for species that experience passage through a greater number of the Columbia and Snake River mainstem dams.

Increased spring spill levels could also potentially negatively affect juvenile survival (e.g., increased proportion of juveniles passing through routes with lower survival). Both spring migrating adults and juveniles will be exposed to somewhat higher TDG levels from the higher spill treatment. However, TDG levels above 120 to 125 percent would only occur as a result of conditions requiring lack of market or lack of turbine capacity spill. Further, the Gas Cap spill levels at Bonneville Dam will only occur for about 16 hours each day. Ultimately, given the relatively high survival rates of smolts and the limited number of LCR Chinook salmon populations exposed to the effects of dam passage, we do not anticipate the proposed changes in operations will measurably affect the number of adult LCR Chinook salmon returns of the five affected populations or the two MPGs in which they are included.

The other proposed changes to CRS operations are not anticipated to negatively affect LCR Chinook salmon survival. In particular, the changes in usable forebay ranges (MOP 1.5-foot range) at the Lower Snake River reservoirs and the change in operating range at the John Day forebay (MIP 2-foot range) will result in inconsequential variations in the timing and amount of flow in the lower Columbia River.

The Action Agencies will continue to fund predator control activities, estuary habitat improvements, and modify operations to improve survival. The implementation of the CRS mitigation and enhancement programs will continue to reduce long-term impacts and continue to allow for improvement in the status for the five populations that spawn above Bonneville Dam (White Salmon Spring and Hood Spring in the Gorge Spring MPG, and Upper Gorge Fall, White Salmon Fall and Hood Fall in the Gorge Fall MPG), as was seen for most populations in the last status review. The estuary program is anticipated to improve habitat conditions and contribute to improved survival and productivity for all populations, especially for fall-run populations. Because the Action Agencies propose to continue maintaining the reduced amounts of nesting habitat achieved for terns and cormorants on East Sand Island (BPA et al. 2018a), we expect that any reduced predation rates achieved for LCR Chinook salmon under the 2008 FCRPS biological opinion and associated RPA will continue during the interim period.

As a general matter, the effects of the proposed action are very similar to a short-term continuation of the same effects caused by the current operations and maintenance of the CRS as well as the associated measures implemented to avoid, minimize or offset adverse effects. Therefore, we do not anticipate large changes in mortality caused by the CRS or substantial new risks to LCR Chinook salmon or their habitat, and we do not expect considerable changes in the effects on reproduction, numbers, or distribution. However, we do anticipate additional improvements in habitat conditions in the estuary that will accrue over time.

The environmental baseline includes the past and present impacts of hydropower, changes in tributary and mainstem habitat (both beneficial and adverse), harvest, and hatcheries on LCR Chinook salmon. The baseline provides important context for assessing the effects of the action described above.

Regarding changes in hatchery effects to the LCR Chinook salmon ESU, in 2017, NMFS completed a biological opinion on its funding of the Mitchell Act program (NMFS 2017a). As a result, several additional reform measures have been implemented including changes in broodstock management to better align hatchery broodstocks with the diversity of the natural-origin populations and modifications to the number of hatchery fish produced and released in certain programs, along with the installation of new seasonal weirs. The production level changes will reduce the pHOS and reduce genetic and ecological risk. Improvements in hatchery management are likely to support improvements in the viability of LCR populations, including the five populations that pass above Bonneville Dam, in the foreseeable future.

NMFS also recently completed a biological opinion on the 2018-2027 *U.S. v. Oregon* Management Agreement, which provides a framework for managing salmon and steelhead fisheries and hatchery programs in much of the Columbia River basin. Stocks are managed subject to an abundance rate schedule for the fall-run component of the LCR Chinook salmon ESU that applies to all ocean and inriver fisheries below Bonneville Dam and allows for a total ER that ranges from 30 to 41 percent. Mark selective fisheries are used below Bonneville Dam to limit impacts to natural-origin spring Chinook salmon. Impacts to the spring populations in the ESU in the winter, spring and summer seasons are low with an expected harvest rate ranging from 0.2-2.0 percent. The biological opinion concluded that the effects of harvest on LCR Chinook salmon, when considering the current reliance on hatchery programs, will allow gains in VSP scores to continue to accrue.

Tributary habitat in the action area for LCR Chinook salmon is highly degraded and contributes to the current status of the ESU. Many spring-run populations still lack adequate access to historical habitats. The recovery plan identifies the tributary hydropower impacts (non-CRS) as a primary limiting factor; however, relatively recent removal of some tributary dams has improved some access and habitat conditions. Continued urbanization and habitat degradation in combination with the potential effects of climate change (discussed further below) also present risks for all populations. Reduced or lost habitat complexity, connectivity, quantity and quality (including water quality and toxics) in lower river tributaries and along the estuary floodplain remains a specific area of concern. The series of dams and reservoirs have also blocked natural sediment transport; the delivery of suspended particulate matter to the lower river and estuary has been reduced and has altered the development of habitat along the margins of the river. Predation by pinnipeds, birds and fish is also a significant source of mortality for both juvenile and adult LCR Chinook salmon. Efforts to reduce predation rates have only been moderately successful, partly due to recent increases in pinniped abundance in the lower river. The effect of increased sea lion predation on spring-migrating Chinook salmon adults is particularly concerning.

Improvements including tributary hydrosystem modification and habitat restoration (e.g., in the estuary), coupled with significant harvest reductions from historic levels, have allowed for progress in improving LCR Chinook salmon abundance, productivity, spatial structure and diversity. However, these improvements also occur in the context of natural fluctuations in environmental conditions, such as cyclical changes in ocean circulation and the unusually warm ocean conditions seen predominating during 2015, which can temporarily adversely affect survival and adult returns of all salmonid species even if freshwater habitat conditions are improving.

The status of LCR Chinook salmon is also likely to be affected by climate change. Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycle. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater and changes to food webs in freshwater, estuarine and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management actions may help alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations, increased riparian vegetation to control water temperatures, etc.).

Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life-history types that will be successful in the future are neither static nor predictable. Therefore, maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the LCR Chinook salmon ESU. Because of its location in the lower Columbia River basin, the ESU is likely to be more affected by climate related effects in the estuary for fall-run subyearlings, and in tributary streams (altered seasonal flows and temperatures) for spring-run populations. Emerging research using complex life-cycle modeling indicates a potentially strong link between SST and survival of Snake River spring/summer Chinook salmon populations. However, the apparent link between SST and survival is presumably caused by food web interactions, relationships which could be disrupted by major transformations of community dynamics as well as ocean acidification and other factors under a changing climate. The degree to which SST is linked to survival of LCR Chinook salmon and how that relationship interacts with other variables throughout the LCR Chinook salmon life cycle will likely be an important area of future research.

When evaluating the effects of the action, those effects must be taken together with the effects on LCR Chinook salmon of future state or private activities, not involving federal activities that are reasonably certain to occur within the action area. NMFS anticipates that human development activities will continue to have adverse effects on LCR Chinook salmon in the action area. Many of these activities and their effects occurred in the recent past and were included in the environmental baseline but are also reasonably certain to occur in the future. Within the action area, nonfederal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Habitat restoration efforts lead by state, and local agencies; tribes; environmental organizations; and local communities are likely to continue. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives that, in some cases, are identified through ESA recovery plans. Larger, more regionwide, restoration and conservation efforts are either underway or planned throughout the Columbia River basin. These state and private actions have helped restore habitat, improve fish passage, and reduce pollution. While these efforts are reasonably certain to continue to occur, funding levels may vary on an annual basis.

With respect to recovery, for spring-run populations, the recovery plan identifies the greatest gains from tributary habitat and tributary dam passage improvements, combined with hatchery reintroduction programs. For fall-run populations, the recovery plan targets improvements by protecting and restoring tributary and estuarine habitat, and by reducing impacts of hatcheries and harvest. For late-fall-run populations, the recovery plan calls for maintenance of the North Fork Lewis and Sandy populations. The Sandy population’s status depends largely on harvest and hatchery changes. Some of the needed hatchery and harvest improvements have been the subject of recent section 7 consultations (as discussed above) and are currently being implemented. Improvements to estuarine habitat are part of the proposed action for this consultation. The recovery plan was finalized in July 2013 and identifies recovery actions to be implemented, generally over a 25-year period, as specified in the management unit plans and estuary recovery plan module. Effective implementation requires that the recovery efforts of diverse private, local, state, tribal, and federal parties across two states be coordinated at multiple levels. The proposed action will not result in reductions to LCR Chinook salmon reproduction, numbers, or distribution that would impede the ability to successfully carry out the identified recovery measures and actions over the time frames considered in the recovery plan.

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, cumulative effects, and considering the interim nature of the proposed action, it is NMFS' biological opinion that the proposed action is not likely to reduce appreciably the likelihood of both survival and recovery of LCR Chinook salmon.

2.5.5.2 Critical Habitat

Critical habitat for LCR Chinook salmon encompasses ten subbasins in Oregon and Washington containing 47 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005, 2013). However, most of these watersheds have some, or high potential for improvement. Similar to the discussion above for species, the status of critical habitat is likely to be affected by climate change with predicted rising temperatures and alterations in stream flow patterns. Past and future modifications to the hatchery program, improved passage in tributaries, and habitat restoration efforts will help ameliorate those effects to critical habitat.

The environmental baseline includes a broad range of past and present actions and activities that have affected the conservation value of critical habitat for LCR Chinook salmon. These include the effects of hydropower, changes in tributary and mainstem habitat (both positive and negative), and hatcheries on freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine areas and nearshore marine areas. Despite a long-term trend in degradation of these habitats, there have been localized improvements in their conservation value through the combined efforts of federal, state, and local agencies; tribes; and other stakeholders. Tributary dams and other barriers have been removed, estuarine habitats restored and reconnected to the floodplain, and water quality has improved. Despite significant losses to predators in the migration corridor, the combined efforts of multiple parties has reduced the effect of predation, and the Action Agencies propose to continue predator management activities.

Continued operation of the CRS will continue the inundation of spawning habitat for fall-run Chinook salmon in the lower reaches of the tributaries to the Bonneville Pool (continued loss of habitat for spawning). Increased levels of TDG in the gorge area during spring spill will increase TDG levels within Bonneville Dam's reservoir and for at least 35 miles downstream. However, this is not expected to substantially affect the water quality PBF at the designation level given that the effect will be limited to a relatively small portion of designated critical habitat for this species and considering the ability of fish to avoid higher TDG levels by swimming deeper in the water. The conservation value of the safe passage PBF in the migration corridor is affected by passage at Bonneville Dam only for the five populations that pass the dam. The benefits of continued operation of fish passage structures will continue. However, passage conditions for adult survival (increased fallback) and potentially for juvenile survival (e.g. differential survival between passage routes – spillway, juvenile bypass or corner collector, and turbines) could negatively affect safe passage, although the CSS predicts survival benefits and a reduction in latent mortality (increased juvenile survival and adult returns). Conversely, the proposed action will continue to improve the functioning of many of the PBFs; for example, reducing predation by pinnipeds, birds,[55] and northern pikeminnows will continue to improve safe passage for juveniles and the hazing of pinnipeds and deployment of sea lion excluder devices will continue to benefit safe passage of adult migrants. The estuary habitat restoration program will reconnect floodplains and provide additional feeding and rearing areas at the project scale; these benefits will accrue at the designation scale over time.

Considering the ongoing and future effects of the environmental baseline and cumulative effects and in light of the status of critical habitat, the proposed action will not appreciably reduce the value of designated critical habitat for the conservation of LCR Chinook salmon.

2.5.6 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of LCR Chinook salmon or destroy or adversely modify its designated critical habitat.

[55] Although there is uncertainty about the efficacy of avian predation management in the estuary, the hazing efforts in the tailrace of Bonneville Dam are known to reduce predation.

2.6 Lower Columbia River (LCR) Steelhead

This section applies the analytical framework described in section 2.1 to the LCR steelhead DPS and provides NMFS' finding regarding whether the proposed action is likely to jeopardize the continued existence of the LCR steelhead DPS or destroy or adversely modify its critical habitat.

2.6.1 Rangewide Status of the Species and Critical Habitat

The status of LCR steelhead is determined by the level of extinction risk that the listed species faces, based on parameters considered in documents such as the recovery plan, status reviews, and listing decisions. The species status also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. This informs the description of the species' current likelihood of both survival and recovery. The condition of critical habitat throughout the designated area is determined by the current function of the PBFs that help to form that conservation value.

2.6.1.1 Status of Species

On March 19, 1998, NMFS listed the LCR steelhead DPS as a threatened species (63 FR 13347). The threatened status was reaffirmed on January 5, 2006 (71 FR 834), and most recently on April 14, 2014 (79 FR 20802). Critical habitat for LCR steelhead was designated on September 2, 2005 (70 FR 52833; Figure 2.6-1). The recovery plan was completed in 2013 (NMFS 2013a), and the most recent status review was completed in 2015 (NWFSC 2015). Table 2.6-1 provides information on status and limiting factors for LCR steelhead. More information can be found in the recovery plan and status review for this species. These documents are available on the NMFS West Coast Region website.[56]

[56] Currently these documents can be found within the NMFS West Coast Region website at: http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/salmon_and_steelhead_listings/steelhead/lower_columbia_river/lower_columbia_river_steelhead.html. Last accessed August 2018.

Table 2.6-1. The status summary and limiting factors for LCR steelhead (NWFSC 2015).

Status Summary	Limiting Factors
This DPS comprises 23 historical populations, 17 winter-run and six summer-run populations. Nine populations are at very high risk, seven populations are at high risk, six populations are at moderate risk, and one population is at low risk. The majority of winter-run steelhead populations in this DPS continue to persist at low abundances. Hatchery interactions remain a concern in select basins, but the overall situation is somewhat improved compared to prior reviews. Summer-run steelhead populations were similarly stable, but at low abundance levels. The decline in the Wind River summer-run population is a source of concern, given that this population has been considered one of the healthiest of the summer runs; however, the most recent abundance estimates suggest that the decline was a single-year aberration. Passage programs in the Cowlitz and Lewis basins have the potential to provide considerable improvements in abundance and spatial structure, but have not produced self-sustaining populations to date. Even with modest improvements in the status of several winter-run DIPs, none of the populations appear to be at fully viable status, and similarly, none of the MPGs meet the criteria for viability.	● Degraded estuarine and nearshore marine habitat ● Degraded freshwater habitat ● Reduced access to spawning and rearing habitat ● Avian and marine mammal predation ● Hatchery-related effects ● An altered flow regime ● Reduced access to off-channel rearing habitat in the lower Columbia River ● Reduced productivity resulting from sediment and nutrient-related changes in the estuary ● Juvenile fish wake strandings ● Contaminants

The LCR steelhead DPS includes all naturally spawned anadromous *O. mykiss* originating below natural and manmade impassable barriers from rivers between the Cowlitz and Wind Rivers (inclusive) and the Willamette and Hood Rivers (inclusive), and excludes such fish originating from the upper Willamette River basin above Willamette Falls. This DPS also includes steelhead from seven artificial propagation programs.[57] Historically, the LCR steelhead DPS consisted of 23 independent populations, all of which are extant. These 23 populations include 17 winter-run populations and six summer-run populations, which are divided into four MPGs: Cascade Winter (14 populations), Cascade Summer (four populations), Gorge Winter (three populations), and Gorge Summer (two populations).[58]

[57] Cowlitz Trout Hatchery Late Winter-run Program; Kalama River Wild Winter-run and Summer-run Programs; Clackamas Hatchery Late Winter-run Program; Sandy Hatchery Late Winter-run Program; Hood River Winter-run Program; and the Lewis River Wild Late-run Winter Steelhead Program (79 FR 20802).

[58] The Willamette–Lower Columbia Technical Recovery Team used the term "strata" to refer to these population groupings, which are significant in identifying delisting criteria. The strata are analogous to the "major population groups" defined by the Interior Columbia Technical Recovery Team. For consistency, we use the term major population group throughout this biological opinion.

Steelhead spawn in a wide range of conditions ranging from large streams and rivers to small streams and side channels. Returning adult summer-run steelhead can reach headwater areas above waterfalls that are impassable to winter steelhead during high-velocity winter flows.

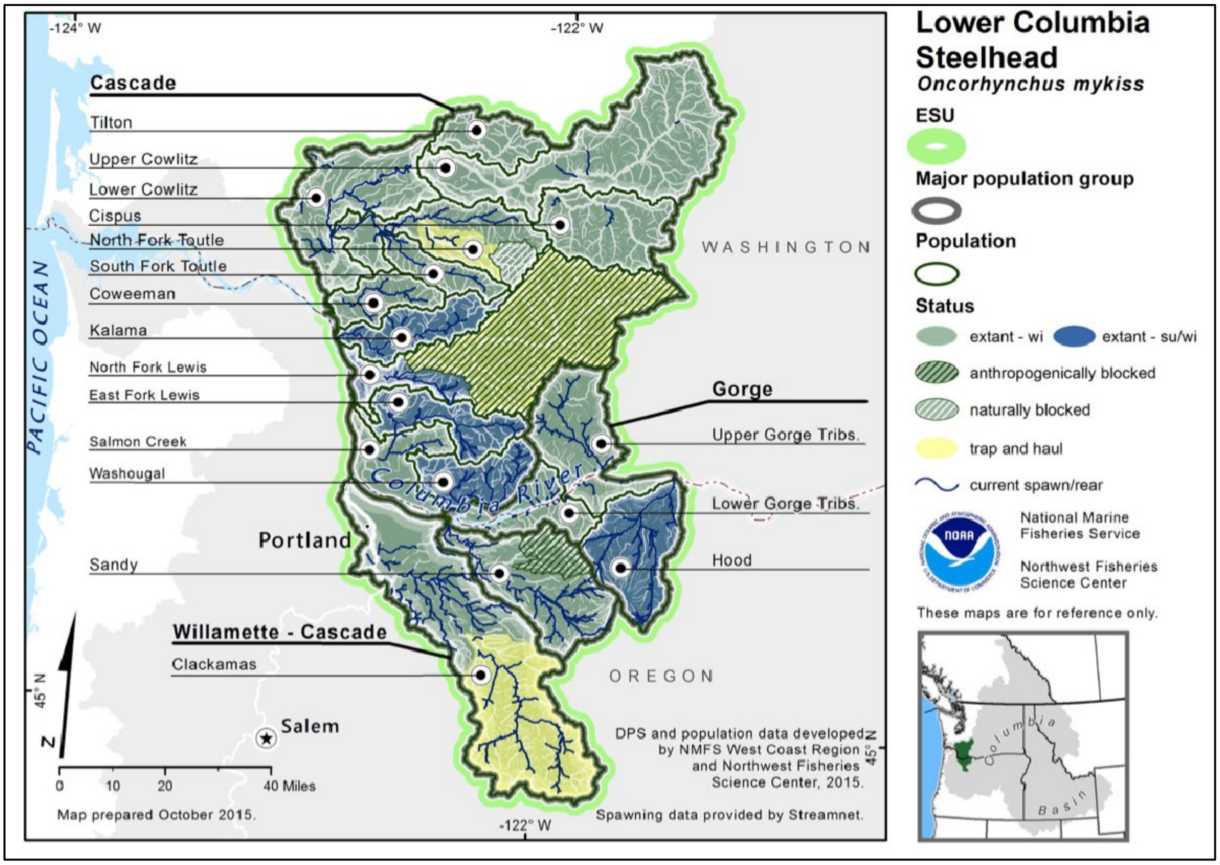


Figure 2.6-1. Map of populations in the Lower Columbia River steelhead DPS. Source: NWFSC 2015.

LCR basin populations include summer and winter steelhead (Table 2.6-2). The two life-history types differ in degree of sexual maturity at freshwater entry, spawning time, and frequency of repeat spawning (NMFS 2013a). Generally, summer steelhead enter freshwater from May to October in a sexually immature condition, and require several months in freshwater to reach sexual maturity and spawn between late February and early April. Winter steelhead enter freshwater from November to April in a sexually mature condition and spawn in late April and early May. Iteroparity (repeat spawning) rates for Columbia Basin steelhead have been reported as high as 2 to 6 percent for summer steelhead and 8 to 17 percent for winter steelhead (Leider et al. 1986; Busby et al. 1996; Hulett et al. 1996). The holding period for summer steelhead allows them to take advantage of periodically favorable passage conditions, but it may also result in higher pre-spawning mortality that puts summer steelhead at a competitive disadvantage relative to winter steelhead. Young steelhead typically rear in streams for 1–4 years before migrating to the ocean, with most migrating after two years in freshwater. In the lower Columbia River, outmigration of steelhead smolts (of both summer and winter life-history types) generally occurs from March to June, with peak migration usually in April or May (NMFS 2013a).

Only four populations (Wind summer-run, Hood summer-run, Upper Gorge winter-run, and Hood winter-run) of the 23 populations in this DPS are subject to CRS impacts involving passage at Bonneville Dam, and based on PIT-tag detections at The Dalles Dam, some of these fish also move upstream of The Dalles Dam and John Day Dam (Columbia River Data Access in Real Time, queried May 4, 2018). All populations are affected by habitat alteration (loss of floodplain connection, shallow-water rearing habitats) in the Columbia River mainstem and estuary.

There is no direct harvest of naturally produced LCR steelhead other than a catch and release fishery in the Wind River (NWFSC 2015). They are intercepted in mainstem fisheries targeting unlisted hatchery and naturally produced Chinook salmon and unlisted steelhead.

Total steelhead hatchery releases in the Lower Columbia River steelhead DPS have decreased since the last status review, declining from a total (summer- and winter-run) release of approximately 3.5 million to 3 million from 2008 to 2014. Some populations continue to have relatively high fractions of hatchery-origin spawners, whereas others (e.g., Wind River) have relatively few hatchery-origin spawners.

The LCR steelhead DPS is at moderate risk. Spatial structure for LCR steelhead has largely been maintained for most populations in the DPS (NMFS 2013a). This means that returning adults can access most areas of historical habitat. Except for the North Fork Lewis subbasin, where dams have impeded access to historical spawning habitat, most summer steelhead populations continue to have access to historical production areas in forested, mid-to-high-elevation subbasins that remain largely intact. For the Upper Cowlitz, Cispus, Tilton, and North Fork Lewis winter-run populations, passage to upper-basin habitat is partially or entirely blocked by dams (LCFRB 2010; ODFW 2010); the Upper Gorge winter-run population is constrained by hatchery weirs, and the Hood River winter-run population is constrained by the presence and operation of an irrigation dam. However, steelhead distribution has been partially restored in the Upper Cowlitz, Cispus, and Tilton subbasin by trapping and transferring adults and juveniles around impassable dams (NMFS 2013a).

Historical hatchery effects and ongoing hatchery straying have reduced genetic diversity and productivity in both summer- and winter-run LCR steelhead populations (NMFS 2013a). For summer populations, the Hood River population has the highest pHOS at 53 percent (ODFW 2010). The LCFRB (2010) reported that the highest pHOS rate among the Washington populations was 35 percent for the East Fork Lewis, and modeled estimates of current production in the LCR indicate pHOS estimates as high at 51 percent in the Cowlitz River for winter steelhead (WDFW 2014).

A total of five out of 22 populations are at or near their recovery viability goals, although only two of these populations had scores above 2.0 (moderate risk) under the recovery plan scenario. The remaining populations generally require substantial improvements to reach their viability goals (NWFSC 2015). Table 2.6-2 displays the abundance, productivity, spatial structure, diversity, and overall persistence probability for LCR steelhead, organized by individual populations. It is likely that genetic and life-history diversity have been reduced as a result of pervasive hatchery effects and population bottlenecks. Spatial structure remains relatively high for most populations. Out of the 23 populations, 16 are considered to have a low or very low probability of persisting over the next 100 years, and six populations have a moderate overall persistence probability. All four strata in the DPS fall short of the WLC-TRT criteria for viability (NWFSC 2015).

Table 2.6-2. LCR steelhead major population groups (MPGs), run timing, populations, and scores for the key viable salmonid population (VSP) elements (abundance/productivity [A/P], spatial structure, and diversity) used to determine overall net persistence probability of the population (NWFSC 2015). Persistence probability ratings and key element scores range from very low (VL), low (L), moderate (M), high (H), to very high (VH). The populations that spawn upstream of Bonneville Dam are highlighted in gray.

MPG		Population	A/P	Spatial Structure	Diversity	Overall Persistence Probability
Ecological Subregion	**Run Timing**					
Cascade Range	Spring	Kalama (WA)	H	VH	M	M
		North Fork Lewis River (WA)	VL	VL	VL	VL
		East Fork Lewis River (WA)	VL	VH	M	VL
		Washougal River (WA)	M	VH	M	M
	Winter	Lower Cowlitz (WA)	L	M	M	L
		Upper Cowlitz (WA)	VL	M	M	VL
		Cispus (WA)	VL	M	M	VL
		Tilton River (WA)	VL	M	M	VL
		South Fork Toutle River (WA)	VL	H	M	VL
		North Fork Toutle River (WA)	VL	H	H	VL
		Coweeman River (WA)	L	VH	VH	L
		Kalama River (WA)	L	VH	H	L
		North Fork Lewis River (WA)	VL	M	M	VL
		East Fork Lewis River (WA)	M	VH	M	M
		Salmon Creek (WA)	VL	H	M	VL
		Clackamas (OR)	M	VH	M	M
		Sandy (OR)	L	M	M	L
		Washougal (WA)	L	VH	M	L
Columbia Gorge	Summer	Wind (WA)	VH	VH	H	H
		Hood River (OR)	VL	VH	L	VL

MPG		Population	A/P	Spatial Structure	Diversity	Overall Persistence Probability
Ecological Subregion	Run Timing					
	Winter	Lower Gorge (WA & OR)	L	VH	M	L
		Upper Gorge (WA & OR)	L	M	M	L
		Hood (OR)	M	VH	M	M

Baseline persistence probabilities were estimated to be low or very low for three out of the six summer steelhead populations that are part of the LCR steelhead DPS, moderate for two, and high for one, the Wind River, which is considered viable. Thirteen of the 17 LCR winter steelhead populations have low or very low baseline probabilities of persistence, and the remaining four are at moderate probability of persistence (NWFSC 2015).

The most recent status review (NWFSC 2015) concluded that the majority of winter and summer steelhead populations continue to persist at low abundances. Hatchery interactions remain a concern in select basins, but the overall situation is somewhat improved compared to the prior review in 2011. The decline in the Wind River summer population is a concern, given that this population has been considered one of the healthiest of the summer populations; however, the most recent abundance estimates suggest that the decline was a single-year aberration. Efforts to provide passage above dams in the North Fork Lewis River offer the opportunity for substantial improvements in the winter steelhead population and the only opportunity to reestablish the summer steelhead population. Habitat degradation continues to be a concern for most populations. Even with modest improvements in the status of several winter-run populations, none of the populations appear to be at fully viable status, and similarly, none of the MPGs meet the criteria for viability. The DPS therefore continues to be at moderate risk (NWFSC 2015).

The primary limiting factors for LCR winter steelhead populations include: degraded riparian conditions along tributaries; channel structure and form issues in tributaries and the estuary; impaired side channel and wetland conditions in tributaries; loss/degradation of floodplain habitat in tributaries; sediment conditions in the estuary; altered hydrology in the estuary; and avian and marine mammal predation (NMFS 2013a). The primary limiting factors for summer steelhead populations include all of the above with the addition of sediment conditions in tributaries, and do not include channel structure and form issues in the estuary. Tributary hydropower development is a primary limiting factor for the North Fork Lewis summer population and several populations in the Cascade winter steelhead MPG. Stray hatchery fish interbreeding with natural-origin fish are also a concern.

This species is included in the Lower Columbia River recovery plan (NMFS 2013a). For this species, threats in all categories must be reduced, but the most crucial elements are protecting favorable tributary habitat and restoring habitat in the Upper Cowlitz, Cispus, North Fork Toutle, Kalama, and Sandy subbasins (for winter steelhead), and the East Fork Lewis and Hood subbasins (for summer steelhead). Protection and improvement is also needed among the South Fork Toutle and Clackamas winter steelhead populations. Hatchery-induced selection poses a threat to LCR steelhead, as discussed in the recovery plan; this indicates that population-level effects of hatchery fish interbreeding with natural-origin fish were a primary limiting factor. We expect this factor to reduce greatly in the near future when NMFS adopts (and WDFW implements) reforms from the opinion evaluating Mitchell Act funding (NMFS 2017a), which terminated out-of-DPS releases of hatchery steelhead inside this DPS's geographic range. While the low to very low baseline persistence probabilities of most LCR steelhead populations reflect low productivity, abundance is improving, and likely reductions in genetic and life-history diversity as a result of pervasive hatchery effects and population bottlenecks (NMFS 2013a) will be alleviated by switching to hatchery broodstocks whose genetic origins are from the lower Columbia River (NMFS 2017a).

2.6.1.2 Status of Critical Habitat

This section describes the status of designated critical habitat affected by the proposed action by examining the condition and trends of the PBFs of that habitat throughout the designated area. These features are essential to the conservation of the ESA-listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration, and foraging). Table 2.6-3 summarizes status information for designated critical habitat for LCR steelhead based on the detailed information on the status of critical habitat provided in the recovery plan for the species (NMFS 2013a). LCR steelhead critical habitat is within the Willamette/Lower Columbia River recovery domain.

Table 2.6-3. Critical habitat, designation date, Federal Register citation, and status summary for LCR steelhead critical habitat.

Designation Date and Federal Register Citation	Critical Habitat Status Summary
9/02/05 **70 FR 52630**	Critical habitat encompasses nine subbasins in Oregon and Washington containing 41 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005a; NWFSC 2015). However, most of these watersheds have some, or a high, potential for improvement. We rated conservation value of HUC5 watersheds as high for 28 watersheds, medium for 11 watersheds, and low for two watersheds.

The status of critical habitat is discussed in more detail in the Environmental Baseline section, below. We reviewed the status of designated critical habitat by examining the condition and trends of PBFs throughout the range of LCR steelhead. The PBFs for LCR steelhead salmon critical habitat include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine areas, and nearshore marine areas. Removal of multiple barriers has improved access and allowed the restoration of hydrological processes that may improve downstream habitat conditions. However, the value of PBFs remains impaired by tributary barriers, loss of habitat complexity, toxics and water-quality issues, and concerns about predation during migration.

2.6.1.3 Climate Change Implications for LCR Steelhead and Critical Habitat

One factor affecting the rangewide status of LCR steelhead and aquatic habitat is climate change. The U.S. Global Change Research Program (USGCRP), mandated by Congress in the Global Change Research Act of 1990, reports average warming of about 1.3ºF from 1895 to 2011. As the climate changes, air temperatures in the Pacific Northwest are expected to increase 4 to 13°F by the end of the century, with the largest increases expected in the summer (Mantua et al. 2009; Mote et al. 2014). Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004; Scheuerell and Williams 2005; Zabel et al. 2006; ISAB 2007). According to the ISAB, these effects pose the following impacts into the future:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a smaller snowpack, watersheds will see their runoff diminished earlier in the season, resulting in lower stream flows in the June through September period. River flows in general and peak river flows are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures are expected to rise, especially during the summer months when lower stream flows co-occur with warmer air temperatures.

The proposed action is only expected to be implemented in the interim time period between 2019 and the completion of the NEPA process; however, the effects of the proposed action will extend many years (e.g., maturation of estuary habitat projects). Thus, both natural climate variation and climate change are relevant to our analysis.

Likely changes in temperature, precipitation, wind patterns, and sea-level height have implications for survival and recovery of LCR steelhead in both its freshwater and marine habitats and the PBFs of its critical habitat. As the climate changes, air temperatures in the Pacific Northwest are expected to increase 4 to 13°F by the end of the century, with the largest increases expected in the summer (Mantua et al. 2009; Mote et al. 2014). While total precipitation changes are uncertain, increasing air temperature will result in more precipitation falling as rain rather than snow in watersheds across the basin (NMFS 2017a). In general, these changes in air temperatures, river temperatures, and river flows are expected to cause changes in salmon distribution, behavior, growth, and survival, although the magnitude of these changes remains unclear. In coastal areas, projections indicate an increase of 1–4 feet of global sea-level rise by the end of the century; sea-level rise and storm surge pose a risk to infrastructure and coastal wetlands and tide flats are likely to erode or be lost as a result of seawater inundation (Mote et al. 2014). Ocean acidification is also expected to negatively impact Pacific salmon and organisms within their marine food webs.

There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management of these factors may help further alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations, management of flows through the mainstem dams to address temperature concerns, etc.). Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life-history types that will be successful in the future are neither static nor predictable, so maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the LCR steelhead DPS.

Climate change would affect LCR steelhead and critical habitat through physical and chemical changes to their habitats (e.g., increased water temperature, decreased ocean pH, changes in the timing and volume of stream flow). The physical and chemical changes can result in biological impacts such as, but not limited to, reduced ocean survival, changes in growth and development, changes in run timing and spawning timing (Link et al. 2015). These biological changes can result in changes in species productivity and abundance, distribution, food web structure, community structure, invasive species impacts, and biodiversity and resilience (Link et al. 2015). Because of the location of the DPS in the lower Columbia River basin, the DPS is likely to be more affected by climate-related effects in the estuary, and summer populations may be subject to additional effects from climate change to the stream ecosystems (changes in flow timing).

2.6.2 Environmental Baseline

The environmental baseline includes the past and present impacts of all federal, state, or private actions and other human activities in an action area, the anticipated impacts of all proposed federal projects in an action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process.

For LCR steelhead, we focus our description of the environmental baseline on that portion of the action area where LCR steelhead juveniles and adults are exposed to the effects of the proposed action. We also include tributary habitat because these habitats, while not influenced by the proposed action, are primary drivers for the elements of VSP for LCR steelhead, and thus are key habitats for recovery of the DPS and are important to understand in the context of the proposed action.

To determine the upstream extent of LCR steelhead distribution and thus exposure, we reviewed LCR steelhead PIT detections at Bonneville, The Dalles and McNary dams from 2008 through 2017 (data are only available starting in 2013 for The Dalles Dam). PIT detections are an indication of presence/absence and not absolute abundance, because the proportion of the population that is tagged varies from year to year and is not known. The five-year average of LCR steelhead detections is 296 adults at Bonneville Dam, ten adults at The Dalles Dam, and <1 at McNary Dam. No PIT-detection data are available for the John Day Dam, but we assume that a small number of LCR steelhead ascend John Day Dam and use the John Day pool. Thus, for this consultation, the upper extent of the area where we anticipate LCR steelhead will be affected by the proposed action is the John Day pool (Columbia River Data Access in Real Time, queried May 4, 2018). The downstream extent of the effects of the action, based on observed changes in flow, is the plume.[59] The area includes tributary confluences in this reach to the extent that they are affected by flow management and habitat mitigation actions in the Columbia River and estuary.[60] The area also includes tributary habitats as described above; at this time, the Action Agencies have not proposed habitat actions in the tributary habitats of LCR steelhead.

2.6.2.1 Mainstem Habitat

On the mainstem of the Columbia River, hydropower projects (including the CRS), water storage projects (including reservoirs in Canada operated under the Columbia River Treaty), and the withdrawal of water for irrigation and urban uses have significantly degraded salmon and steelhead habitats (Bottom et al. 2005; Fresh et al. 2005; NMFS 2013a). The volume of water discharged by the Columbia River varies seasonally according to runoff, snowmelt, and hydropower demands. Mean annual discharge is estimated to be 265 kcfs, but may range from lows of 71–106 kcfs to highs of 530 kcfs (Hamilton 1990; NOAA 1998; Prahl et al. 1998; USACE 1999). Naturally occurring maximum flows on the river would occur in May, June, and July as a result of snowmelt in the headwater regions. Minimum flows would occur from September to March, with periodic peaks due to heavy winter rains (Holton 1984). Interannual variability in stream flow is strongly correlated with two recurrent climate phenomena, the ENSO and the PDO (Newman et al. 2016).

Water storage projects (dams and reservoirs) and water management activities have reduced flows between Bonneville and the mouth of the Columbia River compared to natural flows in the late spring and summer months; on average, this reduction can range from nearly 15 kcfs in August to over 230 kcfs in May (see Figure 2.6-2). Recognizing that the flow versus survival relationships for some interior basin ESUs/DPSs displayed a plateau over a wide range of flows but declined markedly as flows dropped below some threshold (NMFS 1995b, 1998), NMFS and the CRS Action Agencies have attempted to manage Columbia and Snake River water resources

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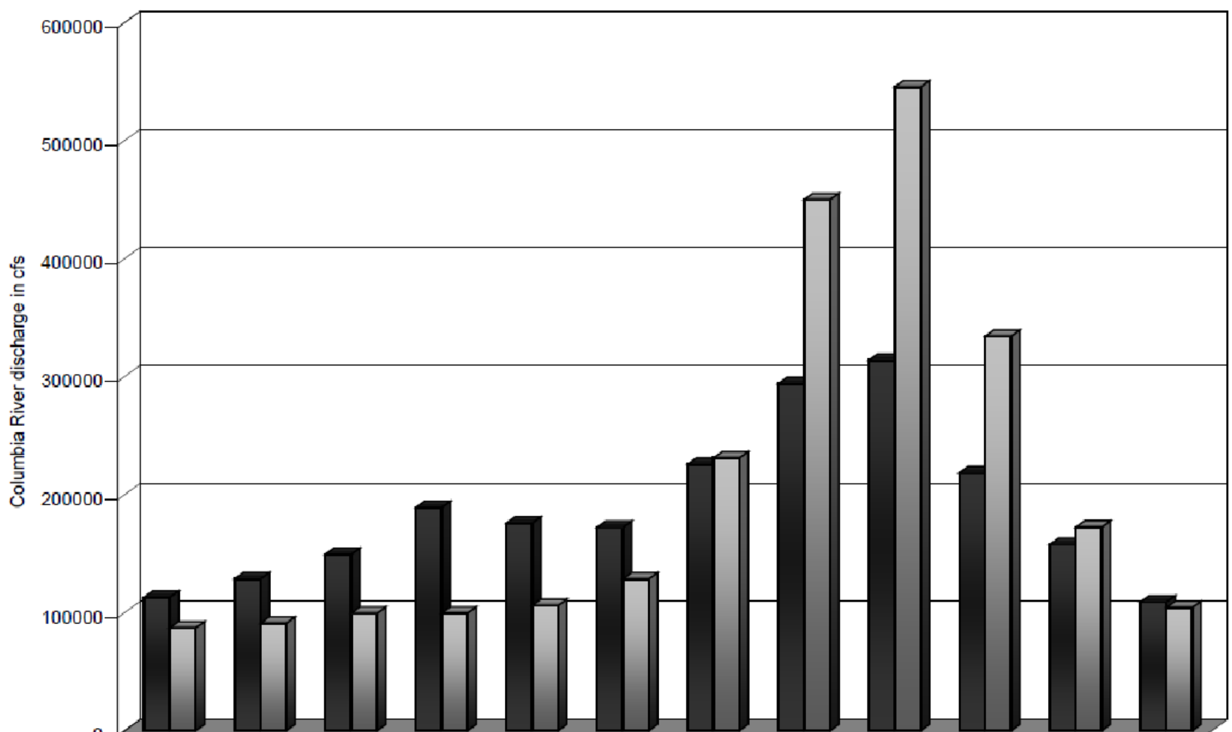
[59] The Columbia River plume is defined as those waters contiguous to the mouth of the Columbia River having salinity less than 32.5 percent (Park 1966). Historically, the outflow from the Columbia River was viewed as a freshwater plume oriented southwest over the Oregon shelf during summer and north or northwest over the Washington shelf during winter. However, more recent data show that the plume extends in both directions and is frequently present up to 100 miles north of the river mouth from spring to fall (Hickey et al. 2005).
[60] At this time, the Action Agencies have not proposed mitigation habitat actions in the tributaries of LCR steelhead.

to maintain seasonal flows above threshold objectives given the amount of runoff in a given year. This has been accomplished by avoiding excessive drafts going into spring to minimize the flow reductions needed to refill the reservoirs and by drafting the storage reservoirs during summer to augment flows. These flow objectives have guided preseason reservoir planning and in-season flow management. Nonetheless, since the development of the hydrosystem, average monthly flows at Bonneville Dam have been substantially lower during May–July and higher in October–March than an unregulated system. Reduced flows have increased travel times during outmigration for juvenile salmonids and reduced access to high-quality estuarine habitats during spring through early summer.



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Current	113017	128641	149403	189076	175921	172150	225689	293948	313930	218523	157935	109020
Natural	87115	91029	99387	99496	106033	128580	231047	450040	545561	334238	172430	104310

Figure 2.6-2. Comparison of monthly discharge (flow) in the Columbia River between current conditions (black) and normative flows (gray). These data show that pre-development flows were lower in the winter and higher in the spring and early-summer months.

The series of dams and reservoirs have also blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is only one-third of nineteenth-century levels (Simenstad et al. 1982, 1990; Sherwood et al. 1990; Weitkamp 1994; NRC 1996; NMFS 2008a). Similarly, Bottom et al. (2005) estimated that the delivery of suspended sediment to the lower river and estuary has been reduced by about 60 percent (as measured at Vancouver, Washington). This reduction has altered the development of habitat along the margins of the river.

Industrial harbor and port development are also significant influences on the lower Willamette and lower Columbia Rivers (Bottom et al. 2005; Fresh et al. 2005; NMFS 2013a). Since 1878, the Army Corps of Engineers has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the lower Willamette River as a navigation channel. Originally dredged to a 20-foot minimum depth, the federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The navigation channel supports many ports on both sides of the river, resulting in several thousand commercial ships traversing the river every year. The dredging, along with diking, draining, and fill material placed in wetlands and shallow habitat, also disconnects the river from its floodplain, resulting in the loss of shallow-water rearing habitat and the ecosystem functions that floodplains provide (e.g., supply of prey, refuge from high flows, temperature refugia; Bottom et al. 2005).

The most extensive urban development in the lower Columbia River subbasin has occurred in the Portland/Vancouver area. Common water-quality issues both in areas with urban development and rural residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff (LCREP 2007).

2.6.2.2 Passage Survival

Only four of the 23 populations in this DPS are affected by passage conditions at Bonneville Dam: Wind summer steelhead, Hood summer steelhead, Hood winter steelhead, and Upper Gorge winter steelhead. Based on PIT detections, small numbers of adult LCR steelhead (about 10 per year) also migrate upstream of The Dalles Dam. Some of these fish could spawn in tributaries above The Dalles Dam, but there are no data to support this hypothesis. It is likely that most fall back, either through the turbines or the sluiceway (a safer route), and find their home tributaries. The survival of juvenile downstream migrants, including LCR steelhead, has improved in recent years with the installation of minimum gap turbine blade runners at Bonneville Powerhouse 1, fish guidance efficiency improvements at Powerhouse 2, the surface collector bypass system at Powerhouse 2, improvements to sluiceway fish guidance system (efficiency and conveyance) at Powerhouse 1, and increases in the percent of flow approaching the dam that goes over the spillway.[61] The spillway wall and optimized spill patterns at the The Dalles Dam have resulted in high spillway passage efficiency and survival for juvenile migrants. All of these measures reduce travel time and the likelihood of turbine passage for juvenile migrants (Ploskey et al. 2012). Plosky et al. (2012) estimated 96.9 percent passage survival for juvenile LCR steelhead at Bonneville Dam based on a study that looked at survival through the spillway, Powerhouse 2 (juvenile bypass system, turbines, and corner collector) and Powerhouse

[61] At Bonneville Dam, juvenile steelhead survival rates through the various passage routes under tested operational conditions are generally: turbines < spillway < PH1 surface passage route (sluiceway) < PH2 juvenile bypass system and surface passage route (corner collector). Increasing spill would be expected to increase survival rates to the extent fish are moved from turbine units to this route of passage, but would tend to decrease survival rates to the extent fish are moved from surface passage routes or the juvenile bypass system.

1 (turbines and sluiceway). Passage survival estimates incorporate passage under general operations and typical maintenance (e.g., screen blockages/cleaning) conditions.

The effects of tributary dams vary among steelhead populations. In the Cascade Winter steelhead MPG, tributary hydropower development is a primary limiting factor for adults and juveniles in the Upper Cowlitz, Cispus, and North Fork Lewis populations, which historically were among the most productive winter steelhead populations. For the Tilton population, access to significant amounts of historical habitat in these river systems has been blocked by tributary dams, which also have had adverse impacts on downstream habitat through reduced gravel recruitment and other effects. Tributary hydropower issues related to upstream passage of adult winter steelhead past the Bull Run water system dams in the Sandy subbasin, and downstream passage of juvenile winter steelhead through the Portland General Electric Clackamas River Project, were identified as secondary limiting factors. There are no tributary hydropower facilities in the Coweeman, Toutle, Kalama, Salmon Creek, or Washougal subbasins.

In the Cascade summer steelhead MPG, impaired habitat access and passage has been identified as a primary limiting factor for North Fork Lewis summer steelhead; tributary dams have blocked access to or inundated about 50 percent of the historical habitat for that population (LCFRB 2010). In addition, tributary dams have adverse effects on downstream habitat through reduced gravel recruitment and other impacts. There are no tributary hydropower facilities in the Kalama and Washougal subbasins.

In the Gorge Winter steelhead MPG, impaired adult passage is considered a secondary limiting factor for the Hood River population because of Laurence Lake Dam and Powerdale Dam (removed in 2010). The impacts of Bonneville Dam on adult and juvenile passage are identified as a secondary factor for both the Upper Gorge Winter and Hood Winter steelhead populations. Upstream passage to potential spawning grounds is limited by Bonneville Dam, and inundation of historical habitat has reduced habitat quantity for juveniles.

In the Gorge Summer steelhead MPG, Powerdale Dam on the Hood River hindered access of adult steelhead to historical spawning areas until its removal in 2010 (NMFS 2013a). Inundation from the Bonneville Dam and the concomitant loss of historical riparian ecosystems has also reduced habitat quality for juvenile summer steelhead in the Hood River population.

CRS related mortality of downstream migrating kelts is not well known at this time. Colotelo et al. (2013) estimated that in 2012 only 40.2 and 44.8 percent of Snake River steelhead kelts survived from the Lower Granite forebay to the Lower Columbia River (RM156) and the Bonneville dam face (RM 234), respectively, and only 60.4 and 67.3 percent survived from the McNary forebay to the Lower Columbia River (RM156) and Bonneville dam face, respectively. It is important to note that in this study, only fair and good condition kelts were selected for tagging, and these survival rates cannot be applied to poor condition kelts. In a similar study conducted by Harnish et al. 2014, the survival of steelhead kelt through the four Snake River dams averaged 77 percent in 2012 and 49 percent in 2013.

Based on this limited information, up to 40 percent of kelts arriving at McNary Dam are lost upstream of Bonneville Dam. Far lower proportions of kelts entering Bonneville reservoir would be expected to be lost. Assuming roughly equal losses between the three projects in this reach, about 10-15 percent of LCR kelts from populations upstream of Bonneville Dam might be lost prior to passing the dam.These data represents total mortality to outmigrating SR steelhead kelts and does not distinguish between mortality caused by factors in the environmental baseline or the effects of the CRS. It is not technically possible to provide separate estimates of these components. Estimates of "natural" mortality rates for these fish are not available, but are thought to be high which have typically gone many months without feeding while expending considerable energy migrating and spawning.

2.6.2.3 Water Quality

Water quality in the action area is impaired. Common toxic contaminants found in the Columbia River system include PCBs, PAHs, PBDEs, DDT and other legacy pesticides, current use pesticides, pharmaceuticals and personal care products, and trace elements (LCREP 2007). The LCREP report noted widespread presence of PCBs and PAHs, both geographically and in the food web. Urban and industrial portions of the lower river contribute significantly to contaminant levels in juvenile steelhead; juvenile salmon are absorbing toxic contaminants during their time rearing and feeding in the lower Columbia River (LCREP 2007). Likewise, juvenile salmon accumulate DDT in their tissues and are exposed to estrogen-like compounds in the lower river, likely associated with pharmaceuticals and personal care products. Concentrations of copper are present at levels that could interfere with crucial salmon behaviors.

Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute municipal and industrial waste discharges to the lower Columbia River. Industrial and municipal wastes from the Portland/Vancouver metro areas, including the superfund-designated reach in the lower Willamette River, also contribute to degraded water quality in the lower Columbia River. Mining areas scattered around the basin deliver higher background concentrations of metals. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river. Small releases of materials such as lubricants occur during dam operation and maintenance and contribute to background exposure to contaminants in the Columbia River.

Outside of urban areas, the majority of residences and businesses rely on septic systems. Common water-quality issues with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff. Under these environmental conditions, fish in the action area are stressed. Stress may lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival).

Water temperatures in the Columbia River are a concern; because of temperature standard exceedances, the Columbia River is included on the Clean Water Act §303(d) list of impaired waters established by Oregon and Washington. Temperature conditions in the Columbia River basin area affected by many factors, including:

- Natural variation in weather and river flow;
- Construction of the dam and reservoir system (the large surface areas of reservoirs and resulting slower river velocities contribute to warmer late summer/fall water temperatures);
- Increased temperatures of tributaries due to water withdrawn for irrigated agriculture, and due to grazing and logging;
- Point-source thermal discharges from cities and industries; and
- Climate change.

The EPA is working with federal and state agencies, tribes, and other stakeholders to develop water-quality improvement plans (total maximum daily loads) for temperature in the Columbia River and lower Snake River. As part of the 2015 biological opinion on EPA's approval of water-quality standards, including temperature (NMFS 2015a), EPA committed to work with federal, state, and tribal agencies to identify and protect thermal refugia and thermal diversity in the lower Columbia River and its tributaries.

Comparisons of long-term temperature monitoring in the migration corridor before and after impoundment reveal a change in the thermal regime of the Snake and Columbia Rivers. Using historical flows and environmental records for the 35-year period 1960–95, Perkins and Richmond (2001) compared water temperature records in the lower Snake River with and without the lower Snake River dams and found three notable differences between the current versus unimpounded river:

- Maximum summer water temperature has been slightly reduced;
- Water temperature variability has decreased; and
- Post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall, a phenomenon termed thermal inertia.

These hydrosystem effects (influenced by the temperatures of tributary streams entering the Snake and Columbia Rivers both upstream of, within, and downstream of the mainstem dams) continue downstream and influence temperature conditions in the lower Columbia River. At a macro scale, water temperature affects salmonid distribution, behavior, and physiology (Groot and Margolis 1991); at a finer scale, temperature influences migration swim speed of salmonids (Salinger and Anderson 2006), timing of river entry (Peery et al. 2003), susceptibility to disease and predation (Groot and Margolis 1991), and, at temperature extremes, survival.

TDG levels also affect mainstem water quality and habitat conditions. To facilitate the downstream movement of juvenile salmonids, state regulatory agencies issue waivers for TDG as measured in the forebay and tailrace (NMFS 1995b). Specifically, water that passes over the spillway at a mainstem dam can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). Historically, TDG supersaturation was a major contributor to juvenile salmon mortality; to reduce TDG supersaturation, the Corps installed spillway improvements, typically "flip lips," at each mainstem dam except The Dalles Dam. Biological monitoring shows that the incidence of GBT in both migrating smolts and adults remains between 1–2 percent when TDG concentrations in the upper water column do not exceed 120 percent of saturation in CRS project tailraces. When those levels are exceeded, there is a corresponding increase in the incidence of signs of GBT symptoms. Fish migrating at depth avoid exposure to the higher TDG levels due to pressure compensation mechanisms (Weitkamp et al. 2003).

2.6.2.4 Tributary Habitat

Tributary habitat conditions throughout the LCR steelhead DPS have been significantly degraded by an array of land uses including urbanization, agriculture, forest management, transportation networks, and some gravel mining. These land uses have blocked access to historically productive habitats, simplified stream and side channels, degraded floodplain connectivity and function, increased delivery of fine sediment to streams, and degraded riparian conditions (contributing to stream channel simplification, reduced bank stability, increased sediment load, and elevated water temperatures; NMFS 2013a; NWFSC 2015). Inundation from the Bonneville Dam when it was completed in 1938 reduced habitat quality for juvenile summer steelhead in the Hood River population (NMFS 2013a). Despite this, most populations have maintained their spatial structure, meaning that returning adults can access most areas of significant historical habitat (although many of these habitats no longer support significant production; LCFRB 2010; ODFW 2010). For the Upper Cowlitz, Cispus, Tilton, North Fork Lewis, and Sandy populations, passage to upper-basin habitat is partially or entirely blocked by dams (LCFRB 2010; ODFW 2010); the Upper Gorge population is constrained by hatchery weirs, and the Hood population is constrained by the presence and operation of an irrigation dam. Steelhead distribution has been partially restored in the Upper Cowlitz, Cispus, and Tilton subbasin by trapping and transferring adults and juveniles around impassable dams (NMFS 2013a).

Impaired side channel and wetland conditions, along with degraded floodplain habitat, have significant negative impacts on juvenile steelhead throughout the DPS and are identified as primary limiting factors for all summer populations and all winter steelhead populations except the North Fork Lewis and Hood, where they are identified as secondary factors (NMFS 2013a). In most cases, these limiting factors have resulted from extensive channelization, diking, wetland conversion, stream clearing, and gravel extraction, which have barred steelhead from historically productive habitats and simplified remaining habitats, weakening watershed processes that are essential to the maintenance of healthy ecosystems and reducing refugia and resting places. Degraded riparian conditions and channel structure and form issues are also primary limiting factors for juveniles of all summer steelhead populations and all winter populations except the North Fork Lewis and Hood, where these conditions are identified as secondary factors. A lack of large wood and appropriately sized gravel in the remaining accessible tributary habitat has significantly reduced the amount of suitable spawning and rearing habitat for winter steelhead.

Numerous tributary habitat protection and restoration efforts have been implemented in recent years through the efforts of local recovery planning groups, federal and state agencies, tribal governments, local governments, conservation groups, private landowners, and other entities. These efforts have led to some local improvements in tributary habitat conditions. However, degraded habitat conditions, particularly with regard to channel complexity, floodplain connectivity, water-quality and hydrologic patterns, and toxic contamination, continue to negatively affect the abundance, productivity, spatial structure, and diversity of LCR steelhead. Continued land development and habitat degradation, in combination with the potential effects of climate change, may present a continuing strong negative influence into the foreseeable future (NWFSC 2015).

2.6.2.5 Estuary Habitat

The estuary provides important migration habitat for LCR steelhead. Since the late 1800s, 68–70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening combined with flow regulation and other modifications (Kukulka and Jay 2003; Bottom et al. 2005; Marcoe and Pilson 2017). Disconnection of tidal wetlands and floodplains has reduced the production of wetland macrodetritus supporting salmonid food webs (Simenstad et al. 1990; Maier and Simenstad 2009), both in shallow water and for larger juveniles migrating in the mainstem (ERTG 2018).

Restoration actions in the estuary, such as those highlighted in the latest five-year review, have improved access and connectivity to floodplain habitat (NWFSC 2015). From 2004 through 2017, restoration sponsors implemented 58 projects, including dike and levee breaching or lowering, tide-gate removal, and tide-gate upgrades that reconnected 5,412 acres of historical tidal floodplain habitat to the mainstem. This represents a 2.5 percent net increase in the connectivity of these habitats (Johnson et al. 2018). Although yearling steelhead migrants are less likely to enter and rear in these areas, improved opportunities for feeding on commonly consumed prey (chironomid insects and corophiid amphipods; PNNL and NMFS 2018) that drift into the mainstem are likely to contribute to survival at ocean entry.

2.6.2.6 Hatcheries

Historical hatchery effects and ongoing hatchery straying have reduced genetic diversity and productivity in both summer and winter LCR steelhead populations (NMFS 2013a). NMFS directs federal funding to many of the hatchery programs that affect the LCR steelhead DPS through the Mitchell Act. In 2017, NMFS completed an EIS and new biological opinion on its funding of the Mitchell Act program (NMFS 2017a). The Mitchell Act Record of Decision directs NMFS to apply strong performance goals to reduce the risks of hatchery programs on natural-origin populations. As a result, several additional hatchery reform measures have been or will be implemented, as described below. The implementation of these reform measures is expected to improve the status of the DPS:

- Changes in broodstock management to better align hatchery broodstocks with the diversity of the natural-origin populations that could be potentially affected by the hatchery programs.
- Modifications to the number of hatchery fish produced and released in certain programs along with the installation of six new seasonal weirs because, in some tributaries, there have been too many hatchery-origin fish spawning naturally, which has posed both a genetic and ecological risk. The production-level changes will reduce the pHOS[62] (Table 2.6-4) and reduce genetic and ecological risk.
- Elimination of the release of Chambers Creek steelhead, a hatchery stock that does not originate from within the Columbia River basin. This change will reduce genetic risk to the ESA-listed LCR steelhead DPS.
- Upgrades to hatchery facilities to bring water intake screens into compliance with new standards, ensuring that they minimize adverse impacts to ESA-listed fish.
- Even with these improvements, hatchery production will continue to limit the diversity and productivity of natural-origin LCR steelhead. In addition, LCR steelhead are affected by hatchery production of salmon and steelhead from other ESUs and Distinct Population Segments. Hatchery programs were designed to conserve vital genetic resources and to supplement harvest levels to compensate for losses throughout their life cycle. Some scientists suspect that closely spaced releases of hatchery fish from all Columbia Basin hatcheries may lead to increased competition with natural-origin fish for food and habitat space in the estuary. NMFS (2006) and the Lower Columbia Fish Recovery Board (LCFRB 2010) identified competition for food and space among hatchery-origin and natural-origin juveniles in the estuary as a critical uncertainty. ODFW (2010) acknowledged this uncertainty, but listed competition for food and space as a secondary limiting factor for juveniles of all populations.

[62] Percent hatchery fish on the spawning grounds.

Table 2.6-4. Expected genetic effect levels on LCR steelhead populations potentially affected by Mitchell Act-funded hatchery programs.

Major Population Group	Population	Recovery Designation	Expected maximum gene flow from MA programs once fully implemented	Expected Census pHOS levels from MA programs once fully implemented
Cascade (winter)	Coweeman	Primary	≤2.0%	≤5.0%
	SF Toutle	Primary	≤2.0%	≤5.0%
	Kalama	Primary	≤2.0%	≤5.0%
	Salmon Cr	Stabilizing	≤2.0%	≤5.0%
	Clackamas	Primary	N/A	Winter program: ≤10.0% Summer program: ≤5.0%
	Washougal	Contributing	≤2.0%	≤5.0%
	Sandy	Primary	N/A	Winter program: ≤10.0% Summer program: ≤5.0%
Cascade (summer)	Kalama	Primary	≤2.0%	≤5.0%
	Washougal	Primary	≤2.0%	≤5.0%
Gorge (winter)	Upper Gorge	Stabilizing	≤2.0%	≤5.0%

2.6.2.7 Recent Ocean and Lower River Harvest

In February 2018, NMFS signed the 2018–27 *U.S. v. Oregon* Management Agreement of the Columbia River Basin, which provides a framework for managing salmon and steelhead fisheries and hatchery programs in much of the Columbia River basin. The decision was based on both our recently completed Final EIS and the associated biological opinion (NMFS 2018a). This agreement supports salmon and steelhead fishing opportunities for the states of Oregon, Washington, and Idaho; ensures fair sharing of harvestable fish between tribal and nontribal fisheries in accordance with treaty fishing rights and *U.S. v. Oregon*; protects and conserves ESA-listed and unlisted species; and ensures NMFS fulfills its trust/treaty responsibilities to Columbia Basin tribes. There is no direct fishery for naturally produced LCR steelhead other than a catch-and-release fishery in the Wind River.

Steelhead are intercepted in mainstem fisheries targeting unlisted hatchery and naturally produced Chinook salmon, and unlisted steelhead. Mark-selective net fisheries in the mainstem Columbia River can result in post-release mortality rates of 10 to over 30 percent, although there is considerable disagreement on the overall rate (NMFS 2016c). Recreational fisheries targeting marked hatchery-origin steelhead encounter natural-origin fish at a relatively high rate, but hooking mortalities are generally lower than those in the net fisheries. Estimated mortality for naturally produced winter-run steelhead has averaged 2.2 percent (2009–13) for nontribal commercial and recreational fisheries (ODFW and WDFW 2015). The current *U.S. v. Oregon* Management Agreement has, on average, maintained reduced harvest impact for LCR steelhead fisheries, with 2014 harvest rates for winter-run steelhead in mainstem fisheries at 0.6 percent and with harvest rates for summer-run steelhead below 15 percent for those above Bonneville Dam (NWFSC 2015).

2.6.2.8 Predation

The existence of dams and reservoirs around the Columbia Basin also blocks sediment transport. Total sediment discharge into the estuary and Columbia River plume is about one-third of nineteenth-century levels (NMFS 2008a). This reduces turbidity in the lower river, especially during spring, which is likely to make juvenile outmigrants more vulnerable to visual predators like piscivorous birds and fishes.

2.6.2.8.1 Avian Predation

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, are having a significant impact on the survival of juvenile salmonids (including LCR steelhead) in the Columbia River. Caspian terns on Rice Island, an artificial dredged-material disposal island in the estuary, consumed about 5.4-14.2 million juveniles per year in 1997 and 1998, or 5-15 percent of all the smolts reaching the estuary (Roby et al. 2017). Efforts began in 1999 to relocate the tern colony 13 miles closer to the ocean at East Sand Island where the tern diet would diversify to include marine forage fish. During 2001-15, estimated consumption by terns on East Sand Island averaged 5.1 million smolts per year, about a 59 percent reduction compared to when the colony was on Rice Island. Management efforts are ongoing to further reduce salmonid consumption by terns in the lower Columbia River and similar efforts are in progress to reduce the nesting population of double-crested cormorants in the estuary.

Researchers have not estimated predation rates for LCR steelhead because these fish are not PIT tagged. However, based on detection rates for fish from interior Columbia Basin steelhead DPSs at the East Sand Island colonies, steelhead are more vulnerable to avian predation than Chinook salmon (Evans et al. 2018a), possibly because they are more surface-oriented (Beeman and Maule 2006). Predation rates by East Sand Island terns on steelhead from interior DPSs ranged from about 15-22 percent per year before the management plans were implemented, but have dropped to about 9 percent per year for each DPS (Evans et al. 2018a). Predation rates by East Sand Island cormorants on interior steelhead, pre-management, ranged from about 5-9 percent per year. Due to failures of the cormorant colony in 2016 and 2017 (Appendix C), there are no estimates of predation rates since management of that colony began. In addition, substantial numbers of cormorants have relocated to the Astoria-Megler Bridge (preliminary report of 1,737 in 2018) and hundreds more are observed on the Longview Bridge, navigation aids, and transmission towers in the lower river (Anchor QEA et al. 2017). Smolts may constitute a larger proportion of the diet of cormorants nesting at these sites than if the birds were foraging from East Sand Island. Thus, the success of the East Sand Island tern and cormorant management plans at meeting their underlying goals of reducing salmonid predation is uncertain at this time.

In the hydrosystem reach, the Action Agencies have employed wire arrays, pyrotechnics, water cannons, and other measures, including limited lethal take at project tailraces in the lower Columbia River. These measures have been shown to reduce predation rates on juvenile salmonids at John Day and The Dalles Dams, and may have had similar effects at Bonneville Dam (Zorich et al. 2012).

2.6.2.8.2 Piscivorous Fish Predation

Native pikeminnow are significant predators of juvenile salmonids in the Columbia River basin, followed by nonnative smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011, 2015). Before the start of the NPMP in 1990, this species was estimated to eat about eight percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River basin each year. Williams et al. (2017) compared current estimates of northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. On average, 37 adult steelhead and 217 juveniles were killed and/or handled each year in the Sport Reward Fishery during 2013-17. The fishery is conducted over a much larger area than that occupied by LCR steelhead, but small numbers of these fish could have been from this DPS.

The Action Agencies also conduct a Dam Angling Program at The Dalles and John Day Dams. Anglers did not catch any steelhead during 2013-17 (Williams 2013, 2014; Williams et al. 2015, 2016, 2017).

Juvenile salmonids are also consumed by nonnative fishes including walleye, smallmouth bass, and channel catfish. Both the Oregon and Washington Departments of Fish and Wildlife have removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids.

2.6.2.8.3 Pinniped Predation

California and Steller sea lions prey on adult steelhead below Bonneville Dam and throughout the lower Columbia River. The population size of California sea lions has shown a steady increase from lows in the mid-1970s to levels in 2014 above maximum net productivity level (Lakke et al. 2018). Recent declines in pup production and survival suggest the population may have stopped growing. Consumption of at-risk salmonids (including steelhead) at Bonneville Dam by California sea lions and Steller sea lions has ranged from a low of 0.35 percent in 2002 to highs of 5.5 percent in 2016 and 4.5 percent in 2017 (Tidwell et al. 2018). Adult LCR steelhead are also vulnerable to pinniped predation throughout the lower Columbia River. This vulnerability is primarily for spring-run populations that migrate during May and June, when the pinniped abundance is highest. Under an authorization under the Marine Mammal Protection

Act, management agencies have implemented numerous measures to reduce predation at Bonneville Dam and Astoria, from hazing to removal. From 2008 through 2017, 15 California sea lions at Bonneville Dam were captured and placed in captivity (Brown et al. 2017). During that same period, 163 California sea lions were euthanized at Bonneville Dam and five at Astoria (Brown et al. 2017).

2.6.2.8.4 Compensatory Effects and Predation on Salmonid Populations

An estimate of the effect of a predator population on adult returns to Bonneville Dam (e.g., the effect of smolt consumption by northern pikeminnow or Caspian terns) has the potential to be erroneous if it does not consider whether other factors intervene to compensate for the change in mortality (ISAB 2016). The primary mechanisms for compensatory effects are: (1) increased fish survival due to reduced densities in later life stages, (2) selective predation based on fish size and condition, and (3) predator switching from one prey species to another. Compensatory effects are difficult to quantify because they can occur later in the life cycle and can vary over time; efforts are currently underway to better understand compensatory effects (Haeseker 2015; Evans et al. 2018b).

2.6.2.9 Research and Monitoring Activities

The primary effects of the past and ongoing CRS-related RM&E programs on LCR steelhead is associated with the capturing and handling of fish. The RM&E program is a collaborative, regionally coordinated approach to fish and habitat status monitoring, action effectiveness research, critical uncertainty research, and data management. The information derived from the program facilitates effective adaptive management through better understanding the effects of the ongoing CRS action. Capturing, handling, and releasing fish generally leads to stress and other sublethal effects, but fish sometimes die from such treatment. The mechanisms by which these activities affect fish have been well documented and are detailed in Section 8.1.4 of the 2008 biological opinion. Some RM&E actions also involve sacrificial sampling of fish. We estimated the number of LCR steelhead that have been handled or killed each year during the implementation of RM&E under the 2008 RPA as the average annual take reported for 2013-2017:

- The average annual estimates for handling and mortality of LCR steelhead associated with the associated with the Smolt Monitoring Program and the Comparative Survival Study: (1) no hatchery or wild adults handled; (2) no hatchery or wild adults died; (3) 551 hatchery and 80 wild juveniles handled and (4) zero hatchery and one wild juvenile died.
- No adult or juvenile LCR steelhead were handled or died during implementation of the ISEMP.
- Estimates for LCR steelhead handling and mortality for all other RM&E programs: (1) two hatchery and four wild adults handled; (2) zero hatchery and zero wild adults died; (3) 341 hatchery and 1,002 wild juveniles handled; and (4) 58 hatchery and 172 wild juveniles died.

The combined take (i.e., handling, including injury, and incidental mortality) associated with these elements of the RM&E program has, on average, affected less than 1 percent of the wild (i.e., natural origin) adult returns or juvenile production for the LCR steelhead DPS (Bellerud 2018). This relatively small effect is deemed worthwhile because it allows the Action Agencies and NMFS to evaluate the effects of CRS operations, including modifications to facilities, operations, and mitigation actions.

In addition, northern pikeminnow are tagged as part of the Sport Reward Fishery and their rate of recapture is used to calculate exploitation rates. Northern pikeminnow are collected for tagging using boat electrofishing in select reaches of the Columbia River. During 2017, boat electrofishing operations in the Columbia River extended upstream from RM 47 (near Clatskanie, Oregon) to RM 394 (Priest Rapids Dam), and in the Snake River from RM 10 (Ice Harbor Dam) to RM 41 (Lower Monumental Dam) and from RM 70 (Little Goose Dam) to RM 156 (upstream of Lower Granite Dam). Researchers conducted four sampling events consisting of 15 minutes of boat electrofishing effort in shallow water within each 0.6-mile reach during April-July.

A side effect of the electrofishing effort is that salmon and steelhead may be exposed to the electrofishing field, with the potential for injury, stress, and fatigue and even cardiac or respiratory failure (Snyder 2003). Some adult and juvenile LCR steelhead are likely to be present in shallow shoreline areas during the April-July time period. Most sampling occurs in darkness (1800-0500 hours). Operators shut off the electrical field if salmonids are seen and because most stunned fish quickly recover and swim away, they cannot be identified to species (i.e., Chinook, coho, chum, or sockeye salmon or steelhead). Barr (2018) reported encountering an annual average of 891 adult and 60,312 juvenile salmonids in the lower Columbia River each year during 2013-17 electrofishing operations based on visual estimation methods. It is likely that some of these were LCR steelhead.

2.6.2.10 Critical Habitat

The environmental baseline for the PBFs for LCR steelhead critical habitat are discussed above and summarized here in Table 2.6-5. Tributary barriers are a concern for freshwater spawning sites, freshwater rearing sites, and migration corridors. Water quality is a concern for all PBFs. Restoration activities addressing migration barriers and water quality have improved the baseline condition for PBFs; however, more restoration is needed before the PBFs can fully support the conservation of LCR steelhead.

Table 2.6-5. Physical and biological features (PBFs) of designated critical habitat for LCR steelhead.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the
Freshwater spawning sites	Water quantity and quality and substrate to support spawning, incubation, and larval development	• Tributary barriers (culverts, dams, water withdrawals) • Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) • Loss of wetland and side channel connectivity (urban and rural development, forest and agricultural practices, channel manipulations) • Excessive sediment in spawning gravel (forest and agricultural practices) • Elevated water temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices • Inundation of spawning sites under Bonneville Reservoir (hydrosystem development)
Freshwater rearing sites	Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility, water quality and forage, and natural cover	• Tributary barriers (culverts, dams, water withdrawals) • Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) • Loss of wetland and side channel connectivity (urban and rural development, forest and agricultural practices, channel manipulations) • Excessive sediment in spawning gravel (forest and agricultural practices) • Elevated water temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices)
Freshwater migration corridors	Free of obstruction and excessive predation, adequate water quality and quantity, and natural cover	• Delay and mortality of some juveniles and adults • Concerns about increased opportunities for predators, especially birds and pinnipeds (construction of dredge-material islands in the lower river and other human-built structures used by terns and cormorants for nesting, constricted passage opportunities for adult steelhead in the Bonneville tailrace)
Estuarine areas	Free of obstruction and excessive predation with water quality, quantity	• Diking off areas of the estuary floodplain (land use), combined with reduced peak spring flows (water

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the
	and salinity, natural cover, and juvenile and adult forage	diversions and water storage and hydroelectric projects), have reduced access to floodplain habitat for rearing and prey production
Nearshore marine areas[1]	Free of obstruction and excessive predation with water quality, quantity, and forage	• Concerns about increased opportunities for pinniped predators, adequate forage

[1] Designated area includes only the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

2.6.2.11 Future Anticipated Impacts of Completed Consultations

The environmental baseline also includes the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, including the consultation on the operation and maintenance of the Bureau of Reclamation's upper Snake River projects. The 2016 five-year review evaluated new information regarding the status and trends of LCR steelhead, including recent biological opinions issued for the LCR steelhead and key emergent or ongoing habitat concerns (NMFS 2016c). Since the beginning of 2015 through 2017, we completed 456 formal consultations (131 in 2015, 131 in 2016, and 194 in 2017) that addressed effects to LCR steelhead.[63] These numbers do not include the many projects implemented under programmatic consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed salmonids. Some of the completed consultations are large (large action area, multiple species), such as the Mitchell Act consultation and the consultation on the 2018–27 *U.S. v. Oregon* Management Agreement. Many of the completed actions are for a single activity within a single subbasin.

Some current and proposed restoration projects will improve access to blocked habitat and riparian condition, and increase channel complexity and instream flows. For example, under BPA's Habitat Improvement Programmatic consultation, BPA implemented 29 projects in the Columbia Basin that improved fish passage in 2017, and 99 projects that involved river, stream, floodplain, and wetland restoration. These projects will benefit the viability of the affected populations by improving abundance, productivity, and spatial structure. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more, and typically less, than a few weeks).

[63] PCTS data query, July 31, 2018.

Other types of federal projects, including grazing allotments, dock and pier construction, and bank stabilization, will be neutral or have short- or even long-term adverse effects on viability. All of these actions have undergone section 7 consultation and the actions or the RPA were found to meet the ESA standards for avoiding jeopardy.

Similarly, future federal restoration projects will improve the functioning of the PBFs safe passage, spawning gravel, substrate, water quantity, water quality, cover/shelter, food, and riparian vegetation. Projects implemented for other purposes will be neutral or have short- or even long-term adverse effects on some of these same PBFs. However, all of these actions, including any RPAs, have undergone section 7 consultation and were found to meet the ESA standards for avoiding adverse modification of critical habitat.

2.6.2.12 Summary

The factors described above have negatively affected the abundance, productivity, diversity, and spatial structure of LCR steelhead populations. Recent improvements in passage conditions at Bonneville Dam and at tributary barriers, the small net improvement in floodplain connectivity achieved through the CRS estuary habitat program, and efforts to improve hatchery practices and lower harvest rates are positive signs, but other stressors are likely to continue. NMFS (2016c) identified past land development, habitat degradation, and predation, in combination with the potential effects of climate change, as likely to present a continuing strong negative influence into the foreseeable future.

Likewise**,** the environmental baseline within the action area does not fully support the conservation value of designated critical habitat for LCR steelhead. The PBFs essential for the conservation of LCR steelhead include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine rearing areas, and nearshore marine areas (at the mouth of the Columbia River).

The CRS Action Agencies and other federal and nonfederal entities have taken actions in recent years to improve the functioning of some of the PBFs of critical habitat. For stream-type juveniles, projects that have protected or restored riparian areas and breached or lowered dikes and levees in the estuary have improved the functioning of the juvenile migration corridor. For subyearling smolts, restoration projects in the estuary are improving the functioning of areas used for growth and development. However, other factors that have negative effects on these PBFs are expected to continue into the future.

2.6.3 Effects of the Action

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

The proposed action is an ongoing action that has been modified over time to reflect capital improvements, as well as changes in operation based on existing conditions and improved information on how CRS operations affect UWR Chinook salmon and other listed species and their critical habitats. The current proposed action includes operational measures (e.g., flood risk management, navigation, fish passage, and hydropower generation) and non-operational measures (e.g., support for conservation hatchery programs, predation management, habitat improvement actions) that will be implemented beginning in 2019. The proposed action, however, is of limited duration. The Action Agencies are developing an EIS in accordance with NEPA that will assess and update the approach for long-term system operations, maintenance, and configuration as well as evaluate measures to avoid, offset, or minimize impacts to resources affected by the management of the CRS, including ESA-listed species and designated critical habitat. A court order currently requires the Action Agencies to issue Records of Decision on or before September 24, 2021.[64] Based on scoping, the range of alternatives being examined is broad and includes potential large-scale changes in the action. Thus, there is substantial uncertainty regarding what system operations, maintenance, and configuration the Action Agencies will propose at the conclusion of the NEPA process. Likewise, it is unknown what measures intended to avoid, offset, or minimize adverse effects will ultimately be included in the final preferred alternative.

As described in section 2.1 above, our analysis of effects for LCR steelhead extends from 2019 into the future, but emphasizes the evaluation of effects that are reasonably certain to occur as a result of implementing the proposed action pending completion of the EIS and our issuance of a subsequent biological opinion addressing the effects of the final preferred alternative. To the extent our consideration of potential effects beyond that time period assumes the current proposed action remains in place, it is intended, in part, to inform the evaluation of alternatives in the EIS.

The Action Agencies will operate the run-of-river lower Columbia River projects (McNary, John Day, The Dalles, and Bonneville Dams) in accordance with the annual Water Management Plan and Fish Passage Plan (including all appendices). These projects are operated for multiple purposes, including fish and wildlife conservation, irrigation, navigation, power, recreation, and, in the case of John Day Dam, limited flood risk management.

The effects of the proposed action are generally consistent with the effects caused by a continuation of the CRS operations as described in the environmental baseline section, with the addition of the following operational changes:

- Flexible spring spill operation;

[64] The Presidential Memorandum on Promoting the Reliable Supply and Delivery of Water in the West, issued on October 19, 2018, required the development of an expedited schedule for completion of the NEPA process. The Council on Environmental Quality has confirmed a revised schedule that calls for completing the Draft EIS in February 2020, the Final EIS in June 2020 and Records of Decision by September 30, 2020. These dates are consistent with, but earlier than, the court-ordered deadlines.

- 0.5-ft increase in reservoir operating range at John Day and Lower Snake River Projects.

Of these alterations, only the flexible spring spill operation is expected to alter conditions for the four LCR steelhead populations migrating upstream of Bonneville Dam. The other operational changes are not anticipated to alter the effects to LCR steelhead because very few or no fish in the DPS will be exposed to the effects of those changes.

2.6.3.1 Effects to Species

Juvenile and adult steelhead from all populations of LCR steelhead will be exposed to the continuing effects of the action in the mainstem Columbia River. The four populations that migrate above Bonneville Dam (Upper Gorge winter steelhead, Wind summer steelhead, Hood winter steelhead, and Hood summer steelhead) will also be exposed to effects of the action above Bonneville Dam, and possibly to the John Day pool.

2.6.3.1.1 Hydrosystem Operation

For LCR steelhead, the effect of the continued operation of the CRS is essentially a continuation of the effects from recent hydrosystem operations described in the environmental baseline (resulting from implementation of the 2008 biological opinion's reasonable and prudent alternative hydro actions), with the addition of the proposed flexible spring spill operation. Direct mainstem hydropower system impacts on LCR steelhead are most significant for the four gorge tributary populations upstream from Bonneville Dam, all of which are in the Gorge winter (Upper Gorge and Hood) and Gorge Summer (Wind and Hood) MPGs. These populations are affected by upstream and downstream passage at Bonneville Dam and by the inundation of historical habitat, which has been used by juveniles in the past (McElhany et al. 2004). Impacts on populations originating in subbasins below Bonneville Dam are limited to effects on migration and habitat conditions in the LCR (below Bonneville Dam), including the estuary because of changes in the hydrograph and movement of sediment.

Recent passage improvements[65] improved the survival of juvenile steelhead that pass through Bonneville Dam (Upper Gorge winter steelhead, Wind summer steelhead, Hood winter steelhead, and Hood summer steelhead populations). Based on a 2010 steelhead passage and survival study, we estimate that 96.9 percent of juvenile steelhead that migrate past Bonneville Dam will survive.

For adults, the direct survival rate of steelhead at Bonneville Dam is quite high. Based on PIT-tag detections at Bonneville and The Dalles Dam, upstream passage survival rate of adult LCR steelhead is 98.5 percent (adjusted for harvest and straying).

The survival for steelhead kelts passing through The Dalles Dam and Bonneville Dam was studied in spring 2012 (Rayamajhi et al. 2013). Survival for LCR steelhead at The Dalles Dam

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[65] These include the installation of minimum gap runners at Bonneville PH1 and the FGE improvements at PH2, and improvements to the sluiceway fish guidance system (efficiency and conveyance) at PH1.

ranged from 70 to 75 percent depending on passage route. Survival at Bonneville Dam ranged from 50 to 100 percent depending on passage route.

During periods of increased spill (spring), the effects to LCR steelhead include: (1) potential for increased fallback of adults for the two summer-run populations that spawn upstream of Bonneville Dam (Wind and Hood) that move upstream in the spring; (2) increased likelihood that juveniles from all populations that spawn upstream of Bonneville Dam will go through the spillway rather than the juvenile bypass, corner collector, or turbine units,; and (3) exposure to increased levels of TDG in Bonneville Pool and below Bonneville Dam.

Increased spill has been correlated with increased fallback behavior at Bonneville Dam for steelhead (Boggs et al. 2004), and fallback is a concern since increased fallback has been demonstrated to reduce conversion to natal tributaries for adult salmonids (Keefer et al. 2005). While the additional spill could increase the overall proportion of adult LCR steelhead that fallback, the reduction in flow through the powerhouse could reduce the proportion of LCR steelhead that fallback through turbine units which is the lowest survival route for adult salmonids to pass (Normandeau et. al 2014). The overall effect to adult survival and conversion success associated with the increase in spill is difficult to quantify with the existing information, but any impacts associated with an increase in spillway fallback will likely be outweighed by a reduction in turbine fallback and have minimal overall impact to adult survival.

Downstream passage of juvenile steelhead through the spillway as compared to the bypass or corner collector could result in lower survival based on the relative survival estimates of these routes of passage (Ploskey et al. 2012). However, higher spill will also result in fewer LCR steelhead passing through turbines, and since spillway survival is higher than turbine survival (Fredricks 2017), the consequence of more fish passing through the spillway should positively benefit population-level survival. While there is potential for negative effects, we expect there will be no substantial change in survival at Bonneville Dam because of the increase in spill during the flexible spring spill operation. The CSS study hypothesizes that increased spill will substantially reduce latent mortality of populations moving downstream through the mainstem dams (CSS 2017).

Compared to recent operations,[66] increased spill levels from April 10 to June 15 will increase the exposure of adult spring migrating adults and smolts to higher concentrations of TDG from the Bonneville pool downstream to at least 35 miles below Bonneville Dam. The increased exposure will likely affect the four populations within the Bonneville Reservoir and those populations most proximal to Bonneville Dam, though increased TDG levels can be measured for at least 35 miles downstream of the dam. Exposure to elevated TDG (up to state water quality critera) as a result of increased juvenile fish passage spill may negatively affect individual smolts, but should have little, if any, substantive effect on juveniles migrating swiftly past Bonneville Dam and its tailrace, especially considering the limited duration of this proposed action. Adults could be

[66] The hydro action under the environmental baseline targeted 100 kcfs spill from 2008–17. In 2018, spill levels were increased to the Gas Cap limit (up to 120 percent TDG in the tailrace of Bonneville Dam).

exposed for hours or days to elevated TDG levels as they seek out fishway entrances in the tailrace of Bonneville Dam. However, the potential impacts of exposure up to 120-125 percent TDG levels will likely be very limited due to depth compensation and run timing.

2.6.3.1.2 Predator Management and Monitoring Actions

The Corps' program to install and operate sea-lion excluder gates at Bonneville Dam will continue and is likely to positively affect the four populations that pass upstream of Bonneville Dam. Likewise, the Corps' and BPA's support of land- and water-based sea-lion harassment and removal efforts from the area downstream of Bonneville are likely to substantially reduce adult mortality of summer-run populations (compared to if these actions were not taken), and would slightly reduce adult mortality of winter-run populations.

The pikeminnow predation management program includes the Sport Reward Fishery and Dam Angling programs, which will continue as part of the proposed action. The first is implemented in the Columbia River, including the estuary. This fishery removes approximately 10–20 percent of predatory-sized pikeminnow per year, and is open from May through September when juvenile steelhead can be rearing and migrating in mainstem habitats. We expect that this ongoing measure will continue the 30 percent reduction in predation rates achieved under the 2008 RPA. We estimate that the numbers of steelhead, including some from the LCR steelhead DPS, handled and/or killed in the Sport Reward Fishery will be no more than 100 adults and 600 juveniles per year, system-wide during the interim period.

The Action Agencies will also continue to implement the Northern Pikeminnow Dam Angling Program at The Dalles and John Day Dams, as described under the environmental baseline. These ongoing measures will continue the reduction in predation rates achieved under the 2008 RPA. We estimate that no more than ten adult and 20 juvenile steelhead, including LCR steelhead, will be caught in the Dam Angling Program per year during the interim period.

The Action Agencies propose to continue implementation of the Caspian Tern Nesting Habitat Management Plan (USACE 2015a) and the Double-crested Cormorant Management Plan (USACE 2015b). As discussed in the Environmental Baseline section above, it is difficult to quantify an increased survival because of observations of birds relocating to other sites in the estuary and year-to-year variation in bird population size. Because the Action Agencies propose to continue maintaining the reduced amounts of nesting habitat achieved for terns and cormorants on East Sand Island (BPA et al. 2018a), we expect that any reduced predation rates achieved for LCR steelhead under the 2008 FCRPS biological opinion and associated RPA will continue during the interim period. The Action Agencies will also continue to implement, and improve as needed, the avian predation deterrence measures at the tailrace of Bonneville Dam, which address another source of juvenile LCR steelhead mortality.

The Action Agencies propose to synthesize avian colony size and predation rate data collected under the tern and cormorant colony management plans. The intent of the synthesis report is to provide the Action Agencies, cooperating agencies, and NMFS with a summary of predation by piscivorous waterbirds on ESA-listed salmonids in the Columbia River basin before, during, and after the management actions, in order to assess their effectiveness on a basinwide scale. This review will help the Action Agencies prioritize any efforts to take place during this interim period or to be discussed as future mitigation measures in the CRS Operations NEPA document.

2.6.3.1.3 Habitat Actions

For those LCR steelhead populations that have been negatively affected by the CRS, the Action Agencies will provide funding and/or technical assistance for tributary habitat improvement actions consistent with basinwide criteria for prioritizing actions, including recovery plan priorities, as funding allows. If implemented, and if implemented in a manner consistent with scientifically sound identification and prioritization of limiting factors and geographic locations, such actions could provide benefits to the targeted populations. However, because the Action Agencies have not proposed a commitment to implement tributary habitat improvement actions for LCR steelhead as part of this proposed action, or proposed them in a manner where we could meaningfully assess the effects (e.g., committing to achieve specific amounts or types of restoration), we are not considering the benefits of potential actions in our analysis.

The Action Agencies have committed to continuing to implement the CEERP to increase the capacity and quality of estuarine ecosystems and improve access for juvenile salmonids. The Action Agencies will continue to emphasize reconnection of floodplain areas in tidally influenced waters of the lower Columbia River and estuary, primarily through modifying levees. Additional actions at habitat improvement sites will include recreating historical channel networks, reducing the presence of nonnative species, and revegetating habitat improvement sites with native vegetation to ensure a site's resiliency. These projects are expected to provide indirect (increased transfer of insect and amphipod prey to the mainstem migration corridor) benefits to LCR steelhead as they migrate through the estuary.

NMFS agrees with the ISAB's assessment findings that it is difficult to reliably quantify the survival benefits of estuary habitat restoration, but the Action Agencies' assessment method, including review by the ERTG,[67] is useful to prioritize projects. The Action Agencies' proposed action includes a commitment to reconnect an average of 300 acres of floodplain per year to the mainstem, a goal that they have a record of achieving in 2008-17 (BPA et al. 2018b). The habitat's conservation value is likely to improve as more habitat gets reconnected, and the benefits are likely to accrue as the habitat patches get larger (Spiesman et al. 2018). While we agree that a link to a survival increase has not been demonstrated, these habitats provide important prey items for yearling steelhead in the mainstem (Johnson et al. 2018). It is also likely that these benefits will increase as habitat quality matures.

[67] As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss with ERTG and regional partners relevant climate change science in an effort to understand whether their planned estuary projects are resilient to climate change (i.e., sea level rise, temperatures, and mainstem flow levels). In addition, the Action Agencies' annual update of their restoration and monitoring plans for the estuary will document any needed adjustments in design, location, or other elements of a given project to address climate change impacts, both during and beyond the interim period.

2.6.3.1.4 Research and Monitoring Activities

The Action Agencies' RM&E program will be similar to the current program, or will be implemented at a reduced scale. Thus, the level of injury and mortality discussed in the Environmental Baseline, primarily from the capturing and handling of fish, is likely to continue at a similar or reduced level. We estimate that, on average, the following numbers of LCR steelhead will be affected each year during the interim period:

- Projected estimates of LCR steelhead handling and mortality during activities associated with the Smolt Monitoring Program and the CSS: (1) zero hatchery or wild adults handled or killed; and (2) zero hatchery or wild juveniles handled or killed.
- No LCR steelhead will handled or killed during activities associated with the Fish Status Monitoring.
- Projected estimates of LCR steelhead handling and mortality for all other RM&E programs: (1) 80 hatchery and 128 wild adults handled; (2) one hatchery and one wild adult killed; (3) 4,558 hatchery and 277 wild juveniles handled; and (4) 46 hatchery and 3 wild juveniles killed.

The combined take (i.e., handling, including injury, and incidental mortality) associated with these elements of the RM&E program will, on average, affect less than one percent of the wild (i.e., natural origin) adult returns or juvenile production for the LCR steelhead DPS (Bellerud 2018). This relatively small effect is deemed worthwhile because it will allow the Action Agencies and NMFS to continue to evaluate the effects of CRS operations including modifications to facilities, operations, and mitigation actions.

Electrofishing operations for the NPMP during the interim period are expected to continue at the same level of effort as in recent years (four 15-minute sampling events per 0.6-mile reach between RM 47 near Clatskanie, Oregon, and McNary Dam during April-July; a total of 550 hours system-wide). Some adult and juvenile LCR steelhead are likely to be present in shallow shoreline areas during electrofishing activities and may be stunned and even killed. However, because the operator releases the electrical field as soon as salmonids are observed and most of these fish quickly recover and swim away, we are unable to use observations from past operations to estimate the number of fish from this DPS that will be affected. Information obtained through electrofishing supports management of the NPMP, which is reported to have reduced salmonid predation by about 30 percent (Williams et al. 2017). This level of take is anticipated to occur for the duration of this proposed action, pending completion of the NEPA process.

2.6.3.2 Effects to Critical Habitat

Implementation of the proposed action is likely to affect passage at Bonneville Dam for four (all of which are in the Gorge Winter and Gorge Summer MPGs) of the 32 populations.

Implementation will also affect the volume and timing of flow in the Columbia River, which has the potential to alter habitat in the Columbia River mainstem and estuary in all extant populations. The PBFs that could be affected by the proposed action are described in Table 2.6-6.

Table 2.6-6. Effects of the proposed action on the physical and biological features (PBFs) essential for the conservation for the DPS.

PBF	Effect of the Proposed Action
Freshwater spawning sites	The proposed action will continue the inundation of spawning habitat for steelhead in the lower reaches of the tributaries to the Bonneville Pool. We do not know how much habitat was inundated when the dam was constructed and the pool filled; the inundation cannot be alleviated by project operation unless the reservoir is drawn down to near original river elevation.
Freshwater rearing sites	Juvenile LCR steelhead rear in the mainstem Columbia River. This PBF is negatively affected by morphological changes in the river and continued disconnection from floodplain habitat, which can affect food supply and supply of resting habitat.
Freshwater migration corridors	Increased levels of total dissolved gas (TDG; water quality) in the gorge area during spring spill up to 120-125 percent could affect the conservation value of the habitat within Bonneville reservoir and at least 35 miles downstream. This area serves as critical habitat for the Gorge Summer and Winter MPGs and one population in each of the Cascade Summer and Winter MPGs. Smolts are able to use behavioral mechanisms to avoid elevated TDG (i.e., by migrating deeper in the water column).. Sediment will continue to accumulate behind CRS dams, reducing turbidity in the migration corridor during the smolt outmigration, which could affect the safe passage PBF by increasing the risk of predation. The migration corridor is affected by passage at Bonneville Dam for the four populations that pass the dam. Passage conditions for both adults (increased fallback) and for juveniles (increased spill passed fish versus reduced turbine passage [worse route] and reduced juvenile bypass system or corner collector passage [better route) and could, potentially negatively affect survival, resulting in reduced conservation value of this PBF. Any reduced predation rates achieved under the 2008 biological opinion and associated RPA will continue during the interim period. (safe passage).
Estuarine areas free of obstruction and excessive predation, with adequate water quality and salinity	This PBF will continue to improve with the proposed reconnection of an average of 300 acres of floodplain habitat per year during implementation of this proposed action.

PBF	Effect of the Proposed Action
	Because estuary bird colonies and predation rates are in flux, it is not clear whether the continued tern and cormorant colony management is likely to continue any existing survival benefits; thus, we expect this PBF to remain unchanged.

2.6.4 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation (50 CFR 402.02). Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Nonfederal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. These projects also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth management programs (planning and regulation); a variety of stream and riparian habitat projects; watershed planning and implementation; acquisition of water rights for instream purposes and sensitive areas; instream flow rules; stormwater and discharge regulation; TMDL implementation to achieve water-quality standards; hydraulic project permitting; and increased spill and bypass operations at hydropower facilities. NMFS determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. These activities are likely to have beneficial cumulative effects that will significantly improve conditions for the salmon and steelhead, including LCR steelhead.

NMFS also noted that some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects are activities that occurred in the recent past and were included in the environmental baseline. Some of these activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the action area, nonfederal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. All of these activities can contaminate local or larger areas with hydrocarbon-based materials. Continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations.

Overall, we anticipate that projects to restore and protect habitat, restore access to and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area.

2.6.5 Integration and Synthesis

In this section, we add the effects of the action (Section 2.6.3) to the environmental baseline (Section 2.6.2) and the cumulative effects (Section 2.6.4), taking into account the status of the species and critical habitat (Section 2.6.3.1-2.6.3.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat for the conservation of the species.

2.6.5.1 Species

NMFS' recent status review affirmed LCR steelhead as threatened but identified some positive trends in LCR steelhead status (NWFSC 2015; NMFS 2016c). For example, hatchery interactions remain a concern in select basins, but the overall situation is somewhat improved compared to the prior review in 2011. A total of five out of the 22 populations are at or near their recovery viability goals, although two of these populations had scores above 2 (moderate risk) under the recovery plan scenario. Spatial structure remains relatively high for most populations, meaning that returning adults can access most areas of significant historical habitat, although many of these habitats can no longer support significant production. The status review concluded that the majority of winter and summer steelhead populations continue to persist at low abundances. Habitat degradation continues to be a concern for most populations. Even with modest improvements in the status of several winter-run populations, none of the populations appear to be at fully viable status, and similarly, none of the MPGs meet the criteria for viability. The DPS continues to be at moderate risk (NWFSC 2015).

The effects of CRS operations on populations originating in subbasins downstream of Bonneville Dam (19 out of 32 populations) are limited to the effects of flow management and marginally increased exposure to higher TDG levels during migration and rearing in the Columbia River, including the estuary. Reduced flows from May through July will be an ongoing effect of CRS operations as proposed, which will continue to increase travel times during outmigration for juvenile salmonids (including LCR steelhead) and reduce access to high quality estuarine habitats during spring through early summer. These alterations impair sediment transport, influence habitat-forming processes, reduce access to peripheral habitat, and change food webs. Moreover, the large reservoirs associated with mainstem dams contribute to elevated water temperatures downstream in late summer and fall. These effects likely reduce the survival of juvenile LCR steelhead as they move through the lower Columbia River, although we are not able to quantify the magnitude or scale of those impacts.

Out of 23 LCR steelhead populations, operation of the CRS will continue to reduce survival for four populations (two summer-run populations and two winter-run populations) that are affected by upstream and downstream passage at Bonneville Dam. However, the Upper Gorge winter-run population is constrained by hatchery weirs, and the Hood River winter-run population is constrained by the presence and operation of an irrigation dam. The survival of downstream migrants has improved in recent years due to the construction of the Bonneville Corner Collector and juvenile bypass system at Powerhouse 2, and increases in the percent of flow approaching the dam that goes over the spillway. Both of these measures reduce travel time and the likelihood of turbine passage for juvenile migrants (Ploskey et al. 2012). We anticipate that dam passage survival rates of about 97 percent are likely to continue as a result of the proposed operations.

The spring spill operation proposed by the Action Agencies is expected to increase spill and decrease powerhouse passage rates for juveniles. The CSS hypothesizes that increased spill could substantially reduce latent mortality of juvenile yearling Chinook salmon and steelhead moving downstream through the mainstem dams. If this were to occur for LCR steelhead, SARs would also be improved. On the other hand, the improvement would be limited to the four populations that pass above Bonneville Dam and migrate during the spring, and the hypothesized benefit would generally be less than what may occur for species that experience passage through a greater number of the Columbia and Snake River mainstem dams.

Both spring migrating adults (from the Wind summer-run and Hood summer-run populations) and juveniles (from all four populations) will be exposed to higher TDG levels from the higher spill treatment. However, TDG levels above 125 percent would only occur as a result of conditions requiring lack of market or lack of turbine capacity spill. Adult salmonids typically migrate at a depth of greater than two meters in the Columbia and Snake Rivers allowing for adequate depth compensation during these elevated TDG conditions. We expect that daily reductions in spring spill to eight hours of “performance spill” will optimise ladder attraction conditions and allow sufficient time for adult salmonids to locate ladder entrances and move upstream through the CRS. Ultimately, given the relatively high survival rates of smolts and the limited number of LCR steelhead populations exposed to the effects of dam passage, we do not anticipate the proposed changes in operations will measurably affect the number of adult LCR steelhead returns of the four affected populations or the two MPGs in which they are included.

The other proposed changes to CRS operations are not anticipated to negatively affect LCR steelhead survival. In particular, the changes in usable forebay ranges (MOP 1.5-foot range) at the Lower Snake River reservoirs and the change in operating range at the John Day forebay (MIP 2-foot range) will result in inconsequential variations in the timing and amount of flow in the LCR and are not anticipated to increase or decrease LCR steelhead survival given their limited exposure to dam passage.

The Action Agencies will continue to fund predator control activities, estuary habitat improvements, and modify operations to improve survival. The implementation of the CRS mitigation and enhancement programs will continue to reduce long-term impacts and continue to allow for improvement in the status for the four populations that spawn above Bonneville Dam (Hood summer-run and Wind summer-run populations in the Gorge Summer-run MPG, and Upper Gorge winter-run and Hood winter-run populations in the Gorge Winter-run MPG), as was seen for most populations in the last status review. Because the Action Agencies propose to continue maintaining the reduced amounts of nesting habitat achieved for terns and cormorants on East Sand Island (BPA et al. 2018a), we expect that any reduced predation rates achieved for LCR steelhead under the 2008 FCRPS biological opinion and associated RPA will continue during the interim period. The estuary program is anticipated to improve habitat conditions and contribute to improved survival and productivity for all populations, especially for fall-run populations.

As a general matter, the effects of the proposed action are very similar to a short-term continuation of the same effects caused by the current operations and maintenance of the CRS as well as the associated measures implemented to avoid, minimize or offset adverse effects. Therefore, we do not anticipate large changes in mortality caused by the CRS or substantial new risks to LCR steelhead or their habitat, and we do not expect considerable changes in the effects on reproduction, numbers, or distribution. However, we do anticipate additional improvements in habitat conditions in the estuary that will accrue over time.

The environmental baseline includes the past and present impacts of hydropower, changes in tributary and mainstem habitat (both beneficial and adverse), harvest, and hatcheries on LCR steelhead. The baseline provides important context for assessing the effects of the action described above.

Regarding changes in hatchery effects to the LCR steelhead DPS, in 2017, NMFS completed a biological opinion on its funding of the Mitchell Act program (NMFS 2017a). As a result, several additional reform measures have been implemented including changes in broodstock management to better align hatchery broodstocks with the diversity of the natural-origin populations and modifications to the number of hatchery fish produced and released in certain programs, along with the installation of new seasonal weirs. The production level changes will reduce the pHOS and reduce genetic and ecological risk. Improvements in hatchery management are likely to support improvements in the viability of LCR populations, including the four populations that pass above Bonneville Dam, in the foreseeable future.

NMFS also recently completed a biological opinion on the 2018-2027 *U.S. v. Oregon* Management Agreement, which provides a framework for managing salmon and steelhead fisheries and hatchery programs in much of the Columbia River basin. Steelhead are intercepted in mainstem fisheries targeting unlisted hatchery and naturally produced Chinook salmon, and unlisted steelhead. Mark selective net fisheries in the mainstem Columbia River can result in post-release mortality rates of ten to over 30 percent, although there is considerable disagreement on the overall rate (NMFS 2016c). Estimated mortality for naturally produced winter-run steelhead has averaged 2.2 percent for nontribal commercial and recreational fisheries (ODFW and WDFW 2015). The current *U.S. v. Oregon* Management Agreement has maintained reduced harvest impact for LCR steelhead fisheries, with 2014 harvest rates for winter-run steelhead in mainstem fisheries at 0.6 percent and harvest rates for summer-run steelhead below 15 percent for those fish above Bonneville Dam (NWFSC 2015). The biological opinion concluded that the effects of harvest on LCR steelhead, when considering the current reliance on hatchery programs, will allow gains in VSP scores to continue to accrue.

Tributary habitat in the action area for LCR steelhead is highly degraded and contributes to the current status of the ESU. The recovery plan identifies the tributary hydropower impacts (non-CRS) as a primary limiting factor for the North Fork Lewis Summer population and several populations in the Cascade Winter steelhead MPG; however, relatively recent removal of some tributary dams has improved some access and habitat conditions. Continued urbanization and habitat degradation in combination with the potential effects of climate change (discussed further below) also present risks for all populations. Reduced or lost habitat complexity, connectivity, quantity and quality (including water quality and toxics) in lower river tributaries and along the estuary floodplain remains a specific area of concern. The series of dams and reservoirs have also blocked natural sediment transport; the delivery of suspended particulate matter to the lower river and estuary has been reduced and has altered the development of habitat along the margins of the river. Predation by pinnipeds, birds and fish is also a significant source of mortality for both juvenile and adult LCR steelhead. Efforts to reduce predation rates have only been moderately successful, partly due to recent increases in pinniped abundance in the lower river.

Improvements including tributary hydrosystem modification and habitat restoration (e.g., in the estuary), coupled with hatchery improvement and significant harvest reductions from historic levels, have allowed for progress in improving LCR steelhead abundance, productivity, spatial structure and diversity. However, these improvements also occur in the context of natural fluctuations in environmental conditions, such as cyclical changes in ocean circulation and the unusually warm ocean conditions seen predominating during 2015, which can temporarily adversely affect survival and adult returns of all salmonid species even if freshwater habitat conditions are improving.

The status of LCR steelhead is also likely to be affected by climate change. Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycle. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater and changes to food webs in freshwater, estuarine and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management actions may help alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations, increased riparian vegetation to control water temperatures, etc.).

Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life-history types that will be successful in the future are neither static nor predictable. Therefore, maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the LCR steelhead DPS. Because of its location in the lower Columbia River basin, the DPS is likely to be more affected by climate related effects in the estuary for late-migrating juveniles, and in tributary streams (altered seasonal flows and temperatures) for summer-run populations. Emerging research using complex life-cycle modeling indicates a potentially strong link between SST and survival of Snake River spring/summer Chinook salmon populations. However, the apparent link between SST and survival is presumably caused by food web interactions, relationships which could be disrupted by major transformations of community dynamics as well as ocean acidification and other factors under a changing climate. The degree to which SST is linked to survival of LCR steelhead and how that relationship interacts with other variables throughout the LCR steelhead life cycle will likely be an important area of future research.

When evaluating the effects of the action, those effects must be taken together with the effects on LCR steelhead of future State or private activities, not involving Federal activities that are reasonably certain to occur within the action area. NMFS anticipates that human development activities will continue to have adverse effects on LCR steelhead in the action area. Many of these activities and their effects occurred in the recent past and were included in the environmental baseline but are also reasonably certain to occur in the future. Within the action area, nonfederal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Habitat restoration efforts lead by state, and local agencies; tribes; environmental organizations; and local communities are likely to continue. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives that, in some cases, are identified through ESA recovery plans. Larger, more regionwide, restoration and conservation efforts are either underway or planned throughout the Columbia River basin. These state and private actions have helped restore habitat, improve fish passage, and reduce pollution. While these efforts are reasonably certain to continue to occur, funding levels may vary on an annual basis.

With respect to recovery, for all populations, the recovery plan identifies the greatest gains from tributary riparian habitat improvements; channel structure and form issues in tributaries and the estuary; and improvements to side channel and wetland conditions in tributaries that have affected the loss and degradation of floodplain habitat. For some populations, improvements in status depends largely on harvest and hatchery changes. Some of the needed hatchery and harvest improvements have been the subject of recent section 7 consultations (as discussed above) and are currently being implemented. Improvements to estuarine habitat are part of the proposed action for this consultation. The recovery plan was finalized in July 2013 and identifies recovery actions to be implemented, generally over a 25-year period, as specified in the management unit plans and estuary recovery plan module. Effective implementation requires that the recovery efforts of diverse private, local, state, tribal, and federal parties across two states be coordinated at multiple levels. The proposed action will not result in reductions to LCR steelhead reproduction, numbers, or distribution that would impede the ability to successfully carry out the identified recovery measures and actions over the time frames considered in the recovery plan.

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, cumulative effects, and considering the interim nature of the proposed action, it is NMFS' biological opinion that the proposed action is not likely to reduce appreciably the likelihood of both survival and recovery of LCR steelhead.

2.6.5.2 Critical Habitat

Critical habitat for LCR steelhead encompasses nine subbasins in Oregon and Washington containing 41 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005a, 2013a). However, most of these watersheds have some, or high potential for improvement. Similar to the discussion above for species, the status of critical habitat is likely to be affected by climate change with predicted rising temperatures and alterations in stream flow patterns. Past and future modifications to the hatchery program, improved passage in tributaries, and habitat restoration efforts will help ameliorate those effects to critical habitat.

The environmental baseline includes a broad range of past and present actions and activities that have affected the conservation value of critical habitat for LCR steelhead. These include the effects of hydropower, changes in tributary and mainstem habitat (both positive and negative), and the presence of hatcheries on freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine areas and nearshore marine areas. Despite a long-term trend in degradation of these habitats, there have been localized improvements in their conservation value through the combined efforts of federal, state, and local agencies; tribes; and other stakeholders. Tributary dams and other barriers have been removed, estuarine habitats restored and reconnected to the floodplain, and water quality has improved. Despite significant losses to predators in the migration corridor, the combined efforts of multiple parties has reduced the effect of predation, and the Action Agencies propose to continue predator management activities.

Continued operation of the CRS will continue the inundation of spawning habitat for steelhead in the lower reaches of the tributaries to the Bonneville Pool. Increased levels of TDG in the gorge area during spring spill will increase TDG levels within Bonneville Dam's reservoir and for at least 35 miles downstream. However, this is not expected to substantially affect the water quality PBF at the designation level given that the effect will be limited to a relatively small portion of designated critical habitat and considering the ability of fish to avoid higher TDG levels by swimming deeper in the water. The conservation value of the safe passage PBF in the migration corridor is affected by passage at Bonneville Dam for the four populations that pass the dam. The benefits of continued operation of fish passage structures will continue. However, passage conditions for adult survival (increased fallback) and potentially for juvenile survival (e.g. differential survival between passage routes – spillway, juvenile bypass or corner collector, and turbines) could negatively affect safe passage, although the CSS predicts survival benefits and a reduction in latent mortality (increased juvenile survival and adult returns). Conversely, the proposed action will continue to improve the functioning of many of the PBFs; for example, reducing predation by pinnipeds, birds,[68] and northern pikeminnows will continue to improve safe passage for juveniles and the hazing and deployment of sea lion excluder devices will continue to benefit safe passage of adult migrants. The estuary habitat restoration program will reconnect floodplains and provide additional feeding and rearing areas at the project scale; these benefits will accrue at the designation scale over time.

Considering the ongoing and future effects of the environmental baseline and cumulative effects and in light of the status of critical habitat, the proposed action will not appreciably reduce the value of designated critical habitat for the conservation of LCR steelhead.

2.6.6 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of LCR steelhead or destroy or adversely modify its designated critical habitat.

[68] Although there is uncertainty about the efficacy of avian predation management in the estuary, the hazing efforts in the tailrace of Bonneville Dam are known to reduce predation.

2.7 Lower Columbia River (LCR) Coho Salmon

This section applies the analytical framework described in section 2.1 to the LCR coho salmon ESU and provides NMFS' finding regarding whether the proposed action is likely to jeopardize the continued existence of the LCR coho salmon ESU or destroy or adversely modify its critical habitat.

2.7.1 Rangewide Status of the Species and Critical Habitat

The status of LCR coho salmon is determined by the level of extinction risk that the listed species faces, based on parameters considered in documents such as the recovery plan, status reviews, and listing decisions. The species status also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. This informs the description of the species' likelihood of both survival and recovery. The condition of critical habitat throughout the designated area is determined by the current function of the essential PBFs that help to form that conservation value.

2.7.1.1 Status of Species

The LCR coho salmon ESU includes naturally spawned coho salmon originating from the Columbia River and its tributaries downstream from the White Salmon and Hood Rivers (inclusive) and any such fish originating from the Willamette River and its tributaries below Willamette Falls (Figure 2.7-1). The ESU also includes coho salmon from 21 artificial propagation programs. The ESU spans three ecological regions (Coast, Cascade, and Gorge); each of these three ecological regions is considered a major population group containing a total of 24 independent populations.[69] On June 28, 2005, NMFS listed the LCR coho salmon ESU as a threatened species (70 FR 37160). The threatened status was reaffirmed on April 14, 2014. Critical habitat was designated on January 24, 2016 (81 FR 9252). Table 2.7-1 provides information on the status and limiting factors for LCR coho salmon. More information can be found in the recovery plan (NMFS 2013a) and status review (NWFSC 2015) for this species. These documents are available on the NMFS West Coast Region website.[70]

[69] The Willamette–Lower Columbia Technical Recovery Team used the term "strata" to refer to these population groupings, which are significant in identifying delisting criteria. The strata are analogous to the "major population groups" defined by the Interior Columbia Technical Recovery Team. For consistency, we use the term major population group throughout this biological opinion.
[70] Currently these documents can be found within the NMFS West Coast Region website at: http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/salmon_and_steelhead_listings/coho/lower_columbia_river_coho.html. Last accessed August 2018.

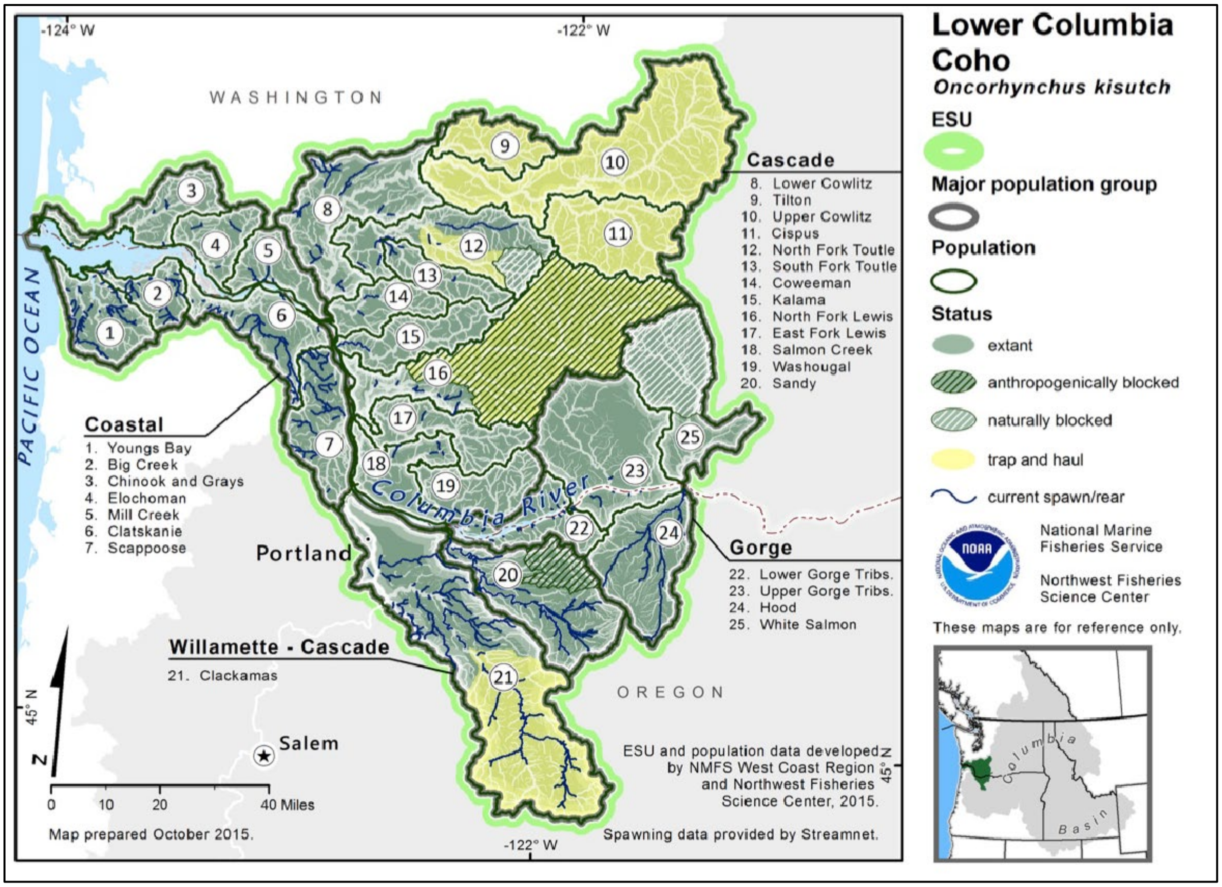


Figure 2.7-1. Map of the Lower Columbia River coho salmon ESU's spawning and rearing areas, illustrating populations and major population groups.

Table 2.7-1. Status summary and limiting factors for each species considered in this opinion.

Status Summary	Limiting Factors
While recovery efforts have likely improved the status of a number of coho salmon populations, abundances are still at low levels, and the majority of the populations remain at moderate or high risk. For the lower Columbia River region, land development and increasing human population pressures will likely continue to degrade habitat, especially in lowland areas. Although populations in this ESU have generally improved, especially in the 2013–14 and 2014–15 return years, recent poor ocean conditions suggest that population declines might occur in the upcoming return years. Regardless, this ESU is still considered to be at moderate risk (NWFSC 2015).	• Degraded riparian conditions along tributaries • Impaired side channel and wetland conditions in tributaries • Loss/degradation of floodplain habitat in tributaries • Channel structure and form issues in tributaries and the Columbia River estuary • Sediment conditions in the estuary • Direct mortality from fisheries • Reduction in population diversity as a result of stray hatchery fish interbreeding with natural-origin fish

McElhany et al. (2007) observed that, with the exception of the Clackamas and Sandy populations, it is likely that most of the wild LCR coho salmon populations were effectively extirpated in the 1990s and that no viable populations appear to exist in either the Coast or Gorge MPGs. Although there was evidence of some natural production in this ESU, the majority of populations remained dominated by hatchery-origin spawners, and until recently, no population was thought to be naturally self-sustaining, with the majority of spawners believed to be hatchery strays (NMFS 2018a). The extreme loss of naturally spawning populations, the low abundance of extant populations, diminished diversity, and fragmentation and isolation of the remaining naturally produced fish conferred considerable risks to LCR coho salmon.

The estimated changes in VSP status for coho salmon populations since the early 2000s reflect improvements in abundance, diversity, spatial structure, and also in monitoring (NWFSC 2015). As discussed earlier, previous status reviews lacked adequate quantitative data on abundance and hatchery contribution for a number of populations. During previous status reviews, anecdotal information provided suggested that hatchery-origin fish dominated many of the populations and that natural productivity was very low. Recent surveys provide a more accurate understanding of the status of these populations; however, with only two or three years of data, it is not possible to determine whether there has been a true improvement in status. It is, however, certain that the contribution of naturally produced fish is much higher than previously thought.

A total of six of 24 populations are at or near their recovery viability goals, although, under the recovery plan scenario, none of these populations had recovery goals above 2.0 (moderate risk). The remaining populations generally require a higher level of viability, and most require substantial improvements to reach their viability goals (Table 2.7-2). In the Coastal MPG, the Scappoose Creek DIP is the only population at moderate risk, with the Clatskanie River DIP at moderate to high risk; the others remain at high risk. Similarly, in the Cascade MPG, the Clackamas River DIP and the Upper Cowlitz and Cispus DIPs may be in the moderate to low-risk categories, with the remainder of the DIPs at moderate to high risk. All of the populations in the Gorge MPG are likely in the very-high-risk category.

Table 2.7-2. LCR coho salmon major population groups (MPGs), run timing, populations, and scores for the key viable salmonid population (VSP) elements (abundance/productivity [A/P], spatial structure, and diversity) used to determine overall net persistence probability of the population (NWFSC 2015). Persistence probability ratings and key element scores range from very low (VL), low (L), moderate (M), high (H), to very high (VH). The populations that spawn upstream of Bonneville Dam are highlighted in gray.

Ecological Subregion	Population	A/P	Spatial Structure	Diversity	Overall Persistence Probability
Coast Range	Youngs Bay (OR)	VL	VH	VL	VL
	Grays/Chinook Rivers (WA)	VL	H	VL	VL
	Big Creek (OR)	VL	H	L	VL
	Elochoman/Skamokawa creeks (WA)	VL	H	VL	VL
	Clatskanie River (OR)	L	VH	M	L
	Mill, Germany, & Abernathy creeks (WA)	VL	H	L	VL
	Scappoose River (OR)	M	H	M	M
Cascade Range	Lower Cowlitz (WA)	VL	M	M	VL
	Upper Cowlitz (WA)	VL	M	L	VL
	Cispus (WA)	VL	M	L	VL
	Tilton River (WA)	VL	M	L	VL
	South Fork Toutle River (WA)	VL	H	M	VL
	North Fork Toutle River (WA)	VL	M	L	VL
	Coweeman River (WA)	VL	H	M	VL
	Kalama River (WA)	VL	H	L	VL
	North Fork Lewis River (WA)	VL	L	L	VL
	East Fork Lewis River (WA)	VL	H	M	VL
	Salmon Creek (WA)	VL	M	VL	VL
	Clackamas (OR)	M	VH	H	M
	Sandy (OR)	VL	H	M	VL
	Washougal (WA)	VL	H	L	VL
Columbia Gorge	Lower Gorge (WA & OR)	VL	M	VL	VL
	Upper Gorge/White Salmon (WA)	VL	M	VL	VL
	Lower Gorge Tributaries/Hood (OR)	VL	VH	L	VL

For most populations, the proportion of hatchery-origin fish naturally spawning exceeds criteria set for primary and contributing populations. With recent dam removals on tributaries and the initiation of trap-and-haul programs, there are few major spatial structure limitations; however, smaller migrational barriers such as culverts limit spatial structure.

Improved monitoring has substantiated the presence of natural-origin coho salmon in a number of populations previously thought to be dominated by hatchery production; however, overall abundance is still relatively low. Furthermore, none of the MPGs meet the criteria for viability. The LCR coho salmon ESU most likely remains at the moderate risk category (NMFS 2016c). Thus, the status of a number of coho salmon populations has changed since the reviews by McElhany et al. (2006), Ford et al. (2012), and NMFS (2013a). Changes in abundance and productivity, diversity, and spatial structure were generally positive; however, this appears to be mostly due to the improved level of monitoring (and therefore understanding of status) in Washington tributaries, rather than a true change in status over time. In the absence of specific abundance and diversity data, earlier status reviews had concluded that hatchery-origin fish dominated many of the coho salmon populations in the LCR ESU and that there was little natural productivity (NMFS 2018a). Recent recovery efforts may have contributed to the observed natural production, but in the absence of longer-term datasets it is not possible to parse out these effects. Abundances are still at low levels and the majority of the DIPs remain at moderate or high risk. For the Lower Columbia River region, land development and increasing human population pressures will likely continue to degrade habitat, especially in lowland areas. Although populations in this ESU have generally improved, recent poor ocean conditions suggest that population declines might occur in the upcoming return years.

2.7.1.2 Status of Critical Habitat

This section describes the status of designated critical habitat affected by the proposed action by examining the condition and trends of the PBFs of that habitat throughout the designated area. These features are essential to the conservation of the ESA-listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration, and foraging). Table 2.7-3 summarizes status information for designated critical habitat for LCR coho salmon based on the detailed information on the status of critical habitat provided in the recovery plan for this species (NMFS 2013a). LCR coho salmon habitat is within the Willamette/Lower Columbia River recovery domain.

Table 2.7-3. Critical habitat, designation date, Federal Register citation, and status summary for critical habitat considered in this opinion.

Designation Date and Federal Register Citation	Critical Habitat Status Summary
2/24/2016 **81 FR 9251**	The specific areas designated for lower Columbia River coho include approximately 2,300 mi of freshwater and estuarine habitat in Oregon and Washington. The areas designated are all occupied and contain physical and biological features essential to the conservation of the species that may require special management considerations or protection. No unoccupied areas were identified that are considered essential for the conservation of the species. There are 55 watersheds within the range of this ESU. Three watersheds received a low conservation value rating, 18 received a medium rating, and 34 received a high rating (NMFS 2015a). The lower Columbia River rearing/migration corridor downstream of the spawning range is considered to have a high conservation value.

2.7.1.3 Climate Change Implications for LCR Coho Salmon and Critical Habitat

One factor affecting the rangewide status of LCR coho salmon and aquatic habitat is climate change. The U.S. Global Change Research Program (USGCRP), mandated by Congress in the Global Change Research Act of 1990, reports average warming of about 1.3ºF from 1895 to 2011. As the climate changes, air temperatures in the Pacific Northwest are expected to increase 4 to 13°F by the end of the century, with the largest increases expected in the summer (Mantua et al. 2009; Mote et al. 2014). Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004; Scheuerell and Williams 2005; Zabel et al. 2006; ISAB 2007). According to the ISAB, these effects pose the following impacts into the future:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a smaller snowpack, watersheds will see their runoff diminished earlier in the season, resulting in lower stream flows in the June through September period. River flows in general and peak river flows are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures are expected to rise, especially during the summer months when lower stream flows co-occur with warmer air temperatures.

The proposed action is only expected to be implemented in the interim time period between 2019 and the completion of the NEPA process; however, the effects of the proposed action will extend many years (e.g., maturation of estuary habitat projects). Thus, both natural climate variation and climate change are relevant to our analysis.

Likely changes in temperature, precipitation, wind patterns, and sea-level height have implications for survival and recovery of LCR coho in both its freshwater and marine habitats and the PBFs of its critical habitat. While total precipitation changes are uncertain, increasing air temperature will result in more precipitation falling as rain rather than snow in watersheds across the basin (NMFS 2017a). In general, these changes in air temperatures, river temperatures, and river flows are expected to cause changes in salmon distribution, behavior, growth, and survival, although the magnitude of these changes remains unclear. In coastal areas, projections indicate an increase of 1–4 feet of global sea-level rise by the end of the century; sea-level rise and storm surge pose a risk to infrastructure and coastal wetlands, and tide flats are likely to erode or be lost as a result of seawater inundation (Mote et al. 2014). Ocean acidification is also expected to negatively impact Pacific salmon and organisms within their marine food webs.

There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bioecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management of these factors may help further alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations, management of flows through the mainstem dams to address temperature concerns, etc.). Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life-history types that will be successful in the future are neither static nor predictable, so maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the LCR coho salmon ESU.

Climate change would affect LCR coho salmon and critical habitat through physical and chemical changes to their habitats (e.g., increased water temperature, decreased ocean pH, changes in the timing and volume of stream flow). The physical and chemical changes can result in biological impacts such as, but not limited to, reduced ocean survival, changes in growth and development, changes in run timing, and spawning timing (Link et al. 2015). These biological changes can result in changes in species productivity and abundance, distribution, food web structure, community structure, invasive species impacts, and biodiversity and resilience (Link et al. 2015). Because of the location of the ESU in the lower Columbia River basin, the ESU is likely to be more affected by climate-related effects in the estuary, and spring-run populations may be subject to additional effects from climate change to the stream ecosystems (changes in flow timing).

Climate change would affect LCR coho salmon in the following ways: (1) changes in ocean survival, (2) changes in growth and development rates, (3) changes in disease resistance, and (4) changes in flow regime (especially flooding and low-flow events) that could affect survival and behavior (run timing, spawning timing, etc.).

2.7.2 Environmental Baseline

The environmental baseline includes the past and present impacts of all federal, state, or private actions and other human activities in an action area, the anticipated impacts of all proposed federal projects in an action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions that are contemporaneous with the consultation in process.

For LCR coho salmon, we focus our description of the environmental baseline on that portion of the action area where LCR coho salmon juveniles and adults are exposed to the effects of the proposed action. We also include tributary habitat because these habitats, while not influenced by the proposed action, are primary drivers for the elements of VSP for LCR coho salmon, and thus are key habitats for recovery of the ESU and are important to understand in the context of the proposed action.

The range of LCR coho salmon extends from the Columbia River and its tributaries downstream from the Big White Salmon (Washington) and Hood (Oregon) Rivers downstream to the ocean. Thus, for this consultation, the upper extent of the area where LCR coho salmon are exposed to the effects of the proposed action is the Bonneville Reservoir, and the tributaries in that reach. The downstream extent of the effects of the action, based on observed changes in flow, is the plume.[71] This includes tributary confluences in this reach to the extent that they are affected by flow management and habitat mitigation actions in the Columbia River.[72] The area also includes tributary habitats as described above.

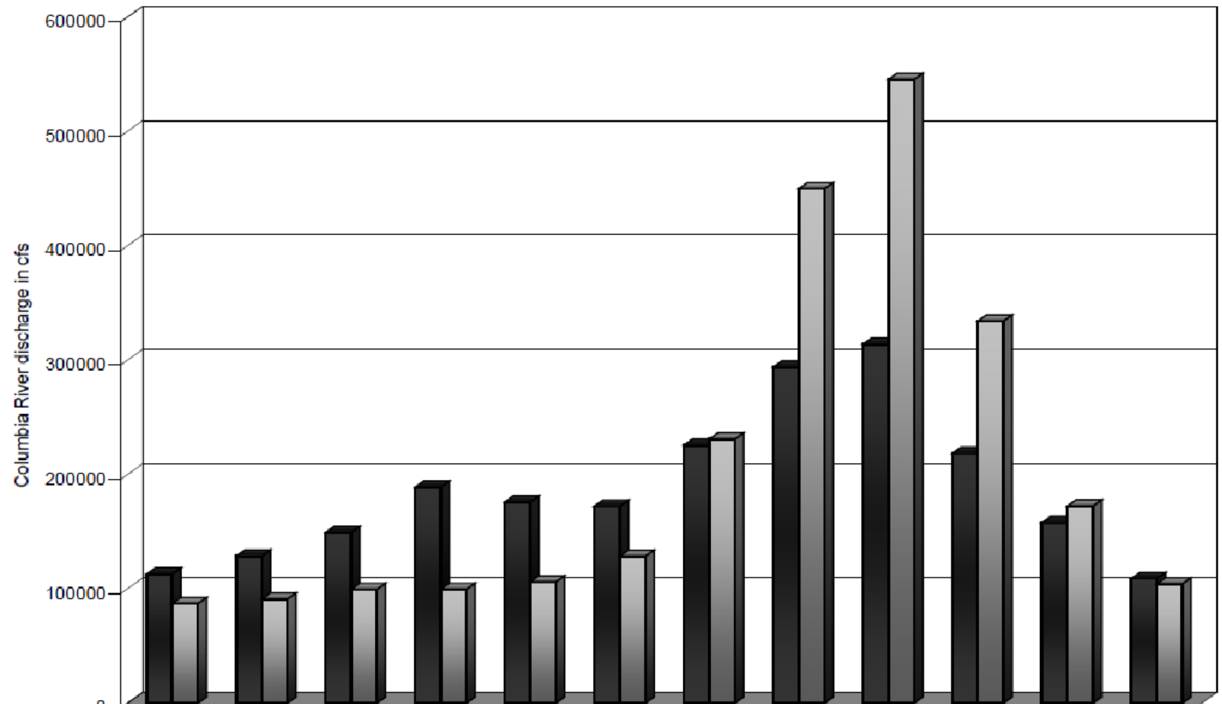
2.7.2.1 Mainstem Habitat

On the mainstem of the Columbia River, hydropower projects (including the CRS), water storage projects (including reservoirs in Canada operated under the Columbia River Treaty), and the withdrawal of water for irrigation and urban uses have significantly degraded salmon and steelhead habitats (Bottom et al. 2005; Fresh et al. 2005; NMFS 2013a). The volume of water discharged by the Columbia River varies seasonally according to runoff, snowmelt, and hydropower demands. Mean annual discharge is estimated to be 265 kcfs, but may range from lows of 71–106 kcfs to highs of 530 kcfs (Hamilton 1990; NMFS 1998; Prahl et al. 1998; USACE 1999). Naturally occurring maximum flows on the river would occur in May, June, and

[71] The Columbia River plume is defined as those waters contiguous to the mouth of the Columbia River having salinity less than 32.5 percent (Park 1966). Historically, the outflow from the Columbia River was viewed as a freshwater plume oriented southwest over the Oregon shelf during summer and north or northwest over the Washington shelf during winter. However, more recent data show that the plume extends in both directions and is frequently present up to 100 miles north of the river mouth from spring to fall (Hickey et al. 2005).
[72] At this time, the Action Agencies have not proposed mitigation habitat actions in the tributaries of LCR coho.

July as a result of snowmelt in the headwater regions. Minimum flows would occur from September to March, with periodic peaks due to heavy winter rains (Holton 1984). Interannual variability in stream flow strongly correlates with two recurrent climate phenomena, the ENSO and the PDO (Newman et al. 2016).

Water storage projects (dams and reservoirs) and water management activities have reduced flows between Bonneville and the mouth of the Columbia River compared to natural flows in the late spring and summer months; on average, this reduction can range from nearly 15 kcfs in August to over 230 kcfs in May (see Figure 2.7-2). Recognizing that the flow versus survival relationships for some interior basin ESUs/DPSs displayed a plateau over a wide range of flows but declined markedly as flows dropped below some threshold (NMFS 1995b, 1998), NMFS and the CRS Action Agencies have attempted to manage Columbia and Snake River water resources to maintain seasonal flows above threshold objectives given the amount of runoff in a given year. This has been accomplished by avoiding excessive drafts going into spring to minimize the flow reductions needed to refill the reservoirs and by drafting the storage reservoirs during summer to augment flows. These flow objectives have guided preseason reservoir planning and in-season flow management. Nonetheless, since the development of the hydrosystem, average monthly flows at Bonneville Dam have been substantially lower during May-July and higher in October–March than an unregulated system. Reduced flows have increased travel times during outmigration for juvenile salmonids and reduced access to high-quality estuarine habitats during spring through early summer.



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Current	113017	128641	149403	189076	175921	172150	225689	293948	313930	218523	157935	109020
Natural	87115	91029	99387	99496	106033	128580	231047	450040	545561	334238	172430	104310

Figure 2.7-2. Comparison of monthly discharge (flow) in the Columbia River between current conditions (black) and normative flows (gray). These data show that pre-development flows were lower in the winter and higher in the spring and early summer months.

The series of dams and reservoirs have also blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is only one-third of nineteenth-century levels (Simenstad et al. 1982, 1990; Sherwood et al. 1990; Weitkamp 1994; NRC 1996; NMFS 2008a). Similarly, Bottom et al. (2005) estimated that the delivery of suspended sediment to the lower river and estuary has been reduced by about 60 percent (as measured at Vancouver, Washington). This reduction has altered the development of habitat along the margins of the river.

Industrial harbor and port development are also significant influences on the lower Willamette and lower Columbia Rivers (Bottom et al. 2005; Fresh et al. 2005; NMFS 2013a). Since 1878, the Army Corps of Engineers has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the lower Willamette River as a navigation channel. Originally dredged to a 20-foot minimum depth, the federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The navigation channel supports many ports on both sides of the river, resulting in several thousand commercial ships traversing the river every year. The dredging, along with diking, draining, and fill material placed in wetlands and shallow habitat, also disconnects the river from its floodplain, resulting in the loss of shallow-water rearing habitat and the ecosystem functions that floodplains provide (e.g., supply of prey, refuge from high flows, temperature refugia; Bottom et al. 2005).

The most extensive urban development in the lower Columbia River subbasin has occurred in the Portland/Vancouver area. Common water-quality issues, both in areas with urban development and rural residential septic systems, include warmer water temperatures, lowered dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff (LCREP 2007).

2.7.2.2 Passage Survival

Only two out of 24 populations in this ESU are affected by passage conditions at Bonneville Dam, the only dam within the action area: Upper Gorge/Hood and Upper Gorge/White Salmon.

There are no studies of downstream passage survival for juvenile LCR coho salmon. The survival of downstream migrants is likely to have improved in recent years due to the construction of the Bonneville Corner Collector and juvenile bypass system at Powerhouse 2, and increases in the percent of flow approaching the dam that goes over the spillway. Both of these measures reduce travel time and the likelihood of turbine passage for juvenile migrants (Ploskey et al. 2012). However, as for other species, the likelihood that adult coho salmon ascending the fish ladders will fall back below the dam increases with percent spill (Boggs et al. 2004). NMFS (2008a) estimated that the adult passage mortality rate for coho salmon at Bonneville Dam was similar to that of Snake River fall Chinook salmon (about 3.1 percent), which are present during the same time period. Passage survival estimates incorporate passage under general operations and typical maintenance (e.g., screen blockages/cleaning) conditions.

2.7.2.3 Water Quality

Water quality in the action area is impaired. Common toxic contaminants found in the Columbia River system include PCBs, PAHs, PBDEs, DDT and other legacy pesticides, current use pesticides, pharmaceuticals and personal care products, and trace elements (LCREP 2007). The LCREP report noted widespread presence of PCBs and PAHs, both geographically and in the food web. Urban and industrial portions of the lower river contribute significantly to contaminant levels in juvenile salmon; juvenile salmon are absorbing toxic contaminants during their time rearing and feeding in the lower Columbia River (LCREP 2007). Likewise, juvenile salmon are accumulating DDT in their tissues and are exposed to estrogen-like compounds in the lower river, likely associated with pharmaceuticals and personal care products. Concentrations of copper are present at levels that could interfere with crucial salmon behaviors.

Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute municipal and industrial waste discharges to the lower Columbia River. Industrial and municipal wastes from the Portland/Vancouver metro areas, including the superfund-designated reach in the lower Willamette River, also contribute to degraded water quality in the lower Columbia River. Mining areas scattered around the basin deliver higher background concentrations of metals. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river. Small releases of materials such as lubricants occur during dam operation and maintenance and contribute to background exposure to contaminants in the Columbia River.

Outside of urban areas, the majority of residences and businesses rely on septic systems. Common water-quality issues with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff. Under these environmental conditions, fish in the action area are stressed. Stress may lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival).

Water temperatures in the Columbia River are a concern. Because of temperature standard exceedances, the Columbia River is included on the Clean Water Act §303(d) list of impaired waters established by Oregon and Washington. Temperature conditions in the Columbia River basin are affected by many factors, including:

- Natural variation in weather and river flow;
- Construction of the dam and reservoir system (the large surface areas of reservoirs and resulting slower river velocities contribute to warmer late summer/fall water temperatures);
- Increased temperatures of tributaries due to water withdrawals for irrigated agriculture, and due to grazing and logging;
- Point-source thermal discharges from cities and industries; and
- Climate change.

The EPA is working with federal and state agencies, tribes, and other stakeholders to develop water-quality improvement plans (total maximum daily loads) for temperature in the Columbia River and lower Snake River. As part of the 2015 biological opinion on EPA's approval of water-quality standards, including temperature (NMFS 2015a), EPA committed to work with federal, state, and tribal agencies to identify and protect thermal refugia and thermal diversity in the lower Columbia River and its tributaries.

Comparisons of long-term temperature monitoring in the migration corridor before and after impoundment reveal a change in the thermal regime of the Snake and Columbia rivers. Using historical flows and environmental records for the 35-year period 1960–95, Perkins and Richmond (2001) compared water-temperature records in the Lower Snake River with and without the lower Snake River dams and found three notable differences between the current versus unimpounded river:

- Maximum summer water temperature has been slightly reduced;
- Water temperature variability has decreased; and

- Post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall, a phenomenon termed thermal inertia.

These hydrosystem effects (influenced by the temperatures of tributary streams entering the Snake and Columbia Rivers both upstream of, within, and downstream of the mainstem dams) continue downstream and influence temperature conditions in the lower Columbia River. At a macro scale, water temperature affects salmonid distribution, behavior, and physiology (Groot and Margolis 1991); at a finer scale, temperature influences migration swim speed of salmonids (Salinger and Anderson 2006), timing of river entry (Peery et al. 2003), susceptibility to disease and predation (Groot and Margolis 1991), and, at temperature extremes, survival.

TDG is another feature of water quality that affects mainstem habitat. To facilitate the downstream movement of juvenile salmonids, Oregon and Washington regulatory agencies issue criteria adjustments for TDG as measured in the forebay and tailrace (NMFS 1995b). Specifically, water that passes over the spillway at a mainstem dam can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). Historically, TDG supersaturation was a major contributor to juvenile salmon mortality; to reduce TDG supersaturation, the Corps installed spillway improvements, typically “flip lips” to create a hydraulic jump and deflect water upwards, at each mainstem dam except The Dalles Dam. Biological monitoring shows that the incidence of GBT in both migrating smolts and adults remains between 1–2 percent when TDG concentrations in the upper water column do not exceed 120 percent of saturation in CRS project tailraces. When those levels are exceeded, there is a corresponding increase in the incidence of signs of GBT symptoms, however, fish migrating at depth generally avoid exposure to the higher TDG levels due to pressure compensation mechanisms (Weitkamp et al. 2003). For the 2018 spill season, the Action Agencies targeted the 115/120 TDG with the goal of improving juvenile passage survival.

2.7.2.4 Tributary Habitat

Tributary habitat conditions throughout the LCR coho salmon ESU have in general been significantly degraded by an array of land uses, including urbanization, agriculture, forest management, transportation networks, and some gravel mining. These land uses have blocked access to historically productive habitats, simplified stream and side channels, degraded floodplain connectivity and function, increased delivery of fine sediment to streams, and degraded riparian conditions (contributing to stream channel simplification, reduced bank stability, increased sediment load, and elevated water temperatures). In addition, tributary dams in the Cascade and Gorge MPGs have blocked or impeded passage for some LCR coho salmon populations. Bonneville Dam also creates passage issues for the Upper Gorge/Hood and Upper Gorge/White Salmon populations, which spawn above the dam. When Bonneville Dam was completed in 1938, the reservoir behind the dam inundated considerable portions of historical spawning habitat for the Upper Gorge/White Salmon coho salmon population (NMFS 2013a).

Numerous tributary habitat protection and restoration efforts have been implemented in recent years through the efforts of local recovery planning groups, federal and state agencies, tribal governments, local governments, conservation groups, private landowners, and other entities. These efforts have led to some local improvements in tributary habitat conditions that should result in improved survival for the LCR coho salmon ESU. However, degraded habitat conditions, particularly with regard to channel complexity, floodplain connectivity, water quality and hydrologic patterns, and toxic contamination continue to negatively affect the abundance, productivity, spatial structure, and diversity of LCR coho salmon populations and impair the ability of habitat to support productive fish populations. Continued land development and habitat degradation, in combination with the potential effects of climate change, may present a continuing strong negative influence into the foreseeable future (NWFSC 2015).

2.7.2.5 Estuary Habitat

The estuary provides important migratory and rearing habitat for LCR coho salmon populations. Since the late 1800s, 68–70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening combined with flow regulation and other modifications (Kukulka and Jay 2003; Bottom et al. 2005; Marcoe and Pilson 2017). Disconnection of tidal wetlands and floodplains has eliminated some historical rearing habitat for coho salmon and reduced the production of wetland macrodetritus supporting salmonid food webs (Simenstad et al. 1990; Maier and Simenstad 2009), both in shallow water and for larger juveniles migrating in the mainstem (ERTG 2018).

Restoration actions in the estuary, such as those highlighted in the latest five-year review (NMFS 2016c), have improved access and connectivity to floodplain habitat. From 2004 through 2017, restoration sponsors implemented 58 projects, including dike and levee breaching or lowering, tide-gate removal, and tide-gate upgrades that reconnected 5,412 acres of historical tidal floodplain habitat to the mainstem. This represents a 2.5 percent net increase in the connectivity of habitats that produce prey consumed by juvenile coho salmon (chironomid insects and corophiid amphipods; Weitkamp et al. 2014). Most juvenile coho salmon are yearling migrants and are less likely to enter and reside in these areas, but improved opportunities for feeding, even while migrating in the mainstem, are likely to contribute to survival at ocean entry.

2.7.2.6 Hatcheries

Hatchery production for LCR coho salmon has reduced the diversity and productivity of natural populations throughout the ESU. NMFS directs federal funding to many of the hatchery programs that affect the LCR coho salmon ESU through the Mitchell Act. NMFS completed a biological opinion on its funding of the Mitchell Act program in 2017 (NMFS 2017a). As a result, several new reform measures have been or will be implemented as described below. The implementation of these reform measures is expected to improve the status of the ESU:

- Changes in broodstock management to better align hatchery broodstocks with the diversity of the natural-origin populations that could be potentially affected by the hatchery programs;
- Modifications to the number of hatchery fish produced and released in certain programs, along with the installation of six new seasonal weirs because, in some tributaries, there have been too many hatchery-origin fish spawning naturally, which has posed both a genetic and ecological risk; and
- Upgrades to hatchery facilities to bring water intake screens into compliance with new standards to ensure they minimize adverse impacts to ESA-listed fish.

Hatchery releases have remained relatively steady at 10–17 million since the 2005 BRT report. The Hatchery Scientific Review Group (HSRG 2009) reported that overall hatchery production remains relatively high (15.7 million coho salmon released in tributary programs and 2.1 million released in Select Area Fisheries Enhancement (SAFE) areas). Most of the populations in the ESU contain a substantial number of hatchery-origin spawners. Recent efforts to shift production into localized areas (e.g., Youngs Bay and Big Creek) in order to reduce the influence of hatchery fish in other nearby populations (e.g., Scappoose and Clatskanie) are considered as in transition at this time (NMFS 2018a). Reductions were also noted in the number of hatchery-origin juvenile coho salmon released into the Sandy River.

Mass marking of hatchery-released fish, in conjunction with expanded coho salmon spawning surveys, has provided more accurate estimates of hatchery straying. Integrated hatchery programs were developed in a number of basins to limit the loss of genetic diversity. The integrated program in the Cowlitz River was recently initiated using predominantly natural-origin broodstock. Large-scale releases of hatchery-origin coho salmon adults into the Upper Cowlitz, Cispus, and Tilton Rivers are likely partly responsible for the high numbers of returning nucleolus organizer regions (NORs; genetic clusters). An integrated program for Type N coho salmon has been ongoing in the Lewis River for over a decade. Still, the majority of hatchery production is from segregated programs, and few populations met the HSRG (2009) criteria for primary or contributing populations.

The HSRG (2009) recommended a number of infrastructure changes to hatcheries to improve the homing and collection of returning hatchery fish. Overall the HSRG (2009) report concludes that changes in hatchery programs alone are unlikely to result in populations achieving their recovery goals without additional changes in harvest (more selective fisheries to remove hatchery-origin fish) and improvements in habitat.

2.7.2.7 Recent Ocean and Lower River Harvest

NMFS signed the 2018–27 *U.S. v. Oregon* Management Agreement of the Columbia River Basin. The decision was based on both our recently completed Final EIS and the associated biological opinion (NMFS 2018a). The Agreement supports salmon and steelhead fishing opportunities for the states of Oregon, Washington, and Idaho; ensures fair sharing of harvestable fish between tribal and nontribal fisheries in accordance with treaty fishing rights and *U.S. v. Oregon*; protects and conserves ESA-listed and unlisted species; and ensures NMFS fulfills its trust/ treaty responsibilities to Columbia Basin tribes. There is no direct commercial fishery for LCR coho salmon.

Lower Columbia River coho salmon are part of the Oregon Production Index, and are harvested in ocean fisheries primarily off the coasts of Oregon and Washington, with some harvest that historically occurred off of the west coast of Vancouver Island. Canadian coho salmon fisheries were severely restricted in the 1990s to protect upper Fraser River coho salmon, and have remained so ever since. Ocean fisheries off California were closed to coho salmon retention in 1993 and have remained closed ever since. Ocean fisheries for coho salmon off of Oregon and Washington were dramatically reduced in 1993 in response to the depressed status of Oregon Coast natural coho salmon and subsequent listing, and moved to mark-selective fishing beginning in 1999. Lower Columbia River coho salmon benefitted from the more restrictive management of ocean fisheries. Overall exploitation rates regularly exceeded 80 percent in the 1980s, but have remained below 30 percent since 1993. In addition, freshwater fisheries impacts on naturally produced coho salmon have been markedly reduced through the implementation of mark-selective fisheries. A recent impact rate for Lower Columbia River coho salmon was 17.1 percent in 2014 (TAC 2015).

2.7.2.8 Predation

The existence of dams and reservoirs around the Columbia Basin also blocks sediment transport. Total sediment discharge into the estuary and Columbia River plume is about one-third of nineteenth-century levels (NMFS 2008a). This reduces turbidity in the lower river, especially during spring, which may make juvenile outmigrants more vulnerable to predation by piscivorous birds and fishes.

2.7.2.8.1 Avian Predation

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, are having a significant impact on the survival of juvenile salmonids (including LCR coho salmon) in the Columbia River. Caspian terns on Rice Island, an artificial dredged-material disposal island in the estuary, consumed about 5.4-14.2 million juveniles per year in 1997 and 1998, or 5-15 percent of all the smolts reaching the estuary (Roby et al. 2017). Efforts began in 1999 to relocate the tern colony 13 miles closer to the ocean at East Sand Island where the tern diet would diversify to include marine forage fish. During 2001-15, estimated consumption by terns on East Sand Island averaged 5.1 million smolts per year, about a 59 percent reduction compared to when the colony was on Rice Island. Management efforts are ongoing to further reduce salmonid consumption by terns in the lower Columbia River and similar efforts are in progress to reduce the nesting population of double-crested cormorants in the estuary.

In an effort to estimate predation rates on LCR coho salmon by birds nesting the lower river, Sebring et al. (2010) released more than 6,000 PIT-tagged LCR coho salmon from several lower

Columbia River hatcheries in 2009. The mean predation rate on PIT-tagged coho salmon released to the estuary from three lower Columbia River hatcheries was 18 percent, which was a significantly higher predation rate ($P = 0.02$) than that of coho salmon detected passing Bonneville Dam in the same year (7 percent). Cormorants consumed a larger proportion of coho salmon released from lower Columbia River hatcheries (87 percent) than terns (13 percent). However, terns consumed a larger proportion of coho salmon detected passing Bonneville Dam (80 percent) than cormorants (20 percent). There was a significant difference in proportional consumption of coho salmon released to the lower Columbia River versus those detected at Bonneville Dam.

In the hydrosystem reach, the Action Agencies have employed wire arrays, pyrotechnics, water cannons, and other measures, including limited lethal take at project tailraces in the lower Columbia River. These measures have been shown to reduce predation rates on juvenile salmonids at John Day and The Dalles Dams, and may have had similar effects at Bonneville Dam (Zorich et al. 2012).

2.7.2.8.2 Piscivorous Fish Predation

Native pikeminnow are significant predators of juvenile salmonids in the Columbia River basin, followed by nonnative smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011, 2015). Before the start of the NPMP in 1990, this species was estimated to eat about eight percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River basin each year. Williams et al. (2017) compared current estimates of northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. On average, one adult and one juvenile coho salmon was killed and/or handled each year in the Sport Reward Fishery during 2013-17 (Williams 2013, 2014; Williams et al. 2015, 2016, 2017). The fishery is conducted over a much larger area than that occupied by LCR coho salmon, but small numbers of these fish could have been from this ESU.

The Action Agencies also conduct a Dam Angling Program at The Dalles and John Day Dams. Anglers did not catch any coho salmon during 2013-17 (Williams 2013, 2014; Williams et al. 2015, 2016, 2017).

Juvenile salmonids are also consumed by nonnative fishes including walleye, smallmouth bass, and channel catfish. Both the Oregon and Washington Departments of Fish and Wildlife have removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids.

2.7.2.8.3 Pinniped Predation

Adult coho salmon enter the lower Columbia River during late summer, and pass Bonneville Dam during August through November (DART 2019b). Steller sea lions have been counted in the reach below Bonneville Dam throughout the year, including months when LCR coho salmon are present. Small numbers of California sea lions may also be present in these months. Under an authorization under the Marine Mammal Protection Act, management agencies have implemented numerous measures to reduce predation at Bonneville Dam and Astoria, from hazing to removal, during the spring and summer months.

2.7.2.8.4 Compensatory Effects and Predation on Salmonid Populations

An estimate of the effect of a predator population on adult returns to Bonneville Dam (e.g., the effect of smolt consumption by northern pikeminnow or Caspian terns) has the potential to be erroneous if it does not consider whether other factors intervene to compensate for the change in mortality (ISAB 2016). The primary mechanisms for compensatory effects are: (1) increased fish survival due to reduced densities in later life stages, (2) selective predation based on fish size and condition, and (3) predator switching from one prey species to another. Compensatory effects are difficult to quantify because they can occur later in the life cycle and can vary over time; efforts are currently underway to better understand compensatory effects (Haeseker 2015; Evans et al. 2018b).

2.7.2.9 Research and Monitoring Activities

The primary effects of the past and ongoing CRS-related RM&E programs on LCR coho salmon are associated with the capturing and handling of fish. The RM&E program is a collaborative, regionally coordinated approach to fish and habitat status monitoring, action effectiveness research, critical uncertainty research, and data management. The information derived from the program facilitates effective adaptive management through better understanding the effects of the ongoing CRS action. Capturing, handling, and releasing fish generally leads to stress and other sub-lethal effects, but fish sometimes die from such treatment. The mechanisms by which these activities affect fish have been well documented and are detailed in Section 8.1.4 of the 2008 biological opinion. Some RM&E actions also involve sacrificial sampling of fish. We estimated the number of LCR coho salmon that have been handled each year during the implementation of RM&E under the 2008 RPA as the average annual take reported for 2013-17:

- Average annual estimates for handling and mortality of LCR coho salmon associated with the Smolt Monitoring Program and the CSS was limited to 224 wild juveniles handled and two wild juveniles died.
- The estimated handling and mortality of LCR coho salmon associated with the ISEMP was limited to two wild juveniles handled and one wild juvenile died.
- Estimates for LCR coho salmon handling and mortality for all other RM&E programs: (1) zero hatchery and one wild adult handled; (2) zero hatchery or wild adults died; (3) 3,099 hatchery and 2,220 wild juveniles handled; and (4) 17 hatchery and 35 wild juveniles died.

The combined take (i.e., handling, including injury, and incidental mortality) associated with these elements of the RM&E program has, on average, affected less than one percent of the wild (i.e., natural origin) adult returns or juvenile production for the LCR coho salmon ESU (Bellerud 2018). This relatively small effect is deemed worthwhile because it allows the Action Agencies and NMFS to evaluate the effects of CRS operations, including modifications to facilities, operations, and mitigation actions.

In addition, northern pikeminnow are tagged as part of the Sport Reward Fishery and their rate of recapture is used to calculate exploitation rates. Northern pikeminnow are collected for tagging using boat electrofishing in select reaches of the Columbia River. During 2017, northern boat electrofishing operations in the Columbia River extended upstream from RM 47 (near Clatskanie, Oregon) to RM 394 (Priest Rapids Dam), and in the Snake River from RM 10 (Ice Harbor Dam) to RM 41 (Lower Monumental Dam) and from RM 70 (Little Goose Dam) to RM 156 (upstream of Lower Granite Dam). Researchers conducted four sampling events consisting of 15 minutes of boat electrofishing effort in shallow water within each 0.6-mile reach during April-July.

A side effect of the electrofishing effort is that salmon and steelhead may be exposed to the electrofishing field, with the potential for injury, stress, and fatigue and even cardiac or respiratory failure (Snyder 2003). Some adult and juvenile LCR coho salmon are likely to be present in shallow shoreline areas during the April-July time period. Most sampling occurs in darkness (1800-0500 hours). Operators shut off the electrical field if salmonids are seen and because most stunned fish quickly recover and swim away, they cannot be identified to species (i.e., Chinook, coho, chum, or sockeye salmon or steelhead). Barr (2018) reported encountering an annual average of 891 adult and 60,312 juvenile salmonids in the lower Columbia River each year during 2013-17 electrofishing operations based on visual estimation methods. It is likely that some of these were LCR coho salmon.

2.7.2.10 Critical Habitat

The environmental baseline for the PBFs for LCR coho salmon critical habitat are discussed above and summarized here in Table 2.7-4. Tributary barriers are a concern for freshwater spawning sites, freshwater rearing sites, and migration corridors. Water quality is a concern for all PBFs. Restoration activities addressing migration barriers and water quality have improved the baseline condition for PBFs; however, more restoration is needed before the PBFs can fully support the conservation of LCR coho salmon.

Table 2.7-4. Physical and biological features (PBFs) of designated critical habitat for LCR coho salmon.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBF
Freshwater spawning sites	Water quantity and quality and substrate to support spawning, incubation, and larval development	● Tributary barriers (culverts, dams, water withdrawals) ● Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) ● Loss of wetland and side channel connectivity (urban and rural development, forest and agricultural practices, channel manipulations) ● Excessive sediment in spawning gravel (forest and agricultural practices) ● Elevated water temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices ● Inundation of spawning sites under Bonneville Reservoir (hydrosystem development)
Freshwater rearing sites	Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility, water quality and forage, and natural cover	● Tributary barriers (culverts, dams, water withdrawals) ● Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) ● Loss of wetland and side channel connectivity (urban and rural development, forest and agricultural practices, channel manipulations) ● Excessive sediment in spawning gravel (forest and agricultural practices) ● Elevated water temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices)
Freshwater migration corridors	Free of obstruction and excessive predation, adequate water quality and quantity, and natural cover	● Delay and mortality of some juveniles and adults ● Concerns about increased opportunities for predators, especially birds and pinnipeds (construction of dredge-material islands in the lower river and other human-built structures used by terns and cormorants for nesting, constricted passage opportunities for adult coho salmon in the Bonneville tailrace)
Estuarine areas	Free of obstruction and excessive predation with water quality,	● Diking off areas of the estuary floodplain (land use), combined with reduced peak spring flows (water

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBF
	quantity, and salinity, natural cover, and juvenile and adult forage	diversions and water storage and hydroelectric projects), have reduced access to floodplain habitat for rearing and prey production
Nearshore marine areas[1]	Free of obstruction and excessive predation with water quality, quantity, and forage	• Concerns about increased opportunities for pinniped predators, adequate forage

[1] Designated area includes only the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

2.7.2.11 Anticipated Impacts of Completed Consultations

The environmental baseline also includes the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, including the consultation on the operation and maintenance of the Bureau of Reclamation's upper Snake River projects. The 2016 five-year review evaluated new information regarding the status and trends of LCR coho salmon, including recent biological opinions issued for LCR coho salmon and key emergent or ongoing habitat concerns (NMFS 2016c). Since the beginning of 2015 through 2017, we completed 444 formal consultations (132 in 2015, 130 in 2016, and 182 in 2017) that addressed effects to LCR coho salmon (PCTS data query July 31, 2018). These numbers do not include the many projects implemented under programmatic consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed salmonids. Some of the completed consultations are large (large action area, multiple species), such as the Mitchell Act consultation and the consultation on the 2018–27 *U.S. v. Oregon* Management Agreement. Many of the completed actions are for a single activity within a single subbasin.

Some current and proposed restoration projects will improve access to blocked habitat and riparian condition, and increase channel complexity and instream flows. For example, under BPA's Habitat Improvement Programmatic consultation, BPA implemented 29 projects in the Columbia Basin that improved fish passage in 2017, and 99 projects that involved river, stream, floodplain, and wetland restoration. These projects will benefit the viability of the affected populations by improving abundance, productivity, and spatial structure. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more, and typically less, than a few weeks).

Other types of federal projects, including grazing allotments, dock and pier construction, and bank stabilization will be neutral or have short- or even long-term adverse effects on viability.

All of these actions have undergone section 7 consultation and the actions or the RPA were found to meet the ESA standards for avoiding jeopardy.

Similarly, future federal restoration projects will improve the functioning of the PBFs safe passage, spawning gravel, substrate, water quantity, water quality, cover/shelter, food, and riparian vegetation. Projects implemented for other purposes will be neutral or have short- or even long-term adverse effects on some of these same PBFs. However, all of these actions, including any RPAs, have undergone section 7 consultation and were found to meet the ESA standards for avoiding adverse modification of critical habitat.

2.7.2.12 Summary

The factors described above have negatively affected the abundance, productivity, diversity, and spatial structure of LCR coho salmon populations. Recent improvements in passage conditions at Bonneville Dam and at tributary barriers, the small net improvement in floodplain connectivity achieved through the CRS estuary habitat program, and efforts to improve hatchery practices and lower harvest rates are positive signs, but other stressors are likely to continue. NMFS (2016c) identified past land development and increasing human population pressures as likely continue to degrade habitat, especially in lowland areas. These factors, in combination with predation pressure and the potential effects of climate change, are likely to present a continuing strong negative influence into the foreseeable future.

Likewise**,** the environmental baseline within the action area does not fully support the conservation value of designated critical habitat for LCR coho salmon. The PBFs essential for the conservation of this species include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine rearing areas, and nearshore marine areas (at the mouth of the Columbia River).

The CRS Action Agencies and other federal and nonfederal entities have taken actions in recent years to improve the functioning of some of these PBFs of critical habitat. For stream-type juveniles, projects that have protected or restored riparian areas and breached or lowered dikes and levees in the estuary have improved the functioning of the juvenile migration corridor. However, other factors that have negative effects on these PBFs are expected to continue into the future.

2.7.3 Effects of the Action

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

The proposed action is an ongoing action that has been modified over time to reflect capital improvements, as well as changes in operation based on existing conditions and improved information on how CRS operations affect UWR Chinook salmon and other listed species and their critical habitats. The current proposed action includes operational measures (e.g., flood risk management, navigation, fish passage, and hydropower generation) and non-operational measures (e.g., support for conservation hatchery programs, predation management, habitat improvement actions) that will be implemented beginning in 2019. The proposed action, however, is of limited duration. The Action Agencies are developing an EIS in accordance with NEPA that will assess and update the approach for long-term system operations, maintenance, and configuration as well as evaluate measures to avoid, offset, or minimize impacts to resources affected by the management of the CRS, including ESA-listed species and designated critical habitat. A court order currently requires the Action Agencies to issue Records of Decision on or before September 24, 2021.[73] Based on scoping, the range of alternatives being examined is broad and includes potential large-scale changes in the action. Thus, there is substantial uncertainty regarding what system operations, maintenance, and configuration the Action Agencies will propose at the conclusion of the NEPA process. Likewise, it is unknown what measures intended to avoid, offset, or minimize adverse effects will ultimately be included in the final preferred alternative.

As described in Section 2.1 above, our analysis of effects for LCR coho salmon extends from 2019 into the future, but emphasizes the evaluation of effects that are reasonably certain to occur as a result of implementing the proposed action pending completion of the EIS and our issuance of a subsequent biological opinion addressing the effects of the final preferred alternative. To the extent our consideration of potential effects beyond that time period assumes the current proposed action remains in place, it is intended, in part, to inform the evaluation of alternatives in the EIS.

The effects of the proposed action are generally consistent with the effects caused by a continuation of the CRS operations as described in the environmental baseline section, with the exception of the flexible spring spill operation, which is expected to alter conditions for the two LCR coho salmon populations migrating upstream of Bonneville Dam. The other operational changes are not anticipated to alter the effects to LCR coho salmon because very few or no fish in the ESU will be exposed to the effects of those changes.

2.7.3.1 Effects to Species

Both juvenile and adult LCR coho salmon from all populations will be exposed to the continuing effects of the action in the mainstem Columbia River. The populations that migrate above Bonneville Dam (Upper Gorge/White Salmon and Upper Gorge Tributaries/Hood) will also be

[73] The Presidential Memorandum on Promoting the Reliable Supply and Delivery of Water in the West, issued on October 19, 2018, required the development of an expedited schedule for completion of the NEPA process. The Council on Environmental Quality has confirmed a revised schedule that calls for completing the Draft EIS in February 2020, the Final EIS in June 2020 and Records of Decision by September 30, 2020. These dates are consistent with, but earlier than, the court-ordered deadlines.

exposed to the habitat effects described above, as well as to changes in operations at Bonneville Dam.

2.7.3.1.1 Hydrosystem Operation

For LCR coho salmon, the effects of the continued operation of the CRS are essentially a continuation of the effects of recent hydrosystem operations described in the environmental baseline (resulting from implementation of the 2008 biological opinion's reasonable and prudent alternative hydro actions), with the addition of the flexible spring spill operation. This includes recent passage improvements that have further improved the survival of juvenile coho salmon that pass through Bonneville Dam (Upper Gorge/White Salmon and Upper Gorge/Hood populations). Though there are no specific data for coho salmon, recent passage improvements[74] have improved the survival of yearling Chinook salmon that pass through Bonneville Dam, are also likely to benefit coho salmon smolts. In our 2008 biological opinion, we estimate that 95.5 percent of yearling Chinook salmon that migrate past Bonneville Dam will survive; coho salmon smolts from tributaries and hatcheries in the Bonneville pool are likely to have similar levels of survival passing the dam.

During periods of increased spring spill while implementing the flexible spring spill operation, the effects to LCR coho salmon include: (1) juveniles from the two populations upstream of Bonneville Dam will be more likely to pass Bonneville Dam via the spillway than via the juvenile bypass or corner collectors, and (2) exposure of juveniles to increased levels of TDG will increase both within Bonneville Reservoir and downstream of the dam for at least 35 miles. Recent studies indicate that direct survival of steelhead and Chinook salmon smolts passing over the Bonneville spillway was lower than through the Bonneville Powerhouse 2 Bypass or the Bonneville corner collector. Thus, shifting passage from these routes to the spillway may lead to a decrease in direct passage survival on the order of 2–3 percent (of the fraction of fish affected). While the CSS predicts increased spillway passage at Bonneville will improve adult returns for Chinook and steelhead (CSS 2017), they make no predictions for LCR coho. The proposed flexible spill operation would likely result in a slight increase in the incidence and severity of GBT symptoms and a very small increase in mortality for individuals from the Gorge and upper portion of the Cascade MPG.

Since adult coho salmon typically pass Bonneville Dam in September and November, and spring spill at Bonneville ceases on June 15, adult coho will not be affected by factors associated with increased levels of spring spill.

2.7.3.1.2 Predator Management and Monitoring Actions

The Corps' program to install and operate sea-lion excluder gates at Bonneville Dam will continue and is likely to positively affect the two populations that pass upstream of Bonneville

[74]These include improvements to the sluiceway fish guidance system (efficiency and conveyance) and the installation of minimum gap runners at Bonneville PH1; the surface passage route (corner collector), FGE improvements, and the juvenile bypass system at PH2; and the provision of 24-hour spill during the spring migration period through the spillway.

Dam. Likewise, the Corps' and BPA's support of land- and water-based sea-lion harassment efforts from the area downstream of Bonneville Dam will continue to reduce adult mortality of the two upstream populations.

The pikeminnow predation management program includes the Sport Reward Fishery and Dam Angling programs, which will continue as part of the proposed action. The first is implemented in the Columbia River, including the estuary. This fishery removes approximately 10–20 percent of predatory-sized pikeminnow per year and is open from May through September, when juvenile coho salmon can be rearing and migrating in mainstem habitats. We expect that this ongoing measure will continue the 30 percent reduction in predation rates achieved under the 2008 RPA. We estimate that numbers of coho salmon, including LCR coho salmon, handled and/or killed in the Sport Reward Fishery will be no more than 100 adults and 100 juveniles per year, system-wide, during the interim period.

The Action Agencies will also continue to implement the Northern Pikeminnow Dam Angling Program at The Dalles and John Day Dams, as described under the environmental baseline. These ongoing measures will continue the reduction in predation rates achieved under the 2008 RPA. We estimate that zero adult or juvenile coho salmon, including LCR coho salmon, will be caught in the Dam Angling Program per year during the interim period.

The Action Agencies propose to continue implementation of the Caspian Tern Nesting Habitat Management Plan (USACE 2015a) and the Double-crested Cormorant Management Plan (USACE 2015b). As discussed in the Environmental Baseline section above, it is difficult to quantify an increased survival because of observations of birds relocating to other sites in the estuary and year-to-year variation in bird population size. Because the Action Agencies propose to continue maintaining the reduced amounts of nesting habitat achieved for terns and cormorants on East Sand Island (BPA et al. 2018a), we expect that any reduced predation rates achieved for LCR coho salmon under the 2008 FCRPS biological opinion and associated RPA will continue during the interim period. The Action Agencies will also continue to implement, and improve as needed, the avian predation deterrence measures at the tailrace of Bonneville Dam, which address another source of juvenile LCR coho salmon mortality.

The Action Agencies propose to synthesize avian colony size and predation rate data collected under the tern and cormorant colony management plans. The intent of the synthesis report is to provide the Action Agencies, cooperating agencies, and NMFS with a summary of predation by piscivorous waterbirds on ESA-listed salmonids in the Columbia River basin before, during, and after the management actions, in order to assess their effectiveness on a basinwide scale. This review will help the Action Agencies prioritize any efforts to take place during this interim period or to be discussed as future mitigation measures in the CRS Operations NEPA document.

2.7.3.1.3 Habitat Actions

For those LCR coho salmon populations that have been negatively affected by the CRS, the Action Agencies will provide funding and/or technical assistance for tributary habitat improvement actions consistent with basinwide criteria for prioritizing actions, including recovery plan priorities, as funding allows. If implemented, and if implemented in a manner consistent with scientifically sound identification and prioritization of limiting factors and geographic locations, such actions could provide benefits to the targeted populations. However, because the Action Agencies have not proposed a commitment to implement tributary habitat improvement actions for LCR coho salmon as part of this proposed action, or proposed them in a manner where we could meaningfully assess the effects (e.g., committing to achieve specific amounts or types of restoration), we are not considering the benefits of potential actions in our analysis.

On the other hand, the Action Agencies have committed to continuing to implement the CEERP to increase the capacity and quality of estuarine ecosystems and improve access for juvenile salmonids. The Action Agencies will continue to emphasize reconnection of floodplain areas in tidally influenced waters of the lower Columbia River and estuary, primarily through modifying levees. Additional actions at habitat improvement sites will include recreating historical channel networks, reducing the presence of nonnative species, and revegetating habitat improvement sites with native vegetation to ensure a site's resiliency. These projects are expected to provide direct (onsite) and indirect (increased transfer of insect and amphipod prey to the mainstem migration corridor) benefits to LCR coho salmon as they rear in and migrate through the estuary. LCR coho salmon are primarily yearling migrants, although subyearling coho salmon have been captured at restored floodplain sites (Johnson et al. 2018). Yearling coho salmon are known to consume prey derived from floodplain wetlands (Bottom et al. 1984; Weitkamp 2013).

NMFS agrees with ISAB's assessment findings that it is difficult to reliably quantify the survival benefits of estuary habitat restoration, but the Action Agencies' assessment method, including review by the ERTG,[75] is useful to prioritize projects. The Action Agencies' proposed action includes a commitment to reconnect an average of 300 acres of floodplain per year to the mainstem river, a goal that they have a record of achieving in 2008-17 (BPA et al. 2018b). The habitat's conservation value is likely to improve as more habitat gets reconnected, and the benefits are likely to accrue as the habitat patches get larger (Spiesman et al. 2018). Juvenile LCR coho salmon have been observed using reconnected habitats (Johnson et al. 2018), which provide important resting and feeding areas as well as prey items for juveniles that remain in the mainstem. It is also likely that these benefits will increase as habitat quality matures.

2.7.3.1.4 Research and Monitoring Activities

The Action Agencies' RM&E program will be similar to the current program, or will be implemented at a reduced scale. Thus, the level of injury and mortality discussed in the

[75] As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss with ERTG and regional partners relevant climate change science in an effort to understand whether their planned estuary projects are resilient to climate change (i.e., sea level rise, temperatures, and mainstem flow levels). In addition, the Action Agencies' annual update of their restoration and monitoring plans for the estuary will document any needed adjustments in design, location, or other elements of a given project to address climate change impacts, both during and beyond the interim period.

Environmental Baseline, primarily from the capturing and handling of fish, is likely to continue at a similar or reduced level. We estimate that, on average, the following numbers of LCR coho salmon will be affected each year during the interim period:

- Projected estimates of LCR coho salmon handling and mortality during activities associated with the Smolt Monitoring Program and the CSS: (1) zero hatchery or wild adults handled or killed; (3) zero hatchery and 2,000 wild juveniles handled; and (4) zero hatchery and 107 wild juveniles killed.
- Projected estimates of LCR coho salmon handling and mortality during activities associated with Fish Status Monitoring: (1) zero hatchery or wild adults handled or killed; and (2) zero hatchery or wild handled or killed.
- Projected estimates of LCR coho salmon handling and mortality for all other RM&E programs: (1) 998 hatchery and 626 wild adults handled; (2) ten hatchery and six wild adult killed; (3) 111,169 hatchery and 15,795 wild juveniles handled; and (4) 1,112 hatchery and 158 wild juveniles killed.

The combined observed mortality associated with these elements of the RM&E program will, on average, affect less than one percent of the wild (i.e., natural origin) adult returns or juvenile production for the LCR coho salmon ESU (Bellerud 2018). Although we estimate that 1.77 percent of the wild adults and 2.78 percent of the wild juvenile production will be handled each year, on average, we expect that only up to one percent of these will die after release (i.e., 0.02 percent of adults and 0.03 percent of juveniles handled). This relatively small effect is deemed worthwhile because it will allow the Action Agencies and NMFS to continue to evaluate the effects of CRS operations including modifications to facilities, operations, and mitigation actions.

Electrofishing operations for the NPMP during the interim period are expected to continue at the same level of effort as in recent years (four 15-minute sampling events per 0.6-mile reach between RM 47 and The Dalles Dam during April-July; a total of 550 hours system-wide). Some adult and juvenile LCR coho salmon are likely to be present in shallow shoreline areas during electrofishing activities and may be stunned and even killed. However, because the operator releases the electrical field as soon as salmonids are observed and most of these fish quickly recover and swim away, we are unable to use observations from past operations to estimate the number of fish from this ESU that will be affected. Information obtained through electrofishing supports management of the NPMP, which is reported to have reduced salmonid predation by about 30 percent (Williams et al. 2017). This level of take is anticipated to occur for the duration of this proposed action, pending completion of the NEPA process.

2.7.3.2 Effects to Critical Habitat

Implementation of the proposed action is likely to affect passage at Bonneville Dam for two of the 24 populations. Implementation will also affect the volume and timing of flow in the

Columbia River, which has the potential to alter habitat in the Columbia River mainstem and estuary. The PBFs that could be affected by the proposed action are described in Table 2.7-5.

Table 2.7-5. Effects of the proposed action on the physical and biological features (PBFs) essential for the conservation for the ESU.

PBF	Effect of the Proposed Action
Freshwater spawning sites	The proposed action will continue the inundation of spawning habitat for coho salmon in the lower reaches of the tributaries to the Bonneville Pool.
Freshwater rearing sites	No changes proposed.
Freshwater migration corridors and estuarine areas	Operations that have improved juvenile passage conditions for populations migrating through Bonneville Dam will continue. Increased levels of total dissolved gas (TDG; water quality) in Bonneville Reservoir and for at least 35 miles downstream of the dam.This area serves as critical habitat for the Gorge MPG and one population in the Cascade MPG. Smolts are able to use behavioral mechanisms to avoid elevated TDG (i.e., by migrating deeper in the water column). The seasonal temperature regime will continue to be altered, exhibiting generally cooler temperatures in the spring and warmer temperatures in the fall, relative to historic conditions. Sediment will continue to accumulate behind CRS dams, reducing turbidity in the migration corridor during the spring smolt outmigration, which could make juveniles more vulnerable to predation. Because estuary bird colonies and predation rates are in flux, it is not clear whether continued tern and cormorant colony management is likely to reduce avian predation (i.e., meet management plan goals).Any reduced predation rates achieved under the 2008 biological opinion and associated RPA will continue during the interim period. Implementation of the pikeminnow removal program and pinniped program will improve survival through the mainstem migration corridor.

2.7.4 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation (50 CFR 402.02). Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Nonfederal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. These projects also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth management programs (planning and regulation); a variety of stream and riparian habitat projects; watershed planning and implementation; acquisition of water rights for instream purposes and sensitive areas; instream flow rules; stormwater and discharge regulation; TMDL implementation to achieve water-quality standards; hydraulic project permitting; and increased spill and bypass operations at hydropower facilities. NMFS has determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. These activities are likely to have beneficial cumulative effects that will significantly improve conditions for the salmon and steelhead, including LCR coho salmon.

NMFS has also noted that some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects are activities that occurred in the recent past and were included in the environmental baseline. Some of these activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the action area, nonfederal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. All of these activities can contaminate local or larger areas with hydrocarbon-based materials. Continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations.

Overall, we anticipate that projects to restore and protect habitat, restore access to and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area.

2.7.5 Integration and Synthesis

In this section, we add the effects of the action (Section 2.7.3) to the environmental baseline (Section 2.7.2) and the cumulative effects (Section 2.7.4), taking into account the status of the species and critical habitat (Sections 2.7.1.1 and 2.7.1.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat for the conservation of the species.

2.7.5.1 Species

NMFS' recent status review affirmed LCR coho salmon as threatened but identified some positive trends in LCR coho salmon status although these observations may be based on improved monitoring data (NWFSC 2015). For most populations, the proportion of hatchery-origin fish naturally spawning in the ESU exceeds recovery criteria and is a key factor limiting recovery. With recent dam removals on tributaries and the integration of trap-and-haul programs, there are few major spatial structure limitations; however, small migrational barriers such as culverts limit spatial structure. Abundances are still at low levels and the majority of the populations remain at moderate or high risk.

The effects of CRS operations on populations originating in subbasins downstream of Bonneville Dam (two out of 24 populations) are limited to the effects of flow management and marginally increased exposure to higher TDG levels during migration and rearing in the Columbia River, including the estuary. Reduced flows from May through July will be an ongoing effect of CRS operations as proposed, which will continue to increase travel times during outmigration for juvenile salmonids (including LCR coho salmon) and reduce access to high quality estuarine habitats during spring through early summer. These alterations impair sediment transport, influence habitat-forming processes, reduce access to peripheral habitat, and change food webs. Moreover, the large reservoirs associated with mainstem dams contribute to elevated water temperatures downstream in late summer and fall. These effects likely reduce the survival of juvenile LCR coho salmon as they move through the lower Columbia River, although we are not able to quantify the magnitude or scale of those impacts.

Out of 24 LCR coho salmon populations, operation of the CRS will continue to reduce survival for two populations (Upper Gorge/White Salmon and Lower Gorge Tributaries/Hood populations in the Columbia Gorge MPG) that are affected by upstream and downstream passage at Bonneville Dam. Changes in VSP scores for these populations were generally positive, but this appears to be mostly due to the improved level of monitoring. The survival of downstream migrants has improved in recent years due to the construction of the Bonneville Corner Collector and juvenile bypass system at Powerhouse 2, and increases in the percent of flow approaching the dam that goes over the spillway. Both of these measures reduce travel time and the likelihood of turbine passage for juvenile migrants (Ploskey et al. 2012). There are no specific data for coho salmon; we have estimated that 95.5 percent of yearling coho salmon that migrate past Bonneville Dam will survive (NMFS 2008a). In the past, we have estimated adult passage mortality rate for coho salmon using data for Snake River fall Chinook salmon (about 3.1 percent) because of similar timing (NMFS 2008a). This survival rate is likely to continue as a result of the proposed operations, but as described below, changes to spring spill could potentially alter the proportion of LCR juveniles Chinook salmon subjected to the various passage routes.

The spring flexible spring spill operation proposed by the Action Agencies is expected to affect the two populations that migrate upstream of Bonneville Dam. The CSS (2017) makes no prediction in terms of survival benefits for LCR coho salmon. The CSS predicts that increased spill could substantially reduce latent mortality of juvenile yearling Chinook salmon and steelhead moving downstream through the mainstem dams. If this were to occur for LCR coho salmon, SARs would also be improved for the two populations that pass above Bonneville Dam and migrate during the spring, and the potential benefit would generally be less than what may occur for species that experience passage through a greater number of the Columbia and Snake River mainstem dams.

Increased spring spill levels could benefit direct survival at some dams, but could also potentially negatively affect juvenile survival (e.g., increase proportion of juveniles passing through routes with lower survival) at other dams. Higher spill will also expose juveniles to somewhat higher TDG levels from the higher spill treatment. However, TDG levels above state water quality limits would only occur as a result of conditions requiring lack of market or lack of turbine capacityspill. Further, the flexible spring spill operation would only occur during the spring spill period, and thus the effects on reproduction, numbers, and distribution of the two populations that spawn upstream of Bonneville Dam is limited by timing and exposure. Ultimately, given the relatively high survival rates of smolts and the limited number of LCR coho salmon populations exposed to the effects of dam passage, we do not anticipate the proposed changes in operations will measurably affect the number of juvenile LCR Chinook salmon returns of the two affected populations or the one MPG in which they are included. LCR coho salmon adults will not be exposed to the effects of the flexible spring spill operation due to run timing.

The other proposed changes to CRS operations are not anticipated to negatively affect LCR coho salmon survival. In particular, the changes in usable forebay ranges (MOP 1.5-foot range) at the Lower Snake River reservoirs and the change in operating range at the John Day forebay (MIP 2-foot range) will result in inconsequential variations in the timing and amount of flow in the lower Columbia River.

The Action Agencies will continue to fund predator control activities, estuary habitat improvements, and modify operations to improve survival. The implementation of the CRS mitigation and enhancement programs will continue to reduce long-term impacts and continue to allow for improvement in the status for the two populations that spawn above Bonneville Dam (Upper Gorge/White Salmon and Lower Gorge Tributaries/Hood populations in the Columbia Gorge MPG), as was seen for most populations in the last status review (although there is some concern that the observations were based on improved monitoring capacity). Any reduced predation rates achieved under the 2008 biological opinion and associated RPA will continue during the interim period. The estuary program is anticipated to improve habitat conditions and contribute to improved survival for all populations, especially for fall-run populations.

As a general matter, the effects of the proposed action are very similar to a short-term continuation of the same effects caused by the current operations and maintenance of the CRS as well as the associated measures implemented to avoid, minimize or offset adverse effects.

Therefore, we do not anticipate large changes in mortality caused by the CRS or substantial new risks to LCR coho salmon or their habitat, and we do not expect considerable changes in the effects on reproduction, numbers, or distribution. However, we do anticipate additional improvements in habitat conditions in the estuary that will accrue over time.

The environmental baseline includes the past and present impacts of hydropower, changes in tributary and mainstem habitat (both beneficial and adverse), harvest, and hatcheries on LCR coho salmon. The baseline provides important context for assessing the effects of the action described above.

Regarding changes in hatchery effects to the LCR coho salmon ESU, in 2017, NMFS completed a biological opinion on its funding of the Mitchell Act program (NMFS 2017a). As a result, several additional reform measures have been implemented including changes in broodstock management to better align hatchery broodstocks with the diversity of the natural-origin populations and modifications to the number of hatchery fish produced and released in certain programs, along with the installation of new seasonal weirs. The production level changes will reduce the pHOS and reduce genetic and ecological risk. Improvements in hatchery management are likely to support improvements in the viability of LCR populations, including the two populations that pass above Bonneville Dam, in the foreseeable future.

NMFS also recently completed a biological opinion on the 2018-2027 *U.S. v. Oregon* Management Agreement, which provides a framework for managing salmon and steelhead fisheries and hatchery programs in much of the Columbia River basin. LCR coho salmon are part of the Oregon Production Index, and are harvested in ocean fisheries primarily off the coasts of Oregon and Washington. Ocean fisheries for coho salmon off of Oregon and Washington were drastically reduced in 1993 in response to the depressed status of Oregon Coast coho salmon and subsequent listing, and moved to mark-selective fishery beginning in 1999. This benefitted LCR coho salmon, and overall exploitation rates have remained below 30 percent since 1993. In addition, freshwater fisheries impacts on naturally produced coho salmon have been markedly reduced through mark-selective fisheries, and the impact rate for LCR coho salmon was 17.1 percent in 2014 (TAC 2015). The 2017 *U.S. v. Oregon* biological opinion concluded that the effects of harvest on LCR coho salmon, when considering the current reliance on hatchery programs, will allow gains in VSP scores to continue to accrue.

Tributary habitat in the action area for LCR coho salmon is significantly degraded and contributes to the current status of the ESU. Many tributaries are degraded by an array of land uses including urbanization, agriculture, forest management, transportation networks, and some gravel mining. These land uses have blocked access to historically productive habitats, simplified stream and side channels, degraded floodplain connectivity and function, and increased delivery of fine sediment to streams. In addition, tributary dams in the Cascade and Gorge MPGs have blocked or impeded passage for some LCR coho salmon populations. Predation by pinnipeds (primarily Steller sea lions due to late summer river entry), birds and fish is also a significant source of mortality for both juvenile and adult LCR coho salmon. Efforts to reduce predation rates have only been moderately successful, partly due to recent increases in pinniped abundance in the lower river.

Improvements including tributary hydrosystem modification and habitat restoration (e.g., in the estuary), coupled with significant hatchery improvement, have likely allowed for progress in improving LCR coho salmon abundance, productivity, spatial structure and diversity. However, these improvements also occur in the context of natural fluctuations in environmental conditions, such as cyclical changes in ocean circulation and the unusually warm ocean conditions seen predominating during 2015, which can temporarily adversely affect survival and adult returns of all salmonid species even if freshwater habitat conditions are improving.

The status of LCR coho salmon is also likely to be affected by climate change. Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycle. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater and changes to food webs in freshwater, estuarine and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management actions may help alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations, increased riparian vegetation to control water temperatures, etc.).

Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life-history types that will be successful in the future are neither static nor predictable. Therefore, maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the LCR coho salmon ESU. Because of its location in the lower Columbia River basin, the ESU is likely to be more affected by climate related effects in the estuary, and in tributary streams (altered seasonal flows and temperatures). Emerging research using complex life-cycle modeling indicates a potentially strong link between SST and survival of Snake River spring/summer Chinook salmon populations. However, the apparent link between SST and survival is presumably caused by food web interactions, relationships which could be disrupted by major transformations of community dynamics as well as ocean acidification and other factors under a changing climate. The degree to which SST is linked to survival of LCR coho salmon and how that relationship interacts with other variables throughout the LCR coho salmon life cycle will likely be an important area of future research.

When evaluating the effects of the action, those effects must be taken together with the effects on LCR coho salmon of future state or private activities, not involving federal activities that are reasonably certain to occur within the action area. NMFS anticipates that human development activities will continue to have adverse effects on LCR coho salmon in the action area. Many of these activities and their effects occurred in the recent past and were included in the environmental baseline but are also reasonably certain to occur in the future. Within the action area, nonfederal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Habitat restoration efforts lead by state, and local agencies; tribes; environmental organizations; and local communities are likely to continue. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives that, in some cases, are identified through ESA recovery plans. Larger, more regionwide, restoration and conservation efforts are either underway or planned throughout the Columbia River basin. These state and private actions have helped restore habitat, improve fish passage, and reduce pollution. While these efforts are reasonably certain to continue to occur, funding levels may vary on an annual basis.

With respect to recovery, the recovery plan (NMFS 2013a) identifies the greatest gains from improvements in the hatchery program and tributary habitat restoration. Some of the needed hatchery and harvest improvements have been the subject of recent section 7 consultations (as discussed above) and are currently being implemented. Improvements to estuarine habitat are part of the proposed action for this consultation. The recovery plan was finalized in July 2013 and identifies recovery actions to be implemented, generally over a 25-year period, as specified in the management unit plans and estuary recovery plan module. Effective implementation requires that the recovery efforts of diverse private, local, state, tribal, and federal parties across two states be coordinated at multiple levels. The proposed action will not result in reductions to LCR coho salmon reproduction, numbers, or distribution that would impede the ability to successfully carry out the identified recovery measures and actions over the time frames considered in the recovery plan.

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, cumulative effects, and considering the interim nature of the proposed action, it is NMFS' biological opinion that the proposed action is not likely to reduce appreciably the likelihood of both survival and recovery of LCR coho salmon.

2.7.5.2 Critical Habitat

Critical habitat for LCR coho salmon encompasses 55 watershed and 2,300 stream miles. Three watersheds received a low conservation value rating, 18 received a medium rating, and 34 received a high rating (NMFS 2005a). Most watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005a, 2013a). However, most of these watersheds have some, or high, potential for improvement. Similar to the discussion above for species, the status of critical habitat is likely to be affected by climate change, with predicted rising temperatures and alterations in stream flow patterns. Past and future modifications to the hatchery program and improved passage in tributaries will help ameliorate those effects to critical habitat.

The environmental baseline provides context for a broad range of past and present actions and activities that have affected the conservation of critical habitat for LCR coho salmon and contributed to its current status. The environmental baseline analysis considers the effects of hydropower, changes in tributary and mainstem habitat (both positive and negative), and the effects of hatcheries on freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine areas, and nearshore marine areas. Despite a long-term trend in degradation of these habitats, there have been localized improvements in their conservation value through the combined efforts of federal, state, and local agencies, tribes, and other stakeholders. Tributary dams and other barriers have been removed, estuarine habitats restored and reconnected to the floodplain, and water quality has improved. Despite significant losses to predators in the migration corridor, the combined efforts of multiple parties have reduced the effect of predation, and they will continue to look for solutions to improve the conservation value of this PBF.

Continued operation of the CRS will continue the inundation of spawning habitat for one population of LCR coho salmon in the lower reaches of the tributaries to the Bonneville Pool. Increased levels of TDG in the gorge area during the flexible spring spill will increase TDG levels within Bonneville Dam's reservoir and for at least 35 miles downstream. However, this is not expected to substantially affect the water quality PBF given that the effect will be limited to a relatively small portion of designated critical habitat for this species and considering the ability of fish to avoid higher TDG levels by swimming deeper in the water. The conservation value of the safe passage PBF in the migration corridor is affected by passage at Bonneville Dam for the two populations that pass the dam. The benefits of continued operation of fish passage structures will continue. However, for juvenile survival (e.g. differential survival between passage routes – spillway, juvenile bypass or corner collector, and turbines) could negatively affect safe passage, although the CSS predicts survival benefits and a reduction in latent mortality (increased juvenile survival and adult returns). The proposed action will continue to improve the functioning of many of the PBFs; for example, reducing predation by pinnipeds, birds,[76] and northern pikeminnows will continue to improve safe passage for juveniles, and the hazing and deployment of sea-lion excluder devices will continue to benefit safe passage of adult migrants. The estuary habitat restoration program will reconnect floodplains and provide additional feeding and rearing areas at the project scale; these benefits will accrue at the designation scale over time.

Considering the ongoing and future effects of the environmental baseline and cumulative effects, and in light of the status of critical habitat, the proposed action will not appreciably reduce the value of designated critical habitat.

2.7.6 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of LCR coho salmon or destroy or adversely modify its designated critical habitat.

[76] Although there is uncertainty about the efficacy of avian predation management in the estuary, the hazing efforts in the tailrace of Bonneville Dam are known to reduce predation.

2.8 Columbia River (CR) Chum Salmon

This section applies the analytical framework described in section 2.1 to the CR chum salmon ESU and provides NMFS' finding regarding whether the proposed action is likely to jeopardize the continued existence of CR chum salmon ESU or destroy or adversely modify its critical habitat.

2.8.1 Rangewide Status of the Species and Critical Habitat

The status of CR chum salmon is determined by the level of extinction risk that the listed species faces, based on parameters considered in documents such as the recovery plan, status reviews, and listing decisions. The species status also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. This informs the description of the species' likelihood of both survival and recovery. The condition of critical habitat throughout the designated area is determined by the current function of the essential PBFs that help to form that conservation value.

2.8.1.1 Status of Species

The CR chum salmon ESU includes all naturally spawned populations of chum salmon in the Columbia River and its tributaries in Oregon and Washington (Figure 2.8-1).[77] This ESU also includes two artificial propagation programs.[78] The ESU spans three distinct ecological regions (Coast, Cascade, and Gorge); each of these three ecological regions is considered an MPG.[79] On March 25, 1999, NMFS listed the CR chum salmon ESU as a threatened species (64 FR 14508). The threatened status was reaffirmed on April 14, 2014. Critical habitat was designated on September 2, 2005 (70 FR 52746). Table 2.8-1 provides a summary of status information and limiting factors for CR chum salmon. More information can be found in the recovery plan (NMFS 2013) and status review for this species (NWFSC 2015). These documents are available on the NMFS West Coast Region website.[80]

CR chum salmon numbers began to decline by the early 1950s (Johnson et al. 2012) because of habitat degradation and harvest rates. The recovery plan for this species identifies ESU- and MPG-level biological recovery criteria,[81] and within each MPG, it also identifies specific

[77] The historical upstream boundary for chum salmon is generally considered to have been Celilo Falls, which historically was located approximately where The Dalles Dam is now located (NMFS 2013a).

[78] The Grays River Program and the Washougal River Hatchery/Duncan Creek Program.

[79] The Willamette–Lower Columbia Technical Recovery Team used the term "strata" to refer to these population groupings, which are significant in identifying delisting criteria. The strata are analogous to the "major population groups" defined by the Interior Columbia Technical Recovery Team. For consistency, we use the term major population group throughout this biological opinion.

[80] Currently these documents can be found within the NMFS West Coast Region website at: http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/salmon_and_steelhead_listings/chum/columbia_river/columbia_river_chum.html. Last accessed March 2019.

[81] The ESU-level criterion is that each MPG that historically existed must have a high probability of persistence or have a probability of persistence consistent with its historical condition. The recovery plan also contains criteria for

population-level goals consistent with the MPG-level criteria (NMFS 2013a). For chum salmon, all populations are affected by aspects of habitat loss and degradation. CR chum salmon have been—and continue to be—affected by loss and degradation of spawning and rearing habitat, the impacts of mainstem hydropower dams on upstream access and downstream habitats, and the legacy effects of historical harvest. Land development, especially in the low gradient reaches that chum salmon prefer, will continue to be a threat to most chum salmon populations due to projected increases in the population of the greater Vancouver/Portland area and the lower Columbia River overall (Metro 2014). The pervasive loss of critical spawning, incubation, and rearing habitat is a primary limiting factor for chum salmon throughout the lower Columbia. Chum salmon typically spawn in upwelling areas of clean gravel beds in mainstem and side channel portions of low-gradient reaches above tidewater.

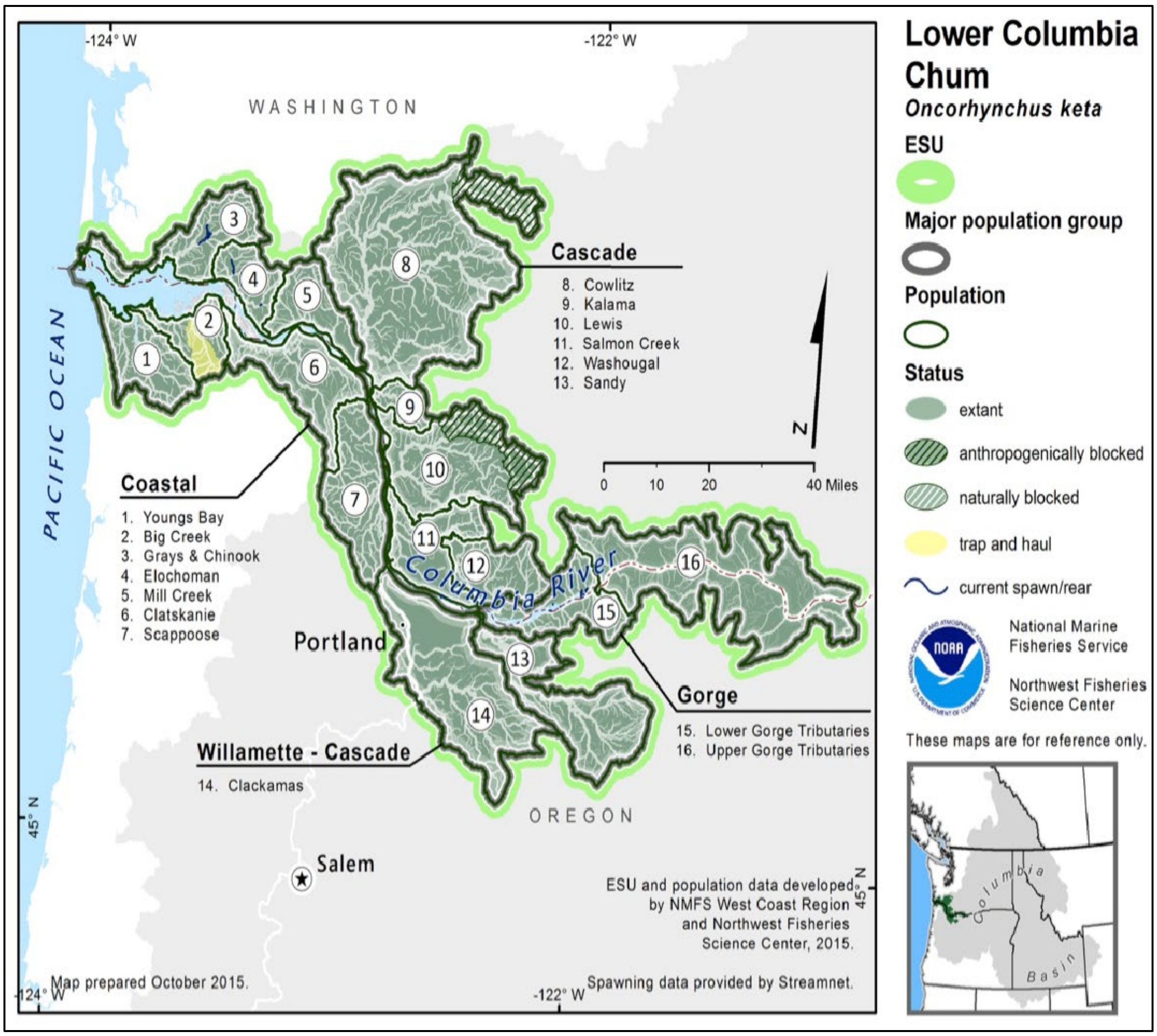


Figure 2.8-1. Map of the Columbia River chum salmon ESU's spawning and rearing areas, illustrating populations and major population groups.

determining whether an MPG has met that standard, based on the status of the individual populations in the MPG (NMFS 2013a).

Table 2.8-1. Status summary and limiting factors for CR chum salmon.

Status Summary	Limiting Factors
The CR chum salmon ESU consists of 17 historical populations in three MPGs: Coast, Cascade, and Gorge. The majority of the populations in this ESU are at high to very high risk, with very low abundances (NWFSC 2015). These populations are at risk of extirpation due to demographic stochasticity and Allee effects. One population, Grays River, is at low risk, with spawner abundances in the thousands and demonstrating a recent positive trend. The Washougal River and Lower Gorge populations maintain moderate numbers of spawners and appear to be relatively stable. The life history of chum salmon is such that ocean conditions have a strong influence on the survival of emigrating juveniles. The viability of this ESU is relatively unchanged since the last review, and the modest improvements in some populations do not warrant a change in risk category, especially given the uncertainty regarding climatic effects in the near future. This ESU therefore remains at moderate to high risk (NWFSC 2015).	• Reduced access to spawning and rearing habitat • Land development, especially in the low-gradient reaches that chum salmon prefer • An altered flow regime and Columbia River plume • Reduced access to off-channel rearing habitat • Reduced productivity resulting from sediment and nutrient-related changes in the estuary • Contaminants

For chum salmon, recovery requires improving all three MPGs to a high probability of persistence or to a probability of persistence consistent with their historical condition.[82] While some improvements in status have been observed recently, most populations in this ESU remain at high to very high risk, with low abundances; some are extirpated or nearly so. Most will require very large improvements to reach their recovery goals (NWFSC 2015). Achieving recovery will require improving tributary and estuarine habitat conditions, reducing or mitigating hydropower impacts, and reestablishing chum salmon populations where they may have been extirpated.

Continued land development and habitat degradation, in combination with the potential effects of climate change, will present a continuing strong negative influence into the foreseeable future. In addition, coastal ocean conditions in outmigrant year classes resulted in below-average ocean survival, with a corresponding drop in spawner abundance for a number of years leading to the latest status review (NWFSC 2015). This overall trend of poorer-than-average ocean conditions appears to have continued through 2016 and 2017.

The most recent status review (NWFSC 2015) concluded that only three of 17 populations are at or near their recovery viability goals, although, under the recovery plan scenario, these three populations are those that have very low recovery goals of zero. The remaining populations generally require a higher level of viability, and most require substantial improvements to reach their viability goals. Even with the improvements observed during the last five years, the majority of natural populations in this ESU remain at a high or very high risk category, and considerable progress remains to be made to achieve the recovery goals (Table 2.8-2; NWFSC 2015).

[82] The historical role of the Gorge MPG is unclear and warrants further investigation (NMFS 2013a).

Table 2.8-2. CR chum salmon major population groups (MPGs), run timing, populations, and scores for the key viable salmonid population (VSP) elements (abundance/productivity (A/P), spatial structure, and diversity) used to determine overall net persistence probability of the population (NWFSC 2015). Persistence probability ratings and key element scores range from very low (VL), low (L), moderate (M), high (H), to very high (VH). The populations that spawn upstream of Bonneville Dam are highlighted in gray. * = no data.

MPG		Population	A/P	Spatial Structure	Diversity	Overall Persistence Probability
Ecological Subregion	**Run Timing**					
Coast Range	Fall	Youngs Bay (OR)	*	*	*	VL
		Grays/Chinook Rivers (WA)	VH	M	H	M
		Big Creek (OR)	*	*	*	VL
		Elochoman/Skamokawa creeks (WA)	VL	H	L	VL
		Clatskanie River (OR)	*	*	*	VL
		Mill, Germany, & Abernathy creeks (WA)	VL	H	L	VL
		Scappoose River (OR)	*	*	*	VL
Cascade Range	Summer	Cowlitz River(WA)	VL	L	L	VL
	Fall	Cowlitz (WA)	VL	H	L	VL
		Kalama River (WA)	VL	H	L	VL
		Lewis River (WA)	VL	H	L	VL
		Salmon Creek (WA)	VL	L	L	VL
		Clackamas (OR)	*	*	*	VL
		Sandy (OR)	*	*	*	VL
		Washougal (WA)	VL	H	L	VL
Columbia Gorge	Fall	Lower Gorge (WA & OR)	VH	H	VH	H
		Upper Gorge (WA & OR)	VL	L	L	VL

2.8.1.2 Status of Critical Habitat

This section describes the status of designated critical habitat affected by the proposed action by examining the condition and trends of the PBFs of that habitat throughout the designated areas. These features are essential to the conservation of the ESA-listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration, and foraging). Table 2.8-3 summarizes status information for designated critical habitat for CR chum salmon based on the detailed information on the status of critical habitat throughout the designation area provided in the recovery plan for the species (NMFS 2013a), and discussed more fully in the environmental baseline below.

Table 2.8-3. Critical habitat, designation date, Federal Register citation, and status summary for CR chum salmon critical habitat.

Designation Date and Federal Register Citation	Critical Habitat Status Summary
9/02/05 **70 FR 52630**	Critical habitat encompasses six subbasins in Oregon and Washington containing 19 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005b). However, most of these watersheds have some, or high, potential for improvement. We rated conservation value of HUC5 watersheds as high for 30 watersheds, medium for 13 watersheds, and low for four watersheds (this includes watersheds along the migration corridor).

2.8.1.3 Climate Change Implications for CR Chum Salmon and Critical Habitat

One factor affecting the rangewide status of CR chum salmonand aquatic habitat is climate change. The U.S. Global Change Research Program (USGCRP),[83] mandated by Congress in the Global Change Research Act of 1990, reports average warming of about 1.3ºF from 1895 to 2011. As the climate changes, air temperatures in the Pacific Northwest are expected to increase 4 to 13°F by the end of the century, with the largest increases expected in the summer (Mantua et al. 2009; Mote et al. 2014). Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004; Scheuerell and Williams 2005; Zabel et al. 2006; ISAB 2007). According to the ISAB,[84] these effects pose the following impacts into the future:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a smaller snowpack, watersheds will see their runoff diminished earlier in the season, resulting in lower stream flows in the June through September period. River flows in general and peak river flows are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures are expected to rise, especially during the summer months when lower stream flows co-occur with warmer air temperatures.

The proposed action is only expected to be implemented in the interim time period between 2019 and the completion of the NEPA process; however, the effects of the proposed action will extend many years (e.g., maturation of estuary habitat projects). Thus, both natural climate variation and climate change are relevant to our analysis.

[83] http://www.globalchange.gov

[84] The Independent Scientific Advisory Board (ISAB) serves the National Marine Fisheries Service (NOAA Fisheries), Columbia River Indian Tribes, and Northwest Power and Conservation Council by providing independent scientific advice and recommendations regarding scientific issues that relate to the respective agencies' fish and wildlife programs: https://www.nwcouncil.org/fw/isab/.

Likely changes in temperature, precipitation, wind patterns, and sea-level height have implications for survival and recovery of CR chum salmon in both its freshwater and marine habitats and the PBFs of their critical habitat. While total precipitation changes are uncertain, increasing air temperature will result in more precipitation falling as rain rather than snow in watersheds across the basin (NMFS 2017a). In general, these changes in air temperatures, river temperatures, and river flows are expected to cause changes in salmon distribution, behavior, growth, and survival, although the magnitude of these changes remains unclear. In coastal areas, projections indicate an increase of 1–4 feet of global sea-level rise by the end of the century; sea-level rise and storm surge pose a risk to infrastructure, and coastal wetlands and tide flats are likely to erode or be lost as a result of seawater inundation (Mote et al. 2014). Ocean acidification is also expected to negatively impact Pacific salmon and organisms within their marine food webs.

There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management of these factors may help further alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations, management of flows through the mainstem dams to address temperature concerns, etc.). Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life-history types that will be successful in the future are neither static nor predictable; therefore, maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the CR chum salmon ESU.

Climate change would affect CR chum salmon and critical habitat through physical and chemical changes to their habitats (e.g., increased water temperature, decreased ocean pH, changes in the timing and volume of stream flow). The physical and chemical changes can result in biological impacts such as, but not limited to, reduced ocean survival, changes in growth and development, changes in run timing, and spawning timing (Link et al. 2015). These biological changes can result in changes in species productivity and abundance, distribution, food web structure, community structure, invasive species impacts, and biodiversity and resilience (Link et al. 2015). Because of the location of the ESU in the lower Columbia River basin, the ESU is likely to be more affected by climate-related effects in the estuary.

2.8.2 Environmental Baseline

The environmental baseline includes the past and present impacts of all federal, state, or private actions and other human activities in an action area, the anticipated impacts of all proposed federal projects in an action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process.

For CR chum salmon, we focus our description of the environmental baseline, on that portion of the action area where CR chum salmon juveniles and adults are exposed to the effects of the proposed action. We also include tributary habitat because these habitats, while not influenced by the proposed action, are primary drivers for the elements of VSP for CR chum salmon, and thus are key habitats for recovery of the ESU and are important to understand in the context of the proposed action.

To determine the upstream extent of CR chum salmon and thus exposure, we reviewed CR chum salmon passage observations at Bonneville Dam (2013–17) and The Dalles Dam (2013–17). An average of 107 adults per year were detected at Bonneville Dam across the five years, with a range of 21 fish in 2017 to 176 fish in 2015. For the five years where data were available, either zero or four fish overshot The Dalles Dam. Thus, the upper extent of the area where CR chum salmon are exposed to the effects of the proposed action is The Dalles pool. The downstream extent of the effects of the action (changes in flow) is the plume. Thus, the area includes the Columbia River from The Dalles pool to the plume, and includes the mouths of tributaries to the Columbia River in this reach to the extent that they are affected by flow management and habitat mitigation actions in the Columbia River.[85] The area also includes tributary habitats as described above.

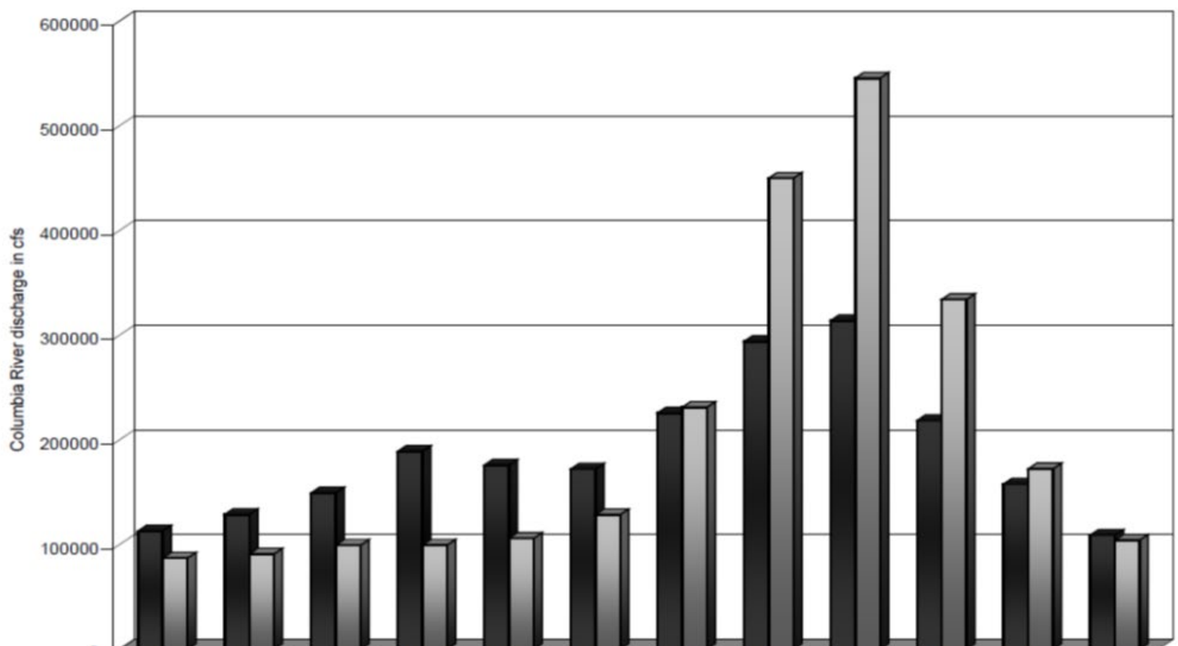
2.8.2.1 Mainstem Habitat

On the mainstem of the Columbia River, hydropower projects (including the CRS), water storage projects (including reservoirs in Canada operated under the Columbia River Treaty), and the withdrawal of water for irrigation and urban uses have significantly degraded salmon and steelhead habitats (Bottom et al. 2005; Fresh et al. 2005; NMFS 2013a). The volume of water discharged by the Columbia River varies seasonally according to runoff, snowmelt, and hydropower demands. Mean annual discharge is estimated to be 265 kcfs, but may range from lows of 71–106 kcfs to highs of 530 kcfs (Hamilton 1990; NMFS 1998; Prahl et al. 1998; USACE 1999). Naturally occurring maximum flows on the river occur in May, June, and July as a result of snowmelt in the headwater regions. Minimum flows occur from September to March, with periodic peaks due to heavy winter rains (Holton 1984). Interannual variability in stream flow strongly correlates with two recurrent climate phenomena, the ENSO and the PDO (Newman et al. 2016).

Water storage projects (dams and reservoirs) and water management activities have reduced flows between Bonneville and the mouth of the Columbia River compared to natural flows in the late spring and summer months; on average, this reduction can range from nearly 15 kcfs in August to over 230 kcfs in May (see Figure 2.8-2). Recognizing that the flow versus survival relationships for some interior basin ESUs/DPSs displayed a plateau over a wide range of flows but declined markedly as flows dropped below some threshold (NMFS 1995b, 1998), NMFS and the CRS Action Agencies have attempted to manage Columbia and Snake River water resources to maintain seasonal flows above threshold objectives given the amount of runoff in a given year.

[85] At this time, the Action Agencies have not proposed habitat mitigation actions in the tributaries of CR chum.

This has been accomplished by avoiding excessive drafts going into spring to minimize the flow reductions needed to refill the reservoirs and by drafting the storage reservoirs during summer to augment flows. These flow objectives have guided preseason reservoir planning and in-season flow management. Nonetheless, since the development of the hydrosystem, average monthly flows at Bonneville Dam have been substantially lower during May–July and higher in October–March than an unregulated system. Reduced flows have increased travel times during outmigration for juvenile salmonids and reduced access to high-quality estuarine habitats during spring through early summer.



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
■ Current	113017	128641	149403	189076	175921	172150	225689	293948	313930	218523	157935	109020
■ Natural	87115	91029	99387	99496	106033	128580	231047	450040	545561	334238	172430	104310

Figure 2.8-2. Comparison of monthly discharge (flow) in the Columbia River between current conditions (black) and normative flows (gray). These data show that pre-development flows were lower in the winter and higher in the spring and early summer months.

CR chum salmon spawn in the mainstem at the Ives/Pierce Island complex in the Bonneville tailrace. For this large spawning aggregation, which is part of the Lower Gorge chum salmon population, access to spawning and incubation habitat at higher elevations around the islands and the Washington shoreline can be limited by hydrosystem operations. These include flow management at upper basin reservoirs and load following for electricity production at Bonneville Dam. The Action Agencies provide a tailwater elevation at Bonneville Dam each year that supports chum spawning during late fall and winter and incubation in the Ives Island complex into spring. This typically requires flow augmentation from storage reservoirs before reliable flow forecast information becomes available. If the tailwater elevation level selected during the spawning season is too high (i.e., requires deeper reservoir drafts), there is an increased risk of missing the April 10th refill objective at Grand Coulee Dam, which has the potential to reduce spring flow augmentation for juvenile outmigrants from the interior ESUs and DPSs. Conversely, if flows must be reduced during the chum salmon incubation period to target refill, there is the risk of dewatering those redds. When this conflict arises, the interagency Technical Management Team discusses how to balance refill at the storage projects with spring flows that benefit multiple ESUs, which generally have priority over maintaining the chum tailwater elevations set in December (BPA et al. 2018a).

The series of dams and reservoirs have also blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is at only one-third of nineteenth-century levels (Simenstad et al. 1982, 1990; Sherwood et al. 1990; Weitkamp 1994; NRC 1996; NMFS 2008a). Similarly, Bottom et al. (2005) estimated that the delivery of suspended sediment to the lower river and estuary has been reduced by about 60 percent (as measured at Vancouver, Washington). This reduction has altered the development of habitat along the margins of the river.

Industrial harbor and port development are also significant influences on the lower Willamette and lower Columbia Rivers (Bottom et al. 2005; Fresh et al. 2005; NMFS 2013a). Since 1878, the Army Corps of Engineers has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the lower Willamette River as a navigation channel. Originally dredged to a 20-foot minimum depth, the federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The navigation channel supports many ports on both sides of the river, resulting in several thousand commercial ships traversing the river every year. The dredging, along with diking, draining, and fill material placed in wetlands and shallow habitat, also disconnects the river from its floodplain, resulting in the loss of shallow-water rearing habitat and the ecosystem functions that floodplains provide (e.g., supply of prey, refuge from high flows, temperature refugia; Bottom et al. 2005).

The most extensive urban development in the lower Columbia River subbasin has occurred in the Portland/Vancouver area. Common water-quality issues both in areas with urban development and rural residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff (LCREP 2007).

2.8.2.2 Passage Survival

Only one population in this ESU is affected by passage conditions at Bonneville Dam: Upper Gorge chum salmon. There are no studies of downstream passage survival for juvenile CR chum salmon. The survival of downstream migrants is likely to have improved in recent years due to the construction of the Bonneville Corner Collector and juvenile bypass system at Powerhouse 2 and increases in the percent of flow approaching the dam that goes over the spillway. Both of these measures reduce passage time and the likelihood of turbine passage for juvenile migrants (Ploskey et al. 2012).

Adult chum salmon counts in the ladders at Bonneville Dam have ranged from 17 in 2000 to 411 in 2003, averaging 107 adults per year. The most recent 10-year average (2008–17) is 96 adults (McCann 2018), which is similar to the 107 adults mentioned above as the average number of adults moving upstream of Bonneville Dam between 2013 and 2017 based on dam counts. NMFS (2008a) estimated that the adult passage mortality rate for chum salmon at Bonneville Dam was similar to that of Snake River fall Chinook salmon, which are present during the same time period (about 3.1 percent). Passage survival estimates incorporate passage under general operations and typical maintenance (e.g., screen blockages/cleaning) conditions.

2.8.2.3 Water Quality

Water quality in the action area is impaired. Common toxic contaminants found in the Columbia River system include PCBs, PAHs, PBDEs, DDT and other legacy pesticides, current use pesticides, pharmaceuticals and personal care products, and trace elements (LCREP 2007). The LCREP report noted widespread presence of PCBs and PAHs, both geographically and in the food web. Urban and industrial portions of the lower river contribute significantly to contaminant levels in juvenile salmon; juvenile salmon are absorbing toxic contaminants during their time rearing and feeding in the lower Columbia River (LCREP 2007). Likewise, juvenile salmon are accumulating DDT in their tissues and are exposed to estrogen-like compounds in the lower river, likely associated with pharmaceuticals and personal care products. Concentrations of copper are present at levels that could interfere with crucial salmon behaviors.

Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute municipal and industrial waste discharges to the lower Columbia River. Industrial and municipal wastes from the Portland/Vancouver metro areas, including the superfund-designated reach in the lower Willamette River, also contribute to degraded water quality in the lower Columbia River. Mining areas scattered around the basin deliver higher background concentrations of metals. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river. Small releases of materials such as lubricants occur during dam operation and maintenance and contribute to background exposure to contaminants in the Columbia River.

Outside of urban areas, the majority of residences and businesses rely on septic systems. Common water-quality issues with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff. Under these environmental conditions, fish in the action area are stressed. Stress may lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival).

Oils, greases, and other lubricants (derived from animal, fish, vegetable, petroleum or marine mammal origin) are used at each of the CRS projects (and all other dams in the Columbia River basin), including, but not limited to, the following: hydropower turbines, hydraulic systems, lubricating systems, gear boxes, machining coolant systems, heat transfer systems, transformers, circuit breakers, and electrical systems. Leakage of oils, greases, or other lubricants into rivers has the potential to affect salmon and steelhead (avoidance, exposure to toxic compounds, or even, in some circumstances death). In response to increased concerns regarding the releases of oils and greases from lower Columbia and lower Snake River dams (and Dworshak and Chief Joseph Dams) the Corps has taken steps to minimize these risks. For equipment in contact with the water, the Corps has developed best management practices to avoid accidental releases and to minimize the adverse effects in the case of an accidental release. The Corps has also begun using, where feasible, "environmentally acceptable lubricant" greases and in some cases has replaced greased equipment with greaseless equipment. The Corps has also developed and are implementing oil accountability plans with enhanced inspection protocols and are reporting annually.

The extent to which leaked grease or oil, occurring under the environmental baseline in the Clearwater River (Dworshak Dam), Upper Columbia River (Chief Joseph), or lower Snake or lower Columbia Rivers, has affected the behavior, health, or survival of CR chum salmon in the past is unknown, but likely to be small given that the size of these river systems. For comparison, a large leak of 100 gallons per day is the equivalent of 0.00016 cubic feet per second and the average annual discharge of the Columbia River has ranged from roughly 125,000 to 250,000 cubic feet per second since about 1940 (ISAB 2000). Nevertheless, to the extent past leakages have potentially affected passage or survival, these effects would be encompassed by annual juvenile or adult reach survival estimates. Recent actions (adoption of best management practices, use of environmentally acceptable lubricants, use of greaseless equipment, etc.) would further reduce the potential for negative effects stemming from these materials and slightly improve conditions for juvenile and adult migrants.

Water temperatures in the Columbia River are a concern; because of temperature standard exceedances, the Columbia River is included on the Clean Water Act §303(d) list of impaired waters established by Oregon and Washington. Temperature conditions in the Columbia River basin area affected by many factors, including:

- Natural variation in weather and river flow;
- Construction of the dam and reservoir system (the large surface areas of reservoirs and resulting slower river velocities contribute to warmer late summer and fall water temperatures);
- Increased temperatures of tributaries;
- Water managed for irrigated agriculture, and due to grazing and logging;
- Point-source thermal discharges from cities and industries; and
- Climate change.

The EPA is working with federal and state agencies, tribes, and other stakeholders to develop water-quality improvement plans (total maximum daily loads) for temperature in the Columbia River and lower Snake River. As part of the 2015 biological opinion on EPA's approval of water-quality standards including temperature (NMFS 2015a), EPA committed to work with federal, state, and tribal agencies to identify and protect thermal refugia and thermal diversity in the lower Columbia River and its tributaries.

Comparisons of long-term temperature monitoring in the migration corridor before and after impoundment reveal a change in the thermal regime of the Snake and Columbia Rivers. Using historical flows and environmental records for the 35-year period 1960–95, Perkins and Richmond (2001) compared water temperature records in the lower Snake River with and without the lower Snake River dams and found three notable differences between the current versus unimpounded river:

- Maximum summer water temperature has been slightly reduced;
- Water temperature variability has decreased; and
- Post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall, a phenomenon termed thermal inertia.

These hydrosystem effects (influenced by the temperatures of tributary streams entering the Snake and Columbia Rivers both upstream of, within, and downstream of the mainstem dams) continue downstream and influence temperature conditions in the lower Columbia River. At a macro scale, water temperature affects salmonid distribution, behavior, and physiology (Groot and Margolis 1991); at a finer scale, temperature influences migration swim speed of salmonids (Salinger and Anderson 2006), timing of river entry (Peery et al. 2003), susceptibility to disease and predation (Groot and Margolis 1991), and, at temperature extremes, survival.

TDG levels also affect mainstem water quality and habitat. To facilitate the downstream movement of juvenile salmonids, state regulatory agencies issue waivers for TDG as measured in the forebay and tailrace (NMFS 1995a). Specifically, water that passes over the spillway at a mainstem dam can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). Historically, TDG supersaturation was a major contributor to juvenile salmon mortality; to reduce TDG supersaturation, the Corps installed spillway improvements, typically “flip lips,” at each mainstem dam except The Dalles Dam. Biological monitoring shows that the incidence of GBT in both migrating smolts and adults remains between 1–2 percent when TDG concentrations in the upper water column do not exceed 120 percent of saturation in CRS project tailraces. When those levels are exceeded, there is a corresponding increase in the incidence of signs of GBT symptoms. Fish migrating at depth avoid exposure to the higher TDG levels due to pressure compensation mechanisms (Weitkamp et al. 2003).

Adult chum salmon are in the vicinity of the Bonneville Dam tailrace during November through December each year, and therefore are not likely to be exposed to elevated levels of TDG. Eggs are present in the mainstem spawning area near the tailrace (the Ives/Pierce Island area) during winter, and fry are present in the bypass system at Bonneville and the mainstem spawning area through May. The Action Agencies, as coordinated through the Technical Management Team, minimize the risk of GBT to these life stages by maintaining a Bonneville tailwater elevation of between 11.5 and 13 feet through spawning if reservoir elevations (indicative of available storage) and climate forecasts indicate this operation will be feasible.

2.8.2.4 Tributary Habitat

CR chum salmon primarily use habitat in the lower ends of tributaries (e.g., within or just above the range of tidal influence in tributaries below Bonneville Dam; NMFS 2013a). The pervasive loss of some critical spawning and incubation habitat is a primary limiting factor for CR chum salmon, which typically spawn in upwelling areas of clean gravel beds. These habitats have been eliminated in many systems through a combination of channel alteration and sedimentation that is attributable largely to past and current land uses, including forest management, agriculture, rural residential uses, urban development, and gravel extraction. Low-elevation stream reaches have been affected by extensive channelization, diking, wetland conversion, stream clearing, and gravel extraction. Impaired watershed processes continue to limit chum salmon habitat through effects on floodplain and wetland habitat conditions and connectivity, riparian conditions, and channel structure. For example, high densities of unimproved rural roads increase fine sediment concentrations in tributary streams that settle out in the low gradient areas, covering spawning gravels and increasing turbidity. Highway and transportation corridors run parallel to the Columbia River shoreline on both sides of the river, traversing all creek drainages in ways that restrict access and disconnect upland and lowland habitat processes, especially for the Upper and Lower Gorge chum salmon populations.

In addition, one of the historical Upper Gorge populations spawned in the lower ends of tributaries that were inundated by Bonneville Reservoir (NMFS 2013a). Although current spawning areas have not been identified in Bonneville pool, small numbers of adults and juveniles are counted in the adult fish ladders and juvenile bypass system each year indicating that some spawning habitat is still available.

2.8.2.5 Estuary Habitat

Chum salmon fry are commonly found in wetland channels in the lower Columbia River estuary floodplain during March–May. Thus, the estuary provides important rearing habitat for CR chum salmon, as well as the migration corridor between spawning and rearing areas and the ocean. Since the late 1800s, 68–70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening, combined with flow regulation and other modifications (Kukulka and Jay 2003; Bottom et al. 2005; Marcoe and Pilson 2017). Disconnection of tidal wetlands and floodplains has eliminated much of the historical rearing habitat for subyearling salmon and reduced the production of wetland macrodetritus supporting salmonid food webs (Simenstad et al. 1990; Maier and Simenstad 2009), both in shallow water and for larger juveniles migrating in the mainstem (ERTG 2018).

Restoration actions in the estuary, such as those highlighted in the latest five-year review, have improved access and connectivity to floodplain habitat (NMFS 2016c). From 2004 through 2017, restoration sponsors implemented 58 projects including dike and levee breaching or lowering, tide-gate removal, and tide-gate upgrades that reconnected 5,412 acres of historical tidal floodplain habitat to the mainstem. This represents a 2.5 percent net increase in the connectivity of habitats used extensively by chum salmon fry (Johnson et al. 2018).

2.8.2.6 Hatcheries

The Mitchell Act-funded chum salmon hatchery program supports the ESU in what HSRG (2014) calls the recolonization stage. At this stage, demographic concerns outweigh any risk posed by hatchery-induced selection, so no Proportion of Hatchery-origin fish on the Spawning Grounds (pHOS) / Proportionate Natural Influence (PNI) standards are being applied at this time. However, to continue to be consistent with recovery, the program will in time develop a local stock, and move to PNI-based management. At this time, the benefits of the hatchery program still outweigh the risks (NMFS 2017a).

Hatchery programs have varying levels of effects to the species they culture. The seven risk factors fall into three groups: risks posed by the facilities, directly (such as trapping) or indirectly (such as water withdrawal); RM&E; and biological interactions with natural populations. In the Mitchell Act biological opinion, NMFS concluded that facility effects on the abundance, spatial structure, and diversity VSP parameters of the CR chum salmon ESU are negligible for hatchery operations and small for trapping (NMFS 2017a).

2.8.2.7 Recent Ocean and Lower River Harvest

There is no directed harvest of CR chum salmon. Commercial harvesters in the lower Columbia River have taken fewer than 100 fish per year since 1993, and all recreational fisheries have been closed since 1995. The overall exploitation rate has been less than 1 percent in recent years (NWFSC 2015).

The 2008–16 annual non-treaty commercial landings observed one chum salmon landing in 2009 (TAC 2017). Impacts in the recreational fishery (from non-retention mortalities) are expected to be near zero in 2018–27, as chum salmon enter the Columbia River near the end of October, which coincides with a period of declining angler effort (TAC 2017). The incidental harvest rate is limited to no more than 5.0 percent; however, based on a longer-term data series (since 2001), the expected total impact rate on CR chum salmon between 2018 and 2027 is expected to average only 1.6 percent (TAC 2017, Table 5.1.11). There are no impacts expected in treaty tribal fisheries above Bonneville Dam (TAC 2017).

2.8.2.8 Predation

The existence of dams and reservoirs around the Columbia Basin also blocks sediment transport. Total sediment discharge into the estuary and Columbia River plume is about one-third of nineteenth-century levels (NMFS 2008a). This reduces turbidity in the lower river, especially during spring, which is likely to make juvenile outmigrants more vulnerable to visual predators like piscivorous birds and fishes.

2.8.2.8.1 Avian Predation

There are no estimates of avian predation rates for CR chum salmon using PIT-tag detections. Researchers identified only one chum salmon from 451 foregut samples of cormorants collected near East Sand Island (Lyons et al. 2014), and chum salmon was a negligible component of the diet of Caspian terns nesting on Rice Island (Collis et al. 2002).

2.8.2.8.2 Piscivorous Fish Predation

Native pikeminnow are significant predators of juvenile salmonids in the Columbia River basin, followed by nonnative smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011, 2015). Prior to the start of the NPMP in 1990, native pikeminnow were estimated to eat about 8 percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River basin each year. Williams et al. (2017) compared current estimates of northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. No chum salmon were reported killed and/or handled in the Sport Reward Fishery during 2013-17.

The Action Agencies also conduct a Dam Angling Program at The Dalles and John Day Dams. Anglers did not catch any chum salmon during 2013-17 (Williams 2013, 2014; Williams et al. 2015, 2016, 2017).

Juvenile salmonids are also consumed by nonnative fishes including walleye, smallmouth bass, and channel catfish. Both the Oregon and Washington Departments of Fish and Wildlife have removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids.

2.8.2.8.3 Pinniped Predation

Marine mammal predators of salmon have increased considerably along the northwestern United States coast since the MMPA was enacted in 1972 (Carretta et al. 2013). CSLs, SSLs, and harbor seals (*Phoca vitulina)* consume salmonids from the mouth of the Columbia River and tributaries up to Bonneville Dam. The ODFW has been counting the number of individual CSLs hauling out at the East Mooring Basin in Astoria, Oregon, since 1997. These count data indicate that researchers have observed nearly an order of magnitude increase in predatory CSL individuals at the mouth of the Columbia River during the spring period in the last five years, compared to what was occurring during first five years of the 2008 FCRPS biological opinion (2008–12). Pinniped counts at the East Mooring Basin during the chum salmon migration (November and December) have also increased in recent years, but have been variable and have not increased to the degree they have increased in the spring (Table 2.8-4).

Table 2.8-4. Max monthly counts of California sea lions at Astoria, Oregon, East Mooring Basin (Wright 2018).

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
2008	40	56	67	126	162	46	6	191	213	204	273	157
2009	27	42	84	118	173	45	38	346	376	241	89	84
2010	58	93	136	229	216	157	29	316	356	265	98	54
2011	19	42	77	155	242	126	11	302	246	85	159	106
2012	20	27	82	240	201	92	19	212	187	147	91	21
2013	37	149	595	739	722	153	8	368	377	208	182	100
2014	237	586	1420	1295	793	90	32	423	492	369	94	126
2015	260	1564	2340	2056	1234	623	37	394	1318	459	84	208
2016	788	2144	3834	1212	1077	620	3	291	1004	878	235	246
2017	1498	2345	808	1131	1204	573						

Based on pinniped count data and spring Chinook salmon survival estimates, increasing pinniped abundance in the Columbia River estuary has resulted in an increased loss of adult salmon in recent years. Rub et al. (2018) conducted a five-year mark-recapture tagging study to examine the behavior and survival of spring Chinook salmon returning to the Interior Columbia River basin (above Bonneville) amid increasing pinniped abundance. These researchers found strong evidence that the recent increases in spring Chinook salmon loss estimates were likely a function of the large increase in pinnipeds counted from 2012 to 2015. This is evidence that increased pinniped abundance increases risk to adult salmonids; however, the magnitude of pinniped predation on chum salmon is likely lower than on spring Chinook salmon, due to fewer pinnipeds being present when chum salmon migrate.

SSL abundance in the lower Columbia River has been increasing, and SSL overwintering at Bonneville Dam has become common (Tidwell et al. 2017). Abundance of SSL in the Bonneville tailrace during the fall and winter monitoring period averaged 14.5 individuals per day (Tidwell et al. 2018). Substantial predation on adult salmonids during the chum salmon spawning period has been recorded in the Bonneville tailrace, but adult chum passage at Bonneville Dam is minimal; therefore, predation in the immediate tailrace is not likely a major contributing factor. Chum salmon spawn just downstream of the Bonneville tailrace, but it is currently unknown how many chum salmon are being consumed by SSL at spawning locations. Pinniped predation on individual adult chum salmon has been observed (Hillson 2018b), but the magnitude of the predation events has not been estimated.

2.8.2.8.4 Compensatory Effects and Predation on Salmonid Populations

An estimate of the effect of a predator population on adult returns to Bonneville Dam (e.g., the effect of smolt consumption by northern pikeminnow or Caspian terns) has the potential to be erroneous if it does not consider whether other factors intervene to compensate for the change in mortality (ISAB 2016). The primary mechanisms for compensatory effects are: (1) increased fish survival due to reduced densities in later life stages, (2) selective predation based on fish size and condition, and (3) predator switching from one prey species to another. Compensatory effects are difficult to quantify because they can occur later in the life cycle and can vary over time; efforts are currently underway to better understand compensatory effects (Haeseker 2015; Evans et al. 2018b).

2.8.2.9 Research and Monitoring Activities

The primary effects of the past and ongoing CRS-related RM&E on CR chum salmon are associated with the capturing and handling of fish. The RM&E program is a collaborative, regionally coordinated approach to fish and habitat status monitoring, action effectiveness research, critical uncertainty research, and data management. The information derived from the program facilitates effective adaptive management through better understanding the effects of the ongoing CRS action. Capturing, handling, and releasing fish generally leads to stress and other sublethal effects, but fish sometimes die from such treatment. The mechanisms by which these activities affect fish have been well documented and are detailed in Section 8.1.4 of the 2008 biological opinion. Some RM&E actions also involve sacrificial sampling of fish. We estimated the number of CR chum salmon that have been handled or killed each year during the implementation of RM&E under the 2008 RPA as the average annual take reported for 2013-17:

- Average annual estimates for handling and mortality of CR chum salmon associated with the Smolt Monitoring Program and the CSS was limited to ten wild juveniles handled (zero died).
- No adult or juvenile CR chum salmon were handled or died during implementation of the ISEMP.
- Estimates for CR chum salmon handling and mortality for all other RM&E programs: (1) zero hatchery and one wild adult handled; (2) zero hatchery or wild adults died; (3) 161 hatchery and 319,853 wild juveniles handled; and (4) one hatchery and 3,738 wild juveniles died.

The combined take (i.e., handling, including injury, and incidental mortality) associated with these elements of the RM&E program has, on average, affected less than 1 percent of the wild (i.e., natural origin) adult CR chum salmon run (Bellerud 2018). However, more than 6 percent of the wild juvenile production was handled in the combined RM&E programs. Based on the history of these programs, we assume that up to one percent of these juveniles (i.e., 0.06 percent of the wild production) died from effects of handling after they were released. These relatively small effects are deemed worthwhile because they allow the Action Agencies and NMFS to evaluate the effects of CRS operations, including modifications to facilities, operations, and mitigation actions.

In addition, northern pikeminnow are tagged as part of the Sport Reward Fishery and their rate of recapture is used to calculate exploitation rates. Northern pikeminnow are collected for tagging using boat electrofishing in select reaches of the Columbia River. During 2017, northern boat electrofishing operations in the Columbia River extended upstream from RM 47 (near Clatskanie, Oregon) to RM 394 (Priest Rapids Dam), and in the Snake River from RM 10 (Ice Harbor Dam) to RM 41 (Lower Monumental Dam) and from RM 70 (Little Goose Dam) to RM 156 (upstream of Lower Granite Dam). Researchers conducted four sampling events consisting of 15 minutes of boat electrofishing effort in shallow water within each 0.6-mile reach during April-July.

A side effect of the electrofishing effort is that salmon and steelhead may be exposed to the electrofishing field, with the potential for injury, stress, and fatigue and even cardiac or respiratory failure (Snyder 2003). Some adult and juvenile CR chum salmon are likely to be present in shallow shoreline areas during the April-July time period. Most sampling occurs in darkness (1800-0500 hours). Operators shut off the electrical field if salmonids are seen and because most stunned fish quickly recover and swim away, they cannot be identified to species (i.e., Chinook, coho, chum, or sockeye salmon or steelhead). Barr (2018) reported encountering an annual average of 891 adult and 60,312 juvenile salmonids in the lower Columbia River each year during 2013-17 electrofishing operations based on visual estimation methods. It is likely that some of these were CR chum salmon.

2.8.2.10 Critical Habitat

The environmental baseline for the PBFs for CR chum salmon critical habitat are reflected in the same impacts discussed above (e.g., loss of spawning and rearing areas in the lower ends of tributaries and along the estuary floodplain, inundation of historical spawning areas under Bonneville pool) and summarized here in Table 2.8-5. Restoration activities addressing loss of floodplain rearing sites have improved the baseline condition for PBFs; however, more restoration is needed before the PBFs can fully support the conservation of CR chum salmon.

Table 2.8-5. Physical and biological features (PBFs) of designated critical habitat for CR chum salmon.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBF
Freshwater spawning sites	Water quantity and quality and substrate to support spawning, incubation, and larval development	● Loss of upwelling areas of clean gravel beds through channel alteration and sedimentation (forest management, agriculture, rural residential uses, urban development, and gravel extraction) ● Loss of wetland and side channel connectivity (channel manipulations, diking, wetland conversion, stream clearing, gravel extraction) ● Excessive sediment in spawning gravel (unimproved roads, forest and agricultural practices in upstream watersheds) ● Inundation of spawning sites in the lower ends of tributaries under Bonneville Reservoir (hydrosystem development)
Freshwater rearing sites	Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility, water quality and forage, and natural cover	● Loss of upwelling areas of clean gravel beds through channel alteration and sedimentation (forest management, agriculture, rural residential uses, urban development, and gravel extraction) ● Loss of wetland and side channel connectivity (channel manipulations, diking, wetland conversion, stream clearing, gravel extraction) ● Excessive sediment in streambed (unimproved roads, forest and agricultural practices in upstream watersheds)
Freshwater migration corridors	Free of obstruction and excessive predation, adequate water quality and quantity, and natural cover	● Delay and mortality of some juveniles and adults ● Concerns about increased opportunities for pinniped predation in mainstem spawning areas below Bonneville Dam
Estuarine areas	Free of obstruction and excessive predation with water quality, quantity, and salinity, natural cover, and juvenile and adult forage	● Diking off areas of the estuary floodplain (land use), combined with reduced peak spring flows (water diversions and water storage and hydroelectric projects), have reduced access to floodplain habitat for rearing and prey production
Nearshore marine areas[1]	Free of obstruction and excessive predation with water quality, quantity, and forage	● Concerns about increased opportunities for pinniped predators, adequate forage

[1] Designated area includes only the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties

2.8.2.11 Future Anticipated Impacts of Completed Consultations

The environmental baseline also includes the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, including the consultation on the operation and maintenance of the Bureau of Reclamation's upper Snake River projects. The 2016 five-year review evaluated new information regarding the status and trends of CR chum salmon, including recent biological opinions issued for CR chum salmon and key emergent or ongoing habitat concerns (NMFS 2016c). Since the beginning of 2015 through 2017, we completed 252 formal consultations (54 in 2015, 67 in 2016 and 131 in 2017) that addressed effects to CR chum salmon (PCTS data query July 31, 2018). These numbers do not include the many projects implemented under programmatic consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed salmonids. Some of the completed consultations are large (large action area, multiple species), such as the Mitchell Act consultation and the consultation on the 2018–27 *U.S. v. Oregon* Management Agreement. Many of the completed actions are for a single activity within a single subbasin.

Some of the projects will improve access to blocked habitat and riparian condition, and increase channel complexity and instream flows. For example, under BPA's Habitat Improvement Programmatic consultation, BPA implemented 29 projects in the Columbia Basin that improved fish passage in 2017, and 99 projects that involved river, stream, floodplain, and wetland restoration. These projects will benefit the viability of the affected populations by improving abundance, productivity, and spatial structure. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more, and typically less, than a few weeks).

Other types of federal projects, including grazing allotments, dock and pier construction, and bank stabilization, will be neutral or have short- or even long-term adverse effects on viability. All of these actions have undergone section 7 consultation, and the actions or the RPA were found to meet the ESA standards for avoiding jeopardy.

Similarly, future federal restoration projects will improve the functioning of the PBFs safe passage, spawning gravel, substrate, water quantity, water quality, cover/shelter, food, and riparian vegetation. Projects implemented for other purposes will be neutral or have short- or even long-term adverse effects on some of these same PBFs. However, all of these actions, including any RPAs, have undergone section 7 consultation and were found to meet the ESA standards for avoiding adverse modification of critical habitat.

2.8.2.12 Summary

The factors described above have negatively affected the abundance, productivity, diversity, and spatial structure of CR chum salmon populations. Recent improvements in passage conditions at Bonneville Dam and at tributary barriers, and the small net improvement in floodplain connectivity achieved through the CRS estuary habitat program, are positive signs, but other stressors are likely to continue. NMFS (2016c) identified freshwater habitat conditions in the lower ends of tributaries as negatively influencing spawning and early rearing success and contributing to the overall low productivity of the ESU. Land development in these low-gradient reaches will continue to be a threat to most chum salmon populations, due to projected increases in the population of the greater Portland/Vancouver area and the lower Columbia River overall.

These factors, in combination with the potential effects of climate change, are likely to present a continuing strong negative influence into the foreseeable future.

Likewise, the environmental baseline within the action area does not fully support the conservation value of designated critical habitat for CR chum salmon as described above. The PBFs essential for the conservation of CR chum salmon include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine rearing areas, and nearshore marine areas (at the mouth of the Columbia River).

The CRS Action Agencies and other federal and nonfederal entities have taken actions in recent years to improve the functioning of some of these critical habitat PBFs. Recent surface passage improvements are expected to reduce delay and mortality of juvenile chum salmon at Bonneville Dam. For subyearling smolts (fry), restoration projects in the estuary are improving the functioning of areas used for growth and development. However, other factors that have negative effects on these PBFs are expected to continue into the future.

2.8.3 Effects of the Action

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

The proposed action is an ongoing action that has been modified over time to reflect capital improvements as well as changes in operation based on existing conditions and improved information on how CRS operations affect CR chum salmon and other listed species and their critical habitats. The current proposed action includes operational measures (e.g., flood risk management, navigation, fish passage, and hydropower generation) and non-operational measures (e.g., support for conservation hatchery programs, predation management, habitat improvement actions) that will be implemented beginning in 2019.

As described in Section 2.1 above, our analysis of effects for CR chum salmon extends from 2019 into the future, but emphasizes the evaluation of effects that are reasonably certain to occur as a result of implementing the proposed action pending completion of the EIS and our issuance of a subsequent biological opinion addressing the effects of the final preferred alternative. To the extent our consideration of potential effects beyond that time period assumes the current proposed action remains in place, it is intended, in part, to inform the evaluation of alternatives in the EIS.

The Action Agencies will operate the run-of-river lower Columbia River projects (McNary, John Day, The Dalles, and Bonneville Dams) in accordance with the annual Water Management Plan and Fish Passage Plan (including all appendices). These projects are operated for multiple purposes, including fish and wildlife conservation, irrigation, navigation, power, recreation, and, in the case of John Day Dam, limited flood-risk management.

The effects of the proposed action are generally consistent with the effects caused by a short-term continuation of recent CRS operations as described in the environmental baseline section, with the exception of the addition of the flexible spring spill operation, which is expected to alter conditions for the one CR chum salmon population migrating upstream of Bonneville Dam. The other operational changes are not anticipated to alter the effects to CR chum salmon because no fish in the ESU will be exposed to the effects of those changes. This continued CRS operation includes operating Bonneville Dam in a manner that will target an 11.5-foot or greater tailwater elevation in the vicinity of Ives Island, which is a spawning ground for mainstem CR chum salmon. However, depending upon environmental conditions (e.g., flows in the lower Columbia River and its tributaries), this elevation may not be maintained throughout the entire spawning and incubation period. The targeted elevation will also allow chum salmon to access tributary spawning habitat in Hamilton and Duncan Creeks.

2.8.3.1 Effects to Species

Both juvenile and adult CR chum salmon from all populations will be exposed to the continuing effects of the action in the mainstem Columbia River. The population that migrates above Bonneville Dam (Upper Gorge) will also be exposed to the habitat effects described above, as well as to operations at Bonneville Dam.

2.8.3.1.1 Hydrosystem Operation

For CR chum salmon juveniles that are produced upstream of Bonneville Dam, the proposed increased spring spill will result in: (1) higher proportions of juveniles passing downstream via the spillway than via the juvenile bypass or corner collectors, and (2) exposure to increased levels of TDG below Bonneville.

Exposure to TDG will increase for chum salmon fry that may still be present downstream of Bonneville Dam in April and May. Elevated TDG levels from the flexible spring spill operation (up to 120 or 125 percent TDG) will likely extend downstream to at least the Camas/Washougal TDG monitoring station, over 35 miles downstream of Bonneville Dam. In the spring of 2019, any remaining chum fry downstream of Bonneville Dam will experience a small (0-2 percent) increase in TDG exposure that is not expected to substantially affect the species since the average exposure will be similar to what was experienced in the baseline. In 2020, TDG exposure and any associated effects may increase substantially if state water quality limits increase and Bonneville Dam spills up to 125 percent (150 cfs Cap) in the tailrace. If this occurs, there may be increased injury or death for chum salmon fry associated with these conditions (Geist et al. 2013) for individuals that remain in shallow water and have not yet emerged. Assuming typical water temperature conditions, the majority of chum salmon fry will likely have emerged and migrated to the ocean by the time spring spill begins on April 10 (Murray et al. 2011). Adults which migrate and spawn in the fall, will be unaffected by the flexible spring spill operation.

2.8.3.1.2 Predator Management and Monitoring Actions

The Corps' program to install and operate sea-lion excluder gates at Bonneville Dam will continue, and has the potential to positively affect the population that passes upstream of Bonneville Dam.

The NPMP includes the Sport Reward Fishery and Dam Angling programs, which will continue as part of the proposed action. The first is implemented in the lower Columbia River, including the estuary. This fishery removes approximately 10–20 percent of predatory-sized pikeminnow per year and is open from May through September, when juvenile chum salmon can be rearing and migrating in mainstem habitats. We expect that this ongoing measure will continue the 30 percent reduction in predation rates achieved under the 2008 RPA. We estimate that numbers of CR chum salmon handled or killed in the Sport Reward Fishery will be no more than ten adults and 100 juveniles per year during the interim period.

The Action Agencies will also continue to implement the Northern Pikeminnow Dam Angling Program at The Dalles and John Day Dams, as described under the environmental baseline. These ongoing measures will continue the reduction in predation rates achieved under the 2008 RPA. We estimate that zero adult or juvenile chum salmon will be caught in the Dam Angling Program per year during the interim period.

2.8.3.1.3 Pinnipeds

Adult chum salmon rarely pass Bonneville Dam in numbers that could be impacted by the proposed action (i.e., sea lion excluder devices, hazing, or monitoring). Thus, the proposed action is not expected to affect pinniped predation rates on CR chum salmon.

2.8.3.1.4 Habitat Actions

For those CR chum salmon populations that have been negatively affected by the CRS, the Action Agencies will provide funding and/or technical assistance for tributary habitat improvement actions consistent with basinwide criteria for prioritizing actions, including recovery plan priorities, as funding allows. If implemented, and if implemented in a manner consistent with scientifically sound identification and prioritization of limiting factors and geographic locations, such actions could provide benefits to the targeted populations. However, because the Action Agencies have not proposed a commitment to implement tributary habitat improvement actions for CR chum salmon as part of this proposed action, or proposed them in a manner where we could meaningfully assess the effects (e.g., committing to achieve specific amounts or types of restoration), we are not considering the benefits of potential actions in our analysis.

On the other hand, the Action Agencies have committed to continue to implement the CEERP to increase the capacity and quality of estuarine ecosystems and improve access for juvenile salmonids. The Action Agencies will continue to emphasize reconnection of floodplain areas in tidally influenced waters of the lower Columbia River and estuary, primarily through modifying levees. Additional actions at habitat improvement sites will include recreating historical channel networks, reducing the presence of nonnative species, and revegetating habitat improvement sites with native vegetation to ensure a site's resiliency. These projects are expected to provide direct (onsite) and indirect (increased transfer of insect prey to the mainstem migration corridor) benefits to CR chum salmon as they rear in and migrate through the estuary.

NMFS agrees with ISAB's assessment findings that it is difficult to reliably quantify the survival benefits of estuary habitat restoration, but the Action Agencies' assessment method, including review by the ERTG,[86] is useful to prioritize projects. The Action Agencies' proposed action includes a commitment to reconnect an average of 300 acres of floodplain per year to the mainstem, a goal that they have a record of meeting in 2008-17 (BPA et al. 2018b). The habitat's conservation value is likely to improve as more habitat gets reconnected, and the benefits are likely to accrue as the habitat patches get larger (Spiesman et al. 2018). Juvenile CR chum salmon have been observed using reconnected habitats (Johnson et al. 2018), which provide important resting and feeding areas. It is also likely that these benefits will increase as habitat quality matures.

2.8.3.1.5 Research and Monitoring Activities

The Action Agencies' RM&E program will be similar to the current program, or will be implemented at a reduced scale. Thus, the level of injury and mortality discussed in the Environmental Baseline, primarily from the capturing and handling of fish, is likely to continue at a similar or reduced level. We estimate that, on average, the following numbers of CR chum salmon will be affected each year during the interim period:

- Projected estimates of CR chum salmon handling and mortality during activities associated with the Smolt Monitoring Program and the CSS: (1) zero hatchery or wild adults handled or killed; (2) zero hatchery and 500 wild juveniles handled; and (3) zero hatchery and ten wild juveniles killed.
- No CR chum salmon will be handled or killed during activities associated with Fish Status Monitoring.
- Projected estimates of CR chum salmon handling and mortality for all other RM&E programs: (1) 17 hatchery and 398 wild adults handled; (2) one hatchery and four wild adult killed; (3) 43,532 hatchery and 856,468 wild juveniles handled; and (4) 871 hatchery and 17,129 wild juveniles killed.

The combined observed mortality associated with the RM&E program will, on average, affect less than 1 percent of the wild (i.e., natural origin) adult returns or juvenile production for the CR chum salmon ESU (Bellerud 2018). Although we estimate that 2.26 percent of the wild adults

[86] As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss with ERTG and regional partners relevant climate change science in an effort to understand whether their planned estuary projects are resilient to climate change (i.e., sea level rise, temperatures, and mainstem flow levels). In addition, the Action Agencies' annual update of their restoration and monitoring plans for the estuary will document any needed adjustments in design, location, or other elements of a given project to address climate change impacts, both during and beyond the interim period.

and 15.98 percent of the wild juvenile production will be handled each year, on average, we expect that only up to 1 percent of these will die after release (i.e., 0.02 percent of adults and 0.16 percent of juveniles handled). These relatively small effects are deemed worthwhile because they will allow the Action Agencies and NMFS to continue to evaluate the effects of CRS operations including modifications to facilities, operations, and mitigation actions.

Electrofishing operations for the NPMP during the interim period are expected to continue at the same level of effort as in recent years (four 15-minute sampling events per 0.6-mile reach between RM 47 and The Dalles Dam during April-July; a total of 550 hours system-wide). Some adult and juvenile CR chum salmon are likely to be present in shallow shoreline areas during electrofishing activities and may be stunned and even killed. However, because the operator releases the electrical field as soon as salmonids are observed and most of these fish quickly recover and swim away, we are unable to use observations from past operations to estimate the number of fish from this ESU that will be affected. Information obtained through electrofishing supports management of the NPMP, which is reported to have reduced salmonid predation by about 30 percent (Williams et al. 2017). This level of take is anticipated to occur for the duration of this proposed action, pending completion of the NEPA process.

2.8.3.2 Effects to Critical Habitat

Implementation of the proposed action is likely to affect passage at Bonneville Dam for one population out of the 17 populations, the Upper Gorge chum salmon population, which spawns above Bonneville Dam. Implementation will also affect the volume and timing of flow in the Columbia River, which has the potential to alter habitat in the Columbia River mainstem and estuary in all extant populations. The PBFs that could be affected by the proposed action are described in Table 2.8-6.

Table 2.8-6. Effects of the proposed action on the physical and biological features (PBFs) essential for the conservation for the ESU.

PBF	Effect of the Proposed Action
Freshwater spawning sites	The proposed action will continue the inundation of spawning habitat for chum in the lower reaches of the tributaries to the Bonneville Pool. The proposed action will also continue to provide a minimum tailwater elevation below Bonneville Dam to provide access to spawning habit in the mainstem and in three tributaries in the lower Gorge.
Freshwater rearing sites	Juvenile CR chum rear in the mainstem Columbia River. Some rearing habitat will continue to be inundated.
Freshwater migration corridors and estuarine areas	The migration corridor for the upper gorge populations is affected by passage at Bonneville Dam. Water management activities associated with the CRS will continue to affect flows in the lower Columbia River and plume, increasing flows in the winter and spring and decreasing flows in May and June compared to an unregulated river. Increased levels of total dissolved gas (TDG; water quality) in the gorge area during spring spill up to 120-125 percent could affect the conservation value of habitat within Bonneville reservoir and at least 35 miles downstream. This area serves as critical habitat for the Gorge MPG and one population in the Cascade Fall MPG. Smolts are able to use behavior

PBF	Effect of the Proposed Action
	mechanisms to avoid elevated TDG (i.e., by migrating deeper in the water column). Sediment will continue to accumulate behind CRS dams, reducing turbidity in the migration corridor during the spring smolt migration, which could make juveniles more vulnerable to predation. Sea-lion exclusion devices will continue to protect adult chum salmon that reach the adult fishways at Bonneville Dam. Chum salmon in the Columbia River downstream of Bonneville Dam will continue to be exposed to increased predation by the higher Steller and California sea lion numbers observed in recent years. Reduced numbers of pikeminnow will continue to positively affect the survival rates of juvenile chum in the lower Columbia River.

2.8.4 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation (50 CFR 402.02). Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Nonfederal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. These projects also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth management programs (planning and regulation); a variety of stream and riparian habitat projects; watershed planning and implementation; acquisition of water rights for instream purposes and sensitive areas; instream flow rules; stormwater and discharge regulation; TMDL implementation to achieve water quality standards; hydraulic project permitting; and increased spill and bypass operations at hydropower facilities. NMFS has determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. These activities are likely to have beneficial cumulative effects that will significantly improve conditions for salmon and steelhead, including CR chum salmon.

NMFS has also noted that some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects are activities that occurred in the recent past and were included in the environmental baseline. Some of these activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the action area, nonfederal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. All of these activities can contaminate local or larger areas with hydrocarbon-based materials. Continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations.

Overall, we anticipate that projects to restore and protect habitat, restore access to and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area.

2.8.5 Integration and Synthesis

In this section, we add the effects of the action (Section 2.8.3) to the environmental baseline (Section 2.4.2) and the cumulative effects (Section 2.8.4), taking into account the status of the species and critical habitat (Sections 2.8.1.1 and 2.8.1.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat for the conservation of the species.

2.8.5.1 Species

NMFS' recent status review affirmed CR chum salmon as threatened but identified some positive trends in CR chum salmon status (NWFSC 2015). One population, Grays River, is at low risk, with spawner abundances in the thousands and demonstrating a recent positive trend, although the improving trends may be an artifact of improved monitoring. The Washougal River and Lower Gorge populations maintain moderate numbers of spawners and appear to be relatively stable. However, the majority of populations in this ESU are at high to very high risk, with very low abundances (NWFSC 2015). The life history of chum salmon is such that ocean conditions have a strong influence on the survival of emigrating juveniles. The potential prospect of poor ocean conditions for the near future may put further pressure on these populations (NWFSC 2015).

Continued operation of the CRS will have continuing adverse effects to CR chum salmon. These include reduced survival for that portion of the population (Upper Gorge in the Columbia Gorge MPG) affected by upstream and downstream passage at Bonneville Dam, and spawning habitat in the lower reaches of the tributaries used by the Upper Gorge population inundated by Bonneville pool. CRS effects to populations originating in downstream subbasins are limited to the effects of flow management on migration and rearing conditions in the lower Columbia River. The proposed action will continue flow management efforts to support chum spawning during late fall and winter and incubation in the Ives Island complex into the spring which should continue to positively affect egg to fry survival rates for those fish spawning in the mainstem Columbia River near Bonneville Dam.

For one out of the 17 CR chum salmon populations, operation of the CRS will continue to reduce survival. Adult chum salmon counts in the ladders at Bonneville Dam are low, averaging about 107 adults per year. No survival estimates are available for juveniles or adults; adult survival is presumed to be similar to Snake River fall Chinook salmon, about 3.1 percent. The survival of downstream migrants has improved in recent years due to the construction of the Bonneville Corner Collector and juvenile bypass system at Powerhouse 2, and increases in the percent of flow approaching the dam that goes over the spillway. Both of these measures reduce travel time and the likelihood of turbine passage for juvenile migrants (Ploskey et al. 2012). We anticipate that similar dam passage survival rates are likely to continue as a result of the proposed operations, but as described below, changes to spring spill could potentially alter the proportion of CR chum salmon subjected to the various passage routes.

The flexible spring spill operation proposed by the Action Agencies is expected to decrease powerhouse passage rates for juvenile salmonids. The CSS hypothesizes that increased spill could substantially reduce latent mortality of juvenile yearling Chinook salmon and steelhead moving downstream through the mainstem dams (CSS 2017). The CSS made no such predictions for CR chum salmon, but if this were to occur for CR chum salmon, SARs might be slightly improved for the few juveniles migrating from spawning areas upstream of Bonneville Dam.. On the other hand, the improvement would be limited to the one population that pass above Bonneville Dam, and the hypothesized benefit would generally be less than what may occur for species that experience passage through a greater number of the Columbia and Snake River mainstem dams.

The other proposed changes to CRS operations are not anticipated to negatively affect CR chum salmon survival. In particular, the changes in usable forebay ranges (MOP 1.5-foot range) at the Lower Snake River reservoirs and the change in operating range at the John Day forebay (MIP 2-foot range) will result in inconsequential variations in the timing and amount of flow in the lower Columbia River.

The Action Agencies will continue to fund predator control activities, estuary habitat improvements, and modify operations to improve survival. The implementation of the CRS mitigation and enhancement programs will continue to reduce long-term impacts and continue to allow for improvement in the status for the population that spawns above Bonneville Dam, as was seen for this population in the last status review (although the improvement may have been a function of improved monitoring). The estuary program is anticipated to improve habitat conditions and contribute to improved survival for all populations.

As a general matter, the effects of the proposed action are very similar to a continuation of the same effects caused by the current operations and maintenance of the CRS as well as the associated measures implemented to avoid, minimize or offset adverse effects. Therefore, we do not anticipate large changes in mortality caused by the CRS or substantial new risks to CR chum salmon or their habitat, and we do not expect considerable changes in the effects on reproduction, numbers, or distribution. However, we do anticipate additional improvements in habitat conditions in the estuary that will accrue over time.

The environmental baseline includes the past and present impacts of hydropower, changes in tributary and mainstem habitat (both beneficial and adverse), harvest, and hatcheries on CR chum salmon. The baseline provides important context for assessing the effects of the action described above.

Regarding changes in hatchery effects to the LCR Chinook salmon ESU, in 2017, NMFS completed a biological opinion on its funding of the Mitchell Act program (NMFS 2017a). For CR chum salmon, hatchery production has been low and the benefits of the hatchery program in terms of abundance still outweigh the risks

NMFS also recently completed a biological opinion on the 2018-2027 *U.S. v. Oregon* Management Agreement, which provides a framework for managing salmon and steelhead fisheries and hatchery programs in much of the Columbia River basin. For CR chum salmon, the current incidental fishery impact rate of two percent or less per year meets the impact reduction targets identified in the Washington management unit plan. The *U.S. v. Oregon* biological opinion concluded that the effects of harvest on CR chum salmon, when considering the current reliance on hatchery programs, will allow gains in VSP scores to continue to accrue.

Freshwater habitat conditions may be negatively influencing spawning and early rearing success in some basins, and contributing to the overall low productivity of the ESU. Land development, especially in the low-gradient reaches that chum salmon prefer, will continue to be a threat to most chum salmon populations due to projects increases in the population of the greater Portland/Vancouver area and the lower Columbia River overall (Metro 2014). The viability of this ESU is relatively unchanged since the last review, and the modest improvements in some populations do not warrant a change in risk category, especially given the uncertainty regarding climatic effects in the future (NWFSC 2015).

Improvements including tributary hydrosystem modification and habitat restoration (e.g., in the estuary), coupled with harvest reductions from historic levels, have allowed for progress in improving CR chum salmon abundance, productivity, spatial structure and diversity. However, these improvements also occur in the context of natural fluctuations in environmental conditions, such as cyclical changes in ocean circulation and the unusually warm ocean conditions seen predominating during 2015, which can temporarily adversely affect survival and adult returns of all salmonid species even if freshwater habitat conditions are improving.

As stated above, the status of CR chum salmon is also likely to be affected by climate change. Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycle. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater and changes to food webs in freshwater, estuarine and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management actions may help alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations, increased riparian vegetation to control water temperatures, etc.).

Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life-history types that will be successful in the future are neither static nor predictable. Therefore, maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the CR chum salmon ESU. Because of its location in the lower Columbia River basin, the ESU is likely to be more affected by climate related effects in the estuary. Emerging research using complex life-cycle modeling indicates a potentially strong link between SST and survival of Snake River spring/summer Chinook salmon populations. However, the apparent link between SST and survival is presumably caused by food web interactions, relationships which could be disrupted by major transformations of community dynamics as well as ocean acidification and other factors under a changing climate. The degree to which SST is linked to survival of CR chum salmon and how that relationship interacts with other variables throughout the CR chum salmon life cycle will likely be an important area of future research.

When evaluating the effects of the action, those effects must be taken together with the effects on CR chum salmon of future state or private activities, not involving Federal activities that are reasonably certain to occur within the action area. NMFS anticipates that human development activities will continue to have adverse effects on CR chum salmon in the action area. Many of these activities and their effects occurred in the recent past and were included in the environmental baseline but are also reasonably certain to occur in the future. Within the action area, nonfederal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Habitat restoration efforts lead by state, and local agencies; tribes; environmental organizations; and local communities are likely to continue. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives that, in some cases, are identified through ESA recovery plans. Larger, more regionwide, restoration and conservation efforts are either underway or planned throughout the Columbia River basin. These state and private actions have helped restore habitat, improve fish passage, and reduce pollution. While these efforts are reasonably certain to continue to occur, funding levels may vary on an annual basis.

With respect to recovery, the recovery plan identifies the greatest gains from habitat restoration in low-gradient reaches and in the estuary, and improved access to historical spawning sites. Some of the needed hatchery and harvest improvements have been the subject of recent section 7 consultations (as discussed above) and are currently being implemented. Improvements to estuarine habitat are part of the proposed action for this consultation. The recovery plan was finalized in July 2013 and identifies recovery actions to be implemented, generally over a 25-year period, as specified in the management unit plans and estuary recovery plan module. Effective implementation requires that the recovery efforts of diverse private, local, state, tribal, and federal parties across two states be coordinated at multiple levels. The proposed action will not result in reductions to CR chum salmon reproduction, numbers, or distribution that would impede the ability to successfully carry out the identified recovery measures and actions over the time frames considered in the recovery plan.

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, cumulative effects, and the short-term duration of the proposed action, it is NMFS' biological opinion that the proposed action is not likely to reduce appreciably the likelihood of both survival and recovery of CR chum salmon.

2.8.5.2 Critical Habitat

Critical habitat for CR chum salmon encompasses six subbasins in Oregon and Washington containing 19 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005a, 2013a). However, most of these watersheds have some, or high potential for improvement. Similar to the discussion above for species, the status of critical habitat is likely to be affected by climate change with predicted rising temperatures and alterations in stream flow patterns. Improved access to spawning and rearing habitat, and habitat restoration efforts will help ameliorate those effects to critical habitat.

The environmental baseline includes a broad range of past and present actions and activities that have affected the conservation value of critical habitat for CR chum salmon. These include the effects of hydropower, changes in tributary and mainstem habitat (both positive and negative) on freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine areas and nearshore marine areas. Despite a long-term trend in degradation of these habitats, there have been localized improvements in their conservation value through the combined efforts of federal, state, and local agencies; tribes; and other stakeholders. Tributary dams and other barriers have been removed which has improved habitat quality at tributary confluences. Estuarine habitats have been restored and reconnected to the floodplain, and water quality has improved. Despite significant losses to predators in the migration corridor, the combined efforts of multiple parties have reduced the effect of predation, and the Action Agencies propose to continue predator management activities.

Continued operation of the CRS will continue the inundation of spawning habitat in the lower reaches of the tributaries to the Bonneville Pool (continued loss of habitat for spawning). Increased levels of TDG in the gorge area during spring spill will increase TDG levels within Bonneville Dam's reservoir and for at least 35 miles downstream. However, this is not expected to substantially affect the water quality PBF at the designation level given that the effect will be limited to a relatively small portion of designated critical habitat for this species, the up to 125 percent operation will only be for one year, and considering the ability of fish to avoid higher TDG levels by swimming deeper in the water column.. The conservation value of the safe passage PBF in the migration corridor is affected by passage at Bonneville Dam only for the one population that passes the dam. The benefits of continued operation of fish passage structures will continue. However, passage conditions for adult survival (increased fallback) and potentially for juvenile survival (e.g. differential survival between passage routes – spillway, juvenile bypass or corner collector, and turbines) could negatively affect safe passage. The CSS predicts survival benefits and a reduction in latent mortality (increased juvenile survival and adult returns) for SR spring/summer Chinook salmon, however any potential benefit for CR Chum salmon would likely be very small and limited to those few juveniles migrating from spawning locations upstream of Bonneville Dam. Conversely, the proposed action will continue to improve the functioning of many of the PBFs; for example, reducing predation by pinnipeds, birds,[87] and northern pikeminnows will continue to improve safe passage for juveniles and the hazing and deployment of sea lion excluder devices will continue to benefit safe passage of adult migrants. The estuary habitat restoration program will reconnect floodplains and provide additional feeding and rearing areas at the project scale; these benefits will accrue at the designation scale over time.

Considering the ongoing and future effects of the environmental baseline and cumulative effects and in light of the status of critical habitat, the proposed action will not appreciably reduce the value of designated critical habitat for the conservation of CR chum salmon.

2.8.6 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, and considering the short-term duration of the proposed action, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of CR chum salmon or destroy or adversely modify its designated critical habitat

[87] Although there is uncertainty about the efficacy of avian predation management in the estuary, the hazing efforts in the tailrace of Bonneville Dam are known to reduce predation.

2.9 Middle Columbia River (MCR) Steelhead

This section applies the analytical framework described in section 2.1 to the MCR steelhead DPS and provides NMFS' finding regarding whether the proposed action is likely to jeopardize the continued existence of MCR steelhead DPS or destroy or adversely modify its critical habitat.

2.9.1 Rangewide Status of the Species and Critical Habitat

This opinion examines the status of Middle Columbia River (MCR) steelhead that would be affected by the proposed action. The status is determined by the level of extinction risk that the listed species faces, based on parameters considered in documents such as the Middle Columbia Recovery Plan (recovery plan), status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status also helps to inform the description of the species' current reproduction, numbers, or distribution as described in 50 CFR 402.02. The condition of critical habitat throughout the designated area is determined by the current function of the PBFs that help to form that conservation value.

2.9.1.1 Status of Species

The MCR steelhead DPS includes all naturally spawned anadromous steelhead originating below natural and manmade impassable barriers from the Columbia River and its tributaries upstream of the Wind and Hood Rivers (exclusive) to and including the Yakima River (Figure 2.9-1). This DPS includes steelhead from seven artificial propagation programs: the Touchet River Endemic Program; Yakima River Kelt Reconditioning Program (in Satus Creek, Toppenish Creek, Naches River, and Upper Yakima River); Umatilla River Program (Oregon Department of Fish and Wildlife Stock #91); and the Deschutes River Program (ODFW Stock #66). This DPS does not include steelhead that are designated as part of an experimental population (79 FR 20802). The MCR steelhead DPS comprises 19 historical populations (two extirpated) within four MPGs (Table 2.9-1).

Table 2.9-1. MCR steelhead DPS description and MPGs (Jones 2015; NWFSC 2015). Populations with * are winter-run steelhead populations. All other populations are summer-run steelhead populations.

DPS Description	
Major Population Group (MPG)	***Populations***
Cascades Eastern Slope Tributaries	Deschutes River Eastside, Deschutes River Westside, Fifteenmile Creek, Klickitat River*, Rock Creek*
John Day River	John Day River Lower Mainstem Tributaries, John Day River Upper Mainstem Tributaries, NF John Day River, MF John Day River, SF John Day River
Yakima River	Naches River, Satus Creek, Toppenish Creek, Yakima River Upstream Mainstem
Umatilla/Walla Walla Rivers	Touchet River, Umatilla River, Walla Walla River
Artificial production	
Hatchery programs included in DPS (7)	Touchet River Endemic, Yakima River Kelt Reconditioning (in Satus Creek, Toppenish Creek, Naches River, and Upper Yakima River), Umatilla River, Deschutes River
Hatchery programs not included in DPS (4)	Lyons Ferry NFH, Walla Walla River, Skamania Stock, Skamania Stock*

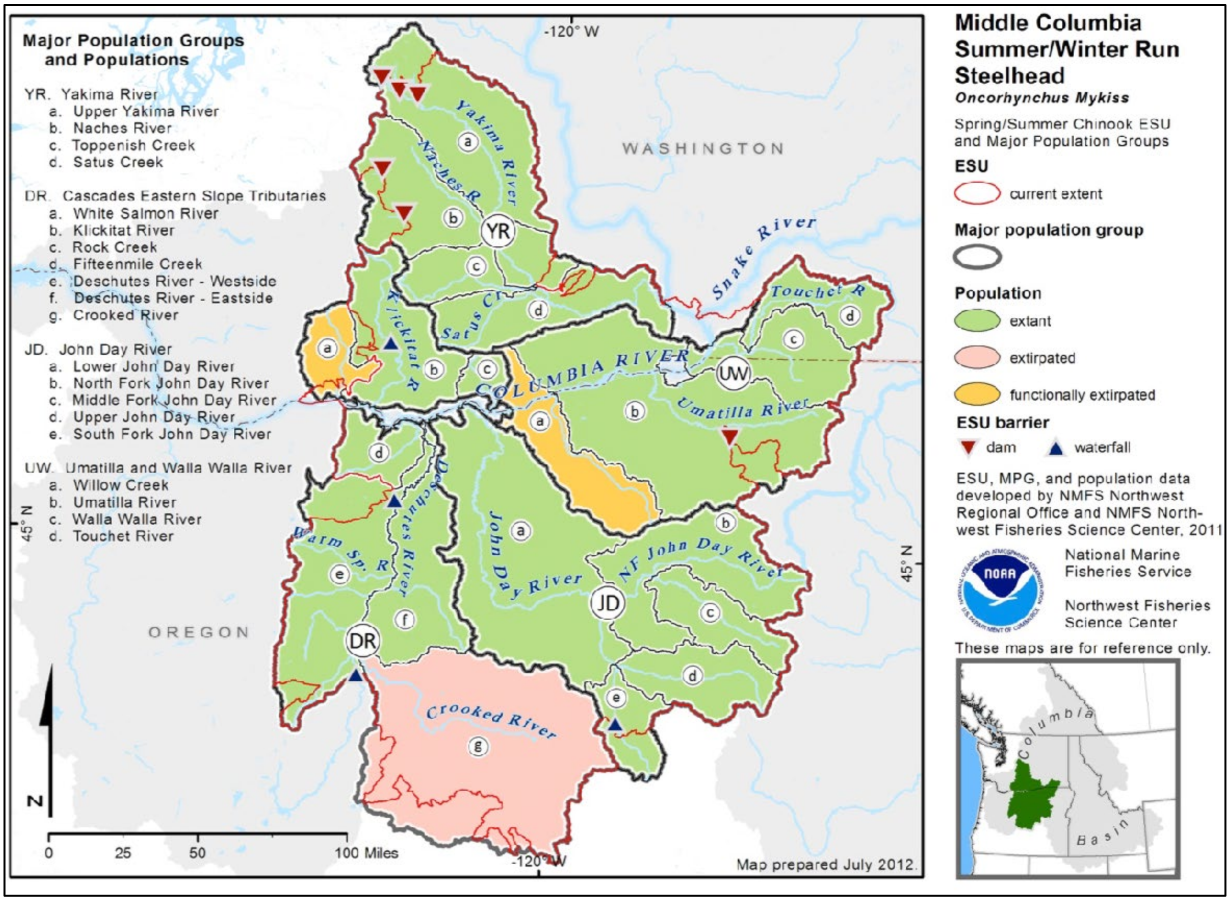


Figure 2.9-1. Map of the Middle Columbia River steelhead DPS' spawning and rearing areas, illustrating populations and major population groups. Source: NWFSC 2015.

In 1999, NMFS listed MCR steelhead under the ESA and classified it as a threatened species (64 FR 14517); this listing was reaffirmed in 2014 (79 FR 20802). Critical habitat was designated in 2005 (71 FR 834). The recovery plan was completed in 2009 and the last five-year status review was completed in 2016 (NMFS 2016d). Table 2.9-2 provides a summary of the status of the DPS and limiting factors. More information can be found in the recovery plan (NMFS 2009a) and the most recent status review (NMFS 2016d). These documents are available on the NMFS West Coast Region website.[88]

[88] Currently these documents can be found on the NMFS West Coast Region website at: http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/salmon_and_steelhead_listings/steelhead/middle_columbia_river/middle_columbia_river_steelhead.html. Last accessed March 2019.

Table 2.9-2. Summary of the most recent status and limiting factors information for the MCR steelhead DPS considered in this biological opinion.

Status Summary	Limiting Factors
This DPS comprises four separate MPGs, and is not currently meeting the viability criteria described in the recovery plan. Overall, the majority of population-level viability ratings remained unchanged from prior reviews for each MPG within the DPS, although there are some positive trends. Natural-origin returns to the majority of populations in two of the four MPGs in this DPS increased modestly relative to the levels reported in the previous five-year review. Three of the four MPGs in this DPS include at least one population rated at low risk for abundance and productivity.	• Reduced access to spawning and rearing habitat • Hatchery-related effects • Harvest-related effects • Genetic introgression through straying • Altered flow regime • Altered Columbia River plume • Reduced productivity resulting from sediment and nutrient-related changes in the estuary • Predation (birds, fish, marine mammals) • Hydroelectric dam passage effects • Temperature effects

The spawning range of the MCR steelhead DPS extends over an area of approximately 35,000 square miles in the Columbia plateau of eastern Washington and eastern Oregon. Major drainages in this DPS are the Deschutes, John Day, Umatilla, Walla Walla, Yakima, and Klickitat River systems. The Cascade Mountains form the western border of the plateau in both Oregon and Washington, while the Blue Mountains form the eastern edge. The southern border is marked by the divides that separate the upper Deschutes and John Day basins from the Oregon High Desert and drainages to the south. The Wenatchee Mountains and Palouse areas of eastern Washington border the Middle Columbia on the north.

Most fish in this DPS smolt at two years and spend one to two years in salt water before re-entering freshwater, where they may remain up to a year before spawning (Howell et al. 1985; Olsen et al. 1992). Age-2 ocean-type steelhead dominate the steelhead run in the Klickitat River, whereas most other rivers with summer steelhead produce about equal numbers of age 1 and 2 ocean-type fish. Juvenile life stages (i.e., eggs, alevins, fry, and parr) inhabit freshwater/riverine areas throughout the range of the DPS. Parr usually undergo a smolt transformation as two-year-olds, at which time they migrate to the ocean. In the Pacific Northwest, summer steelhead enter freshwater between May and October, and winter steelhead enter freshwater between November and April (Ford 2011).

NMFS outlined recovery strategies in the 2009 Middle Columbia River Steelhead Recovery Plan. The recovery plan identifies a set of most likely scenarios to meet the Interior Columbia Technical Recovery Team (ICTRT) recommendations for low-risk populations at the MPG level. NMFS developed the MCR recovery plan by drawing upon the best available scientific information provided by the four regional management unit plans in addition to recommendations from the ICTRT. The management unit plans are the work of local groups and county, state, federal, and tribal entities within the Middle Columbia River region and are built on existing recovery plans, in particular, the Northwest Power and Conservation Council's subbasin plans, and targeted the specific ESA recovery needs of MCR steelhead. The MCR steelhead DPS continues to be affected by habitat degradation, hydropower impacts, harvest, and hatchery production. The recovery plan for this species identifies MPG-level biological recovery criteria, and within each MPG, it also identifies specific population-level goals consistent with the MPG-level criteria listed below.

2.9.1.1.1 Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the MCR steelhead DPS is at moderate risk and remains at threatened status. The most recent status update (NWFSC 2015) used updated abundance and hatchery contribution estimates provided by regional fishery managers to inform the analysis. However, this DPS has been noted as difficult to evaluate in several of the reviews, for reasons such as: the wide variation in abundance for individual natural populations across the DPS, miscounting due to high levels of out-of-basin steelhead seeking thermal refugia in MCR steelhead habitats, and a lack of consistent information on annual spawning escapements in some tributaries (NWFSC 2015).

Many steelhead populations along the west coast can co-occur with conspecific populations of resident rainbow trout. Previous status reviews (e.g., Ford 2011) have recognized that there may be situations where reproductive contributions from resident rainbow trout could mitigate short-term extinction risk for some steelhead DPS populations (Good et al. 2005). In the MCR steelhead DPS, a study in the Deschutes River basin found no evidence of a significant contribution from the very abundant resident form to anadromous returns (Zimmerman and Reeves 2000). A recent study of natural-origin steelhead kelts in the Yakima River basin, comparing chemical patterns in otoliths (i.e., inner ear bones) with water chemistry sampling, found evidence for variable maternal resident contribution rates to anadromous returns, with a high degree of variation among natal areas and across years (Courter et al. 2013; NWFSC 2015).

The productivity of a population (the average number of surviving offspring per parent) is a measure of the natural population's ability to sustain itself. Productivity can be measured as spawner ratios (returns per spawner or recruits per spawner), annual population growth rate, or trends in abundance. Population-specific estimates of abundance and productivity are derived from time series of annual estimates, typically subject to a high degree of annual variability and sampling-induced uncertainties. The ICTRT recommends estimating current intrinsic productivity using spawner-to-spawner return pairs from low to moderate escapements over a recent 20-year period (NMFS 2009a).

Abundance and productivity are linked, as populations with low productivity can still persist if they are sufficiently large, and small populations can persist if they are sufficiently productive. A viable natural population needs sufficient abundance to maintain genetic health and to respond to normal environmental variation, and sufficient productivity to enable the population to quickly rebound from periods of poor ocean conditions or freshwater perturbations (NMFS 2016d). In the most recent status review, NMFS (2016d) updated the risk status of each population based on changes in abundance and productivity and improvements in spatial structure (Table 2.9-3).

2.9.1.1.2 Current Status

The most recent five-year status review of MCR steelhead indicated there have been improvements in the viability ratings for some populations, but the MCR steelhead DPS as a whole is not currently meeting the viability criteria. Status indicators for within-population diversity have changed for some populations, although in most cases the changes have not been sufficient to shift composite risk ratings for any particular populations The review highlighted that natural-origin returns to the majority of populations in two of the four MPGs in this DPS increased relative to the levels reported in the previous five-year review. However, abundance estimates for two of three populations with sufficient data in the remaining two MPGs (Cascades Eastern Slope Tributaries and Walla Walla and Umatilla Rivers) were marginally lower. Natural-origin spawning estimates are highly variable relative to minimum abundance thresholds across the populations in the DPS. Three of the four MPGs in this DPS include at least one population rated at low risk for abundance and productivity. The increases in abundance and productivity needed to achieve goals identified in the recovery plan for the remaining populations are generally smaller than those for the other Interior Columbia River basin-listed DPSs. Updated information indicates that stray levels into the John Day River populations have decreased in recent years. Out-of-basin hatchery stray proportions, although reduced, remain high in spawning reaches within the Deschutes River basin populations. Despite reasons for optimism, the most recent NMFS status review (2016d) indicated that the majority of population-level viability ratings remained unchanged from prior reviews for each MPG within the DPS.

Table 2.9-3 shows the most recent abundance, productivity, spatial structure, and diversity metrics for the 17 populations in the DPS. Overall viability ratings for the populations in the MCR steelhead DPS remained generally unchanged from the prior five-year review (NMFS 2016d). One population, Fifteenmile Creek, shifted downward from viable to maintained status as a result of a decrease in natural-origin abundance to below its ICTRT minimum abundance threshold. The Toppenish River population (in the Yakima MPG) dropped in both estimated abundance and productivity, but the combination remained above the five percent viability curve, and, therefore, its overall rating remained viable. The majority of the populations showed increases in estimates of productivity (NWFSC 2015).

MCR steelhead experienced a recent reduction in adult abundance, primarily due to recent poor ocean conditions (NWFSC 2015, 2017). Recent data indicate improving trends in some ocean indicators that correlate well with higher adult steelhead abundance, however, overall ocean conditions in 2018 were still impacted by recent warming trends (Weitkamp 2018).

Table 2.9-3. Population-level status by MPG for MCR steelhead (NMFS 2016d). Comparison of updated status summary versus recovery plan viability objectives. Key: up arrow = improved since prior review, down arrow = decreased since prior review, oval = no change. A/P is the ratio of abundance to productivity. SS/D is the ratio of spatial structure to diversity.

Population	Abundance/Productivity Metrics				Spatial Structure and Diversity Metrics			Overall Viability Rating
	ICTRT Minimum Threshold	Natural Spawning Abundance	ICTRT Productivity	Integrated A/P Risk	Natural Processes Risk	Diversity Risk	Integrated SS/D Risk	
Eastern Cascades MPG								
Fifteenmile Creek	500	356 (.16) ↓	1.84 (.19) ↑	Moderate	Very Low	Low	Low	Maintained
Westside Deschutes R	1,500 (1,000)	634 (.13) ↑	1.16 (.15) ↑	High	Low	Moderate	Moderate	High Risk
Eastside Deschutes River	1,000	1,749 (.05) ↓	2.52 (.24) ↑	Low	Low	Moderate	Moderate	Viable
Klickitat River	1,000			Moderate	Low	Moderate	Moderate	Maintained
Rock Creek	500				Moderate	Moderate	Moderate	High Risk
Crooked River (E)	2,000							Extirpated
White Salmon (E)	500							Extirpated
Yakima River MPG								
Satus Creek	1,000 (500)	1127 (.17) ↑	1.93 (.12) ↑	Low	Low	Moderate	Moderate	Viable
Toppenish Creek	500	516 (.14) ↓	2.51 (.19) ↓	Low	Low	Moderate	Moderate	Viable
Naches River	1,500	1,244 (.16) ↑	1.83 (.10) ↑	Moderate	Low	Moderate	Moderate	Moderate
Upper Yakima	1,500	246 (.18) ↑	1.87 (.10) ↑	Moderate	Moderate			High Risk
John Day River MPG								
Lower John Day tribs	2,250	1,270 (.22) ↓	2.67 (.19) ↓	Moderate	Very Low	Moderate	Moderate	Maintained
Middle Fork	1,000	1,736 (.41) ↑	3.66 (.26) ↑	Low	Low	Moderate	Moderate	Viable
North Fork	1,000	1,896 (.19) ↑	2.48 (.23) ↓	Very Low	Very Low	Low	Low	Highly Viable
South Fork		697 (.27) ↑	2.01 (.21) ↑	Low	Very Low	Moderate	Moderate	Viable
Upper Mainstem	1,000	641 (.21) ↑	1.32 (.18) □	Moderate	Very Low	Moderate	Moderate	Maintained
Umatilla/Walla Walla MPG								
Umatilla R	1,500	2,379 (.11) ↑	120 (.32) ↑	Moderate	Moderate	Moderate	Moderate	Maintained

Population	Abundance/Productivity Metrics				Spatial Structure and Diversity Metrics			Overall Viability Rating
	ICTRT Minimum Threshold	Natural Spawning Abundance	ICTRT Productivity	Integrated A/P Risk	Natural Processes Risk	Diversity Risk	Integrated SS/D Risk	
Walla Walla R	1,000	877 (.13) ↓	1.65 (.11) ↑	Moderate	Moderate	Moderate	Moderate	Maintained
Touchet R	1,000	382 (.12) ↓	1.25 (.11) ↑	High	Low	Moderate	Moderate	High Risk

2.9.1.1.3 Recovery Plan

The recovery plan (NMFS 2009a) identifies a set of most-likely scenarios to meet the ICTRT recommendations for low-risk populations at the MPG level (Table 2.9-4). In addition, the management unit plans generally call for achieving moderate risk ratings (maintained status) across the remaining extant populations in each MPG. The recovery plan summarizes information from four regional management unit plans covering the range of tributary habitats associated with the DPS in Washington and Oregon. Each of the management unit plans is incorporated as an appendix to the recovery plan, along with modules for the mainstem Columbia hydropower system and the estuary, where conditions affect the survival of steelhead production from all of the tributary populations comprising the DPS. The recovery objectives defined in the recovery plan are all based on the biological viability criteria developed by the ICTRT (Ford 2011).

The recovery plan also provides a detailed discussion of limiting factors and threats and describes strategies for addressing each of them. Chapter 6 of the recovery plan describes the limiting factors on a regional scale and how they affect the populations in the MCR steelhead DPS (NMFS 2009a). Chapter 7 of the recovery plan addresses the recovery strategy for the entire DPS and more specific plans for individual MPGs within the DPS (NMFS 2009a). The recovery plan addresses the topics of:

- Tributary habitat conditions,
- Columbia River mainstem conditions,
- Impaired fish passage,
- Water temperature and thermal refugia,
- Hatchery-related adverse effects,
- Predation, competition, and disease,
- Degradation of estuarine and nearshore marine habitat, and
- Climate change.

Table 2.9-4. Recovery plan information for MCR steelhead.

MPG	Population	Current Status (Overall viability rating)	Recovery Plan Proposed Target
Eastern Cascades	Fifteen Mile Creek	Maintained	The Klickitat River, Fifteenmile Creek, and both the Deschutes River Eastside and Deschutes River Westside populations should reach at least viable status. The management unit plans also call for at least one population to be highly viable, consistent with ICTRT recommendations. MPG viability could be further bolstered if reintroduction of steelhead into the Crooked River succeeds and if the White Salmon River population successfully recolonizes its historical habitat following the removal of Condit Dam.
	Deschutes (Westside)	High Risk	
	Deschutes (Eastside)	Viable	
	Klickitat River	Maintained (?)	
	Rock Creek	High Risk (?)	
	Crooked River	Extirpated	
	White Salmon River	Extirpated	
Yakima River	Satus Creek	Viable	To achieve viable status, two populations should be rated as viable, including at least one of the two classified as large—the Naches River and the Yakima River Upper Mainstem. The remaining two populations should, at a minimum, meet the maintained criteria. The management unit plan also calls for at least one population to be highly viable, consistent with ICTRT recommendations.
	Toppenish Creek	Viable	
	Naches River	Moderate	
	Upper Yakima River	High Risk	
John Day River	Lower John Day Tribs	Maintained	The John Day River Lower Mainstem Tributaries, North Fork John Day River, and either the Middle Fork John Day River or John Day River Upper Mainstem populations should achieve at least viable status to reach recovery. The management unit plan also calls for at least one population to be highly viable, consistent with ICTRT recommendations.
	Middle Fork John Day	Viable	
	North Fork John Day	Highly Viable	
	South Fork John Day	Viable	
	Upper John Day	Maintained	
Umatilla/Walla Walla	Umatilla River	Maintained	Two populations should meet viability criteria to achieve recovery. The management unit plan also calls for at least one population to be highly viable, consistent with ICTRT recommendations. The Umatilla River is the only large population, and therefore needs to be viable. In addition, either the Walla Walla River or Touchet River population also needs to be viable.
	Walla Walla River	Maintained	
	Touchet River	High Risk	

2.9.1.1.4 Limiting Factors

Understanding the limiting factors and threats that affect the MCR steelhead DPS provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting the species is to ensure that the underlying limiting factors and threats have been addressed. There are many factors that affect the abundance, productivity, spatial structure, and diversity of the MCR steelhead DPS. Factors that limit the DPS (in no particular order) have been, and continue to be, loss and degradation of spawning and rearing habitat, impacts of mainstem hydropower dams on upstream access and downstream habitats, and the legacy effects of historical harvest; together, these factors have reduced the viability of natural populations in the MCR steelhead DPS. Historically, extensive beaver activity, dynamic patterns of channel migration in floodplains, human settlement and activities, and loss of rearing habitat quality and floodplain channel connectivity in the lower reaches of major tributaries have all impacted the MCR steelhead DPS populations (NWFSC 2015).

2.9.1.2 Status of Critical Habitat

This section of the biological opinion examines the rangewide status of designated critical habitat for the affected species. Critical habitat includes the stream channels within designated stream reaches and a lateral extent defined by the ordinary high-water line (33 CFR 319.11).

NMFS determines the rangewide status of critical habitat by examining the condition of the PBFs that were identified when critical habitat was designated (Table 2.9-5). These features are essential to the conservation of the listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration, and foraging). Designated areas support one or more life stages (spawning, rearing, and/or migration) and contain the PBFs essential to the conservation of the species. For example, overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks and migration corridors free of artificial obstruction with sufficient water quantity and quality.

Table 2.9-5. Physical and biological features (PBFs) of critical habitats designated for MCR steelhead, and corresponding species life-history events.

Physical and Biological Features	Components of the PBF
Freshwater spawning sites	● Water quantity and quality conditions and substrate supporting spawning, incubation, and larval development
Freshwater rearing sites	● Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility ● Water quality and forage supporting juvenile development ● Natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks
Freshwater migration corridors	● Free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival
Estuarine areas	● Free of obstruction and excessive predation, with: - Water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater - Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels - Juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation
Nearshore marine areas[1]	● Free of obstruction and excessive predation, with: - Water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation - Natural cover such as submerged and overhanging large wood, aquatic vegetation, and large rocks and boulders
Offshore marine areas	● Not designated

1 Designated area includes only the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

The complex life cycle of MCR steelhead gives rise to complex habitat needs, particularly in freshwater. The gravel used for spawning must be a certain size and largely free of fine sediments to allow successful incubation of the eggs and later emergence or escape from the gravel as alevins. Eggs also require cool, clean, and well oxygenated waters for proper development. Juveniles need abundant food sources, including insects, crustaceans, and other small fish. They need instream places to hide from predators (mostly birds and larger fish), such as under logs, root wads, and boulders, as well as beneath overhanging vegetation. They also need refuge from periodic high flows in side channels and off-channel areas and from warm summer water temperatures in cold-water springs and deep pools. Returning adults generally do not feed in freshwater, but instead, rely on limited energy stored to migrate, mature, and spawn.

Like juveniles, the returning adults also require cool water that is free of contaminants and migratory corridors with adequate passage conditions (timing, water quality/quantity) to allow access to the various habitats required to complete their life cycle (NMFS 2005a).

In the following paragraphs, we discuss the current status of the functioning of the PBFs of critical habitat in the Interior Columbia and Lower Columbia River Estuary recovery domains.

2.9.1.2.1 Interior Columbia Recovery Domain

Major tributary river basins in the Interior Columbia River basin include the Klickitat, Deschutes, Yakima, John Day, Umatilla, and Walla Walla Rivers.

The construction and operation of water storage and hydropower projects in the interior Columbia Basin, including the run-of-river mainstem dams, have altered biological and physical attributes of the mainstem migration corridor. These alterations have affected juvenile migrants to a much larger extent than adult migrants. Actions taken since 1995 that have reduced negative effects of the hydrosystem on juvenile and adult migrants include:

- Minimizing winter drafts of the large upper basin storage reservoirs (for flood risk management and power generation) to save water for augmenting spring flows during the peak juvenile passage period (water quantity);
- Releasing additional water from storage to augment flows for juvenile and adult summer migrants (water quantity);
- Constructing juvenile bypass systems and surface passage structures and providing spill at the run-of-river dams to divert smolts and steelhead kelts and upstream migrating adults that fall back over the projects away from turbine units (safe passage); and
- Maintaining and improving the ladders used by adult salmon and steelhead (safe passage).

Water storage and hydropower projects have modified natural flow regimes, resulting in altered water temperature regimes, changes in fish community structure (leading to increased rates of piscivorous and avian predation on juvenile salmonids), and delayed migration time for both adult and juvenile salmonids. Physical features of dams, such as turbines, can also kill migrating fish. In-river survival is inversely related to the number of hydropower projects encountered by emigrating juveniles. In addition to the development and operation of the dams in mainstem rivers, development and operation of irrigation systems and hydroelectric dams for water withdrawal and storage in tributaries have altered hydrological cycles, causing a variety of adverse impacts to salmon and steelhead spawning and rearing habitat.

Habitat quality in tributary streams in the interior Columbia Basin varies from excellent in wilderness and roadless areas to poor in areas subject to heavy agricultural and urban development (McIntosh et al. 1994; Wissmar et al. 1994; Overton et al. 1995). Lack of summer stream flows, impaired water quality, and reduction of habitat complexity are common problems for critical habitat in developed areas. Critical habitat throughout the interior Columbia River basin has been degraded by several management activities, including agriculture, alteration of stream morphology (i.e., channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, timber harvest, mining, and urbanization (Lee et al. 1997). Changes in habitat quantity, availability, diversity, flow, temperature, sediment load, and channel instability are common symptoms of ecosystem decline in areas of critical habitat. Large-scale habitat assessments in the interior Columbia Basin indicate that in watersheds managed for natural resources extraction, the number of large pools has decreased from 87 to 20 percent (McIntosh et al. 1994).

Areas where habitat is still largely functioning appropriately include the upper South Fork Walla Walla, portions of the Deschutes basin, and portions of the North Fork John Day River. Most of these areas are in designated wilderness or roadless areas.

Many stream reaches designated as critical habitat in the interior Columbia Basin are over-allocated for withdrawals under state water law, with more allocated water rights than existing stream flow conditions can support in a given season or year. Irrigated agriculture is common throughout this region, and withdrawal of water and resulting lowered stream flow increases summer stream temperatures, blocks fish migration, strands fish, and alters sediment transport (Spence et al. 1996). Continued operation and maintenance of large water reclamation systems such as the Umatilla Basin and Yakima Projects have disrupted riverine ecosystems. Reduced tributary stream flow has been identified as a limiting factor for MCR steelhead (NMFS 2007; Ford 2011).

On 2 September 2005, NMFS published a final rule (70 FR 52630) to designate critical habitat for MCR steelhead. Critical habitat has been designated for populations of MCR steelhead in the Upper John Day River, the Lower John Day River, and the North, South, and Middle Forks of the John Day River. The Middle Fork, North Fork, and Upper John Day subbasins provide freshwater spawning, rearing, and migration PBFs for MCR steelhead.

Many streams in critical habitat areas for this species are listed as water-quality limited on the ODEQ Section 303(d) Clean Water Act list for parameters such as water temperatures, dissolved oxygen, or biological criteria (ODEQ 2006). Additionally, the ODEQ identified total phosphates and fecal coliform as water-quality limitations for many streams within the Lower Mainstem John Day River, and sediment for many North Fork John Day streams (NMFS 2004a). Contaminants such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste are common in some areas of critical habitat for MCR steelhead.

2.9.1.2.2 Lower Columbia River Estuary Recovery Domain

Critical habitat also has been designated for MCR steelhead in the lower Columbia River estuary. The estuary is broadly defined to include the entire reach where tidal forces and river flows interact, regardless of the extent of saltwater intrusion. This encompasses areas from

Bonneville Dam (RM 146) to the mouth of the Columbia River. It also includes the tidally influenced portions of tributaries below Bonneville Dam, including the lower 26 miles of the Willamette River. This region experiences ocean tides that extend from the mouth of the Columbia River up to Bonneville Dam.

Historically, the downstream half of the Columbia River estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. The mouth of the Columbia River was about four miles wide. Winter and spring floods, low flows in late summer, large woody debris floating downstream, and a shallow bar at the mouth of the Columbia River maintained a dynamic environment. Today, navigation channels have been dredged, deepened, and maintained, jetties and pile-dike fields have been constructed to stabilize and concentrate flow in navigation channels, marsh and riparian habitats have been filled and diked, and causeways have been constructed across waterways. These actions have decreased the width of the mouth of the Columbia River to two miles and increased the depth of the Columbia River channel at the bar from less than 20 to more than 55 feet (NMFS 2008a).

Over time, more than 50 percent of the original marshes and spruce swamps in the estuary have been converted to industrial, transportation, recreational, agricultural, or urban uses. More than 3,000 acres of intertidal marsh and spruce swamps have been converted to other uses since 1948. Many wetlands along the shore in the upper reaches of the estuary have been converted to industrial and agricultural lands after levees and dikes were constructed. Furthermore, water storage and release patterns from reservoirs upstream of the estuary have changed the seasonal pattern and volume of discharge. The peaks of spring/summer floods have been reduced, and the amount of water discharged during winter has increased (NMFS 2008a).

In addition, model studies indicate that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of suspended particulate matter to the lower river and estuary by about 40 percent (as measured at Vancouver, Washington) and have reduced fine sediment transport by 50 percent or more. The significance of these changes for MCR steelhead is unclear, although estuarine habitat provides food for yearling migrants that move rapidly downstream to the ocean (Johnson et al. 2018; PNNL and NMFS 2018).

Functioning estuarine areas are essential to conservation because, without them, juvenile MCR steelhead cannot reach the ocean in a timely manner and use the variety of habitats that allow them to avoid predators, compete successfully, and complete the behavioral and physiological changes needed for life in the ocean. Similarly, these features are essential to the conservation of adult salmonids, because these features in the estuary provide a final source of abundant forage that will provide the energy stores needed to make the physiological transition to freshwater, migrate upstream, avoid predators, and develop to maturity upon reaching spawning areas (NMFS 2005a).

2.9.1.3 Climate Change Implications for MCR Steelhead and Critical Habitat

One factor affecting the rangewide status of MCR steelhead and aquatic habitat is climate change. The U.S. Global Change Research Program (USGCRP),[89] mandated by Congress in the Global Change Research Act of 1990, reports average warming of about 1.3ºF from 1895 to 2011. As the climate changes, air temperatures in the Pacific Northwest are expected to increase 4 to 13°F by the end of the century, with the largest increases expected in the summer (Mantua et al. 2009; Mote et al. 2014). Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004; Scheuerell and Williams 2005; Zabel et al. 2006; ISAB 2007). According to the ISAB,[90] these effects pose the following impacts into the future:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a smaller snowpack, watersheds will see their runoff diminished earlier in the season, resulting in lower stream flows in the June through September period. River flows in general and peak river flows are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures are expected to rise, especially during the summer months when lower stream flows co-occur with warmer air temperatures.

These changes will not be spatially homogeneous across the entire Pacific Northwest. Low-lying areas are likely to be more affected. Climate change may have long-term effects that include, but are not limited to, depletion of important cold-water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, premature emergence of fry, and increased competition among species. Overall, climate change effects likely to occur to some degree over the next ten years are expected at a similar rate as the last ten years.

Climate change is predicted to cause a variety of impacts to Pacific salmon and their ecosystems (Mote et al. 2003; Crozier et al. 2008a; Martins et al. 2012; Wainwright and Weitkamp 2013). The complex life cycles of anadromous fishes, including salmon, rely on productive freshwater, estuarine, and marine habitats for growth and survival, making them particularly vulnerable to environmental variation. Ultimately, the effects of climate change on salmon and steelhead across the Pacific Northwest will be determined by the specific nature, level, and rate of changes and the synergy between interconnected terrestrial/freshwater, estuarine, nearshore, and ocean environments.

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[89] http://www.globalchange.gov

[90] The Independent Scientific Advisory Board (ISAB) serves the National Marine Fisheries Service (NOAA Fisheries), Columbia River Indian Tribes, and Northwest Power and Conservation Council by providing independent scientific advice and recommendations regarding scientific issues that relate to the respective agencies' fish and wildlife programs: https://www.nwcouncil.org/fw/isab/.

The primary effects of climate change on Pacific Northwest salmon and steelhead are:

- Direct effects of increased water temperatures on fish physiology,
- Temperature-induced changes to stream flow patterns,
- Alterations to freshwater, estuarine, and marine food webs, and
- Changes in estuarine and ocean productivity.

While all habitats used by Pacific salmon will be affected, the impacts and certainty of the changes vary by habitat type. Some effects (e.g., increasing temperature) affect salmon at all life stages in all habitats, while others are habitat-specific, such as stream flow variation in freshwater, sea-level rise in estuaries, and upwelling in the ocean. How climate change will affect each stock or population of salmon also varies widely depending on the level or extent of change, the rate of change, and the unique life-history characteristics of different natural populations (Crozier et al. 2008b). For example, a few weeks' difference in migration timing can have large differences in the thermal regime experienced by migrating fish (Martins et al. 2011).

2.9.1.3.1 Temperature Effects

Like most fishes, salmon are poikilotherms (cold-blooded animals); therefore, increasing temperatures in all habitats can have pronounced effects on their physiology, growth, and development rates (see review by Whitney et al. 2016). Increases in water temperatures beyond their thermal optima will likely be detrimental through a variety of processes, including: increased metabolic rates (and therefore food demand), decreased disease resistance, increased physiological stress, and reduced reproductive success. All of these processes are likely to reduce survival (Beechie et al. 2013; Wainwright and Weitkamp 2013; Whitney et al. 2016).

By contrast, increased temperatures at ranges well below thermal optima (i.e., when the water is cold) can increase growth and development rates. Examples of this include accelerated emergence timing during egg incubation stages and increased growth rates during fry stages (Crozier et al. 2008a; Martins et al. 2011). Temperature is also an important behavioral cue for migration (Sykes et al. 2009), and elevated temperatures may result in earlier-than-normal migration timing. While there are situations or stocks where this acceleration in processes or behaviors is beneficial, there are also others where it is detrimental (Martins et al. 2012; Whitney et al. 2016).

2.9.1.3.2 Freshwater Effects

Climate change is predicted to increase the intensity of storms, reduce winter snowpack at low and middle elevations, and increase snowpack at high elevations in northern areas. Middle and lower elevation streams will have larger fall/winter flood events and lower late-summer flows, while higher elevations may have higher minimum flows. How these changes will affect freshwater ecosystems largely depends on their specific characteristics and locations, which vary at fine spatial scales (Crozier et al. 2008b; Martins et al. 2012). For example, within a relatively small geographic area (Salmon River basin, Idaho), survival of some Chinook salmon populations was shown to be determined largely by temperature, while that of others was determined by flow (Crozier and Zabel 2006). Certain salmon populations inhabiting regions that are already near or exceeding thermal maxima will be most affected by further increases in temperature and perhaps the rate of the increases, while the effects of altered flow are less clear and likely to be basin-specific (Crozier et al. 2008b; Beechie et al. 2013). However, river flow is already becoming more variable in many rivers, and is believed to negatively affect anadromous fish survival more than other environmental parameters (Ward et al. 2015). It is likely this increasingly variable flow is detrimental to multiple salmon and steelhead populations, and likely multiple other freshwater fish species in the Columbia River basin as well.

Stream ecosystems will likely change in response to climate change in ways that are difficult to predict (Lynch et al. 2016). Changes in stream temperature and flow regimes will likely lead to shifts in the distributions of native species and provide “invasion opportunities” for exotic species. This will result in novel species interactions, including predator–prey dynamics, where juvenile native species may be either predators or prey (Lynch et al. 2016; Rehage and Blanchard 2016). How juvenile native species will fare as part of “hybrid food webs,” which are constructed from natives, native invaders, and exotic species, is difficult to predict (Naiman et al. 2012).

2.9.1.3.3 Estuarine Effects

In estuarine environments, the two big concerns associated with climate change are rates of sea-level rise and temperature warming (Wainwright and Weitkamp 2013; Limburg et al. 2016). Estuaries will be affected directly by sea-level rise: as sea level rises, terrestrial habitats will be flooded and tidal wetlands will be submerged (Kirwan et al. 2010; Wainwright and Weitkamp 2013; Limburg et al. 2016). The net effect on wetland habitats depends on whether rates of sea-level rise are sufficiently slow that the rates of marsh plant growth and sedimentation can compensate (Kirwan et al. 2010).

Due to subsidence, sea-level rise will affect some areas more than others, with the largest effects expected for the lowlands, like southern Vancouver Island and central Washington coastal areas (Verdonck 2006; Lemmen et al. 2016). The widespread presence of dikes in Pacific Northwest estuaries will restrict upward estuary expansion as sea levels rise, likely resulting in a near-term loss of wetland habitats for salmon (Wainwright and Weitkamp 2013). Sea-level rise will also result in greater intrusion of marine water into estuaries, resulting in an overall increase in salinity, which will also contribute to changes in estuarine floral and faunal communities (Kennedy 1990). While not all anadromous fish species are generally highly reliant on estuaries for rearing, extended estuarine use may be important in some populations (Jones et al. 2014), especially if stream habitats are degraded and become less productive.

2.9.1.3.4 Marine Effects

In marine waters, increasing temperatures are associated with observed and predicted poleward range expansions of fish and invertebrates in both the Atlantic and Pacific Oceans (Lucey and Nye 2010; Asch 2015; Cheung et al. 2015). Rapid poleward species shifts in distribution in response to anomalously warm ocean temperatures have been well documented in recent years, confirming this expectation at short time scales. Range extensions were documented in many species from southern California to Alaska during the unusually warm water associated with "the blob" in 2014 and 2015 (Bond et al. 2015; Di Lorenzo and Mantua 2016) and past strong El Niño events (Pearcy 2002; Fisher et al. 2015).

Exotic species benefit from these extreme conditions to increase their distributions. Green crab recruitment increased in Washington and Oregon waters during winters with warm surface waters, including 2014 (Yamada et al. 2015). Similarly, Humboldt squid dramatically expanded their range during warm years of 2004–09 (Litz et al. 2011). The frequency of extreme conditions, such as those associated with El Niño events or blobs, are predicted to increase in the future (Di Lorenzo and Mantua 2016).

Expected changes to marine ecosystems due to increased temperature, altered productivity, or acidification will have large ecological implications through mismatches of co-evolved species and unpredictable trophic effects (Cheung et al. 2015; Rehage and Blanchard 2016). These effects will certainly occur, but predicting the composition or outcomes of future trophic interactions is not possible with current models.

Wind-driven upwelling is responsible for the extremely high productivity in the California Current Ecosystem (Bograd et al. 2009; Peterson et al. 2014). Minor changes to the timing, intensity, or duration of upwelling, or the depth of water-column stratification, can have dramatic effects on the productivity of the ecosystem (Black et al. 2014; Peterson et al. 2014). Current projections for changes to upwelling are mixed: some climate models show upwelling unchanged, but others predict that upwelling will be delayed in spring and more intense during summer (Rykaczewski et al. 2015). Should the timing and intensity of upwelling change in the future, it may result in a mismatch between the onset of spring ecosystem productivity and the timing of salmon entering the ocean, and a shift toward food webs with a strong subtropical component (Bakun et al. 2015).

Columbia River anadromous fish also use coastal areas of British Columbia and Alaska, and mid-ocean marine habitats in the Gulf of Alaska, although their fine-scale distribution and marine ecology during this period are poorly understood (Morris et al. 2007; Pearcy and McKinnell 2007). Increases in temperature in Alaskan marine waters have generally been associated with increases in productivity and salmon survival (Mantua et al. 1997; Martins et al. 2012), thought to result from temperatures that have been below thermal optima (Gargett 1997). Warm ocean temperatures in the Gulf of Alaska are also associated with intensified downwelling and increased coastal stratification, which may result in increased food availability to juvenile salmon along the coast (Hollowed et al. 2009; Martins et al. 2012). Predicted increases in freshwater discharge in British Columbia and Alaska may influence coastal current patterns (Foreman et al. 2014), but the effects on coastal ecosystems are poorly understood.

In addition to becoming warmer, the world's oceans are becoming more acidic as increased atmospheric CO_2 is absorbed by water. The North Pacific is already acidic compared to other oceans, making it particularly susceptible to further increases in acidification (Lemmen et al. 2016). Laboratory and field studies of ocean acidification show it has the greatest effects on invertebrates with calcium-carbonate shells, and relatively little direct influence on finfish (see reviews by Haigh et al. 2015 and Mathis et al. 2015). Consequently, the largest impact of ocean acidification on salmon will likely be its influence on marine food webs, especially its effects on lower trophic levels, which are largely composed of invertebrates (Haigh et al. 2015; Mathis et al. 2015). Marine invertebrates fill a critical gap between freshwater prey and larval and juvenile marine fishes, supporting juvenile salmon growth during the important early-ocean residence period (Daly et al. 2009, Daly et al. 2014).

2.9.1.3.5 Uncertainty in Climate Predictions

There is considerable uncertainty in the predicted effects of climate change on the globe as a whole, and on the Pacific Northwest in particular, and there is also the question of indirect effects of climate change and whether human "climate refugees" will move into the range of salmon and steelhead, increasing stresses on their respective habitats (Dalton et al. 2013; Poesch et al. 2016).

Many of the effects of climate change (e.g., increased temperature, altered flow, coastal productivity, etc.) will have direct impacts on the food webs that species examined in this analysis rely on in freshwater, estuarine, and marine habitats to grow and survive. Such ecological effects are extremely difficult to predict even in fairly simple systems, and minor differences in life-history characteristics among stocks of salmon may lead to large differences in their response (e.g., Crozier et al. 2008b; Martins et al. 2011, 2012). This means it is likely that there will be "winners and losers," meaning some salmon populations may enjoy different degrees or levels of benefit from climate change while others will suffer varying levels of harm.

Climate change is expected to impact anadromous fish during all stages of their complex life cycles. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater and changes to food webs in freshwater, estuarine, and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty.

2.9.2 Environmental Baseline

The "environmental baseline" includes the past and present impacts of all federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

For MCR steelhead, we focus our description of the environmental baseline on where MCR steelhead juveniles and adults are exposed to the effects of the proposed action. We also consider the broader action area, including tributary habitat, because these areas are important context for understanding the effects of the proposed action.

To determine the upstream extent of MCR steelhead distribution and thus exposure, we reviewed data at each dam to examine the potential for MCR steelhead presence. Recent information indicates a portion of returning MCR steelhead adults migrate into the Snake River, presumably to find thermal refugia during summer months (Keefer and Caudill 2017). This includes all the lower sections of tributaries that have been inundated by reservoir water as a result of the operation of the federal power system. Therefore, the area in which MCR steelhead are exposed to the effects of the proposed action includes all water within the Columbia River from the mouth and plume up to the free-flowing section below Priest Rapids Dam, and includes all waters impounded by Bonneville, The Dalles, John Day, McNary, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite Dams.

2.9.2.1 Mainstem Habitat

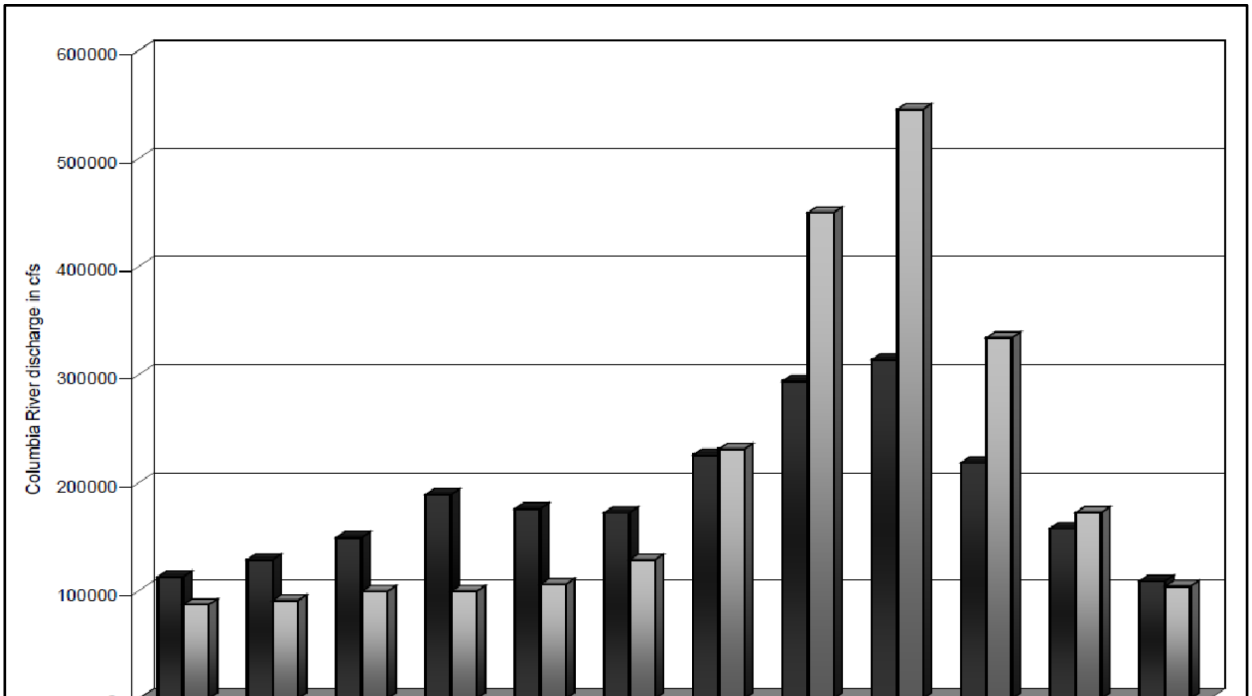
Mainstem habitat in the lower Snake and Columbia Rivers has been substantially altered by basinwide water-management operations, the construction and operation of mainstem hydroelectric projects, the introduction of nonnative species (e.g., smallmouth bass, walleye, channel catfish, invertebrates, etc.), and other human practices that have increased nutrients, pollutants, and toxic contaminants.

2.9.2.1.1 Seasonal Flows

The management of stored water, including runoff stored in Canadian reservoirs, has altered the quantity and timing of flows entering the lower Columbia River compared to historical conditions. The CRS Action Agencies, in coordination with NMFS, currently manage Columbia and Snake River water resources to balance congressionally mandated flood-control objectives while maintaining sufficient seasonal flows given the amount of runoff in a given year. This has been accomplished by avoiding excessive withdrawals going into spring to minimize the flow reductions needed to refill the reservoirs, and by drafting the storage reservoirs during summer to augment flows. In order to meet flood-risk objectives, average spring flows in the CRS are lower than an unregulated system. Conversely, summer flows can be maintained at a higher average flow rate than would have occurred during low summer flow events in an unregulated system.

On the mainstem of the Columbia River, hydropower projects (including the CRS), water-storage projects (including reservoirs in Canada operated under the Columbia River Treaty), and the withdrawal of water for irrigation and urban uses have significantly degraded salmon and steelhead habitats (Bottom et al. 2005; Fresh et al. 2005; NMFS 2013a). The volume of water discharged by the Columbia River varies seasonally according to runoff, snowmelt, flood-control, and hydropower demands. Mean annual discharge is estimated to be 265 kcfs, but may range from lows of 71–106 kcfs to highs of 530 kcfs (Hamilton 1990; NMFS 1998; Prahl et al. 1998; USACE 1999). Naturally occurring maximum flows on the river occur in May, June, and July as a result of snowmelt in the headwater regions. Minimum flows occur from September to March, with periodic peaks due to heavy winter rains (Holton 1984). Interannual variability in stream flow is strongly correlated with two recurrent climate phenomena, the ENSO and the PDO (Newman et al. 2016).

Water storage projects (dams and reservoirs) and water management activities have reduced flows within the CRS impounded sections of the Columbia and Snake Rivers compared to natural flows in the late spring and summer months (Figure 2.9-2). On average, this reduction can range from nearly 15 kcfs in August to over 230 kcfs in May downstream of Bonneville Dam. Lower flow has been demonstrated to reduce survival rates and increase travel time for juvenile migrating salmonids if flows drop too low (NMFS 1995b, 1998). The majority of MCR steelhead smolts migrate to sea during the spring months.



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Current	113017	128641	149403	189076	175921	172150	225689	293948	313930	218523	157935	109020
Natural	87115	91029	99387	99496	106033	128580	231047	450040	545561	334238	172430	104310

Figure 2.9-2. Comparison of monthly discharge (flow) in the Columbia River between current conditions (black) and normative flows (gray). These data show that pre-development flows were lower in the winter and higher in the summer months.

Compared to water management several decades ago, the Action Agencies have made significant changes to more closely approximate the shape of the natural hydrograph, to enhance flows and water quality, and to improve juvenile and adult fish survival. These flow objectives have guided preseason reservoir planning and in-season flow management. Nonetheless, since the development of the hydrosystem, average monthly flows at Bonneville Dam have been substantially lower during May–July and higher in October–March compared to an unregulated system. Reduced flows have increased travel times during outmigration for juvenile MCR steelhead.

2.9.2.2 Water Quality

Sufficient water quality is an essential physical feature for all life stages in the anadromous salmonid life cycle. Degraded water quality is currently listed as a limiting factor in the MCR steelhead recovery plan (NMFS 2009a). Water-quality issues for MCR steelhead in the Columbia River and tributaries combined include: low volume, low flow, high water temperature, low nutrients, low oxygen, sediment, high TDG, and contaminants.

Water temperatures in the Columbia River are a concern. The Columbia River is included on the Clean Water Act §303(d) list of impaired waters established by Oregon, Washington, and Idaho for temperature standard exceedances. Temperature conditions in the Columbia River basin are affected by many factors, including:

- Natural variations in weather and river flow;
- Construction of the dam and reservoir system (the large surface areas of reservoirs and resulting slower river velocities contribute to warmer late summer/fall water temperatures);
- Increased temperatures of tributaries due to water withdrawals for irrigated agriculture, and due to grazing and logging;
- Point-source discharges such as cities and industries; and
- Climate change.

The EPA is working with federal and state agencies, tribes, and other stakeholders to develop water-quality improvement plans (total maximum daily loads) for temperature in the Columbia River and lower Snake River. As part of the 2015 biological opinion on EPA's approval of water-quality standards, including temperature (NMFS 2015a), EPA committed to work with federal, state, and tribal agencies to identify and protect thermal refugia and thermal diversity in the lower Columbia River and its tributaries.

Using historical flows and environmental records for the 35-year period 1960–95, Perkins and Richmond (2001) compared water temperature records in the Columbia Basin and found three notable differences between the current versus an unimpounded river:

- Maximum summer water temperature has been slightly reduced;
- Water temperature variability has decreased; and
- Water temperatures stay cooler longer into the spring and warmer later into the fall.

These hydrosystem effects (influenced by the temperatures of tributary streams entering the Snake and Columbia Rivers both upstream of, within, and downstream of the mainstem dams) continue downstream and influence temperature conditions in the lower Columbia River. At a macro scale, water temperature affects salmonid distribution, behavior, and physiology (Groot and Margolis 1991); at a finer scale, temperature influences migration swim speed of salmonids

(Salinger and Anderson 2006), timing of river entry (Peery et al. 2003), susceptibility to disease and predation (Groot and Margolis 1991), and, at temperature extremes, survival.

Low flows and high summer temperatures in tributary habitats can effectively create temporary migration barriers that reduce habitat access until conditions improve. These impacts to water quality in tributary habitat can affect the run timing and survival to natal spawning areas for adult MCR steelhead. Based on PIT tags and radio-telemetry research, a substantial portion of returning MCR steelhead temporarily reject or overshoot their natal tributaries during the summer migration due to high temperature and/or low tributary flow, and they seek thermal refuge in McNary or the lower Snake River reservoirs (Keefer et al. 2016). Some of these fish fall back over or through the dam, when fish passage protection is available, and return to their natal stream successfully. However, other fish attempt to pass the dams after fish protections have ended (juvenile fish passage spill ends in August, juvenile bypass systems close mid-November), and migrate through turbine units—typically the lowest-survival route for adult steelhead (Colotelo et al. 2014; Normandeau 2014).

TDG levels also affect water quality and mainstem habitat. To facilitate the downstream movement of juvenile salmonids, state regulatory agencies allow an exception to the 110 percent national standard (NMFS 1995b). Specifically, water that passes over the spillway at a mainstem dam can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). Historically, TDG supersaturation was a major contributor to juvenile salmon mortality; to reduce TDG supersaturation, the Corps installed spillway gas-abatement structures at each mainstem dam. Severe GBT symptoms or mortality at or below the state TDG standards are not commonly observed, since fish migrating at depth avoid exposure to the higher TDG levels due to pressure compensation mechanisms (Weitkamp et al. 2003). Biological monitoring conducted by the Smolt Monitoring Program (SMP) shows that the incidence of GBT observed in migrating smolts remains below 2 percent when TDG concentrations are within state water-quality standards and do not exceed 120 percent saturation in CRS project tailraces. Observed symptoms typically become more pronounced when TDG exceeds 125 percent (FPC 2017). In 2018, the Action Agencies operated to meet, but not exceed, the 120 percent tailrace/115 percent forebay TDG caps. Reach survival and GBT symptoms did not indicate measurable problems from TDG at these levels (Zabel 2018; McCann 2018).

Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute municipal (urban runoff) and industrial waste discharges to the lower Columbia River, including the superfund-designated reach in the lower Willamette River. Mining areas in the basin deliver higher background concentrations of metals, and highly developed agricultural areas contribute to increased fertilizer, herbicide, and pesticide pollution in the river. Outside of the major urban areas, the majority of residences and businesses rely on septic systems. Common water-quality issues with septic systems include warmer water temperatures, lowered dissolved oxygen, and increased fecal coliform bacteria. Under these environmental conditions, fish in the action area are stressed. Stress may lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival).

Common toxic contaminants found in the Columbia River system include PCBs, PAHs, PBDEs, DDT and other legacy pesticides, current use pesticides, pharmaceuticals and personal care products, and trace elements (LCREP 2007). The LCREP report noted widespread presence of PCBs and PAHs, both geographically and in the food web. Pollutants from urban and industrial portions of the lower river contribute significantly to contaminant levels in juvenile salmonids, which are absorbing toxic contaminants during their time rearing and feeding in the lower Columbia River (LCREP 2007). Juvenile salmonids in the lower river can also accumulate DDT in their tissues and be exposed to estrogen-like compounds, likely associated with pharmaceuticals and personal care products. Concentrations of copper are present at levels that could interfere with crucial salmon behaviors. Ocean-type salmonids, which spend a significantly longer time rearing in the estuary than MCR steelhead, are more susceptible to bioaccumulation effects; however, both are vulnerable to highly concentrated exposures (Ford 2011).

Oils, greases, and other lubricants (derived from animal, fish, vegetable, petroleum or marine mammal origin) are used at each of the CRS projects, including, but not limited to, the following: hydropower turbines, hydraulic systems, lubricating systems, gear boxes, machining coolant systems, heat transfer systems, transformers, circuit breakers, and electrical systems. Leakage of oils, greases, or other lubricants into rivers has the potential to affect salmon and steelhead (avoidance, exposure to toxic compounds, or even, in some circumstances death). In response to increased concerns regarding the releases of oils and greases from lower Columbia and lower Snake River Dams (and Dworshak and Chief Joseph Dams) the Corps has taken steps to minimize these risks. For equipment in contact with the water, the Corps has developed best management practices to avoid accidental releases and to minimize the adverse effects in the case of an accidental release. The Corps has also begun using, where feasible, "environmentally acceptable lubricant" greases and in some cases has replaced greased equipment with greaseless equipment. The Corps has also developed and is implementing oil accountability plans with enhanced inspection protocols and is reporting annually.

The extent to which leaked grease or oil, occurring under the environmental baseline in the Clearwater River (Dworshak Dam), Upper Columbia River (Chief Joseph), or lower Snake or lower Columbia Rivers, has affected the behavior, health, or survival of MCR steelhead in the past is unknown, but likely to be small given that the size of these river systems. For comparison, a large leak of 100 gallons per day is the equivalent of 0.00016 cubic feet per second and the average annual discharge of the Columbia River has ranged from roughly 125,000 to 250,000 cubic feet per second since about 1940 (ISAB 2000). Nevertheless, to the extent past leakages have potentially affected passage or survival, these effects would be encompassed by annual juvenile or adult reach survival estimates. Recent actions (adoption of best management practices, use of environmentally acceptable lubricants, use of greaseless equipment, etc.) would further reduce the potential for negative effects stemming from these materials and slightly improve conditions for juvenile and adult migrants.

2.9.2.3 Sediment Transport

Changes in the seasonal hydrograph as a result of water use and reservoir storage have altered the size of the plume compared to historical conditions. Miller et al. (2013) found that returns of unlisted UCR summer/fall Chinook salmon, which reach the ocean as subyearlings, were related to plume volume. If a larger plume provided refuge from predators, this could apply to MCR steelhead as well. The series of dams and reservoirs have also blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is about one-third of 19th-century levels. For example, large-scale U.S. and Canadian reservoir storage and flow regulation that began in the 1970s reduced the two-year flood peak discharge, as measured at The Dalles, Oregon, from 580,000 cfs to 360,000 cfs (USACE 1999). Similarly, Bottom et al. (2005) estimated that the delivery of suspended particulate matter to the lower river and estuary has been reduced by about 40 percent (as measured at Vancouver, Washington), and fine sediment transport reduced by 50 percent or more. These reductions have altered the development of habitat along the margins of the river.

Industrial harbor and port development are also significant influences on the lower Willamette and lower Columbia Rivers (Bottom et al. 2005; Fresh et al. 2005; NMFS 2013a). Since 1878, the Army Corps of Engineers has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the Willamette River as a navigation channel. Originally dredged to a 20-foot minimum depth, the federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The navigation channel supports many ports on both sides of the river, resulting in several thousand commercial ships traversing the river every year. The dredging, along with diking, draining, and fill material placed in wetlands and shallow habitat, also disconnects the river from its floodplain, resulting in the loss of shallow-water rearing habitat and the ecosystem functions that floodplains provide (e.g., supply of prey, refuge from high flows, temperature refugia, etc.; Bottom et al. 2005).

2.9.2.4 Tributary Habitat

Nearly all historical habitat for the MCR steelhead DPS has been modified extensively by human activities. Many habitat improvement actions have been implemented that benefit the targeted populations, and those benefits will continue to accrue over time as the habitats mature. In addition, land use practices and regulatory mechanisms have improved from historical practices and regulations (Carmichael and Taylor 2010; NMFS 2009a, 2016d). As a result, in some places, habitat conditions for this DPS are likely improving (Carmichael and Taylor 2010; NMFS 2016d). Overall, however, habitat degradation continues to negatively affect the abundance, productivity, spatial structure, and diversity of MCR steelhead (NMFS 2009a, 2016d).

Generally, the ability of tributary habitats in the middle Columbia River to support the viability of this DPS is limited by one or more of the following factors: (1) impaired fish passage (including tributary dams); (2) reduced stream complexity and channel structure; (3) excess fine sediment; (4) elevated summer water temperature; (5) diminished stream flow during critical periods; (6) reduced floodplain connectivity and function; and (7) degraded riparian condition. Human activities that have contributed to these limiting factors include agricultural development, livestock grazing, forest management, urbanization, gravel mining, beaver removal, construction of tributary dams, and withdrawals of water for irrigation and human consumption. While some streams and stream reaches retain highly functional habitat, human activities—particularly agricultural activities—have had a large and widespread impact on steelhead habitat quality and quantity across the DPS and have degraded spawning and rearing habitat conditions (NMFS 2009a).

Since the ESA listings, and in some cases before, habitat restoration efforts have been implemented throughout the middle Columbia River basin. These efforts have been funded and implemented by the individual and combined efforts of federal, tribal, state, local, and private entities, including the Action Agencies (NMFS 2009a, 2014, 2016d).

Examples of recent tributary habitat improvement actions in this DPS include:

- Cascades Eastern Slope Tributaries MPG: Improved passage and operating procedures at the Pelton Round Butte Dam Project to improve water quality; improvements to other tributary barriers to open previously inaccessible habitat; improvements to stream channel complexity to improve rearing habitat; riparian area restoration and protection to improve water temperatures; restoration of side channels to improve rearing habitat; irrigation system improvements to provide greater efficiency and protect and restore stream flow; restoration and reconnection of floodplains to improve rearing habitat; acquisition of development rights to protect habitat; and agreements among landowners to reduce stream temperatures through appropriate water use. Condit Dam was fully removed in 2012, restoring full passage to historic habitat on the White Salmon River. PacifiCorp restored much of the new bank line in the old reservoir reach to its original contours and conducted extensive planting with native grasses, shrubs, and trees. Engineered log jams were installed at various locations to reduce erosion. This has increased the amount of tributary habitat available to the Cascades Eastern Slope Tributaries MPG (NMFS 2016d).
- John Day River MPG: Between 2010 and 2013, within the lower John Day River watershed, 3,829 acres were acquired to protect habitat, 38 barriers were removed (making an additional 293 stream miles accessible), 40 fish diversions were screened, 44 stream miles were treated to improve habitat complexity, 3,955 acres of riparian habitat were treated or protected, 12 irrigation systems were improved, and 243 water/sediment control structures were installed (NMFS 2016d).
- Umatilla and Walla Walla River MPG: Improvements include: instream flow protection; irrigation systems improvements for greater efficiency; improvements to barriers to provide access to previously inaccessible habitat; and screening of irrigation (NMFS 2016d).

- Yakima River MPG: The Yakima Basin Integrated Plan by the U.S. Bureau of Reclamation and Washington State Department of Ecology in 2012 (this $4 billion, 30-year multi-stakeholder effort focused on improving fish habitat while also meeting the water demands of Washington's agricultural industry, and will benefit steelhead) was approved. Other improvements include: levee removals and setbacks to allow more channel migration and create off-channel habitat; restoration of flows; removal of passage barriers; and screening of diversions (NMFS 2016d).

The CRS Action Agencies have been funding and implementing tributary habitat improvement actions in this DPS as part of mitigation for the CRS since 2007. These actions have included protecting and improving instream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, and removing barriers to spawning and rearing habitat, actions targeted at addressing the limiting factors identified above. Cumulative metrics for these action types for MCR steelhead from the years 2007–15 are shown in Table 2.9-6.

Table 2.9-6. Tributary habitat improvement metrics: MCR steelhead, 2007–15 (BPA et al. 2016).

Action Type*	**Amount Completed**
Acre-feet/year of water protected *(by efficiency improvements and water purchase/lease projects)*	94,135.5
Acres protected *(by land purchases or conservation easements)*	42,823.5
Acres treated *(to improve riparian habitat, such as planting native vegetation or controlling noxious weeds)*	7,488.7
Miles of enhanced or newly accessible habitat *(by providing passage or removing barriers)*	1,857.6
Miles of stream complexity improved *(by adding wood or boulder structures or reconnecting existing habitat, such as side channels)*	157.5
Miles protected *(by land purchases or conservation easements)*	1,139.4
Screens installed or addressed *(for compliance with criteria or by elimination/consolidation of diversions)*	265

*Several of these categories (acres protected, acres treated, miles of enhanced stream complexity, miles protected) also encompass actions directed at reducing sediments and reconnecting floodplains.

NMFS determined, based on best available science, that the actions implemented by the Action Agencies and other entities have and will continue to improve habitat in the targeted populations as these projects mature, and that fish population abundance, productivity, spatial structure, and diversity will respond positively.[91] Benefits of some of these actions will continue to accrue over the next several decades (see Appendix A). RM&E, including IMWs and Columbia Habitat Monitoring Protocol (CHaMP) sampling, have been underway in this DPS to help confirm improvements in habitat productivity and fish population response and the magnitude of those changes. Available empirical evidence supports our view that these actions are improving habitat capacity and productivity as well as population abundance and productivity (see Appendix A; NMFS 2014; Hillman et al. 2016; Griswold and Phillips 2018; Haskell et al. 2018 (draft)).

Best available science and information also indicate that there remains additional potential for improvement (NMFS 2009a, 2016d), although habitat conditions, limiting factors, and the potential for improvement vary among populations. Density dependence has been observed in MCR steelhead populations (ISAB 2015), which also indicates that improvements in tributary habitat capacity or productivity, if targeted at limiting life stages and limiting factors, would be likely to improve overall population abundance and productivity.

In summary, while tributary habitat conditions are likely improving in some places as a result of habitat improvement actions and improved land use practices, in general, tributary habitat conditions are still degraded and continue to negatively affect MCR steelhead abundance, productivity, spatial structure, and diversity. In addition, the potential exists to further improve tributary habitat capacity and productivity in this DPS.

2.9.2.5 Mainstem Adult Migration/Survival

Under typical conditions, after accounting for harvest, adult MCR steelhead typically have relatively high conversion success through dams and reservoirs within the CRS (Keefer et al. 2016). The primary factors influencing safe, timely, and effective adult upstream passage through CRS dams are tailrace flow dynamics, sufficient attraction flows to fish ladder entrances, operating ladders within criteria, reducing fallback,[92] and maintaining safe ladder temperature and differentials. Using adjusted conversion rates of PIT-tagged Snake River steelhead migrating through the CRS as a surrogate, the five-year rolling average of 88.9 percent survival from Bonneville to McNary Dam, and 76.5 percent from Bonneville to Lower Granite Dam, serves as a reasonable estimate of survival through the CRS after accounting for harvest and straying.

Each year, when the mainstem Columbia River temperature increases to above 64.4°F in the summer months, a large portion of MCR steelhead (including other steelhead ESUs) locate thermal refugia in cool tributaries such as the Little White Salmon, White Salmon, or Deschutes

[91]In most cases, near-term benefits would be expected in abundance and productivity. Depending on the population and the scale and type of action, benefits to spatial structure and diversity might also accrue. In addition, while we expect abundance, productivity, spatial structure, and diversity to respond positively to strategically implemented tributary habitat improvement actions, other factors also influence these viability parameters (e.g., ocean conditions) and any resulting trends.
[92] Fallback is the proportion of adult migrants that successfully migrate over a dam and subsequently migrate downstream of the dam.

Rivers, or in deeper/cooler mainstem areas within the CRS. Sections of the Snake River do provide thermal refugia for a portion of MCR steelhead with the operation of deep withdrawals from Dworshak Dam (Keefer et al. 2016). Because of the cold-water withdrawals, the Snake River, from the confluence of the Clearwater River to Little Goose Dam, is thermally stratified in the summer months, providing cool water at depth with sufficient thermal refugia capacity for adult steelhead. Based on PIT detections, in the last five years, an average of 12.3 percent and 4.4 percent of the PIT-tagged MCR steelhead that passed Bonneville Dam also passed Ice Harbor and Lower Granite Dams, respectively (Table 2.9-7). This is evidence of tributary overshoot[93] which can have impacts to survival as adults migrate downstream and migrate to natal tributaries.

Table 2.9-7. Counts and percentage of PIT-tagged adult MCR steelhead (hatchery and wild combined) detected at Bonneville Dam and subsequently detected at a Snake River dam equipped with adult PIT detection in the fish ladder. Note: Any adult detected in a Snake River dam must swim back over the dam to return to spawn in MCR steelhead spawning habitat.

Date	BON	IHR	%	LMN	%	LGS	%	LGR	%
2017	384	55	14.3%	44	11.5%	26	6.8%	23	6.0%
2016	408	69	16.9%	44	10.8%	38	9.3%	28	6.9%
2015	805	128	15.9%	98	12.2%	66	8.2%	41	5.1%
2014	771	86	11.2%	55	7.1%	40	5.2%	28	3.6%
2013	685	38	5.5%					13	1.9%
2012	534	49	9.2%					18	3.4%
2011	821	80	9.7%					38	4.6%
2010	644	103	16.0%					41	6.4%
2009	704	115	16.3%					50	7.1%
2008	439	75	17.1%					25	5.7%
5-Year Avg	611	75	12.3%	60	9.9%	43	7.0%	27	4.4%
10-Year Avg	620	80	12.9%	60	9.7%	43	6.9%	31	4.9%

In July–August during the peak of the MCR steelhead adult migration, solar radiation adds heat to the water in the top portion of the reservoirs (Table 2.9-8), which can lead to high temperatures and differentials in the fish ladders. Ladder temperatures exceeding 68°F and differentials greater than 1.8°F have been demonstrated to cause delay in steelhead and can reduce their successful migration to natal tributaries (Caudill et al. 2013). Ladder temperatures commonly exceed 68°F and ladder differentials regularly exceed 1.8°F while MCR steelhead are migrating (McCann 2018). During the most extreme summer days, ladder temperatures in CRS dams can exceed 75.0°F, and ladder differentials can exceed 4.5°F (FPC 2019). Fish ladder-cooling structures have been installed at Little Goose and Lower Granite Dams that pump colder water from deeper in the reservoir into the fish ladder to reduce ladder temperature differentials.

[93] Tributary overshoot occurs when adult salmonids homing to natal sites continue upstream past the mouth of their natal stream.

There are currently no structures to reduce ladder temperatures at the other CRS dams, but research is ongoing to identify if cooler water is available and can be pumped into ladder exits.

Table 2.9-8. Typical August temperature string profile from the forebay of McNary Dam in 2017 in degrees Fahrenheit at various depths, indicating solar radiation inputs differentially impacting the water surface. Note that the top (.5-m) depths are much warmer than the bottom (21m), especially in the peak of the afternoon. http://pweb.crohms.org/ftppub/water_quality/tempstrings/MCN_S1_2017_08.html

Date	Time	0.5m	1.5m	3m	5m	10m	15m	20m	21m
08/09/2017	00:00	74.6	74.0	72.7	71.3	70.6	70.5	70.5	70.5
	01:00	74.9	74.8	73.0	72.6	70.6	70.5	70.5	70.5
	02:00	75.7	75.0	73.2	71.6	70.6	70.5	70.5	70.5
	03:00	75.0	74.6	72.9	71.3	70.6	70.5	70.5	70.5
	04:00	74.9	74.7	72.6	71.3	70.6	70.5	70.5	70.5
	05:00	74.5	73.7	72.5	71.3	70.6	70.5	70.5	70.5
	06:00	74.4	72.7	72.2	71.3	70.6	70.5	70.5	70.5
	07:00	73.9	73.0	71.8	71.3	70.6	70.5	70.5	70.5
	08:00	73.9	73.3	72.2	71.6	70.6	70.5	70.5	70.4
	09:00	74.2	73.1	71.8	71.0	70.6	70.4	70.5	70.4
	10:00	74.9	73.2	72.1	70.8	70.5	70.4	70.4	70.4
	11:00	74.2	73.0	72.1	70.6	70.5	70.4	70.4	70.4
	12:00	73.8	73.1	72.2	70.7	70.5	70.4	70.4	70.4
	13:00	76.2	73.5	72.6	71.9	70.5	70.4	70.4	70.4
	14:00	76.9	75.5	72.8	71.5	70.4	70.4	70.4	70.3
	15:00	80.1	75.2	72.7	71.6	70.4	70.4	70.4	70.4
	16:00	78.4	74.4	73.1	71.9	70.4	70.4	70.4	70.4
	17:00	78.9	74.4	72.9	71.2	70.4	70.4	70.4	70.4
	18:00	78.0	74.4	72.8	71.1	70.4	70.4	70.4	70.4
	19:00	76.9	76.3	72.6	71.2	70.4	70.4	70.4	70.4
	20:00	75.5	75.5	72.7	71.4	70.4	70.3	70.4	70.3
	21:00	76.4	74.9	73.2	71.8	70.4	70.3	70.3	70.3
	22:00	76.9	74.9	73.6	71.7	70.4	70.3	70.3	70.3
	23:00	77.5	74.8	72.7	71.0	70.4	70.3	70.3	70.3

A large proportion of MCR steelhead from the John Day MPG do not enter the John Day River in the summer, likely because of elevated water temperatures. Based on PIT detections, a large group of these fish migrate past the John Day River in the summer and overshoot McNary Dam, presumably to find cooler water refuge until the John Day River cools. A large portion of these fish do not attempt to migrate back downstream through McNary Dam until after prescribed spill has ended in August, and a smaller portion do not attempt downstream migration until after the juvenile bypass system has shut down in mid-November. This leaves the turbines as the only available passage route for many of these fish, which is the lowest survival route for adult steelhead. Research conducted since the implementation of the 2008 FCRPS biological opinion has demonstrated the spillway weir is the most effective and safe route to pass adult steelhead at

McNary Dam. Normandeau et al. (2014) conducted an adult steelhead balloon tagging study at McNary Dam and found that 98.0 percent of the steelhead passing the TSW survived and were injury-free. The fish passed through the turbine unit had significantly lower survival (91 percent) and more life-threatening injuries, presumably caused by blade strike and shear forces. Colotelo et al. (2013) also found that the survival of adult steelhead kelts through spillways and surface weirs was high (>95 percent) and survival through turbine units was lowest (<80 percent), indicating that overshoots survive at a higher rate when spill protection is provided when they migrate back downstream.

Keefer and his colleagues (2007) found that winter fallback-related mortality is almost certainly not distributed evenly among populations, and overshoot-related winter fallback mortality may be relatively high at dams closest to home tributaries, such as for Deschutes fish at John Day Dam or John Day River fish at McNary Dam. Keefer et al. (2007) estimated the relative survival impacts of winter (November–April) fallbacks by steelhead at lower Columbia and lower Snake River dams, and found that fallbacks in March and November have the largest negative effect on survival, and The Dalles Dam had the largest negative effect on survival across the winter study months (Figure 2.9-3).

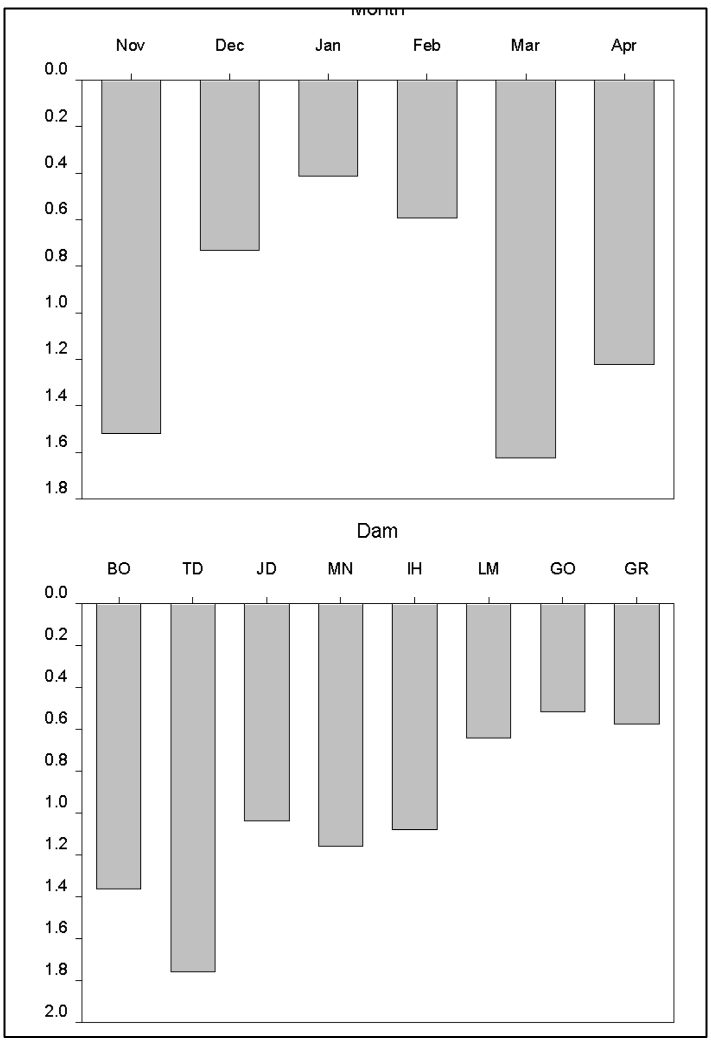


Figure 2.9-3. Index of relative fallback effect by dam and month for radio-tagged adult steelhead migrating through the CRS as reported in Keefer et al. 2007.

CRS related mortality of downstream migrating kelts is not well known at this time. Colotelo et al. (2013) estimated that in 2012 only 40.2 and 44.8 percent of Snake River steelhead kelts survived from the Lower Granite forebay to the Lower Columbia River (RM156) and the Bonneville dam face (RM 234), respectively, and only 60.4 and 67.3 percent survived from the McNary forebay to the Lower Columbia River (RM156) and Bonneville dam face, respectively. It is important to note that in this study, only fair and good condition kelts were selected for tagging, and these survival rates cannot be applied to poor condition kelts. Based on this limited information, up to 40 percent of MCR kelts arriving at McNary Dam (less for MCR kelts entering the mainstem Columbia River in the John Day, The Dalles, or Bonneville Reservoirs) are lost upstream of Bonneville Dam.

2.9.2.6 Mainstem Juvenile Migration/Survival

All populations of the MCR steelhead DPS are affected by juvenile passage conditions through at least one mainstem dam and reservoir. Populations originating from the Yakima and Walla

Walla Rivers must migrate through four mainstem dams and reservoirs, those originating from the John Day and Umatilla basins migrate through three mainstem dams and reservoirs, and populations from the Cascades Eastern Slope Tributaries MPG pass one to two dams depending on stream of origin.

As a result of successful implementation of RPAs in the 2008 biological opinion, extensive structural and operational improvements have been made at the lower four CRS Columbia River dams to improve survival for spring migrants. All four lower Columbia River CRS projects have well-functioning surface passage modifications in addition to 24-hour spring and summer spill programs to facilitate faster juvenile passage and higher survival. The surface passage modifications operated at the dams are the highest survival routes available for juvenile steelhead, and their influence on improving spill passage efficiency and reducing forebay delay is clearly established. A series of performance tests that occurred as a result of the 2008 biological opinion indicated that average juvenile steelhead survival through each of the four lower Columbia River dams typically exceed the survival target of 96.0 percent survival per dam (Fredricks 2017). Juvenile fish transportation efforts ceased at McNary Dam after 2012 due to high cost and limited observed SAR benefit following initiation of the 24-hour spring spill program and operation of the fish survival and passage modifications.

While dam passage survival has improved and is relatively high for steelhead in recent years, estimated survival of juvenile steelhead through these same reservoirs is typically lower and the data are variable. Widener et al. (2017) calculated survival from John Day to Bonneville Dam for hatchery and wild steelhead combined (including Snake River and Upper Columbia populations) and reports that survival increased between 2007 and 2013 from 58 percent to nearly 100 percent. However, survival subsequently decreased from 2013 to 2017 to 64.3 percent. In 2017, survival from McNary Dam to Bonneville Dam for hatchery and wild steelhead combined was 60.5 percent (Table 2.9-10). Estimates from a 2018 reach survival active tag study indicated that 78 percent of steelhead survived from McNary to Bonneville during Gas Cap spill (Harnish et al. 2018).

It is unclear what is causing the variable trends in reach survivals, but they may be due to variability in sampling precision, river flows, spill percentages, bypass debris, fish condition, or predation factors. One important note about these survival estimates is that they are based on PIT-tag detection systems which are located in the juvenile bypass systems. Detection systems have yet to be installed on the spillways, where project survival and SAR tend to be higher. Using bypass PIT detections as a surrogate for spillway past fish could add additional bias to the data. Based on project survival performance testing data, high flow years tend to increase survival of fish passing through the spillways systems (Fredricks 2017); however, fish detected in the bypass systems tend to have lower survival in high-flow years (Widener et al. 2018), indicating higher debris loads and/or TDG may be differentially impacting fish in the shallow-water environment. Descaling and mortality rates tend to increase when flows increase in the CRS, as debris loads increase on the trashracks with the higher flows. It has also been hypothesized that fish with weaker swimming capabilities and a lower chance of survival are more likely to pass through the juvenile bypass systems than via spill, which could mean that these survival estimates among dams may be biased lower than the true population of inference (Zabel et al. 2005).

2.9.2.7 Estuary Habitat

The estuary provides important migratory habitat for MCR steelhead populations. Since the late 1800s, 68–70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening combined with flow regulation and other modifications (Kukulka and Jay 2003; Bottom et al. 2005; Marcoe and Pilson 2017). Disconnection of tidal wetlands and floodplains has reduced the production of wetland macrodetritus supporting salmonid food webs (Simenstad et al. 1990; Maier and Simenstad 2009), both in shallow water and for larger juveniles migrating in the mainstem (ERTG 2018).

Restoration actions in the estuary, such as those highlighted in the latest five-year review, have improved access and connectivity to floodplain habitat. From 2004 through 2017, the Action Agencies implemented 58 projects, including dike and levee breaching or lowering (4,068 acres), tide-gate removal (457 acres), and tide-gate upgrades (887 acres). These projects represented a 2.5 percent net increase in floodplain connectivity below Bonneville Dam (Johnson et al. 2018). In addition, about 2,500 acres of functioning floodplain habitat were acquired for conservation.

Floodplain habitat restoration affects salmon performance directly (for fish that move onto the floodplain) and indirectly (for fish that stay in the mainstem). One direct benefit is that wetland food production supports foraging and growth within the wetland (Johnson et al. 2018). Prey items (primarily chironomid insects and corophiid amphipods; PNNL and NMFS 2018) produced within these wetlands are also exported into mainstem and off-channel habitats behind islands and other landforms, where they become available to salmon and steelhead migrating in these locations. Thus, while most steelhead may not directly enter a tidal wetland channel, they derive indirect benefits from wetland habitats. Improved opportunities for feeding on commonly consumed prey that drift into the mainstem are likely to contribute to survival at ocean entry.

2.9.2.8 Hatcheries

Hatchery programs can provide short-term demographic benefits, such as increases in abundance, during periods of low natural abundance. They also can help preserve genetic resources until limiting factors can be addressed. However, the long-term use of artificial propagation may pose risks to natural productivity and diversity. The magnitude and type of the risk depends on the status of affected populations and on specific practices in the hatchery program.

Hatchery strays pose significant risk to many of Oregon’s MCR steelhead populations, particularly to the Eastside and Westside Deschutes and John Day populations. The Mid-Columbia Expert Panel ranked the impact of hatchery strays as a key concern to the Eastside and Westside Deschutes and Lower John Day populations, and as a secondary concern to the Umatilla and Walla Walla populations (NMFS 2010). Viability assessments identified that a significant proportion of spawners in the Deschutes River and John Day River populations were out-of-DPS strays; however, some out-of-basin steelhead migrating into the Deschutes River appear to be seeking thermal refugia and eventually return to their natal streams (Keefer et al. 2016). In addition, these populations were rated at high risk for spawner composition due to the abundance of strays. Biologists remain especially concerned regarding the continuing detrimental impact of out-of-DPS hatchery fish in natural spawning areas on the genetic traits and productivity of these natural populations.

The five-year status review conducted in 2015 noted a decrease in the proportion of strays in the John Day basin. It is unclear if this trend is temporary or if it will continue to decrease with improved hatchery-management practices. Recent genetic sampling documented Rock Creek's steelhead population to be highly introgressed with the Snake River steelhead DPS, and 85 percent of adult PIT-tag detections with known juvenile origin were of Snake River origin. With a few more years of data, it should become apparent if steelhead in Rock Creek are a viable naturalized subpopulation or are sustained by an annual influx of stray steelhead originating from the Snake River (NWFSC 2015; Conley 2015). Snake River steelhead transport rates have decreased in the last few years as a result of early migrations and higher spill.

Hatchery programs operated within the MCR steelhead DPS—including the Umatilla, Walla Walla, and Westside Deschutes subbasins—also create some risks due to ecological interactions, and genetic introgression. For those hatchery programs that incorporate natural-origin adults into the broodstock or were derived from the endemic population NMFS has determined that these hatchery programs have not changed substantially or in a way to suggest that their level of divergence relative to the local population differs from what would be expected between closely related natural populations with the DPS (Jones 2015).

Collections for the Yakima River Kelt Reconditioning Program are made at the Chandler Juvenile Monitoring Facility (CJMF), where approximately 20 percent of the outmigrating, post spawn steelhead are collected in the spring and then transported to Prosser Hatchery for reconditioning using the methods described by Trammell et al. (2016). After six months the consecutive spawners are released both above and below Prosser Dam when the upper Columbia steelhead run is returning from the ocean. The reconditioned and released fish proceed to over-winter locations with the rest of the Yakima River populations, and to spawning grounds in the spring (Hatch et al. 2018: BPA Annual Report 2007-401-00). From 2000 to 2017 the number of kelt steelhead collected by the Yakima River Program has ranged from 118 to 1,157 fish per year. Of these fish, at least 22 percent and up to 76 percent have been successfully reconditioned and released. (The most released total was 404 in 2010). Since 2009, estradiol levels have been measured in the female kelts in order to determine whether they will be ready to spawn in the spring. The number of known mature females released by the program as consecutive spawners has ranged between 56 and 382 per year from 2009 to 2017 with an average of 175 per year. Since 2013, the program has retained females with low estradiol levels for an additional year of reconditioning. This method has successfully added an additional 8 to 37 (19 on average) "skip spawner" female kelts to the annual releases (Doug Hatch, pers. Comm.).

2.9.2.9 Harvest

Incidental catches of steelhead in ocean fisheries targeting other species are inconsequential (low hundreds of fish each year) to very rare (PFMC 2019), and retention of steelhead in non-treaty fisheries is currently prohibited. Based on currently available information, NMFS has concluded that ocean fishery management actions beyond those already in place that seek to minimize impacts to steelhead are not necessary (Thom 2019). While the general principles for quantifying treaty fishing rights are well established, their application to individual runs during the annual fishing seasons is complicated. Annual calculations of allowable harvest rates depend on (among other things) estimated run sizes for the particular year, the mix of stocks that is present, application of the ESA to mixed-stock fisheries, application of the tenets of the "conservation necessity principle" for treaty Indian fisheries, and the effect of both the ESA and the conservation necessity principle on treaty and non-treaty allocations. While the precise quantification of treaty Indian fishing rights during a particular fishing season often cannot be established by a rigid formula, the treaty fishing right itself continues to exist and must be accounted for in the environmental baseline.

NMFS recently signed the 2018–27 *U.S. v. Oregon* Management Agreement of the Columbia River Basin. That decision was based on both the recently completed Final EIS and the associated biological opinion (NMFS 2018a). The Agreement supports salmon and steelhead fishing opportunities for the states of Oregon, Washington, and Idaho, and ensures fair sharing of harvestable fish between tribal and nontribal fisheries in accordance with treaty fishing rights and *U.S. v. Oregon*. The agreement includes harvest rate limits on Columbia Basin fisheries impacting MCR steelhead, and these harvest limits continue to be annually managed by the fisheries co-managers. The 2018 *U.S. v. Oregon* Management agreement allows 4 percent take (harvest, but 10 percent mortality of wild-released fish) of the summer-run MCR steelhead and 2 percent for the winter-run component. Average take of MCR steelhead since 2008 has been 1.9 percent, ranging from 1.1 to 3.3 percent (NMFS 2018a).

Steelhead presmolts can be encountered in recreational trout fisheries and adults encountered in commercial, recreational, and tribal fisheries on the mainstem Columbia River and its tributaries. However, given current management regulations for mainstem Columbia River and tributary fisheries, harvest is not considered a primary or secondary threat due to the low impact on viability. The ICTRT identified harvest-related effects as a secondary level limiting factor, and the Oregon's Mid-C Expert Panel did not identify harvest as either a key or secondary concern for Oregon's MCR steelhead populations. The panel, however, did express concerns over the impact that mortality associated with catch-and-release fisheries have on Westside and Eastside Deschutes populations.

2.9.2.10 Predation

A variety of bird and fish predators consume juvenile MCR steelhead on their migration from tributary rearing areas to the ocean. Pinnipeds eat returning adults in the estuary, including the tailrace of Bonneville Dam. Predation in the estuary and in the migration corridor, and management measures to reduce the effects of predation, are discussed below.

2.9.2.10.1 Predation in the Lower Columbia River Estuary

Avian Predators

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, are having a significant impact on the survival of juvenile salmonids (including MCR steelhead) in the Columbia River. Caspian terns on Rice Island, an artificial dredged-material disposal island in the estuary, consumed about 5.4-14.2 million juveniles per year in 1997 and 1998, or 5-15 percent of all the smolts reaching the estuary (Roby et al. 2017). Efforts began in 1999 to relocate the tern colony 13 miles closer to the ocean at East Sand Island where the tern diet would diversify to include marine forage fish. During 2001-15, estimated consumption by terns on East Sand Island averaged 5.1 million smolts per year, about a 59 percent reduction compared to when the colony was on Rice Island. Management efforts are ongoing to further reduce salmonid consumption by terns in the lower Columbia River and similar efforts are in progress to reduce the nesting population of double-crested cormorants in the estuary.

Based on PIT-tag recoveries at East Sand Island, average annual tern and cormorant predation rates for this DPS were about 14.9 and 8.3 percent, respectively, before efforts to manage the size of these colonies (Evans et al. 2018a). The Corps has been implementing the Caspian Tern and Double-crested Cormorant Management Plans, but, in terms of effectiveness, has seen mixed results due to the dispersal of both terns and cormorants to other locations within the estuary. Average predation rates on MCR steelhead have decreased to 9.3 percent for terns nesting on East Sand Island, but in 2017 this improvement was offset to some unknown degree by terns roosting farther upstream on Rice Island (Evans et al. 2018a). Due to failures of the cormorant colony in 2016 and 2017, there are no estimates of predation rates since management of that colony began (Appendix C) substantial numbers of cormorants have relocated to the Astoria-Megler Bridge (preliminary report of 1,737 in 2018) and hundreds more are observed on the Longview Bridge, navigation aids, and transmission towers in the lower river (Anchor QEA et al. 2017). Smolts may constitute a larger proportion of the diet of cormorants nesting at these sites than if the birds were foraging from East Sand Island. Thus, the success of the East Sand Island tern and cormorant management plans at meeting their underlying goals of reducing salmonid predation is uncertain at this time.

An important question in predator management is whether mortality due to predation is an additive or compensatory source of mortality. Most importantly, do reductions in smolt predation rates by Caspian terns or double-crested cormorants result in higher adult returns because avian predation adds to the other sources of smolt mortality or are the smolts eaten by birds destined to die before returning as adults regardless of the level of predation? The latter case could occur because avian predation could be compensated for by sources of mortality in the ocean phase of the life cycle so that adult returns are unchanged. Haeseker (2015) and Evans et al. (2018b) have begun modeling the degree to which double-crested cormorant and Caspian tern predation, respectively, are additive versus compensatory sources of mortality.

Given the magnitude of bird predation on juvenile steelhead observed in the Columbia Basin, and that smolts eaten by birds in the lower river have survived hydrosystem passage, it is likely that some of the smolts consumed by birds could otherwise have survived to adulthood. Therefore, even if avian predation is partially compensatory, we expect that limiting the size of these tern and cormorant colonies will contribute to increased SARs for MCR steelhead.

Pinniped Predators

Numbers of pinnipeds that are predators of adult salmonids have increased considerably in the Pacific Northwest since the MMPA was enacted in 1972 (Carretta et al. 2013). CSLs, SSLs, and harbor seals consume salmonids from the mouth of the Columbia River and its tributaries up to the tailrace of Bonneville Dam. A small number of California sea lions have also been observed in Bonneville Reservoir in recent years. The ODFW has been counting the number of individual CSLs hauling out at the East Mooring Basin in Astoria, Oregon, since 1997. Pinniped counts at the East Mooring Basin during July and August, when MCR steelhead are migrating, remained stable during 2008–16 (Table 2.9-9), with a maximum count of 423 CSLs in August, 2014 (Wright 2018).

Table 2.9-9. Maximum monthly counts of California sea lions at Astoria, Oregon, East Mooring Basin (Wright 2018).

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
2008	40	56	67	126	162	46	6	191	213	204	273	157
2009	27	42	84	118	173	45	38	346	376	241	89	84
2010	58	93	136	229	216	157	29	316	356	265	98	54
2011	19	42	77	155	242	126	11	302	246	85	159	106
2012	20	27	82	240	201	92	19	212	187	147	91	21
2013	37	149	595	739	722	153	8	368	377	208	182	100
2014	237	586	1420	1295	793	90	32	423	492	369	94	126
2015	260	1564	2340	2056	1234	623	37	394	1318	459	84	208
2016	788	2144	3834	1212	1077	620	3	291	1004	878	235	246
2017	1498	2345	808	1131	1204	573						

Estimates of steelhead predation by pinnipeds in the lower Columbia River estuary (i.e., downstream of the Bonneville tailrace) are not available for the late-summer time period. Instead, monitoring efforts have focused on CSL predation on SR spring/summer Chinook salmon during January–May (e.g., Rub et al. 2019). Average pinniped impacts to summer migrating adult MCR steelhead are likely relatively small because pinniped counts are generally low in July and August (when most MCR steelhead pass Bonneville Dam) and they are mixed with relatively abundant fall Chinook salmon migrating in September and October.

Fish Predators

The native northern pikeminnow is a significant predator of juvenile salmonids in the Columbia River (reviewed in ISAB 2015). Before to the start of the NPMP in 1990, this species was estimated to eat about 8 percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River (including the hydrosystem reach) each year. Williams et al. (2017) compared current estimates of northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. The Sport Reward Fishery removed an average of 188,636 piscivorous pikeminnow (> 228 mm fork length) per year during 2013-17 (Williams 2013, 2014; Williams et al. 2015, 2016, 2017).

The removal of the larger, piscivorous individuals from northern pikeminnow populations will result in a sustained survival improvement for migrating juvenile steelhead only if it is not offset by a compensatory response by the remaining northern pikeminnow or other piscivorous fishes such as walleye or smallmouth bass. Signs of a compensatory response can include increased numbers of other predators, improved condition factors, or diet shifts. Williams et al. (2017) did not observe increases in numbers of pikeminnow, but did report an increasing trend in condition factor. This could be an intra-specific compensatory mechanism or just a response to beneficial environmental conditions. Similarly, Williams et al. (2017) documented increased numbers of smallmouth bass in parts of the lower Columbia River, which could be related to the NPMP or could be due to factors such as alterations in other parts of the food web or environmental conditions such as warmer temperature that affect this species' consumption rates. Williams et al. (2017) concluded that given these analytical constraints, data collected during 2017 provided ambiguous indicators of a compensatory response from the piscivorous fish community. Given the numbers of fish, bird, and marine mammal predators in the Columbia River and the ocean, we do not expect that all of the steelhead "saved" from predation by pikeminnows survive to adulthood. However, a 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity of steelhead populations, including MCR steelhead.

An average of 37 adult and 197 juvenile steelhead per year were killed and/or handled in the Sport Reward Fishery, system-wide (i.e., in the lower Columbia River and the hydrosystem reach), during 2013-17 (Williams et al. 2013, 2014; Williams et al. 2015, 2016, 2017). Although it was not practical for the field crews to identify these fish to DPS, we assume that some were MCR steelhead.

Non-native fishes such as walleye, smallmouth bass, and channel catfish are present in the slower moving off-channel habitats below Bonneville Dam, but yearling MCR steelhead, which mostly stay in the mainstem migration channel, are not likely to encounter large numbers of these species. The Oregon and Washington Departments of Fish and Wildlife have removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids.

2.9.2.10.2 Predation in the Hydrosystem Reach

The following paragraphs describe predation in the mainstem Columbia River from the tailrace of Bonneville Dam to Lower Granite Dam.

Avian Predators

MCR steelhead survival is affected in the mainstem by avian predators that inhabit the dams and reservoirs. The 2008 FCRPS biological opinion required that the Action Agencies implement avian predation control measures to increase survival of juvenile salmonids in the lower Snake and Columbia Rivers through effective monitoring, hazing, and deterrents at each project. All CRS projects have been using several effective strategies, including wire arrays that crisscross the tailrace areas, spike strips along the concrete, water sprinklers at juvenile bypass outfalls, pyrotechnics, propane cannons, and limited amounts of lethal take. These efforts have reduced avian predation on juvenile salmon at the dams. Zorich et al. (2012) estimated that, compared to the numbers of smolts consumed at John Day Dam in 2009 and 2010, 84–94 percent fewer smolts were consumed by gulls in 2011. At The Dalles Dam, 81 percent fewer smolts were consumed in 2011 than in 2010. Zorich et al. (2012) attribute the observed changes in predation rates to variation in the number of foraging gulls rather than to deterrence efforts, but imply that deterrence activities provide some (unquantifiable) level of protection.[94]

MCR steelhead are also vulnerable to predation by terns nesting in the interior Columbia plateau, including colonies on islands in McNary Reservoir, in the Hanford Reach, and in Potholes Reservoir. Smolts come within foraging range of other nesting sites on the plateau (principally the Blalock Islands in John Day Reservoir) as they continue to migrate downstream. The objective of the Inland Avian Predation Management Plan (IAPMP; USACE 2014), is to reduce predation rates to less than 2 percent per listed ESU/DPS per tern colony per year. The primary management activities have been to keep terns from nesting on Goose Island in Potholes Reservoir (managed by Reclamation) and on Crescent Island in McNary Reservoir (managed by the Corps). Passive dissuasion, hazing, and revegetation have prevented terns from nesting on Crescent Island since 2015, and similar efforts are in progress at Goose Island. However, the number nesting at the Blalock Islands in John Day Reservoir was ten times higher in 2015 than the year before, and resightings of colored leg-banded terns indicated that large numbers had moved there from Crescent Island. Terns also came to the interior plateau from East Sand Island in the estuary and from alternative Corps-constructed colony sites in southeastern Oregon and northeastern California in 2015 when those areas experienced severe drought (Collis et al. 2016).

In 2017, the goal of the IAPMP to reduce ESU/DPS-specific predation rates to less than 2 percent was achieved at Goose Island for the second consecutive year and at Crescent Island for the third year (Collis et al. 2018). Although researchers have not estimated avian predation rates for MCR steelhead, predation rates on Snake River Basin steelhead by Caspian terns have

[94] "For continued protection against avian predation we recommend the current passive deterrents avian lines be maintained and expanded where possible and active deterrents such as hazing from boats or other novel methods continue to be deployed as necessary to minimize foraging by piscivorous birds at the Corps' dams" (Zorich et al. 2012).

declined from up to 3.9 percent at these sites during the pre-management period to <0.1 percent (Collis et al. 2018; Appendix C). Predation rates for UCR steelhead also declined, from 15.7 to <1.0 percent.

Gull predation was not considered in the IAPMP and there are no regional plans to manage these colonies. PIT-tag recoveries indicate that predation rates on smolts from the Snake River Basin steelhead DPS by gulls on Miller Rock Island ranged from 6.7–9.7 percent during 2015–16 (Roby et al. 2016, 2017). Predation rates on UCR steelhead ranged from 10.1–13.2 percent.

Pinniped Predators

Pinniped presence in the Bonneville tailrace has increased in the last six years (Table 2.9-10; Tidwell et al. 2017). SSLs in particular aggregate at the base of the dam in the late summer when MCR steelhead are present. Between 21 July and 31 December 2017, Tidwell et al. (2018) documented an average of 14.5 SSLs at Bonneville Dam and, during many sampling periods, counted more than 20 individuals. A small number of California sea lions have also been observed in Bonneville Reservoir in recent years.

Table 2.9-10. Average daily combined pinniped presence by month at Bonneville Dam.

Month	2011	2012	2013	2014	2015	2016	2017
Aug.	0.0	0.0	0.0	1.0	1.9	5.2	10.8
Sept.	0.0	0.0	1.5	6.8	16.6	30.7	13.2
Oct.	2.4	2.6	13.3	11.7	22.5	26.6	14.8
Nov.	4.9	2.8	15.9	16.8	22.3	18.9	18.5
Dec.	7.0	4.1	10.2	9.2	16.1	16.4	16.4

Due to the repeated entry of sea lions into the adult ladders at Bonneville Dam, the Corps began constructing physical exclusion devices in 2006 to block pinnipeds but allow fish passage. These gates, called Sea Lion Excluder Devices (SLEDs), are installed at all eight ladder entrances at Bonneville when MCR steelhead are present (Tidwell et al. 2017). In addition, the Corps has installed smaller physical exclusion gratings on the 16 Floating Orifice Gates (FOGs) along the face of Bonneville Dam Powerhouse 2 that allow fish to enter the collection channel and pass via the Washington shore ladder. The SLEDs and FOGs successfully prevent pinnipeds from entering the adult fish ladders.

Fish Predators

Native pikeminnow are significant predators of juvenile salmonids in the hydrosystem reach, followed by non-native smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011, 2015). In addition to the Sport Reward Fishery in the lower Columbia River estuary and throughout the hydrosystem reach, the Action Agencies conduct a Dam Angling Program to remove large pikeminnow from the tailraces of The Dalles and John Day Dams. Angling crews removed an average of 5,913 northern pikeminnow from these two projects per year during

2013-17 (Williams 2013, 2014; Williams et al. 2015, 2016, 2017). They reported killing and/or handling zero adult or juvenile steelhead during the five-year period.

Juvenile salmonids are also consumed by large numbers of non-native fishes including walleye, smallmouth bass, and channel catfish in the reservoirs of hydrosystem reach. As described for the lower Columbia River estuary: (1) yearling MCR steelhead mostly stay in the mainstem migration channel and are not likely to encounter large numbers of these species and (2) both the Oregon and Washington Departments of Fish and Wildlife have removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids.

2.9.2.11 Research and Monitoring Activities

The primary effects of past and ongoing CRS-related RM&E programs on MCR steelhead are associated with the capturing and handling of fish. The RM&E program is a collaborative, regionally coordinated approach to fish and habitat status monitoring, action effectiveness research, critical uncertainty research, and data management. The information derived from the program facilitates effective adaptive management through better understanding the effects of the ongoing FCRPS action. Capturing, handling, and releasing fish generally leads to stress and other sublethal effects, but fish sometimes die from such treatment. The mechanisms by which these activities affect fish have been well documented and are detailed in Section 8.1.4 of the 2008 biological opinion. Some RM&E actions also involve sacrificial sampling of fish. We estimated the number of MCR steelhead that have been handled each year during the implementation of RM&E under the 2008 RPA as the average annual take reported for 2013-17:

- Average annual estimates for handling and mortality of MCR steelhead associated with the Smolt Monitoring Program and the CSS were: (1) zero hatchery and zero wild adults handled; (2) zero hatchery and zero wild adults died; (3) 447 hatchery and 762 wild juveniles handled; and (4) two hatchery and three wild juveniles died.
- The estimated handling and mortality of MCR steelhead associated with the ISEMP was: (1) one hatchery and 34 wild adults handled; (2) zero hatchery and one wild adult died; (3) four hatchery and 2,048 wild juveniles handled; and (4) zero hatchery and seven wild juveniles died.
- Estimates for MCR steelhead for all other RM&E programs are as follows: (1) eight hatchery and seven wild adults handled; (2) zero hatchery and zero wild adults died; (3) 163 hatchery and 1,607 wild juveniles handled; and (4) one hatchery and 381 wild juveniles died.

The combined take (i.e., handling, including injury, and incidental mortality) associated with these elements of the RM&E program has, on average, affected less than one percent of the wild (i.e., natural origin) adult MCR steelhead run (Bellerud 2018). However, slightly more than one percent of the wild juvenile production was handled in the combined RM&E programs. Based on the history of these programs, we assume that up to one percent of these juveniles (in this case,

<0.02 percent of the wild production) died after they were released due to effects of handling. This relatively small effect is deemed worthwhile because it allows the Action Agencies and NMFS to evaluate the effects of FCRPS operations, including modifications to facilities, operations, and mitigation actions.

In addition, northern pikeminnow are tagged as part of the Sport Reward Fishery and their rate of recapture is used to calculate exploitation rates. Northern pikeminnow are collected for tagging using boat electrofishing in select reaches of the Columbia River. During 2017, boat electrofishing operations in the Columbia River extended upstream from RM 47 (near Clatskanie, Oregon) to RM 394 (Priest Rapids Dam), and in the Snake River from RM 10 (Ice Harbor Dam) to RM 41 (Lower Monumental Dam) and from RM 70 (Little Goose Dam) to RM 156 (upstream of Lower Granite Dam). Researchers conducted four sampling events consisting of 15 minutes of boat electrofishing effort in shallow water within each 0.6-mile reach during April-July.

A side effect of the electrofishing effort is that salmon and steelhead may be exposed to the electrofishing field, with the potential for injury, stress, and fatigue and even cardiac or respiratory failure (Snyder 2003). Some adult and juvenile MCR steelhead are likely to be present in shallow shoreline areas during the April-July time period. Most sampling occurs in darkness (1800-0500 hours). Operators shut off the electrical field if salmonids are seen and because most stunned fish quickly recover and swim away, they cannot be identified to species (i.e., Chinook, coho, chum, or sockeye salmon or steelhead). Barr (2018) reported encountering an annual average of 1,762 adult and 92,260 juvenile salmonids in the Columbia and Snake Rivers each year during 2013-17 electrofishing operations based on visual estimation methods. It is likely that some of these were MCR steelhead.

2.9.2.12 Critical Habitat

The conditions of the PBFs of MCR steelhead critical habitat are discussed above (e.g., mainstem flows/water quantity, temperature and TDG/water quality, hydrosystem passage/safe passage, etc.) and summarized here in Table 2.9-11. Across the action area, land use activities have disrupted watershed processes (e.g., erosion and sediment transport, storage and routing of water, plant growth and successional processes, input of nutrients and thermal energy, nutrient cycling in the aquatic food web, etc.), reduced water quality, and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and/or current land use or water management activities have adversely affected the quality and quantity of stream and side channel areas (e.g., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for steelhead production have been weakened.

Critical habitat throughout much of the middle portion of the Interior Columbia recovery domain has been degraded by intense agriculture, alteration of stream morphology (i.e., through channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining, and urbanization. Reduced summer stream flows, impaired water quality, and reduction of habitat complexity are common problems for critical habitat in developed areas, including those within the Interior Columbia River recovery domain (NMFS 2016d).

The general effects of mainstem and tributary dams on the functioning of critical habitat include:

- Juvenile and adult passage survival at dams with passage facilities (safe passage in the migration corridor);
- Water quantity (i.e., flow) and seasonal timing (water quantity and velocity, cover/shelter, food/prey, riparian vegetation, and space in rearing areas, including the estuarine floodplain, and migration corridors);
- Temperature, both in the reaches below the large mainstem storage projects and in rearing areas and migration corridors (water quality and safe passage in the migration corridor);
- Sediment transport and turbidity (water quality and safe passage in the migration corridor);
- Total dissolved gas (water quality and safe passage in the migration corridor); and
- Food webs, including both predators and prey (food/prey and safe passage in rearing areas and migration corridors).

The habitat quality of migratory corridors in this area has been severely affected by the development and operation of the CRS dams and reservoirs in the mainstem Columbia River, PGE's Pelton Round-Butte Project, the Deschutes Valley Water District's Opal Springs Hydroelectric Project, and privately owned dams in the Snake and upper Columbia River basins. Hydroelectric development has modified natural flow regimes of the rivers, resulting in warmer late summer/fall water temperatures, changes in fish community structure that lead to increased rates of piscivorous and avian predation on juvenile salmon and steelhead, and delayed migration for both adult and juvenile salmonids. Physical features of dams, such as turbines, also kill out-migrating fish. In-river survival is inversely related to the number of hydropower projects encountered by emigrating juveniles. Additionally, development and operation of extensive irrigation systems and dams for water withdrawal and storage in tributaries have altered hydrological cycles (NMFS 2016d).

Many stream reaches designated as critical habitat are listed on Oregon and Washington's Clean Water Act Section 303(d) lists for water temperature. Many areas that were historically suitable rearing and spawning habitat are now unsuitable due to high summer stream temperatures. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water for agricultural or municipal use all contribute to elevated stream temperatures. Furthermore, contaminants, such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste, are common in some areas of critical habitat (NMFS 2016d). They can negatively impact critical habitat and the organisms associated with these areas.

The effect of large numbers of avian predators nesting on man-made or enhanced structures (dredge material deposits that created Rice Island and increased the size of East Sand Island in the lower Columbia River as well as bridges, aids to navigation, and transmission towers) constitutes excessive predation in the lower Snake and Columbia portions of the juvenile migration corridor. Similarly, sea lion predation on adult MCR steelhead in the tailrace of Bonneville Dam is excessive predation associated with a man-made structure. Predation associated with sea lions in the estuary is a natural phenomenon and is not excessive predation in the context of an effect on the functioning of critical habitat.

In the mainstem of the Columbia and Snake Rivers, the altered habitats in project reservoirs reduce smolt migration rates and create more favorable habitat conditions for fish predators, including native northern pikeminnow and nonnative walleye and smallmouth bass. The effects of the nonnative species and those of pikeminnows, to the extent the latter's predation rates are enhanced by reservoir and tailrace conditions, are also examples of excessive predation in the juvenile migration corridor.

Restoration activities addressing habitat quality and complexity, migration barriers, and water quality have improved the baseline condition for PBFs; however, the conservation role of critical habitat is to provide PBFs that support populations that can contribute to conservation of the DPS. More restoration is needed before the PBFs can fully support the conservation of MCR steelhead.

Table 2.9-11. Physical and biological features (PBFs) of designated critical habitat for MCR steelhead.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBF
Freshwater spawning sites	Water quantity and quality and substrate to support spawning, incubation, and larval development	● Reduced stream complexity and channel structure (loss of substrate, natural cover, vegetation, and forage) ● Degraded riparian condition (elevated temperatures; loss of natural cover, side channels, vegetation, and forage) ● Diminished stream flow (degraded water quantity, elevated temperatures, loss of juvenile and adult mobility) ● Impaired fish passage (obstructions, water withdrawals) ● Excess fine sediment in spawning gravel (degraded water quantity) ● Reduced floodplain condition and connectivity (loss of side channels, natural cover, vegetation)
Freshwater rearing sites	Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility, water quality, forage, and natural cover	● Impaired fish passage (obstructions, water withdrawals) ● Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) ● Elevated water temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices)

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBF
		● Reduced floodplain condition and connectivity (loss of side channels, natural cover, vegetation, and forage)
Freshwater migration corridors	Free of obstruction and excessive predation, adequate water quality and quantity, and natural cover	● Delay and mortality of adults (at up to eight mainstem dams) ● Concerns about increased opportunities for predators, especially birds and pinnipeds (construction of dredge-material islands in the lower river and other human-built structures used by terns and cormorants for nesting)
Estuarine areas	Free of obstruction and excessive predation with water quality, quantity, and salinity, natural cover, and juvenile and adult forage	● Disconnection of much of the historical tidally influenced wetlands and riverine floodplain below Bonneville Dam (reduced water quantity, natural cover, side channels, and forage) and the presence of toxic contaminants (reduced water quality and forage).
Nearshore marine areas	Free of obstruction and excessive predation with water quality, quantity, and forage	● Concerns about increased opportunities for pinniped predators and adequate forage

2.9.2.13 Future Anticipated Impacts of Completed Federal Formal Consultations

The environmental baseline also includes the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, including the consultation on the operation and maintenance of the Bureau of Reclamation's upper Snake River projects. The 2016 five-year review evaluated new information regarding the status and trends of MCR steelhead, including recent biological opinions issued for the MCR steelhead DPS and key emergent or ongoing habitat concerns (NMFS 2016d). Since the beginning of 2015 through 2017, we completed 502 formal consultations (141 in 2015, 162 in 2016, and 199 in 2017) that addressed effects to MCR steelhead (PCTS data query on 31 July 2018). These numbers do not include the many projects implemented under programmatic consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed salmonids. Some of the completed consultations are large (large action area, multiple species), such as the Mitchell Act consultation and the consultation on the 2018–27 *U.S. v. Oregon* Management Agreement. Many of the completed actions are for a single activity within a single subbasin.

Some of the projects will improve access to blocked habitat, improve riparian condition, increase channel complexity, and increase instream flows. For example, under BPA's Habitat Improvement Programmatic consultation, BPA implemented 29 projects in the Columbia Basin that improved fish passage in 2017, and 99 projects that involved river, stream, floodplain, and wetland restoration. These projects will benefit the viability of the affected populations by improving abundance, productivity, and spatial structure. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more than, and typically less than, a few weeks).

Other types of federal projects, including grazing allotments, dock and pier construction, and bank stabilization, will be neutral or have short- or even long-term adverse effects. All of these actions have undergone section 7 consultation and the actions or the RPA were found to meet the ESA standards for avoiding jeopardy.

Similarly, future federal restoration projects that have already undergone consultation will improve the functioning of the PBFs safe passage, spawning gravel, substrate, water quantity, water quality, cover/shelter, food, and riparian vegetation. Projects implemented for other purposes will be neutral or have short- or even long-term adverse effects on some of these same PBFs. However, all of these actions, including any RPAs, have undergone section 7 consultation and were found to meet the ESA standards for avoiding any adverse modification of critical habitat.

2.9.3 Effects of the Action

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

The proposed action is an ongoing action that has been modified over time to reflect capital improvements, as well as changes in operation based on existing conditions and improved information on how CRS operations affect MCR steelhead and other listed species and their critical habitats. The current proposed action includes operational measures (e.g., flood risk management, navigation, fish passage, and hydropower generation) and non-operational measures (e.g., support for conservation hatchery programs, predation management, habitat improvement actions) that will be implemented beginning in 2019. The proposed action, however, is of limited duration. The Action Agencies are developing an EIS in accordance with NEPA that will assess and update the approach for long-term system operations, maintenance, and configuration as well as evaluate measures to avoid, offset, or minimize impacts to resources affected by the management of the CRS, including ESA-listed species and designated critical habitat. A court order currently requires the Action Agencies to issue Records of Decision on or before September 24, 2021.[95] Based on scoping, the range of alternatives being examined is broad and includes potential large-scale changes in the action. Thus, there is substantial uncertainty regarding what system operations, maintenance, and configuration the Action Agencies will propose at the conclusion of the NEPA process. Likewise, it is unknown what

[95] The Presidential Memorandum on Promoting the Reliable Supply and Delivery of Water in the West, issued on October 19, 2018, required the development of an expedited schedule for completion of the NEPA process. The Council on Environmental Quality has confirmed a revised schedule that calls for completing the Draft EIS in February 2020, the Final EIS in June 2020 and Records of Decision by September 30, 2020. These dates are consistent with, but earlier than, the court-ordered deadlines.

measures intended to avoid, offset, or minimize adverse effects will ultimately be included in the final preferred alternative.

Accordingly, our analysis of effects for MCR steelhead and their critical habitat extends from 2019 into the future, but emphasizes the evaluation of effects that are reasonably certain to occur as a result of implementing the proposed action, pending completion of the EIS and our issuance of a subsequent biological opinion addressing the effects of the final preferred alternative. To the extent our consideration of potential effects beyond that time period assumes the current proposed action remains in place, it is intended, in part, to inform the evaluation of alternatives in the EIS.

The effects of the proposed action for MCR steelhead are generally consistent with the effects caused by a continuation of the CRS operations as described in the environmental baseline section, with the following exceptions:

- Implementation of the flexible spring spill operation.;
- A 0.5-ft increase in operating range at John Day and Lower Snake River reservoirs; and
- The potential for reduction of spill at mainstem projects (August 15 to 31) of 2020 pending consensus among parties.

2.9.3.1 Effects to Species

Both juvenile and adult MCR steelhead will be exposed to the effects of the action in the mainstem Columbia River from McNary pool downstream to the plume. In addition, adult MCR steelhead which overshoot their natal streams and move up the Snake River will be exposed to the effects of one to four Snake River dams from July through as late as April of the following year. Populations from MPGs originating in tributaries further upstream that pass up to four dams will experience greater effects of the action than those populations originating in tributaries further downstream that may only pass one dam. All populations of the MCR steelhead DPS are affected by juvenile passage conditions through at least one mainstem dam and reservoir. Populations originating from the Yakima and Walla Walla Rivers must migrate through four mainstem dams and reservoirs, those originating from the John Day and Umatilla basins migrate through three mainstem dams and reservoirs, and populations from the Cascades Eastern Slope Tributaries MPG pass one to two dams, depending on stream of origin.

2.9.3.1.1 Hydrosystem operation

The Action Agencies will operate the run-of-river lower Columbia River projects (McNary, John Day, The Dalles, and Bonneville Dams) in accordance with the annual Water Management Plan and Fish Passage Plan (including all appendices). These projects are operated for multiple purposes, including fish and wildlife conservation, irrigation, navigation, power, recreation, and, in the case of John Day Dam, limited flood risk management.

The Action Agencies propose to increase spill at the lower Columbia River and lower Snake River Dams during the spring spill period which is intended to improve juvenile survival through the dams (and improve adult returns). The Action Agencies propose to implement a flexible spring spill operation which utilizes spill to state water quality limits for 16 hours per day, and performance spill for 8 hours per day. Gas Cap Spill operations are proposed to increase from up to 120 to up to 125 percent TDG Gas Cap levels starting in 2020. Performance spill was developed using a combination of 2008 FCRPS biological opinion prescribed spill and performance standard testing guidelines.

The main effect of the higher spill is a small decrease in forebay delay, and a moderate increase in spill passage efficiency. COMPASS results for SRB steelhead, which serves as a surrogate for MCR steelhead in the lower Columbia River, estimates that the travel time from McNary Dam to Bonneville Dam will be reduced from 6.5 days to 6.4 days (about 2 hours). The additional flow through conventional spillbays will likely draw a greater proportion of juvenile steelhead migrants from the powerhouse routes (turbine and bypass) and surface passage routes (surface weir and sluiceway) to conventional spill bays. While turbine survival is generally lower than spillway survival by a substantial margin, bypass and sluiceway survival can be close to, equal to, or often greater than spillway survival in terms of direct survival. The COMPASS model relies on juvenile route survival estimates, and predicts the increase in spill (flexible spill up to 120 percent TDG) will result in a 0.4 percent increase in juvenile SR steelhead reach survival passing eight dams. Survival improvement for MCR steelhead may be less since they pass fewer dams. It is important to note that since higher spill levels result in unbalanced energy and degraded tailrace conditions, juvenile survival could be lower than COMPASS predicts as a result of extended tailrace delay and the potential for predation at some projects.

The CSS hypothesizes that the greatest increase in survival from increasing spill will occur in the form of a reduction in delayed mortality (CSS 2017), which is thought to occur further downstream than direct survival estimates measure. The CSS did not model MCR steelhead survival; however, we assume the effects to MCR steelhead are similar to SR steelhead except that MCR steelhead pass fewer dams.

For SR Chinook salmon passing eight dams, the CSS hypothesizes that SARs will increase an average of 23 percent for the fish experiencing the increase in spill to the 120/115 gas cap: "Spill increases had similar effects on the Chinook SAR simulations, with biological opinion spill resulting in a 23 percent increase in survival over historical SARs." However, the CSS predicts less benefit for SR steelhead—"the modeled benefits of spill for steelhead SARs were relatively lower than for Chinook"—where 120/115 gas cap spill simulations resulted in a 0.2 to 13 percent increase in SR steelhead SARs (CSS 2017). Even if the full benefits that CSS hypothesizes for SR steelhead (as a surrogate for MCR steelhead) are correct, this benefit will likely be less than 13 percent for MCR steelhead since MCR steelhead juveniles pass fewer dams than SR steelhead. For this reason, even under the most optimistic scenario that CSS hypothesizes, benefits to MCR steelhead from the flexible spring spill operation will likely be less than a 5 percent increase in SARs.

While fish migrating through spillways have been demonstrated to return at a higher rate than bypassed fish, it is less clear if this difference is due to the size and condition of the fish (Zabel et al. 2005) or if this survival difference is primarily due to harm caused by the bypass passage experience (CSS 2017). However, there is considerable uncertainty associated with both bypass effects and the CSS latent-mortality hypothesis. Should the CSS latent-mortality hypothesis prove correct, SARs would also be expected to increase somewhat (5 percent) for MCR steelhead.

The available information indicates that supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). For MCR steelhead smolts, the proposed flexible spill operation (up to 120 or 125 percent TDG) would increase the exposure of spring migrating juveniles to elevated TDG levels from the tailrace of McNary Dam to at least 35 miles downstream of Bonneville Dam. Individuals from all “upstream” populations and MPGs would be exposed to a greater extent than those from “downstream” populations and MPGs. Smolts typically migrate at depths which effectively reduce TDG exposure due to pressure compensation mechanisms (Weitkamp et al. 2003). However, the proposed flexible spill operation would likely result in a slight increase in the incidence and severity of GBT symptoms and a very small (not measurable through reach survival studies) increase in mortality.

The majority of adult MCR steelhead migrate after the spring spill period and will not be affected by the proposed flexible spring spill operation. Those adults which do not enter the tributaries prior to the start of flexible spring spill operations (April 3 at the Snake River projects or April 10 at the lower Columbia River projects) would be exposed to increase TDG levels. Adults also migrate at depths which reduce the effective exposure to TDG through depth compensation mechanisms. The proposed flexible spill operation would likely result in a slight increase in the incidence and severity of GBT symptoms and a very small (not measurable) increase in mortality for those adults that are exposed.

Potential spill reduction starting in August (15-31) of 2020, pending consensus among parties, would not affect juvenile UCR steelhead which migrate in the spring. Effects on adults (fallback related impacts) are likely negligible because sufficient volumes of water are provided to allow volitional passage for downstream migrating adults.

The Action Agencies propose a change in pool elevation in the John Day and the lower four Snake River projects to increase operational flexibility. Increasing the elevation of the reservoir will likely increase downstream travel time for juveniles, because an increase in surface area with a given river flow will slow down the water and the fish migrating through it. The John Day Dam forebay will be operated within 2 feet of the lowest elevation range (minimum irrigation pool level, or MIP). This is an increase from the previous operation that limited John Day to within 1.5 feet of MIP. The Proposed Action describes that this change will allow full use of the 1.5-foot operating range and irrigation withdrawals from 10 April through 30 September. Increasing the pool elevation in the four lower Snake River reservoirs by 0.5 ft will not affect MCR steelhead juveniles, which are not present in that reach, and is not expected to affect the behavior of adult MCR steelhead that move that far upstream. Increasing the John Day pool operating range from 1.5 to 2.0 feet of MIP could result in a slight increase in travel time for juvenile steelhead migrants. However, the net effect of the John Day pool and flexible spill operations, based on COMPASS modeling for UCR steelhead (see section 2.10.3.1.4), is likely to be a small reduction in travel time.

2.9.3.1.2 Nonoperational Conservation Measures to Benefit ESA-listed Salmon and Steelhead

Kelt Reconditioning

The Action Agencies propose to fund the kelt reconditioning program on the Yakima River for MCR steelhead and to monitor kelt passage to improve our understanding of how the survival of downstream migrating kelts is affected by fish passage structures and operations. The Kelt Reconditioning and Reproductive Success Evaluation Project funded through the Columbia Basin Fish Accords conducted research at the Cle Elum Supplementation and Research Facility (CESRF) to assess the reproductive success of the program's reconditioned steelhead kelts (2015-17). While several factors prevented the researchers from quantifying the average number of fry produced per redd, the study did demonstrate that reconditioned kelt steelhead can build redds, successfully spawn, and produce viable offspring (Hatch et al. 2018: BPA Annual Report 2007-401-00). Additionally, in a study conducted by Trammell et al. (2016), kelts reconditioned by the Yakima Program exhibited a higher return rate of repeat spawners (range, 11.5–17.6 percent) when compared with the control group, which were naturally returning (in-river) Yakima kelts (2.7 percent). These results indicate that long-term steelhead kelt reconditioning is more successful than in-river migration at increasing potential repeat spawner abundance and providing recovery benefits in river systems that have experienced substantial losses in natural productivity due to loss of habitat and habitat connectivity. The operation of the kelt reconditioning program on the Yakima River will continue at the same level as it has been in recent years, for which no more than 2,900 adults may be collected in a year (given the maximum amount of hatchery space and maximum mortality rates) and should continue to boost natural production for the Yakima MPG (Doug Hatch, CRITFC, pers. comm.).

Proposed passage improvements for juvenile salmon and steelhead, including surface passage routes such as RSWs and sluiceways, are likely to also benefit downstream migrating kelts. This should lead to improved survival through the CRS. Reduced forebay residence times which lead to a reduction in total travel time may also contribute to an improvement in kelt return rates. It is not possible to calculate the precise amount of improvement expected, because the interactions between improved surface passage and improved kelt survival and return rates are unclear.

2.9.3.1.3 Predator Management and Monitoring Actions

Predation Management in the Lower Columbia River Estuary

Avian Predators

The Action Agencies propose continued implementation of the Caspian Tern Nesting Habitat Management Plan (USACE 2015a) and the Double-crested Cormorant Management Plan (USACE 2015b). Tern habitat on East Sand Island will continue to be maintained at no less than one acre for the interim period covered by this consultation. Management actions for double-crested cormorants on East Sand Island will be limited to passive dissuasion and hazing, except that limited egg take (up to 500 eggs) may be requested from USFWS each year to preclude cormorants from nesting in new or different areas on East Sand Island. These ongoing actions are likely to continue current levels of predation by birds nesting on East Sand Island, which, in the case of Caspian terns, has been shown to be an improvement compared to the pre-colony management period. Due to the dispersal of the colony in 2016 and 2017, predation rates for East Sand Island cormorants are not available for the management period. Colony size and predation rate data from 2018 and during the interim period will be needed whether this program is meeting its management goals.

In addition, the Action Agencies propose to synthesize colony size and predation rate data collected under the tern and cormorant colony-management plans. The intent of the synthesis report is to summarize data on predation by piscivorous waterbirds on ESA-listed salmonids in the Columbia River basin before, during, and after the management actions, in order to assess their effectiveness on a basinwide scale. For example, the dispersal of double-crested cormorants from East Sand Island to nest sites on the Astoria-Megler Bridge in recent years, and observations of thousands of Caspian terns roosting on Rice Island in 2017, indicate that the numbers of avian predators in the estuary are still in flux and their effects on the viability of salmonids such as MCR steelhead is variable. The synthesis report will help managers assess whether to recommend that the Action Agencies or other regional parties consider additional measures for implementation over the long term.

Ongoing annual monitoring will include estimates of double-crested cormorant abundance, nesting density, and PIT-tag detection on East Sand Island. The average estimated three-year peak colony size will be used to evaluate management activities relative to plan objectives (2019–21); the management plan will be considered successful when the average three-year peak colony size estimate does not exceed 5,939 nesting pairs while no management actions are conducted. Annual PIT detection will continue for five to ten years to assess overall trends in predation rates (through the 2023 breeding season, at minimum), accounting for annual variability in predation impacts. These measures are likely to effectively constrain double-crested cormorant predation on listed salmonids such as MCR steelhead at Corps-managed sites in the estuary. However, additional years of predation rate data will be needed to determine whether these have decreased from the premanagement period and have thereby improved the viability of MCR steelhead populations. Any reduced predation rates that were achieved under the 2008 biological opinion and associated RPA will continue during the interim period.

Fish Predators

The Action Agencies will continue to implement the NPMP Sport Reward Fishery in the hydrosystem reach and the Dam Angling Program at The Dalles and John Day Dams as described under the environmental baseline. These ongoing measures will continue the reduction in predation rates achieved under the 2008 RPA. We estimate that the 2013-17 annual average numbers of steelhead, including MCR steelhead, which will be handled and/or killed in the Sport Reward Fishery will continue as described above (Predation Management in the Lower

Columbia River Estuary). In addition, we estimate that no more than ten adult and 20 juvenile steelhead, including some from the MCR steelhead DPS, will be caught in the Dam Angling Program per year during the interim period.

Predation Management in the Hydrosystem Reach

Avian Predators

The Corps will continue to implement and improve, as needed, avian predator deterrent programs at lower Columbia and Snake River dams. At each dam, bird numbers will be monitored, feeding birds will be hazed, and passive predation deterrents, such as irrigation sprinklers and bird wires, will be deployed. Hazing, including launching long-range pyrotechnics at concentrations of feeding birds near the spillway, powerhouse discharge, and juvenile bypass outfall areas, will also continue. These measures will continue to reduce levels of predation on juvenile MCR steelhead, although the amount of protection has not been quantified (Zorich et al. 2012).

The Action Agencies propose to continue to address Caspian tern predation at lands that they manage on the Columbia plateau: Crescent Island (Corps) and Goose Island (Reclamation). The Corps has excluded tern use on Crescent Island via revegetation since 2015, but will continue to monitor that site to ensure that conditions remain unfavorable for nesting. If tern use does resume during the interim period, the Corps will work with NMFS and USFWS to address concerns, perform any necessary environmental compliance, and seek permits and funding for active hazing, if warranted. If no nesting of concern to the Corps and NMFS is identified, the Corps will discontinue monitoring after three years. These measures are likely to preclude use of Crescent Island by Caspian terns during the interim period of this consultation.

Reclamation has excluded Caspian terns from Goose Island using ropes and flagging, and is currently experimenting with revegetation. They propose to maintain the ropes and flagging and to monitor for tern presence on a regular basis between late February and early July each year. If terns resume nesting, and if the number of terns exceeds metrics identified in the IAPMP (more than 40 nesting pairs on Goose Island or more than 200 pairs at sites across the interior Columbia Basin; USACE 2014), Reclamation will work with NMFS to identify management actions and tools that can be in place to dissuade tern use of the island before the next nesting season (e.g., permits from USFWS for hazing and egg take). These measures are likely to successfully preclude use of Goose Island by Caspian terns during the interim period of this consultation.

Pinniped Predators

The Corps will continue to install, and improve as needed, sea-lion excluder gates at all adult fish ladder entrances at Bonneville Dam each year. In addition, the Corps and Bonneville will continue to support land- and water-based harassment efforts by ODFW, WDFW, and CRITFC to keep sea lions away from the area downstream of Bonneville Dam. The Corps will continue estimating sea lion abundance, spatial distribution, temporal distribution, predation attempts, and predation rates in the Bonneville Dam tailrace annually from early August through 31 May. Collection of predation data will occur when sea lion abundance is greater than or equal to 20 animals. The Corps will continue to use adaptive management, including recommendations from the Fish Passage Operations and Management Coordination Team and the Sea Lion Task Force, to address changing circumstances as they relate to sea lion harassment efforts and predation monitoring at Bonneville Dam. These ongoing measures are expected to maintain current levels of sea lion predation on MCR steelhead in the Bonneville tailrace, which is currently estimated at 1.5 percent (Tidwell et al. 2018). If pinnipeds are observed at The Dalles Dam, the Corp may respond with hazing at adult fish ladder entrances.

Fish Predators

The Action Agencies will continue to implement the Northern Pikeminnow Sport Reward Fishery in the hydrosystem reach and the Dam Angling Program at The Dalles and John Day Dams as described under the Environmental Baseline. These ongoing measures will continue the reduction in predation rates achieved under the 2008 RPA. We assume that the 2013-17 annual averages and ranges of incidental take for steelhead, including MCR steelhead, system-wide, will continue as described above (Predation Management in the Lower Columbia River Estuary).

The Action Agencies will continue to implement the NPMP Sport Reward Fishery in the hydrosystem reach and the Dam Angling Program at The Dalles and John Day Dams as described under the Environmental Baseline. These ongoing measures will continue the reduction in predation rates achieved under the 2008 RPA. We estimate that the 2013-17 annual average incidental catch of steelhead, including MCR steelhead, in the Sport Reward Fishery will continue as described above (Predation Management in the Lower Columbia River Estuary). In addition, we estimate that no more than ten adult and 20 juvenile steelhead, including some from the MCR steelhead DPS, will be caught in the Dam Angling Program per year during the interim period.

2.9.3.1.4 Tributary Habitat

For those MCR steelhead populations that have been affected by CRS management, the Action Agencies will provide funding and/or technical assistance for habitat improvement actions consistent with recovery plan priorities and other regional efforts, as funding allows.

If implemented, and if implemented in a manner consistent with scientifically sound identification and prioritization of limiting factors and geographic locations, such actions could provide benefits to the targeted populations. However, because the Action Agencies have not proposed a commitment to implement tributary habitat improvement actions for MCR steelhead as part of this proposed action, or proposed them in a manner where we could meaningfully assess the effects (e.g., committing to achieve specific amounts or types of restoration), we are not considering the benefits of potential projects in our analysis.

2.9.3.1.5 Estuary Habitat

The Action Agencies will continue to implement the CEERP (Ebberts et al. 2018; BPA and USACE 2018). Program goals are to increase the capacity and quality of estuarine ecosystems and to improve access to these resources for juvenile salmonids. Floodplain reconnections are expected to continue to increase the production and availability of commonly consumed prey (chironomid insects and corophiid amphipods) to MCR steelhead as they migrate through the estuary.

NMFS agrees with ISAB's assessment findings (ISAB 2014) that it has been difficult to quantify the survival benefits of estuary habitat restoration, but the Action Agencies' assessment method, including review by the ERTG,[96] is useful to prioritize projects. For the interim period, the Action Agencies' proposed commitment is therefore to reconnect an average of 300 acres of floodplain per year, a goal that they have a record of meeting in 2008-17 (BPA et al. 2018b), rather than to achieve a specific survival improvement. NMFS also agrees with ISAB that the Action Agencies' assessment method, including review by the ERTG (Krueger et al. 2017), remains useful for prioritizing projects and for optimizing project design (number of breaches and channels, etc.) to site conditions. Thus, NMFS expects that the proposed implementation of the estuary program during the biological opinion will continue to help mitigate for effects of flow management that, combined with dikes and levees, have cut much of the floodplain off from the mainstem river. The improving trend (net increase in connected area; Johnson et al. 2018) is expected to continue during the interim period, providing benefits (flux of insect and amphipod prey to the mainstem migration corridor) to juvenile MCR steelhead. It is likely that these benefits will increase as habitat quality matures.

The Action Agencies also propose continued implementation of their estuary habitat monitoring program, the CEERP component that provides a basis for adaptive management. This includes action effectiveness monitoring at each restoration site. A set of "standard" indicators (photo points, water surface elevation, and salinity) are measured at all sites (Level 3); core indicators (plant species composition, percent cover, and biomass) are measured at a subset of the sites (Level 2); and intensive indicators (juvenile salmonid species composition, density, diet, and growth, along with structures and controlling factors) are measured at an even smaller number of sites (Level 1; Johnson et al. 2018). Monitoring will continue at recently built sites and will be initiated for sites constructed during the interim period. Johnson et al. (2018) evaluated the action effectiveness monitoring data collected since 2012, and found that they generally indicated that the restoration of physical and biological processes was underway at these sites. Continued implementation and evaluation of this monitoring program will show that these floodplain reconnections are enhancing conditions for salmonids such as MCR steelhead as they migrate through the mainstem. This monitoring program will also provide sufficient information to the Action Agencies that site selection or project design will improve through adaptive management.

As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss with ERTG and regional partners relevant climate change science in an effort

[96] As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss with ERTG and regional partners relevant climate change science in an effort to understand whether their planned estuary projects are resilient to climate change (i.e., sea level rise, temperatures, and mainstem flow levels). In addition, the Action Agencies' annual update of their restoration and monitoring plans for the estuary will document any needed adjustments in design, location, or other elements of a given project to address climate change impacts, both during and beyond the interim period.

to understand whether their planned estuary projects are resilient to climate change (i.e., sea level rise, temperatures, and mainstem flow levels). In addition, the Action Agencies' annual update of their restoration and monitoring plans for the estuary will document any needed adjustments in design, location, or other elements of a given project to address climate change impacts, both during and beyond the interim period.

2.9.3.1.6 Fish Status Monitoring Actions

Adult Overshoot

A large proportion of MCR steelhead from the John Day and Umatilla MPGs do not enter their natal tributaries during the summer migration period, likely because of elevated water temperatures and low flow. Based on PIT detections, a large group of these fish overshoot McNary Dam, presumably to hold until conditions in natal tributaries improve. Many of these fish do not attempt to migrate back downstream through McNary Dam until after prescribed spill has ended in August, and a smaller portion do not attempt downstream migration until after the juvenile bypass system has shut down in mid-November–which leaves the turbines (lowest survival route for adult steelhead) as the only available passage route for many of these fish.

The 2008 biological opinion required that the Action Agencies investigate methods of estimating overshoot fallback and develop operations or structural improvements, if prudent, to improve survival for adult steelhead that fall back over mainstem dams. Research has demonstrated the spillway weir is the most effective and safe route to pass adult steelhead at McNary Dam, and confirmed that the turbine unit had significantly lower survival, presumably caused by blade strike and shear forces (Normandeau et al. 2014).

Keefer and his colleagues (2007) found that overshoot-related winter fallback mortality may be relatively high at dams closest to home tributaries, such as for John Day River fish at McNary Dam. They estimated the relative survival impacts of winter (November–April) fallbacks by steelhead at lower Columbia and lower Snake River dams and found that fallback in March and November has the largest negative effect on survival. They concluded that providing alternative fallback routes at dams during winter can improve overall survival of steelhead. Richins and Skalski (2018) found evidence that successful arrival at spawning tributaries was reduced for steelhead that overshot dams, and provide evidence that spill during the steelhead spawning migration period should improve homing to natal tributaries.

As described in the proposed action (Ponganis 2019), the Action Agencies plan to fund and support an overshoot steelhead evaluation at McNary Dam beginning in September of 2019. A limited volume of TSW spill (8-11 Kcfs) will be used in conjunction with hydroacoustic and PIT tag monitoring to evaluate passage timing and migration success (and to assess potential impacts to non-targeted stocks of fish). The results of this study are necessary to develop a future operation that supports a high rate of adult MCR steelhead migration success without creating unnecessary losses to power revenue by effectively syncing the timing of a long term operation and providing an effective volume of water.

2.9.3.1.7 Research and Monitoring Activities

The Action Agencies' RM&E program will be similar to the current program, or will be implemented at a reduced scale. Thus, the level of injury and mortality discussed in the Environmental Baseline, primarily from the capture and handling of fish, is likely to continue at a similar or reduced level. We estimate that, on average, the following number of MCR steelhead will be affected each year during the interim period:

- Projected estimates of MCR steelhead handling and mortality during activities associated with the Smolt Monitoring Program and CSS: (1) zero hatchery or wild adults handled; (2) zero hatchery or wild adults killed; (3) 1,000 hatchery and 23,495 wild juveniles handled; and (4) ten hatchery and 266 wild juveniles killed.
- Projected estimates of MCR steelhead handling and mortality during activities associated with Fish Status Monitoring:[97] (1) 100 hatchery and 1,200 wild adults handled; (2) one hatchery and 12 wild adults killed; (3) 8,613 hatchery and 43,642 wild juveniles handled; and (4) 86 hatchery and 436 wild juveniles killed.
- Projected estimates of MCR steelhead handling and mortality for all other RM&E programs: (1) 720 hatchery and 200 wild adults handled; (2) seven hatchery and two wild adults killed; (3) 1,001 hatchery and 15,308 wild juveniles handled; (4) ten hatchery and 153 wild juveniles killed.

The combined observed mortality associated with these elements of the RM&E program will, on average, affect less than 1 percent of the wild (i.e., natural origin) adult returns or juvenile production for the MCR steelhead DPS (Bellerud 2018). Although we estimate that 5.44 percent of the wild adults and 19.76 percent of the wild juvenile production will be handled each year, on average, we expect that only up to 1 percent of these will die after release (in this case, 0.05 percent of adults and 0.20 percent of juveniles handled). This relatively small effect is deemed worthwhile because it will allow the Action Agencies and NMFS to continue to evaluate the effects of CRS operations including modifications to facilities, operations, and mitigation actions.

Electrofishing operations for the NPMP during the interim period are expected to continue at the same level of effort as in recent years (four 15-minute sampling events per 0.6-mile reach between RM 47 near Clatskanie, Oregon, and Priest Rapids Dam on the Columbia River and the head of Lower Granite Reservoir on the Snake River during April-July). Some adult and juvenile MCR steelhead are likely to be present in shallow shoreline areas during electrofishing activities and may be stunned and even killed. However, because the operator releases the electrical field as soon as salmonids are observed and most of these fish quickly recover and swim away, we are unable to use observations from past operations to estimate the number of fish from this DPS that will be affected. Information obtained through electrofishing supports management of the NPMP, which is reported to have reduced salmonid predation by about 30 percent (Williams et

[97] Fish Status Monitoring is intended to include individuals handled/killed during status and trend, "fish-in/fish out," and habitat effectiveness monitoring projects.

al. 2017). This level of take is anticipated to occur for the duration of this proposed action, pending completion of the NEPA process.

2.9.3.2 Effects to Critical Habitat

Implementation of the proposed flexible spring spill operation is likely to affect passage at the four lower Columbia River dams.

Implementation will also affect the volume and timing of flow in the Columbia and Snake Rivers, which has the potential to alter habitat in the mainstem of both rivers and the Columbia River estuary. The PBFs that could be affected by the proposed action are described in Table 2.9-12.

Table 2.9-12. Effects of the proposed action on the physical and biological features (PBFs) essential for the conservation of the MCR steelhead DPS.

Physical and Biological Feature (PBF)	Effects of the Proposed Action
Freshwater spawning and rearing sites	Due to uncertainty about whether the Action Agencies will implement actions within spawning and rearing areas designated as critical habitat for this DPS, and the types of action, locations of actions, and level of effort, it is not possible to predict effects on PBFs
Freshwater migration corridors	Continuation of altered seasonal flows (decreased spring and early-summer flows and increased winter flows) due to system wide storage operations, including those at CRS reservoirs (reduced water quantity in the juvenile migration corridor) Continuation of delayed spring warming, delayed fall cooling, and reduced daily temperature variability due to the thermal inertia of the CRS reservoirs (reduced water quality in juvenile and adult migration corridors) Continuation of decreased survival through the CRS dams and reservoirs, although the flexible spring spill operation is likely to slightly improve travel time and direct juvenile survival to below Bonneville Dam (safe passage) Continuation of adult steelhead overshoot and fallback at CRS run-of-river dams and funding study to examine steelhead overshoot at McNary Dam (safe passage) Increasing the operating range by six inches at John Day Dam (MIP 2-foot range) will slightly increase juvenile travel times and exposure to predators (obstructions and excessive predation in juvenile migration corridors) Sediment will continue to accumulate behind CRS dams, reducing turbidity in the migration corridor during the spring smolt outmigration, which could affect the safe passage PBF by increasing the risk of predation Ongoing implementation of the Action Agencies' predator-management programs will continue the current functioning of critical habitat relative to predation in the juvenile and adult migration corridors (safe passage) Increase in TDG levels up to the state-approved limits (up to 120 or 125 percent TDG) at the CRS run-of-river projects) will result in only a slight increase in the incidence and severity of GBT symptoms (water quality in the juvenile and adult migration corridor) (water quality in the juvenile and adult migration corridor) Increased spill levels resulting from the flexible spring spill operation (up to 120 or 125 percent TDG levels) can degrade tailrace conditions (especially at John

Physical and Biological Feature (PBF)	Effects of the Proposed Action
	Day Dam under low flow conditions), slightly increasing the risk of bird and fish predation (safe passage)
Estuarine areas	This PBF will continue to improve with the proposed reconnection of an average of 300 acres of floodplain habitat per year during implementation of this proposed action (increased access to forage) Because estuary bird colonies and predation rates are in flux, it is not clear whether the continued tern and cormorant colony management is likely to continue any existing survival benefits; thus, we expect the predation risk to remain unchanged (safe passage)

2.9.4 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation (50 CFR 402.02). Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Nonfederal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. These projects also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth management programs (planning and regulation); a variety of stream and riparian habitat projects; watershed planning and implementation; acquisition of water rights for instream purposes and sensitive areas; instream flow rules; stormwater and discharge regulation; TMDL implementation to achieve water-quality standards; hydraulic project permitting; and increased spill and bypass operations at hydropower facilities. NMFS determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. These activities are likely to have beneficial cumulative effects that will significantly improve conditions for the salmon and steelhead, including MCR steelhead.

NMFS also noted that some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects are activities that occurred in the recent past and were included in the environmental baseline. Some of these activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if

authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the action area, nonfederal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations.

Some continuing nonfederal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult, if not impossible, to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline.

Overall, we anticipate that projects to restore and protect habitat, restore access to and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area.

2.9.5 Integration and Synthesis

In this section, we add the effects of the action (Section 2.9.3) to the environmental baseline (Section 2.9.2) and the cumulative effects (Section 2.9.4), taking into account the status of the species and critical habitat (Sections 2.9.1.1 and 2.9.1.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat for the conservation of the species.

2.9.5.1 Species

The MCR steelhead DPS, among those residing in the CRS action area, has the best prospects of recovery. The MCR recovery plan predicts that the DPS can achieve a low risk of extinction within a reasonable time frame—e.g., 25 to 50 years—if recovery actions are taken and have the predicted effects on steelhead habitat and survival. The most recent five-year status review indicated there have been improvements in the viability ratings of some 17 populations in the DPS, but the DPS as whole is not currently meeting the viability criteria. While one MPG (John Day) appears to be on a pathway to meet recovery plan goals, with all populations achieving at least a maintained or viable status, the other MPGs all have at least one population that are rated at high risk. While four populations within the DPS are currently rated at high risk, perhaps the greatest attribute that MCR steelhead have in resisting extinction is the large number of maintained or viable populations with healthy adult returns that support the overall viability of the DPS; 12 of the 17 populations are currently ranked highly viable, viable, or maintained.

The pattern of population viability is important as well. For example, each MPG has at least two of the healthier populations, even though there is a difference in the number of mainstem dams that the populations within each MPG are exposed to. Populations in the Eastern Cascades MPG (five extant populations) are exposed to one or two mainstem dams, and the current overall viability ratings include two populations at high risk and one population at viable. Similarly, all five populations in the John Day River MPG are exposed to three mainstem dams and one population is rated highly viable, two are currently viable, and two are maintained. Thus, the important risk factor does not appear to be the number of dams that the population must pass to reach natal habitat. Rather, important risk factors that continue to affect these populations include: (1) blocked access to historic tributary spawning areas; (2) degraded spawning and rearing habitat; (3) juvenile mortality due to passage through the dams; (4) predation in the reservoirs; (5) adult survival through mainstem dams and reservoirs; and (6) out-of-basin straying and introgression.

The environmental baseline conditions remain degraded, but baseline conditions have shown some notable improvements. In the mainstem, a 24-hour spill program, surface passage routes, improved spill patterns, and improvements to juvenile bypass systems have all benefited survival rates and passage in recent years. Estimates from McNary to Bonneville Dam (which include both natural and dam-related losses) indicate that an average of 62 percent of steelhead smolts survive, and while there is some variability in the data, the lowest survival estimates observed in the last ten years are far higher than the lowest survival estimates measured prior to these improvements. While much of the tributary habitat remains degraded, recent barrier removals (i.e., Condit dam; irrigation diversions) and other tributary habitat improvements funded and implemented by the Action Agencies and other federal, tribal, state, local, and private entities are improving habitat conditions in some places, and available information indicates that fish populations have responded, and will continue to respond positively.

Other environmental baseline conditions regarding predation have shown no change or have degraded conditions for the DPS. Pinniped predation on MCR steelhead downstream of Bonneville Dam has increased slightly with recent increases in the abundance of SSL in the summer and fall. With respect to avian predation in the estuary, the ongoing management of the tern and cormorant colonies at East Sand Island is expected to reduce smolt predation rates, but monitoring results from 2018 and the interim period and the data compilation expected in the avian predation synthesis report will be needed for confirmation. Increased numbers of predators, including birds and native and nonnative fishes that prey on yearling steelhead, are also present in the hydrosystem reach. The reduced levels of predation by Caspian terns nesting on Goose and Crescent Islands on the interior Columbia plateau that were achieved under the 2008 RPA will be maintained by the continued implementation of the IAPMP.

The status of MCR steelhead is also likely to be affected by climate change. Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycles. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater and changes to food webs in freshwater, estuarine, and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management actions may help alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations, increased riparian vegetation to control water temperatures, etc.).

Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life-history types that will be successful in the future are neither static nor predictable. Therefore, maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the MCR steelhead DPS. Because of its location in the Columbia River basin, the ESU is likely to be more affected by climate-related effects in the estuary, and in tributary streams (altered seasonal flows and temperatures) that support spawning and early rearing. Emerging research using complex life-cycle modeling indicates a potentially strong link between SST and survival of Snake River spring/summer Chinook salmon populations. However, the apparent link between SST and survival is presumably caused by food web interactions, relationships which could be disrupted by major transformations of community dynamics as well as ocean acidification and other factors under a changing climate. The degree to which SST is linked to survival of MCR steelhead, and how that relationship interacts with other variables throughout the MCR steelhead life cycle, will likely be an important area of future research.

When evaluating the effects of the action, those effects must be taken together with the effects on MCR steelhead of future state or private activities, not involving federal activities that are reasonably certain to occur within the action area. NMFS anticipates that human development activities will continue to have adverse effects on MCR steelhead in the action area. Many of these activities and their effects occurred in the recent past and were included in the environmental baseline, but are also reasonably certain to occur in the future. Within the action area, nonfederal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Habitat restoration efforts led by state and local agencies, tribes, environmental organizations, and local communities are likely to continue. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives that, in some cases, are identified through ESA recovery plans. Larger, more regionwide, restoration and conservation efforts are either underway or planned throughout the Columbia River basin. These state and private actions have helped restore habitat, improve fish passage, and reduce pollution. While these efforts are reasonably certain to continue to occur, funding levels may vary on an annual basis.

Based on the proposed action, the future operation of the CRS will generally continue to affect MCR steelhead within the action area in the manner described in the environmental baseline (changes to flows, highly altered/inundated habitat, juvenile and adult passage survival, exposure to predators, predator hazing and reduction programs, alterations in water quality, reduced survival, research and monitoring, etc.). The following actions will affect MCR steelhead differently than operations that have occurred recently. During the spring spill period,the proposed spring spill will increase juvenile fish passage spill levels up to state water quality limits, which is likely to reduce powerhouse passage, increase spillway passage, and lead to a slight reduction in travel time. While these estimated differences are small, shorter travel times can lead to quicker ocean entry and potentially improve survival for MCR steelhead.

The Action Agencies propose to reduce August spill at all four lower Snake River dams and the four lower Columbia dams in 2020 if consensus is achieved among parties to the legal agreement. However, this should have minimal effect on MCR steelhead, since juveniles do not pass through the Snake River and the small portion of overshooting MCR steelhead adults do not readily fall back and migrate to natal tributaries during warm August passage conditions (Keefer et al. 2016). The McNary adult overshoot evaluation is likely to improve conditions for MCR steelhead adults and increase the percentage of adults returning to spawning grounds. Ending transport in the summer (as proposed for consideration in 2020) would have no effect on MCR steelhead as juveniles of this species migrate earlier in the spring.

Continued estuary habitat and, potentially, tributary habitat restoration activities may benefit MCR steelhead migrating through the estuary. Improved conditions in estuary habitat are hypothesized to improve amount and quality of prey available to MCR steelhead, and tributary habitat actions that have occurred or may occur are expected to improve on degraded habitat conditions, with the greatest benefits occurring over a longer time scale (i.e., riparian habitat developing over a scale of 10–50 years).

The Middle Columbia steelhead recovery plan outlines specific objectives for each of the four MPGs and the 17 extant populations. While none of the MPGs are meeting the identified viability objectives (refer to Table 2.9-5), all four MPGs have viable or maintained populations and realistic strategies for achieving MPG-level viability. The recovery plan addresses the underlying limiting factors and threats for MCR steelhead, including hydropower projects, predation, hatchery effects, legacy effects from historical harvest, tributary habitat, and ocean conditions. The recovery plan identifies recovery actions to be implemented, generally over a 25-year period, as specified in the four management unit plans. Effective implementation requires that the recovery efforts of diverse private, local, state, tribal, and federal parties across two states be coordinated at multiple levels. The proposed action will not result in reductions to MCR steelhead reproduction, numbers, or distribution that would impede the ability to successfully carry out the identified recovery measures and actions over the time frames considered in the recovery plan.

After reviewing and analyzing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, and considering the interim nature of this proposed action pending the decision to implement a new action as a result of the NEPA process, it is NMFS' biological opinion that the proposed action is not likely to reduce appreciably the likelihood of both survival and recovery of MCR steelhead by reducing MCR steelhead numbers, reproduction, or distribution.

2.9.5.2 Critical Habitat

Critical habitat for MCR steelhead encompasses 15 subbasins containing 111 occupied watersheds, as well as the Columbia River rearing/migration corridor. Across the designated area, land use activities have disrupted watershed processes, reduced water quality, and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and/or current land use or water management activities have adversely affected the quality and quantity of stream and side channel areas, riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for salmon and steelhead production have been weakened.

Specific effects on the functioning of critical habitat in the migration corridor have included the loss of access to historical spawning habitat upstream of Condit Dam in the White Salmon River (obstructions in the adult migration corridor) until the project was removed in 2012, and upstream of the Opal Springs Hydroelectric Project on the Deschutes River where a fish ladder is under construction. Passage times have increased, and juvenile and adult survival have been reduced, at the CRS run-of-river dams with passage facilities. Some adult steelhead will continue to overshoot their spawning tributaries and fallback at mainstem dams. The proposed flexible spring spill program is likely to slightly reduce travel times and improve the direct survival of juvenile steelhead to below Bonneville Dam. Levels of TDG will increase to state water quality limits during the flexible spill operation, and may somewhat increase the incidence of GBT symptoms. Seasonal flows and temperatures will continue to be altered, with negative effects on water quantity and quality. Increased numbers of predators, including birds and native and nonnative fishes that prey on yearling steelhead, are present in the hydrosystem reach (excessive predation in the juvenile migration corridor). The reduced levels of predation (by Caspian terns on the interior Columbia plateau, northern pikeminnows in project tailraces and reservoirs, and sea lions in the Bonneville tailrace) that were achieved under the 2008 biological opinion and associated RPA will be maintained by the continued implementation of the respective predator-management plans (reduction in the level of excessive predation).

In the lower Columbia River estuary, the proposed habitat restoration program will continue to reconnect the historical floodplain, increasing the availability of wetland-derived prey to yearling steelhead migrating to the ocean (improved forage in estuarine areas). Toxic contaminants, an effect of land use practices, will continue to be present, especially near urban and industrial areas (reduced water quality in estuarine areas). With respect to predator management, the states will have the option to continue to reduce the number of CSL in the lower Columbia River (NMFS' Letter of Authorization under the MMPA extends through 2021). Ongoing management of the tern and cormorant colonies at East Sand Island is expected to reduce smolt predation rates, but monitoring results from 2018 and the interim period and the data compilation expected in the avian predation synthesis report will be needed for confirmation.

Degraded PBFs in tributary habitat include the loss of substrate, side channels, natural cover, vegetation, and forage; degraded water quality; and the presence of obstructions in areas used for spawning and rearing. Due to uncertainty about whether the Action Agencies will implement actions within spawning and rearing areas designated as critical habitat for this DPS, the types and locations of actions, and the level of effort, it is not possible to predict whether the condition of these PBFs is likely to improve.

Considering the ongoing and future effects of the environmental baseline and cumulative effects, and in light of the status of critical habitat, the proposed action will not appreciably reduce the value of designated critical habitat for the conservation of MCR steelhead.

2.9.6 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, and considering the short-term duration of the proposed action, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of MCR steelhead or destroy or adversely modify its designated critical habitat.

2.10 Upper Columbia River (UCR) Steelhead

This section applies the analytical framework described in section 2.1 to the UCR steelhead DPS and provides NMFS' finding regarding whether the proposed action is likely to jeopardize the continued existence of UCR steelhead or destroy or adversely modify its critical habitat.

2.10.1 Rangewide Status of the Species and Critical Habitat

The status of the Upper Columbia River (UCR) steelhead DPS is determined by the level of extinction risk that UCR steelhead face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The condition of critical habitat throughout the designated area is determined by the current function of the PBFs that help to form that conservation value.

2.10.1.1 Status of the Species

The UCR steelhead DPS was originally listed under the ESA in 1997 as an endangered species (62 FR 43937), but was then listed as a threatened species on January 5, 2006 (71 FR 834). The DPS was reclassified as endangered on January 13, 2007 (74 FR 42605). However, the status was changed to threatened again in 2009 (74 FR 42605) and was reaffirmed on April 14, 2014 (79 FR 20802). Critical habitat for the UCR Steelhead DPS was designated on September 2, 2005 (70 FR 52630). In 2016, the five-year review for UCR steelhead concluded the species should remain listed as a "threatened" species (NMFS 2016a).More detailed information can be found in the recovery plan and status review for this species. These documents are available on the NMFS West Coast Region website (http://www.westcoast.fisheries.noaa.gov/).

The UCR steelhead DPS is composed of a single MPG and includes all naturally spawned anadromous *O. mykiss* (steelhead) populations below natural and artificial impassable barriers in streams within the Columbia River basin, upstream from the Yakima River, Washington, to the U.S./Canada border, as well as six artificial propagation programs: Wenatchee River, Wells Hatchery (in the Methow and Okanogan Rivers), Winthrop National Fish Hatchery (NFH), Omak Creek, and the Ringold Hatchery programs. Historically, there were likely a total of three MPGs (Figure 2.10-1). Two additional steelhead MPGs likely spawned above Grand Coulee and Chief Joseph Dams, but these MPGs are extirpated, and reintroduction is not required for ESA recovery (UCSRB 2007). NMFS has defined the UCR steelhead DPS to include only the anadromous members of this species (70 FR 67130).

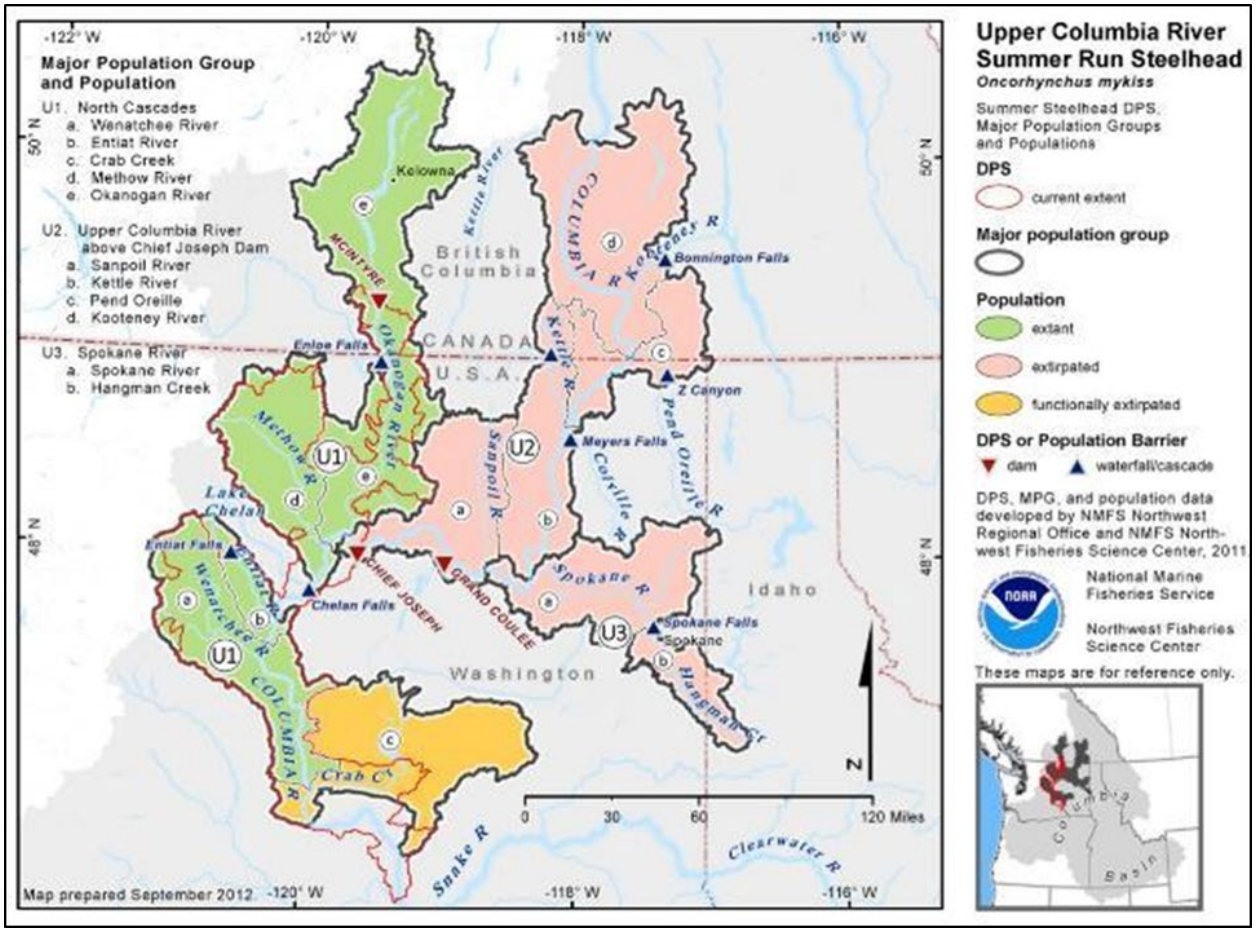


Figure 2.10-1. Map of the UCR steelhead DPS' spawning and rearing areas, illustrating natural populations and both extant and historical MPGs (NWFSC 2015).

The life-history pattern of steelhead in the UCR DPS is complex (Chapman et al. 1994). UCR steelhead exhibit a stream-type life, with individuals exhibiting a yearling life-history strategy (NMFS 2016a). Adults return to the Columbia River in the late summer and early fall. Unlike spring-run Chinook salmon, most steelhead do not move upstream quickly to tributary spawning streams. A portion of the returning run overwinters in the mainstem Columbia River reservoirs, passing into tributaries to spawn in April and May of the following year. Spawning occurs in the late spring of the year following entry into the Columbia River. Juvenile steelhead generally spend one to three years rearing in freshwater before migrating to the ocean, but have been documented spending as many as seven years in freshwater before migrating (Peven 1990; Mullan et al. 1992). Most adult steelhead return to the Upper Columbia River basin after one or two years at sea. UCR steelhead have a relatively high fecundity, averaging between 5,300 and 6,000 eggs (Chapman et al. 1994; UCSRB 2007).

Table 2.10-1. Recent status and limiting factors information for the UCR steelhead DPS considered in this biological opinion.

Status Summary	Limiting Factors
This DPS is comprised of one MPG (Upper Columbia/East Slopes Cascades) and four populations. UCR steelhead populations have increased relative to the low levels observed in the 1990s, but natural-origin abundance and productivity remain well below viability thresholds for three out of the four populations. The abundance and productivity viability rating for the Wenatchee River exceeds the minimum threshold for 5% extinction risk. However, the overall DPS status remains unchanged from the prior review, remaining at high risk driven by low abundance and productivity relative to viability objectives and diversity concerns. The proportions of hatchery-origin returns in natural spawning areas remain high across the DPS, especially in the Methow and Okanogan River populations. The improvements in natural returns in recent years largely reflect several years of relatively good natural survival in the ocean and tributary habitats. Tributary habitat actions called for in the Upper Columbia River steelhead recovery plan are anticipated to be implemented over the next 25 years, and the benefits of some of those actions will require some time to be realized.	● Historically, industrial ocean fishing ● Effects related to hydropower system (including FERC-licensed projects) in the mainstem Columbia River, including reduced upstream and downstream fish passage, altered ecosystem structure and function, altered flows, and degraded water quality ● Degradation of floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream flow, and water quality ● Degraded estuarine and nearshore marine habitat ● Hatchery-related effects ● Persistence of non-native (exotic) fish species continues to affect habitat conditions for listed species ● Harvest in Columbia River fisheries

2.10.1.1.1 Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the UCR steelhead DPS, is at high risk and remains at threatened status. The most recent status update used an updated data series on spawner abundance, age structure, and hatchery-to-wild spawner proportions to generate current assessments of abundance and productivity at the population level. As of the last status review, steelhead numbers had increased relative to the low levels observed in the 1990s, but natural-origin abundance and productivity remained well below viability thresholds for three out of the four populations (NWFSC 2015; NMFS 2016a; Figure 2.10-2). The most recent estimates of natural-origin spawner abundance for each of the four populations show fairly consistent patterns throughout the years. Current risk is driven by low abundance and productivity and concerns about diversity, largely driven by chronic high levels of hatchery spawners within natural spawning areas and lack of genetic diversity among the populations, especially in the Methow and Okanogan Rivers (Table 2.10-2; NMFS 2016a). Recent changes in hatchery practices in the Wenatchee River provide the potential for reduced hatchery contributions or increased spatial separation of hatchery- and natural-origin spawners, which could strengthen the influence of natural selection over time.

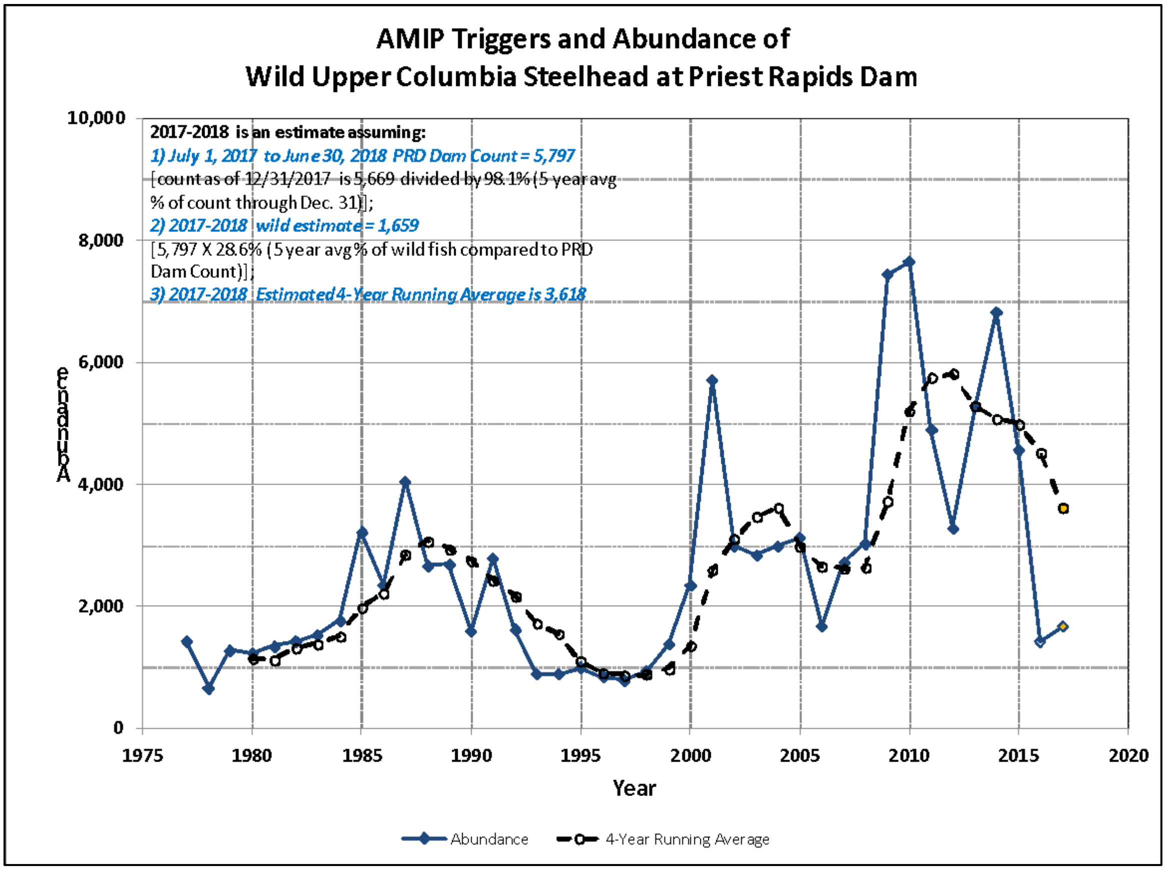


Figure 2.10-2. The abundance of wild UCR steelhead at Priest Rapids Dam from 1977 through 2016.

Table 2.10-2. Viability assessments for extant UCR steelhead populations. Natural spawning abundance: most recent 10-year geometric mean (range). ICTRT productivity: 20-year geometric mean for parent escapements below 75 percent of population threshold. Current abundance and productivity estimates are geometric means. A/P is the ratio of abundance to productivity. SS/D is the ratio of spatial structure to diversity. Upward arrows: current estimates increased over prior review. Oval: no change, downward arrow indicate estimate has decreased (from NWFSC 2015).

	Abundance & productivity metrics				Spatial structure & diversity metrics			Overall viability rating
Population	**ICTRT minimum threshold**	**Natural Spawning Abundance**	**ICTRT productivity**	**Integrated A/P risk**	**Natural processes risk**	**Diversity risk**	**Integrated SS/D risk**	
Wenatchee River	1,000	1,025 ←	1.207 □	Low	Low	High	High	Maintained
Entiat River	500	146 ←	0.434 →	High	Moderate	High	High	High Risk
Methow River	1,000	651 ←	0.371 □	High	Low	High	High	High Risk
Okanogan River	750	189 ←	0.154 □	High	High	High	High	High Risk

All extant natural populations are considered to be at high risk of extinction for the integrated spatial structure and diversity metric (Ford 2011; NWFSC 2015). The high-risk ratings for this metric are largely driven by chronic high levels of hatchery spawners within natural spawning areas and lack of genetic diversity among the populations. The proportions of hatchery-origin returns in natural spawning areas remain extremely high across the DPS, especially in the Methow and Okanogan River populations. In 2015, the five-year review for the UCR steelhead concluded the species should maintain its threatened listing classification (NWFSC 2015).

UCR steelhead populations have increased in natural-origin abundance in recent years, but productivity levels remain low. The modest improvements in natural returns are probably primarily the result of several years of relatively good natural survival in the ocean and tributary habitats (NWFSC 2015; NMFS 2016a), and recent downturns in abundance reflect recent poor ocean conditions. The UCR steelhead populations have increased in size relative to the low levels observed in the 1990s, but natural-origin abundance and productivity remain well below viability thresholds for three out of the four populations. The status of the Wenatchee River steelhead population has continued to improve, based on the additional years of information available for the most recent 2015 status review, and the abundance and productivity viability rating for the population exceeds the minimum threshold for five percent extinction risk. However, the overall DPS status of high risk remains unchanged from the prior review, driven by low abundance and productivity relative to viability objectives and diversity concerns. The required improvements to improve the abundance/productivity estimates for the UCR steelhead populations are at the high end of the range for all listed Interior Columbia DPS populations (NWFSC 2015).

2.10.1.1.2 Recovery Plan

NMFS adopted a recovery plan for UCR steelhead in 2007 (72 FR 57303). The plan was developed by the Upper Columbia Salmon Recovery Board (UCSRB) and is available on the West Coast Region website.[98] Achieving recovery (delisting) via sufficient improvement in abundance, productivity, spatial structure, and diversity is the longer-term goal of the recovery plan. The plan includes specific quantitative criteria expressed relative to population viability curves (UCSRB 2007). The ICTRT had recommended that at least two of the four extant populations be targeted for highly viable status (less than 1 percent risk of extinction over 100 years) because of the relatively low number of extant populations remaining in the DPS. The recovery plan adopted an alternative approach for addressing the limited number of populations in the DPS by requiring that the four extant populations achieve viability (i.e., five percent or less risk of extinction). Thus recovery of the Upper Columbia Steelhead DPS will require recovery of the Wenatchee, Entiat, Methow, and Okanogan populations, but not the Crab Creek population, to viable levels (UCSRB 2007).

[98] https://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/recovery_planning_and_implementation/upper_columbia/upper_columbia_river_salmon_recovery_sub_domain.html (last accessed March 2019).

The recovery plan also notes that restoring the distribution of naturally produced steelhead to previously occupied areas, where practical, would help to reduce extinction risk and conserve the DPS's genetic and phenotypic diversity, but that this is not required for recovery. Specific criteria included in the plan reflect a combination of the criteria recommended by the ICTRT (ICTRT 2007) and an earlier pre-ICTRT analytical project (Ford et al. 2001). The plan incorporates spatial structure criteria specific to each steelhead population. For the Wenatchee River population, the criteria require observed natural spawning in four of the five major spawning areas, as well as in at least one of the minor spawning areas downstream of Tumwater Dam. For the Methow River population, natural spawning should be observed in three major spawning areas. In each case, the major spawning areas should include a minimum of five percent of the total return to the system, or 20 redds, whichever is greater. The plan incorporates criteria for spatial structure and diversity adopted from the ICTRT viability report. The mean score for the three metrics representing natural rates and spatially mediated processes should result in a moderate or lower risk in each of the three populations, and all threats defined as high risk must be addressed. In addition, the mean score for the eight ICTRT metrics tracking natural levels of variation should result in a moderate or lower risk score at the population level (NWFSC 2015).

2.10.1.1.3 Limiting Factors

Understanding the limiting factors and threats that affect the UCR Steelhead DPS provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting the species is to ensure that the underlying limiting factors and threats have been addressed.

Many factors affect the abundance, productivity, spatial structure, and diversity of the UCR steelhead DPS. Factors that limit the DPS (in no particular order) have been, and continue to be, hydropower effects, agricultural effects, and habitat degradation. UCSRB (2017) describes limiting factors for this DPS as including:

- Effects related to the hydropower system (including FERC-licensed projects) in the mainstem Columbia River, including reduced upstream and downstream fish passage, altered ecosystem structure and function, altered flows, and degraded water quality;
- Degradation of floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream flow, and water quality;
- Degraded estuarine and nearshore marine habitat;
- Hatchery-related effects;
- Persistence of non-native (exotic) fish species that continues to affect habitat conditions for listed species; and
- Effects from harvest in Columbia River fisheries, including intense commercial fishing in the lower Columbia River during the mid-to-late 1800s.

2.10.1.2 Status of Critical Habitat

This section examines the rangewide status of designated critical habitat for UCR steelhead. Critical habitat includes the stream channels within designated stream reaches and a lateral extent defined by the ordinary high-water line (33 CFR 319.11).

For UCR steelhead, NMFS ranked watersheds within designated critical habitat at the scale of the fifth-field HUC_5 in terms of the conservation value they provide to each listed species they support.[99] The conservation rankings are high, medium, or low. To determine the conservation value of each watershed to species viability, NMFS' critical habitat analytical review teams (CHARTs) evaluated the quantity and quality of habitat features (e.g., spawning gravels, wood and water condition, and side channels), the relationship of the area compared to other areas within the species' range, and the significance to the species of the population occupying that area (NMFS 2005a). Thus, even a location that has poor quality of habitat could be ranked with a high conservation value if it were essential due to factors such as limited availability (e.g., one of a very few spawning areas), a unique contribution of the population it served (e.g., a population at the extreme end of geographic distribution), or if it serves another important role (e.g., obligate area for migration to upstream spawning areas).

NMFS determines the rangewide status of critical habitat by examining the condition of the PBFs that were identified when critical habitat was designated (Table 2.10-3). These features are essential to the conservation of the listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration, and foraging). These areas include rearing sites with overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks and migration corridors free of artificial obstruction with sufficient water quantity and quality.

[99] The conservation value of a site depends upon "(1) the importance of the populations associated with a site to the ESU [or DPS] conservation, and (2) the contribution of that site to the conservation of the population through demonstrated or potential productivity of the area" (NMFS 2005a).

Table 2.10-3. Physical and biological features (PBFs) of critical habitat designated for UCR steelhead and components of the PBFs.

Physical and Biological Feature	Components of the PBF
Freshwater spawning sites	• Water quantity and quality and substrate to support spawning, incubation, and larval development
Freshwater rearing sites	• Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility • Water quality and forage supporting juvenile development • Natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks
Freshwater migration corridors	• Free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival
Estuarine areas	• Free of obstruction and excessive predation with: - Water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater - Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels - Juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation
Nearshore marine areas[1]	• Free of obstruction and excessive predation with: - Water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation - Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels
Offshore marine areas	• Not designated

1 Designated area includes only the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

The complex life cycle of UCR steelhead gives rise to complex habitat needs, particularly in freshwater. The gravel used for spawning must be a certain size and largely free of fine sediments to allow successful incubation of the eggs and later emergence or escape from the gravel as alevins. Eggs also require cool, clean, and well-oxygenated waters for proper development. Juveniles need abundant food sources, including insects, crustaceans, and other small fish. They need instream places to hide from predators (mostly birds and larger fish), such as under logs, root wads, and boulders, as well as beneath overhanging vegetation. They also need refuge from periodic high flows in side channels and off-channel areas and from warm summer water temperatures in cold-water springs and deep pools. Returning adults generally do not feed in freshwater, but instead rely on limited energy stored to migrate, mature, and spawn. Like juveniles, the returning adults also require cool water that is free of contaminants and migratory corridors with adequate passage conditions (timing, water quality/quantity) to allow access to the various habitats required to complete their life cycle (NMFS 2005a).

In the following paragraphs, we discuss the current status of the functioning of the PBFs of critical habitat in the Interior Columbia and Lower Columbia River Estuary recovery domains.

2.10.1.2.1 Interior Columbia Recovery Domain

Critical habitat has been designated for UCR steelhead in the Interior Columbia recovery domain, which encompasses all of the Columbia River basin accessible to anadromous salmon and steelhead above Bonneville Dam. Habitat quality in tributary streams within this domain varies from excellent in wilderness and roadless areas, to poor in areas subject to heavy agricultural and urban development. Critical habitat throughout much of the Interior Columbia recovery domain has been degraded by intense agriculture, alteration of stream morphology (i.e., through channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining, and urbanization. Reduced summer stream flows, impaired water quality, and reduction of habitat complexity are common problems for critical habitat in developed areas (NMFS 2016a).

Habitat quality of migratory corridors in this area have been severely affected by the development and operation of the CRS dams and reservoirs in the mainstem Columbia River, Bureau of Reclamation tributary projects, and privately owned dams in the upper Columbia River basin. Hydroelectric development has modified natural flow regimes of the rivers, resulting in warmer late summer/fall water temperatures, changes in fish community structure that lead to increased rates of piscivorous and avian predation on juvenile salmon and steelhead, and delayed migration for both adult and juvenile salmonids. Physical features of dams, such as turbines,[100] also kill migrating fish. In-river survival is inversely related to the number of hydropower projects encountered by emigrating juveniles. Additionally, development and operation of extensive irrigation systems and dams for water withdrawal and storage in tributaries have altered hydrological cycles (NMFS 2016a).

Many stream reaches designated as critical habitat are listed on the Oregon and Washington section 303(d) Clean Water Act lists for water temperature. Many areas that were historically suitable rearing and spawning habitat are now unsuitable due to high summer stream temperatures. Removal of riparian vegetation, alteration of natural stream morphology, and

[100] Turbine units include many structures: water intake, scroll case, stay vanes and wicket gates, blades, hub, draft tube, and cooling water intakes.

withdrawal of water for agricultural or municipal use all contribute to elevated stream temperatures. Furthermore, contaminants, such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste, are common in some areas of critical habitat (NMFS 2016a). They can negatively impact critical habitat and the organisms associated with these areas.

2.10.1.2.2 Lower Columbia River Estuary Recovery Domain

Critical habitat also has been designated for UCR steelhead in the lower Columbia River estuary. The estuary is broadly defined to include the entire reach where tidal forces and river flows interact, regardless of the extent of saltwater intrusion. This encompasses areas from Bonneville Dam (RM 146) to the mouth of the Columbia River. It also includes the tidally influenced portions of tributaries below Bonneville Dam, including the lower 26 miles of the Willamette River. This region experiences ocean tides that extend from the mouth of the Columbia River up to Bonneville Dam.

Historically, the downstream half of the Columbia River estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. The mouth of the Columbia River was about four miles wide. Winter and spring floods, low flows in late summer, large woody debris floating downstream, and a shallow bar at the mouth of the Columbia River maintained a dynamic environment. Today, navigation channels have been dredged, deepened, and maintained, jetties and pile-dike fields have been constructed to stabilize and concentrate flow in navigation channels, marsh and riparian habitats have been filled and diked, and causeways have been constructed across waterways. These actions have decreased the width of the mouth of the Columbia River to two miles and increased the depth of the Columbia River channel at the bar from less than 20 to more than 55 feet (NMFS 2008a).

Over time, more than 50 percent of the original marshes and spruce swamps in the estuary have been converted to industrial, transportation, recreational, agricultural, or urban uses. More than 3,000 acres of intertidal marsh and spruce swamps have been converted to other uses since 1948. Many wetlands along the shore in the upper reaches of the estuary were converted to industrial and agricultural lands after levees and dikes were constructed. Furthermore, water storage and release patterns from reservoirs upstream of the estuary have changed the seasonal pattern and volume of discharge. The peaks of spring/summer floods have been reduced, and the amount of water discharged during winter has increased (NMFS 2008a).

In addition, model studies indicate that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of suspended particulate matter to the lower river and estuary by about 40 percent (as measured at Vancouver, Washington) and have reduced fine sediment transport by 50 percent or more. The significance of these changes for UCR steelhead salmon is unclear, although estuarine habitat provides food for yearling migrants that move rapidly downstream to the ocean (Johnson et al. 2018; PNNL and NMFS 2018).

Functioning estuarine areas are essential to conservation because, without them, juvenile UCR steelhead cannot reach the ocean in a timely manner and use the variety of habitats that allow them to avoid predators, compete successfully, and complete the behavioral and physiological changes needed for life in the ocean. Similarly, these features are essential to the conservation of adult salmonids because these features in the estuary provide a final source of abundant forage that will provide the energy stores needed to make the physiological transition to freshwater, migrate upstream, avoid predators, and develop to maturity upon reaching spawning areas (NMFS 2005a).

2.10.1.3 Climate Change Implications for UCR Steelhead and Critical Habitat

One factor affecting the rangewide status of UCR steelhead and aquatic habitat is climate change. The USGCRP[101] reports average warming of about 1.3ºF from 1895 to 2011, and projects an increase in average annual temperature of 3.3ºF to 9.7ºF by 2070 to 2099 (CCSP 2014). Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004; Scheuerell and Williams 2005; Zabel et al. 2006; ISAB 2007). According to the ISAB,[102] these effects pose the following impacts into the future:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season;
- With a smaller snowpack, watersheds will see their runoff diminished earlier in the season, resulting in lower stream-flows in the June through September period. River flows in general and peak river flows are likely to increase during the winter due to more precipitation falling as rain rather than snow; and
- Water temperatures are expected to rise, especially during the summer months when lower stream-flows co-occur with warmer air temperatures.

These changes will not be spatially homogeneous across the entire Pacific Northwest. Low-lying areas are likely to be more affected. Climate change may have long-term effects that include, but are not limited to, depletion of important cold-water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, premature emergence of fry, and increased competition among species.

Climate change is predicted to cause a variety of impacts to Pacific salmon and their ecosystems (Mote et al. 2003; Crozier et al. 2008a; Martins et al. 2012; Wainwright and Weitkamp 2013). The complex life cycles of anadromous fishes, including salmon, rely on productive freshwater, estuarine, and marine habitats for growth and survival, making them particularly vulnerable to environmental variation. Ultimately, the effects of climate change on salmon and steelhead

[101] http://www.globalchange.gov
[102] The Independent Scientific Advisory Board (ISAB) serves the National Marine Fisheries Service (NOAA Fisheries), Columbia River Indian Tribes, and Northwest Power and Conservation Council by providing independent scientific advice and recommendations regarding scientific issues that relate to the respective agencies' fish and wildlife programs. https://www.nwcouncil.org/fw/isab/

across the Pacific Northwest will be determined by the specific nature, level, and rate of change and the synergy between interconnected terrestrial/freshwater, estuarine, nearshore, and ocean environments.

The primary effects of climate change on Pacific Northwest salmon and steelhead include:

- Direct effects of increased water temperatures on fish physiology;
- Temperature-induced changes to stream-flow patterns;
- Alterations to freshwater, estuarine, and marine food webs; and
- Changes in estuarine and ocean productivity.

While all habitats used by Pacific salmon will be affected, the impacts and certainty of the change vary by habitat type. Some effects (e.g., increasing temperature) affect salmon at all life stages in all habitats, while others are habitat-specific, such as stream-flow variation in freshwater, sea-level rise in estuaries, and upwelling in the ocean. How climate change will affect each stock or population of salmon also varies widely depending on the level or extent of change, the rate of change, and the unique life-history characteristics of different natural populations (Crozier et al. 2008b). For example, a few weeks' difference in migration timing can have large differences in the thermal regime experienced by migrating fish (Martins et al. 2011).

2.10.1.3.1 Temperature Effects

Like most fishes, salmon are poikilotherms (cold-blooded animals); therefore, increasing temperatures in all habitats can have pronounced effects on their physiology, growth, and development rates (see review by Whitney et al. 2016). Increases in water temperatures beyond their thermal optima will likely be detrimental through a variety of processes, including increased metabolic rates (and therefore food demand), decreased disease resistance, increased physiological stress, and reduced reproductive success. All of these processes are likely to reduce survival (Beechie et al. 2013; Wainwright and Weitkamp 2013; Whitney et al. 2016).

By contrast, increased temperatures at ranges well below thermal optima (i.e., when the water is cold) can increase growth and development rates. Examples of this include accelerated emergence timing during egg incubation stages, or increased growth rates during fry stages (Crozier et al. 2008a; Martins et al. 2011). Temperature is also an important behavioral cue for migration (Sykes et al. 2009), and elevated temperatures may result in earlier-than-normal migration timing. While there are situations or stocks where this acceleration in processes or behaviors is beneficial, there are also others where it is detrimental (Martins et al. 2012; Whitney et al. 2016).

2.10.1.3.2 Freshwater Effects

Climate change is predicted to increase the intensity of storms, reduce winter snow pack at low and middle elevations, and increase snowpack at high elevations in northern areas. Middle and lower-elevation streams will have larger fall/winter flood events and lower late-summer flows, while higher elevations may have higher minimum flows. How these changes will affect freshwater ecosystems largely depends on their specific characteristics and location, which vary at fine spatial scales (Crozier et al. 2008b; Martins et al. 2012). For example, within a relatively small geographic area (the Salmon River basin in Idaho), survival of some Chinook salmon populations was shown to be determined largely by temperature, while in others it was determined by flow (Crozier and Zabel 2006). Certain salmon populations inhabiting regions that are already near or exceeding thermal maxima will be most affected by further increases in temperature and, perhaps, the rate of the increases. The effects of altered flow are less clear and likely to be basin-specific (Crozier et al. 2008b; Beechie et al. 2013). However, river flow is already becoming more variable in many rivers, and is believed to negatively affect anadromous fish survival more than other environmental parameters (Ward et al. 2015). It is likely this increasingly variable flow is detrimental to multiple salmon and steelhead populations, and likely multiple other freshwater fish species in the Columbia River basin as well.

Stream ecosystems will likely change in response to climate change in ways that are difficult to predict (Lynch et al. 2016). Changes in stream temperature and flow regimes will likely lead to shifts in the distributions of native species and provide "invasion opportunities" for exotic species. This will result in novel species interactions, including predator-prey dynamics, where juvenile native species may be either predators or prey (Lynch et al. 2016; Rehage and Blanchard 2016). How juvenile native species will fare as part of "hybrid food webs," which are constructed from natives, native invaders, and exotic species, is difficult to predict (Naiman et al. 2012).

2.10.1.3.3 Estuarine Effects

In estuarine environments, the two big concerns associated with climate change are rates of sea-level rise and temperature warming (Wainwright and Weitkamp 2013; Limburg et al. 2016). Estuaries will be affected directly by sea-level rise: as sea level rises, terrestrial habitats will be flooded and tidal wetlands will be submerged (Kirwan et al. 2010; Wainwright and Weitkamp 2013; Limburg et al. 2016). The net effect on wetland habitats depends on whether rates of sea-level rise are sufficiently slow that the rates of marsh plant growth and sedimentation can compensate (Kirwan et al. 2010).

Due to subsidence, sea-level rise will affect some areas more than others, with the largest effects expected for the lowlands, like southern Vancouver Island and central Washington coastal areas (Verdonck 2006; Lemmen et al. 2016). The widespread presence of dikes in Pacific Northwest estuaries will restrict upward estuary expansion as sea levels rise, likely resulting in a near-term loss of wetland habitats for salmon (Wainwright and Weitkamp 2013). Sea-level rise will also result in greater intrusion of marine water into estuaries, resulting in an overall increase in salinity, which will also contribute to changes in estuarine floral and faunal communities (Kennedy 1990). While not all anadromous fish species are generally highly reliant on estuaries for rearing, extended estuarine use may be important in some populations (Jones et al. 2014), especially if stream habitats are degraded and become less productive.

2.10.1.3.4 Marine Effects

In marine waters, increasing temperatures are associated with observed and predicted poleward range expansions of fish and invertebrates in both the Atlantic and Pacific Oceans (Lucey and Nye 2010; Asch 2015; Cheung et al. 2015). Rapid poleward species shifts in distribution in response to anomalously warm ocean temperatures have been well documented in recent years, confirming this expectation at short time scales. Range extensions were documented in many species from southern California to Alaska during unusually warm water associated with "the blob" in 2014 and 2015 (Bond et al. 2015; Di Lorenzo and Mantua 2016) and past strong El Niño events (Pearcy 2002; Fisher et al. 2015).

Exotic species benefit from these extreme conditions to increase their distributions. Green crab (*Carcinus maenas*) recruitment increased in Washington and Oregon waters during winters with warm surface waters, including 2014 (Yamada et al. 2015). Similarly, Humboldt squid (*Dosidicus gigas*) dramatically expanded their range during warm years of 2004–09 (Litz et al. 2011). The frequency of extreme conditions, such as those associated with El Niño events or "blobs" is predicted to increase in the future (Di Lorenzo and Mantua 2016).

Expected changes to marine ecosystems due to increased temperature, altered productivity, or acidification, will have large ecological implications through mismatches of co-evolved species and unpredictable trophic effects (Cheung et al. 2015; Rehage and Blanchard 2016). These effects will certainly occur, but predicting the composition or outcomes of future trophic interactions is not possible with current models.

Wind-driven upwelling is responsible for the extremely high productivity in the California Current ecosystem (Bograd et al. 2009; Peterson et al. 2014). Minor changes to the timing, intensity, or duration of upwelling, or the depth of water-column stratification, can have dramatic effects on the productivity of the ecosystem (Black et al. 2014; Peterson et al. 2014). Current projections for changes to upwelling are mixed: some climate models show upwelling unchanged, but others predict that upwelling will be delayed in spring, and more intense during summer (Rykaczewski et al. 2015). Should the timing and intensity of upwelling change in the future, it may result in a mismatch between the onset of spring ecosystem productivity and the timing of salmon entering the ocean, and a shift toward food webs with a strong sub-tropical component (Bakun et al. 2015).

Columbia River anadromous fish also use coastal areas of British Columbia and Alaska and mid-ocean marine habitats in the Gulf of Alaska, although their fine-scale distribution and marine ecology during this period are poorly understood (Morris et al. 2007; Pearcy and McKinnell 2007). Increases in temperature in Alaskan marine waters have generally been associated with increases in productivity and salmon survival (Mantua et al. 1997; Martins et al. 2012), thought to result from temperatures that have been below thermal optima (Gargett 1997). Warm ocean temperatures in the Gulf of Alaska are also associated with intensified downwelling and increased coastal stratification, which may result in increased food availability to juvenile salmon along the coast (Hollowed et al. 2009; Martins et al. 2012). Predicted increases in freshwater discharge in British Columbia and Alaska may influence coastal current patterns (Foreman et al. 2014), but the effects on coastal ecosystems are poorly understood.

In addition to becoming warmer, the world's oceans are becoming more acidic as increased atmospheric CO_2 is absorbed by water. The North Pacific is already acidic compared to other oceans, making it particularly susceptible to further increases in acidification (Lemmen et al. 2016). Laboratory and field studies of ocean acidification show it has the greatest effects on invertebrates with calcium-carbonate shells, and relatively little direct influence on finfish; see reviews by Haigh et al. (2015) and Mathis et al. (2015). Consequently, the largest impact of ocean acidification on salmon will likely be its influence on marine food webs, especially its effects on lower trophic levels, which are largely composed of invertebrates (Haigh et al. 2015; Mathis et al. 2015). Marine invertebrates fill a critical gap between freshwater prey and larval and juvenile marine fishes, supporting juvenile salmon growth during the important early-ocean residence period (Daly et al. 2009, 2014).

2.10.1.3.5 Uncertainty in Climate Predictions

There is considerable uncertainty in the predicted effects of climate change on the globe as a whole, and on the Pacific Northwest in particular, and there is also the question of indirect effects of climate change and whether human "climate refugees" will move into the range of salmon and steelhead, increasing stresses on their respective habitats (Dalton et al. 2013; Poesch et al. 2016).

Many of the effects of climate change (e.g., increased temperature, altered flow, coastal productivity, etc.) will have direct impacts on the food webs that species rely on in freshwater, estuarine, and marine habitats to grow and survive. Such ecological effects are extremely difficult to predict even in fairly simple systems, and minor differences in life-history characteristics among stocks of salmon may lead to large differences in their response (e.g., Crozier et al. 2008b; Martins et al. 2011, 2012). This means it is likely that there will be "winners and losers," meaning some salmon populations may enjoy different degrees or levels of benefit from climate change while others will suffer varying levels of harm.

Climate change is expected to impact anadromous fish during all stages of their complex life cycle. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream-flow patterns in freshwater and changes to food webs in freshwater, estuarine, and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty.

2.10.2 Environmental Baseline

The "environmental baseline" includes the past and present impacts of all federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

For UCR steelhead, we focus our description of the environmental baseline on where UCR steelhead juveniles and adults are exposed to the effects of the proposed action. We also consider the broader action area, including tributary habitat, because the Action Agencies propose to conduct habitat restoration actions and because these areas provide an important context for understanding the effects of the proposed action.

To determine the upstream extent of UCR steelhead distribution and thus exposure, we reviewed data at each dam to examine the potential for UCR steelhead presence. From 2008 to 2017, 14 PIT-tagged adult UCR steelhead were detected at Ice Harbor Dam, representing approximately 0.3 percent of the 4,863 July to December detections at Priest Rapids Dam. Ten of the 14 adults detected at Ice Harbor Dam were detected in 2017 alone (nearly two percent of the 504 adults detected at Priest Rapids Dam). Less than one-tenth of one percent of adults were detected in all the other years combined, compared to detections at Priest Rapids Dam.

Thus, the area in which UCR steelhead are primarily exposed (as either juveniles or adults) to the effects of the proposed action includes all water within the Columbia River from the mouth and plume up to Chief Joseph Dam (with respect to operations that affect flow).

2.10.2.1 Mainstem Habitat

Mainstem habitat in the middle and lower reaches of the Columbia River have been substantially altered by basinwide water management operations, the construction and operation of mainstem hydroelectric projects, the growth of native avian and pinniped predator populations, the introduction of non-native species (e.g., fishes and invertebrates), and other human practices that have degraded water quality.

2.10.2.1.1 Seasonal Flows

Water diversions for a variety of purposes (agricultural, municipal, etc.) and the management of stored water (including runoff stored in Canadian reservoirs, in the U.S. portion of the Columbia Basin, and in the upper Snake River basin, Yakima River basin, and Deschutes River basin) has altered the quantity and timing of flows entering the lower Snake and Columbia Rivers compared to historical conditions.

On the mainstem of the Columbia River, hydropower projects (including the CRS), water storage projects (including reservoirs in Canada operated under the Columbia River Treaty), and the withdrawal of water for irrigation and urban uses have significantly degraded salmon and steelhead habitats (Bottom et al. 2005; Fresh et al. 2005; NMFS 2013a). The volume of water discharged by the Columbia River varies seasonally according to runoff, snowmelt, and hydropower demands. Mean annual discharge is estimated to be 265 kcfs, but may range from lows of 71–106 kcfs to highs of 530 kcfs (Hamilton 1990; NMFS 1998; Prahl et al. 1998; USACE 1999). Naturally occurring maximum flows on the river occur in May, June, and July as a result of snowmelt in the headwater regions. Minimum flows occur from September to March, with periodic peaks due to heavy winter rains (Holton 1984). Interannual variability in stream flow is strongly correlated with two recurrent climate phenomena, the ENSO and the PDO (Newman et al. 2016).

Water storage projects (dams and reservoirs) and water management activities have reduced flows at Bonneville Dam, representing basinwide effects in the lower Columbia River (McNary Reservoir to the mouth of the Columbia River) (Figure 2.10-3) (NMFS 2008b). On average, this reduction can range from nearly 15 kcfs in August to over 230 kcfs in May. Proportional flow reductions of similar magnitude also occur in the middle Columbia River (Chief Joseph tailrace to the Columbia River's confluence with the Snake River within McNary Reservoir).

Recognizing that the flow versus survival relationships for some interior basin ESUs/DPSs displayed a plateau over a wide range of flows but declined markedly as flows dropped below some threshold (NMFS 1995b, 1998), NMFS and the CRS Action Agencies have attempted to manage Columbia and Snake River water resources to maintain seasonal flows above threshold objectives given the amount of runoff in a given year. This has been accomplished by avoiding excessive reservoir drafts going into spring to minimize the flow reductions needed for refill, and by drafting the storage reservoirs during summer to augment flows.[103] These flow objectives have guided preseason reservoir planning and in-season flow management. Nonetheless, since the development of the hydrosystem, average monthly flows at Bonneville Dam have been substantially lower during May–July and higher in October–March compared to an unregulated system. Reduced flows have increased travel times for outmigrating juvenile steelhead and resulted in reduced access to high-quality estuarine habitats from May through July during low tides.

[103] Even though several million acre feet of water are released during summer each year from storage to augment flows and from Dworshak Dam to reduce mainstem temperatures, these volumes do not offset water withdrawals during July and August.

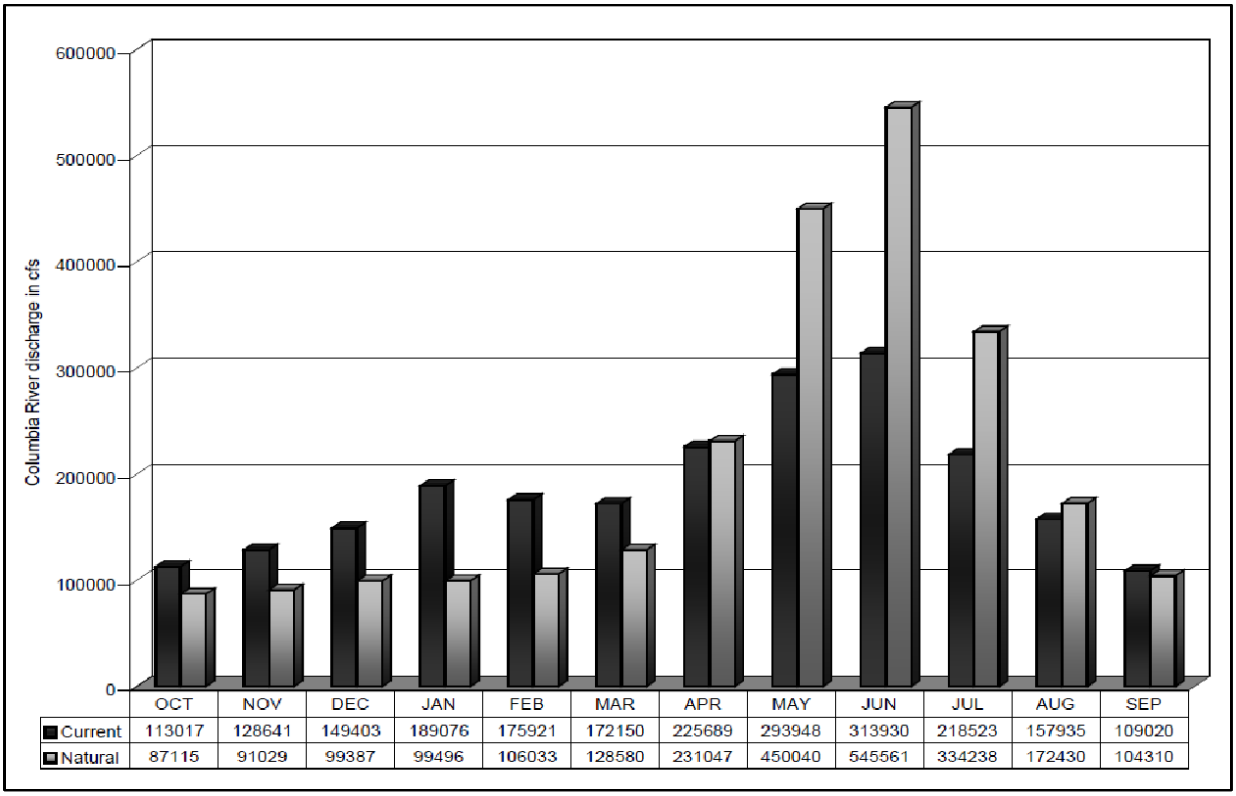


Figure 2.10-3. Comparison of monthly discharge (flow) in the Columbia River between current conditions (black) and normative flows (gray). These data show that pre-development flows were lower in the winter and higher in the summer months.

2.10.2.1.2 Water Quality

Water quality in the action area is impaired as a result of chemical contamination from municipal, agricultural, industrial, and urban land uses (NMFS 2017a). Common toxic contaminants found in the Columbia River system include PCBs, PAHs, PBDEs, DDT and other legacy pesticides, current use pesticides, pharmaceuticals and personal care products, and trace elements (LCREP 2007). The LCREP (2007) report noted widespread presence of PCBs and PAHs, both geographically and in the food web. Urban and industrial portions of the lower river contribute significantly to contaminant levels in juvenile salmon; juvenile salmon are absorbing toxic contaminants during their time rearing and feeding in the lower Columbia River (LCREP 2007). Likewise, juvenile salmon are accumulating DDT in their tissues and are exposed to estrogen-like compounds in the lower river, likely associated with pharmaceuticals and personal care products. Concentrations of copper are present at levels that could interfere with crucial salmon behaviors.

Growing population centers throughout the Columbia River basin and numerous smaller communities contribute municipal and industrial waste discharges to the lower Columbia River. Industrial and municipal wastes from the Portland/Vancouver metro areas, including the superfund-designated reach in the lower Willamette River, also contribute to degraded water quality in the lower river. Legacy and active mining areas scattered around the basin deliver high background concentrations of metals. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river.

Outside of urban areas, the majority of residences and businesses rely on septic systems. Common water-quality issues with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff. Under these environmental conditions, fish in the action area are stressed. Stress may lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival).

Oils, greases, and other lubricants (derived from animal, fish, vegetable, petroleum or marine mammal origin) are used at each of the CRS projects (and all other dams in the Columbia River basin), including, but not limited to, the following: hydropower turbines, hydraulic systems, lubricating systems, gear boxes, machining coolant systems, heat transfer systems, transformers, circuit breakers, and electrical systems. Leakage of oils, greases, or other lubricants into rivers has the potential to affect salmon and steelhead (avoidance, exposure to toxic compounds, or even, in some circumstances death). In response to increased concerns regarding the releases of oils and greases from lower Columbia and lower Snake River dams (and Dworshak and Chief Joseph Dams) the Corps has taken steps to minimize these risks. For equipment in contact with the water, the Corps has developed best management practices to avoid accidental releases and to minimize the adverse effects in the case of an accidental release. The Corps has also begun using, where feasible, “environmentally acceptable lubricant” greases and in some cases has replaced greased equipment with greaseless equipment. The Corps has also developed and are implementing oil accountability plans with enhanced inspection protocols and are reporting annually.

The extent to which leaked grease or oil, occurring under the environmental baseline in the Clearwater River (Dworshak Dam), Upper Columbia River (Chief Joseph), or lower Snake or lower Columbia Rivers, has affected the behavior, health, or survival of CR chum salmon in the past is unknown, but likely to be small given that the size of these river systems. For comparison, a large leak of 100 gallons per day is the equivalent of 0.00016 cubic feet per second and the average annual discharge of the Columbia River has ranged from roughly 125,000 to 250,000 cubic feet per second since about 1940 (ISAB 2000). Nevertheless, to the extent past leakages have potentially affected passage or survival, these effects would be encompassed by annual juvenile or adult reach survival estimates. Recent actions (adoption of best management practices, use of environmentally acceptable lubricants, use of greaseless equipment, etc.) would further reduce the potential for negative effects stemming from these materials and slightly improve conditions for juvenile and adult migrants.

Our understanding of the effects on aquatic life of many contaminants is incomplete, especially when considering the exposure of rearing juveniles to multiple contaminants that may have synergistic or antagonistic effects, or when considering their interactions with other stressors or the food web (NMFS 2017a). Together, these contaminants are likely affecting the productivity and abundance of UCR steelhead, especially during the rearing and juvenile migration life stages. Effects can be direct or indirect, and lethal or sublethal. The interaction of co-occurring stressors may have a greater impact on salmon than if they occur in isolation (Dietrich et al. 2014).

Water temperatures in the Columbia River are a concern; the Columbia and Snake Rivers are included on the Clean Water Act §303(d) list of impaired waters because of temperature-standard exceedances. Temperature conditions in the Columbia River basin area are affected by many factors, including:

- Natural variation in weather and river flow;
- Construction of the dam and reservoir system (the large surface areas of reservoirs and resulting slower river velocities contribute to warmer late summer/fall water temperatures);
- Increased temperatures of tributaries; water managed for irrigated agriculture;
- Point-source discharges, such as cities and industries; and
- Climate change (Overman 2017; EPA 2018).

Temperatures in the middle Columbia River are affected by Grand Coulee Dam, completed in 1942. Thermal inertia from the large mass of water in the reservoir (total storage capacity of 9.6 million acre-feet, active capacity of about 5.2 million acre-feet) results in delayed warming in the spring (cooler temperatures) and delayed cooling in the late summer and fall (warmer temperatures). Even in the extremely warm year of 2015, the average temperature of Grand Coulee outflows was less than 68°F (20°C on Figure 2.10-4; NMFS 2016a), indicating little risk from this environmental parameter to spring migrating UCR steelhead smolts. However, warmer August and September temperatures would increase the risk of effects, such as pre-spawning mortality and reduced gamete viability, to these summer migrating adults.

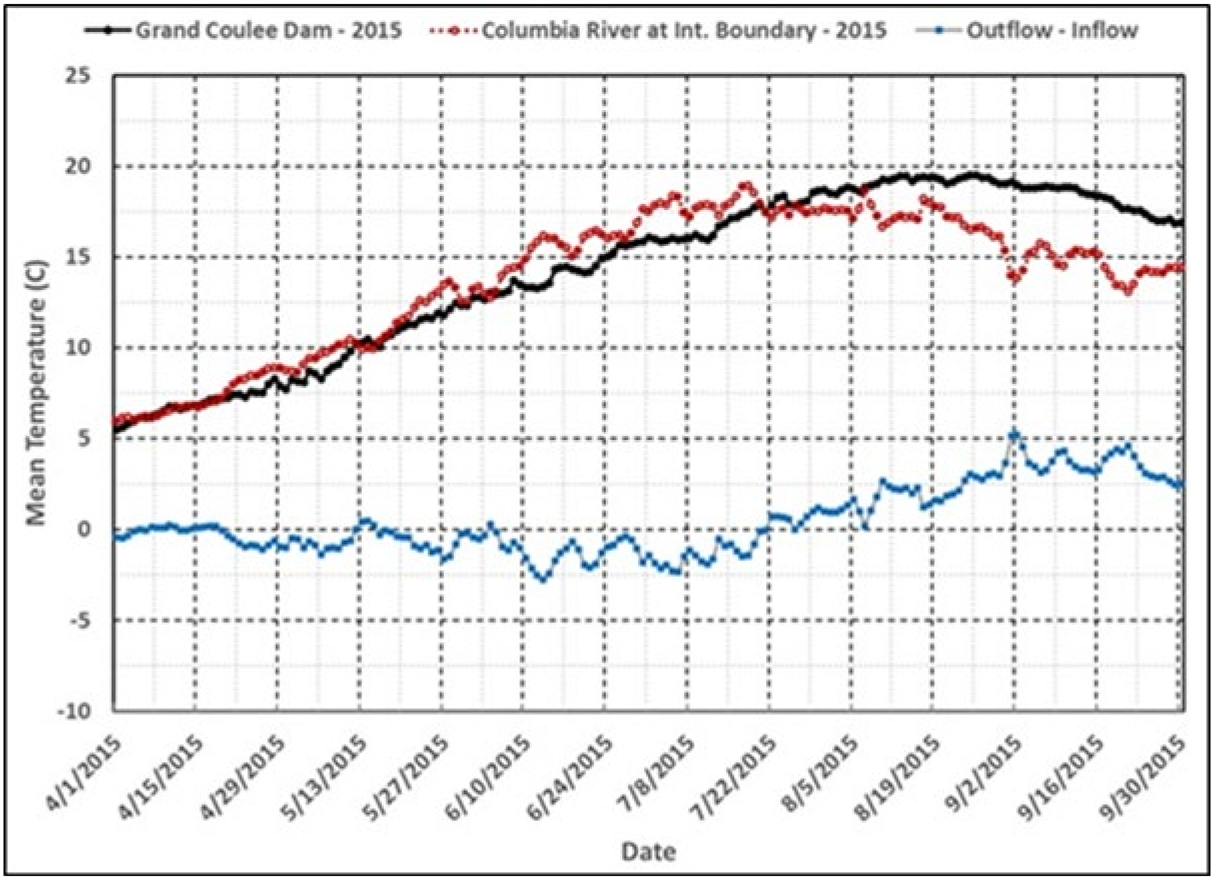


Figure 2.10-4. Outflow temperatures at Grand Coulee Dam compared to upstream Columbia River temperatures at the international boundary. Blue line indicates the difference (inflow – outflow) in temperature. Source: USBR Hydromet Data.

The EPA is working with federal and state agencies, tribes, and other stakeholders to develop water-quality improvement plans (total maximum daily loads) for temperature in the Columbia River and lower Snake River. As part of the 2015 biological opinion on EPA's approval of water-quality standards, including temperature (NMFS 2015a), EPA committed to work with federal, state, and tribal agencies to identify and protect thermal refugia and thermal diversity in the lower Columbia River and its tributaries.

Comparisons of long-term temperature monitoring in the migration corridor before and after impoundment reveal a change in the thermal regime of the Snake River that influence temperatures downstream of its confluence with the Columbia River. Using historical flows and environmental records for the 35-year period 1960–1995, Perkins and Richmond (2001) compared water temperature records in the lower Snake River with and without the lower run-of-river dams and found three notable differences between the current versus unimpounded river:

- Maximum summer water temperature has been slightly reduced;
- Water temperature variability has decreased; and

- Post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall, a phenomenon termed thermal inertia.

Dams in the middle and lower reaches of the Columbia River likely have similar effects.

These hydrosystem effects (influenced by the temperatures of tributary streams entering the Columbia River both upstream of, within, and downstream of the mainstem dams) continue downstream and influence temperature conditions in the lower Columbia River. At a macro scale, water temperature affects salmonid distribution, behavior, and physiology (Groot and Margolis 1991); at a finer scale, temperature influences migration swim speed of salmonids (Salinger and Anderson 2006), timing of river entry (Peery et al. 2003), susceptibility to disease and predation (Groot and Margolis 1991), and at temperature extremes, survival.

Exposure to elevated temperatures in the lower Columbia River from its mouth to its confluence with the Snake River, is greatest for adult UCR steelhead migrating in the late summer when water temperatures are highest (Keefer et al. 2016; Keefer and Caudill 2017).

TDG levels also affect mainstem water quality and habitat (see project spill operations table in 2.10.2.1.5 Juvenile Migration/Survival below). To facilitate the downstream movement of juvenile salmonids, state regulatory agencies issue criteria adjustments for TDG as measured in the forebay and tailrace (NMFS 1995b). Specifically, water that passes over the spillway at a mainstem dam can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). Historically, TDG supersaturation was a major contributor to juvenile salmon mortality; to reduce TDG supersaturation, the Corps has installed "flip lips" at the base of the spillway at each federal mainstem run-of-river dam, except The Dalles Dam, and at Chief Joseph Dam. The FERC-licensed Wanapum Dam in the mid-Columbia reach also uses these structures to control TDG. Biological monitoring shows that the incidence of observable GBT symptoms in both migrating smolts and adults is between 1–2 percent at each monitoring location when TDG concentrations in the upper water column do not exceed 120 percent of saturation in CRS project tailraces. When those levels are exceeded, there is a corresponding increase in the incidence of signs of GBT symptoms. Fish migrating at depth avoid exposure to the higher TDG levels due to pressure compensation mechanisms (Weitkamp et al. 2003).[104] Under recent operations (2008–2018), exposure to excessive high TDG levels (exceeding state standards) has been restricted to lack of market or lack of turbine capacity spill events associated with high flow conditions and/or lack of load — which have most often occurred between mid-May and mid-June, affecting most UCR steelhead smolts.

[104] Roughly, for each meter below the surface an aquatic organism is located, there is a corresponding reduction in the effective TDG the organism experiences of about 10 percent. Thus, if TDG levels are at 120 percent, and organism two meters below the surface would effectively experience 100 percent TDG saturation.

The most extensive urban development in the lower Columbia River basin has occurred in the Portland/Vancouver area. Common water-quality issues, both in areas with urban development and rural residential septic systems, include warmer water temperatures, lowered dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff (LCREP 2007). Similar effects are likely to be proportionally associated with smaller urban areas as well (e.g., Lewiston, Idaho; Tri-Cities, Washington; The Dalles and Hood River, Oregon). While it is not clear what the magnitude of effects are to juvenile or adult UCR steelhead from exposure to these factors (see previous discussion relating to chemical contaminants), they are likely to negatively affect fitness and survival to some extent.

2.10.2.1.3 Sediment Transport

The series of dams and reservoirs have also blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is about one third of nineteenth-century levels (Simenstad et al. 1982, 1990; Sherwood et al. 1990; Weitkamp 1994; NRC 1996; NMFS 2008a). Similarly, Bottom et al. (2005) estimated that the delivery of suspended particulate matter to the lower river and estuary has been reduced by about 40 percent (as measured at Vancouver, Washington), and fine sediment transport reduced by 50 percent or more. These estimates reflect the combined total of all activities throughout the Columbia River basin on sediment transport. Similar reductions would be expected throughout the mainstem. The overall reduction in sediment has altered the development of habitat along the margins of the river, and likely increased the risk of migrating juveniles to visual predators like birds and fish.

Industrial harbor and port development are also significant influences on the lower Snake and lower Columbia Rivers (Bottom et al. 2005; Fresh et al. 2005; NMFS 2013a). Since 1878, the Army Corps of Engineers has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the Willamette River as a navigation channel. Originally dredged to a 20-foot minimum depth, the federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The navigation channel supports many ports on both sides of the river, resulting in several thousand commercial ships traversing the river every year. The dredging, along with diking draining, and fill material placed in wetlands and shallow habitat, also disconnects the river from its floodplain, resulting in the loss of shallow-water rearing habitat and the ecosystem functions that floodplains provide (e.g., supply of prey, refuge from high flows, temperature refugia, etc.; Bottom et al. 2005).

2.10.2.1.4 Adult Migration/Survival

Adults must migrate from the ocean, upstream through the estuary, and pass between seven and nine mainstem dams and reservoirs (four of these are CRS dams) to reach their spawning areas. Factors that affect the survival rates of migrating adults include harvest (either reported or unreported), dam passage (adults must find and reascend ladders if they accidentally fall back over the spillway), straying (either naturally or as a result of impaired homing stemming from transport or other factors), pinniped predation, and temperature and flow conditions that can increase the energetic demands of migrating fish (NMFS 2008a; Keefer et al. 2016; Keefer and Caudill 2017).

PIT-tag detectors placed near the exits of adult ladders at the mainstem dams provide a unique ability to monitor the upstream survival of adults that were tagged as juveniles.[105] Starting with the number of adults detected at Bonneville Dam, minimum survival estimates can be derived to detectors at upstream dams. Termed "conversion rates," these survival estimates are adjusted for reported harvest and the expected rate of straying of natural-origin adults. Figure 2.10-5 depicts minimum estimated survival rates from Bonneville to McNary Dam (three reservoirs and dams in the lower Columbia River) during 2008–17, years that include recent hydropower operations and harvest rates within the "zone 6" fishery (as designated in the *U.S. v. Oregon* Management Agreement). Figure 2.10-5 also shows minimum estimated survival rates from McNary to Priest Rapids Dam (McNary Reservoir and the free-flowing Hanford reach of the Columbia River) or to Wells Dam (McNary to Priest Rapids Dam and an additional four reservoirs and dams) for fish released as juveniles upstream of Wells Dam (2008–17).

From Figure 2.10-5, the ten-year average minimum survival estimates for UCR steelhead from Bonneville to McNary Dam is 92.1 percent (range of 87.6 to 96.8 percent).[106] The minimum survival estimate for UCR adult steelhead released upstream of Wells Dam as juveniles was 76.5 percent (range of 70.9 to 81.1 percent) to Priest Rapids and 73.4 percent (range of 69.3 to 79.3 percent) to Wells Dam. Comparing the McNary to Priest Rapids Dam to the McNary to Wells Dam reach indicates that average survival from 2008–17 was about 96.9 percent (100 – (76.5 – 73.4)) through the Priest Rapids Reservoir; Wanapum, Rock Island, and Rocky Reach Dams and reservoirs; and Wells Dam reaches.

These survival estimates account for total losses from the CRS and PUD-owned dams and reservoirs, as well as any losses in these reaches resulting from elevated temperatures, disease, or other natural causes. Expressed on a "per project" basis (1/3rd root of 92.1 percent), about 97.3 percent of adult UCR steelhead are surviving passage through each project (dam and reservoir) in the lower Columbia River after accounting for reported harvest and natural stray rates. From Priest Rapids to Wells Dam, per project survival rates are averaging around 99.2 percent (1/4th root of 96.9). These relatively high survival rates indicate that upstream passage conditions are not substantially impaired for adult UCR steelhead migrating through impounded reaches of the middle and lower Columbia Rivers. However, substantial losses (about 23.5 percent) of adult UCR steelhead appear to be occurring between McNary and Priest Rapids Dams.

[105] Using only known origin fish that were NOT transported as juveniles; adjusted for reported harvest and natural stray rates.

[106] These minimum survival estimates are often termed conversion rates. Conversion rates close to, or higher than, 100 percent are possible if estimates of harvest rates (or natural rates of straying) are higher than what actually occurred in a given year (biased high). Conversely, if harvest rates are underestimated, the resulting conversion rate estimates would be biased low.

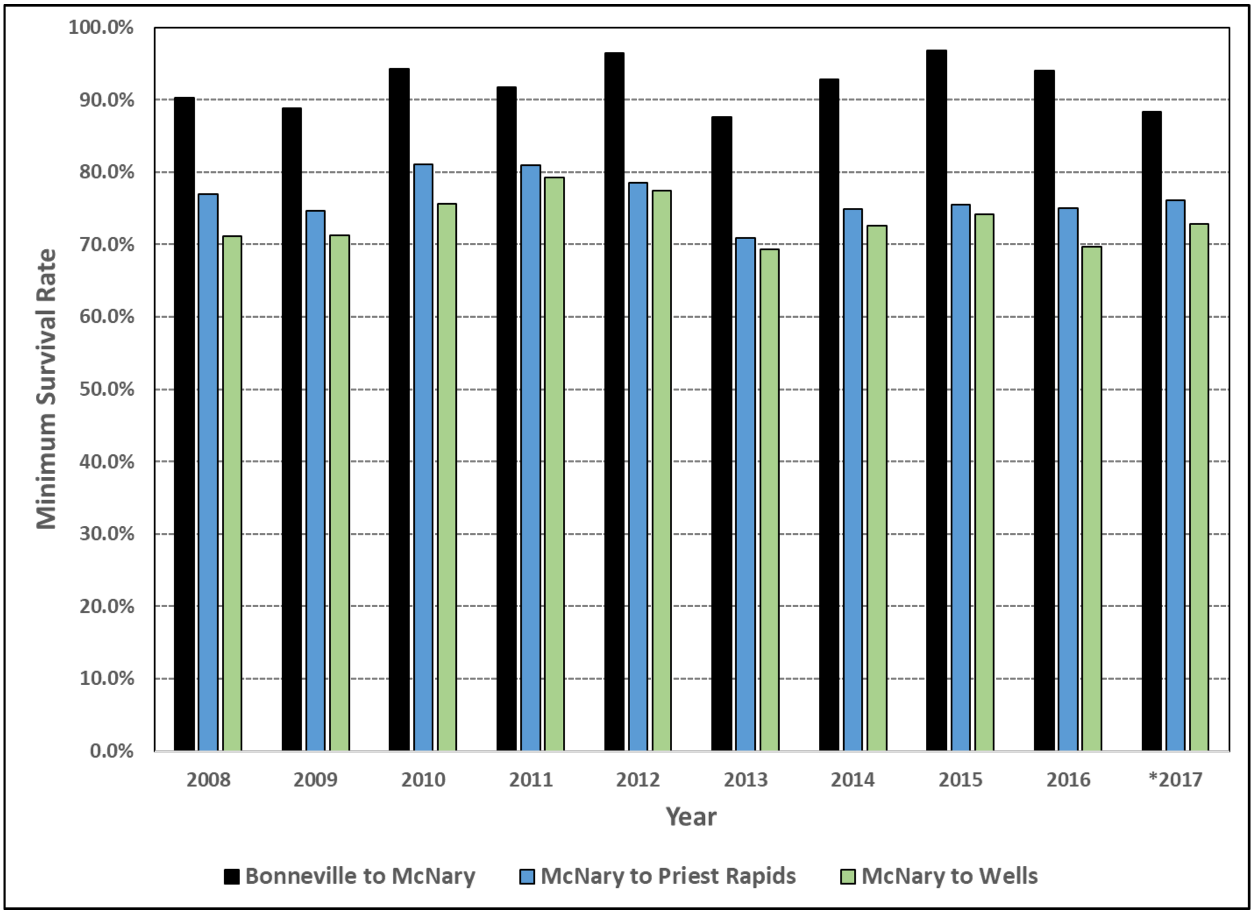


Figure 2.10-5. Minimum survival estimates from Bonneville to McNary Dam (of known-origin PIT-tagged adult UCR steelhead, natural- and hatchery-origin combined), McNary to Priest Rapids Dam, and McNary to Wells Dam (of known-origin PIT-tagged UCR adult steelhead released upstream of Wells Dam as juveniles) from 2008–17. Source: NMFS, using data from PITAGIS and Columbia River Data Access in Real Time.

CRS related mortality of downstream migrating kelts is not well known at this time. Colotelo et al. (2013) estimated that in 2012 only 60.4 and 67.3 percent survived from the McNary forebay to the Lower Columbia River (RM156) and Bonneville dam face, respectively. It is important to note that in this study, only fair and good condition kelts were selected for tagging, and these survival rates cannot be applied to poor condition kelts. Based on this limited information, up to 40 percent of UCR kelts arriving at McNary Dam are lost upstream of Bonneville Dam. These data represents total mortality to outmigrating kelts and does not distinguish between mortality caused by factors in the environmental baseline or the effects of the CRS. It is not technically possible to provide separate estimates of these components.

2.10.2.1.5 Juvenile Migration/Survival

The mainstem dams and reservoirs continue to substantially alter the mainstem migration corridor habitat. The reservoirs have increased the cross-sectional area of the river, reducing water velocity, altering the food web, and creating habitat for native and nonnative species which are predators, competitors, or food sources for migrating juvenile steelhead. The travel times of migrating smolts are increased through the reservoirs, increasing exposure to both native and nonnative predators (see Section 2.10.2.6.1), and some juveniles are injured or killed as they pass through the dams (turbines, bypass systems, spill bays, or surface passage routes; NMFS 2008a, 2008b).

However, based on data summarized in Zabel (2018), overall passage conditions and resulting juvenile survival rates in the migration corridor have improved substantially since 1998, when the species was listed. The improved survival correlates with improved structures and operations and predator-management programs at the Corps and FERC-licensed mainstem projects (24-hour volitional spill, surface passage routes, improved juvenile bypass systems, predator-management measures, etc.; UCSRB 2007).

Table 2.10-4 and 2.10-5 depicts the hydrosystem spillway operations for the five Middle Columbia River Public Utility District (PUD) owned dams (Douglas, Chelan, and Grant County) and the Action Agency-operated dams in the lower Columbia River, respectively. The spillways represent just one of several routes of passage through the dams. For example, the Wells project is constructed as a hydropower combine and utilizes modified spillway bays to efficiently pass juvenile salmon and steelhead past the project in a non-turbine route of passage.

Table 2.10-4. Summary of recent spring spill levels at Middle Columbia River projects.

Project	Recent Spring Spill Operations (Day/Night)[107]
Wells	7% or more Uses of up to five surface bypass entrances (modified spillway bays)
Rocky Reach	9%
Rock Island	10%
Wanapum	20 kcfs
Priest Rapids	27 kcfs

[107] The five Mid-Columbia PUD projects must achieve a minimum 91 percent combined adult and juvenile salmonid survival performance standard at each project (dam and reservoir); translating to approximately 98 percent adult survival and 93 percent juvenile survival per project.

Table 2.10-5. Summary of 2017 and 2018 Fish Operations Plan (FOP) spring spill levels at Lower Columbia River projects.

Project	2017 Spring Spill Operations (Day/Night)	2018 Operations
McNary	40%/40%	120% TDG tailrace (Gas Cap)/115% to the next forebay
John Day	**April 10-April 28:** 30%/30% **April 28-June 15:** 30%/30% and 40%/40%	120% TDG tailrace (Gas Cap)/115% to the next forebay
The Dalles	40%/40%	120% TDG tailrace (Gas Cap)/115% to the next forebay
Bonneville	100 kcfs/100 kcfs	120% TDG tailrace (Gas Cap) to a cap of 150 kcfs because of erosion concerns (no next forebay)

Performance standards testing at the Mid-Columbia PUD FERC-licensed projects indicates that recent average juvenile survival rates to Priest Rapids tailrace are about 78.1 percent for juveniles from the Okanogan and Methow Rivers (five reservoirs and dams), 81.0 percent for juveniles from the Entiat River (four reservoirs and dams), and 84.5 percent for juveniles from the Wenatchee River (three reservoirs and dams). This equates to average per project (reservoir and dam) juvenile survival rates of 93–96 percent.

Widener et al. (2018) estimates that hatchery-origin juvenile steelhead survival rates from McNary to Bonneville Dam (three reservoirs and dams) have ranged from 48.7 to 106.9 percent (2008–2017, an average of 74.4 percent).[108] The estimated survival rate in 2018 was 116.1 percent (standard error of 18.6 percent), indicating that survival was likely high, but the error around the estimate was also high. The reduced survival rates in the lower Columbia River (difference of Lower Granite to McNary Dam and Lower Granite to Bonneville Dam), starting in 2015 and 2016, were likely influenced by increased predation by Caspian terns displaced from Crescent Island to the Blalock Islands in the John Day pool (Roby et al. 2016).

Preliminary estimates of steelhead smolt (hatchery) survival in 2018, resulting from court-ordered "Gas Cap" spill operations at the four lower Columbia River projects, was 116.1 percent[109] (standard error of 18.6 percent) from McNary to Bonneville Dam. This estimate is the

[108] Survival estimates higher than 100 percent are possible given the extremely large variability in the estimate. They are obviously not possible in reality, and would be best interpreted as a high survival rate, likely approaching 100 percent. To calculate the 2008–17 average, 2008 was not included (as too few detections were observed to make reasonable survival estimates) and 1.00 was used for the survival value in 2012, rather than the 1.069 estimated value.

[109] As noted earlier, survival estimates higher than 100 percent are possible given the extremely large variability in the estimate. They are obviously not possible in reality, and would be best interpreted as a high survival rate, likely approaching 100 percent.

highest observed since 2003, but also had the second highest estimated standard error. For comparison, the 2017 estimate was 96.4 percent (standard error of 18.8 percent, the highest estimated since 2003).

Together, these survival rates represent a substantial improvement in migration conditions and survival rates for juvenile UCR steelhead migrating through the impounded reaches of the middle and lower Columbia River compared to the 1970s to the mid-2000s (NMFS 2008a), which increases the overall productivity of the populations and the abundance of returning adults.

2.10.2.1.6 Transportation

Turbine intake screens, part of the juvenile bypass systems,[110] divert UCR steelhead smolts away from turbine units and into a system of channels and flumes before delivering them to either the tailrace below the dam (bypassed) or, as was the case for McNary Dam, into raceways where they can be loaded onto barges and taken to below Bonneville Dam (transported) and released to continue their migration to the ocean. Some UCR steelhead smolts were collected at McNary Dam and transported to below Bonneville Dam until 2012, when the Corps terminated transportation of juveniles. This decision was incorporated into the 2014 FCRPS biological opinion (NMFS 2014).

2.10.2.2 Hatcheries

The Leavenworth National Fish Hatchery Complex consists of three large facilities, one of which, the Winthrop National Fish Hatchery, produces UCR steelhead. These programs were authorized as part of the Grand Coulee Fish Maintenance Project in 1937, to compensate for the loss of access to historical spawning and rearing habitat with the construction of Grand Coulee Dam. At the time, it was estimated that 85–90 percent of the adults counted at Rock Island Dam had originated upstream of Grand Coulee Dam. Until recently, these programs released co-mingled upriver stocks into the Wenatchee, Entiat, and Methow subbasins. Adults were collected at Priest Rapids and later at Wells Dam, and the smolts they produced were released into various tributaries. These programs also released stocks that originated in the lower Columbia River basin.

Under current settlement agreements and stipulations (FERC processes and related biological opinions), the three Mid-Columbia PUDs fund hatchery programs within the upper Columbia Basin. The WDFW began continuous artificial propagation of steelhead in the upper Columbia in the 1960s. These early propagation programs at the Wells and Chelan hatcheries mainly were intended to provide fish for harvest. More recently, the objective for the hatchery component of the No Net Impact standard for these FERC-licensed projects is to contribute to the rebuilding and recovery of natural populations in their native habitats, while maintaining genetic and ecological integrity, and supporting harvest. In 1997, WDFW began a hatchery program for the

[110] All of the powerhouses at the four lower Columbia River mainstem dams have juvenile bypass systems with the exception of The Dalles Dam and Bonneville Dam, Powerhouse 1. Rocky Reach Dam is the only mid-Columbia PUD project which has this type of screening system. And only on some of its turbine units.

Wenatchee basin using locally collected broodstock. Programs in the Methow subbasin use fish that return to the Methow River for broodstock, and the program in the Okanogan subbasin is in the process of transitioning to using fish from the Okanogan River for broodstock.

The Confederated Tribes of the Colville Reservation (CTCR) have initiated a kelt reconditioning program to create a comprehensive integrated recovery program in the Okanogan subbasin. Their kelt reconditioning and release efforts were recently shown to be successful when progeny were identified in Omak Creek (Stephenson et al. 2007). This program improved Omak Creek kelt survival by 26–146 percent in 2009–2013 (Hatch et al. 2011, 2015) and 49 individuals evidenced iteroparity (repeat spawning) (NMFS 2017c). During this time period, the spawning aggregate in Omak Creek was estimated at 1,191, which was a 4 percent increase over previous years, though it is difficult to determine if the increase was primarily due to reconditioning efforts or other environmental variables. This program is currently permitted under a 4(d) rule for the CTCR's Tribal Resource Management Plan (NMFS 2017c), and it is not a CRS mitigation responsibility for the Action Agencies.

The Upper Columbia Kelt Reconditioning Program (UCKRP), operated by the Yakama Confederated Tribes for the past ten years, will continue at the same level consistent with recent years, and will not collect and capture more than 500 adults. The purpose of the program is to enhance the abundance and life-history diversity of naturally produced steelhead. Natural-origin steelhead kelts are collected in two distinct ways: (1) a portion of natural-origin return (NOR) hatchery broodstock (HCP hatchery compensation programs) are live-spawned and then reconditioned; and (2) NOR kelts are collected at a variety of locations including mainstem juvenile bypass systems and tributary smolt traps and weirs. The most recent results provided demonstrate that the UCKRP project collected 69 kelts in 2016 in total and 53 (76.8 percent) survived. Of the 53 which survived, 32 were released at locations on the Methow River and Columbia River (near Wenatchee). The remaining 21 kelts were retained for an additional year of reconditioning. The UCKRP plans to continue collecting 60 to 100 kelts and releasing 30 to 75 reconditioned kelts on an annual basis.

Genetics samples taken in the 1980s indicated little differentiation within populations in the UCR steelhead DPS. Hatchery operations are now aligned with their respective recovery plans, and are meant to ensure that allowable levels of genetic effects will still permit natural populations to improve in productivity, abundance, and diversity, and allow them to adapt to both current and changing environments (NMFS 2017c). Recent changes include a reduction in the hatchery programs funded by the PUDs starting in 2012 because of a revised calculation of their mitigation responsibility based on increased survivals through the PUD-owned dams. Reducing hatchery production has reduced the number of hatchery-origin fish on the spawning grounds (pHOS), resulting in a decrease in the genetic risk to the natural-origin populations. The programs have implemented the following additional reform measures:

- A change in water use at Leavenworth National Fish Hatchery has reduced water withdrawals from Icicle Creek, leaving more instream flow during summer months;

- The Methow component of the Wells Complex steelhead program made changes in their broodstock (i.e., developed a "stepping stone" program with Winthrop National Fish Hatchery) to better link their hatchery fish genetically to natural-origin steelhead. This is a critical step to recovery as these hatchery releases are responsible for a large proportion of the hatchery fish on spawning grounds in the Methow and Okanogan Rivers; and
- Changes were made in the management of adult hatchery-origin steelhead returning to the Wenatchee River basin, which reduced pHOS and genetic risk to that population.

Hatchery programs can provide short-term demographic benefits, such as increases in abundance, during periods of low natural abundance. They also can help preserve genetic resources until limiting factors can be addressed. However, the long-term use of artificial propagation may pose risks to natural productivity and diversity. The magnitude and type of the risk depends on the status of affected populations and on specific practices in the hatchery program. Hatchery programs can affect natural populations of salmon and steelhead in a variety of ways: competition (for spawning sites and food), predation, disease, genetics (outbreeding depression, hatchery-influenced selection), broodstock collection and facility operations (water withdrawals, effluent discharge) (NMFS 2018a). Although hatcheries are an integral part of the hydrosystem mitigation programs for the Upper Columbia, they are not intended to be a substitute for abundant spawning and rearing habitat capable of supporting natural-origin steelhead.

2.10.2.3 Harvest

UCR steelhead are not targeted, and are therefore rarely caught in ocean fisheries within the U.S. Exclusive Economic Zone and the coastal and inland marine waters of the west coast states (Washington, Oregon, and California; NMFS 2018a).

The 2008 *U.S. v. Oregon* agreement allowed for the incidental take of up to 4.0 percent of the total run of UCR steelhead in non-Indian Columbia River fisheries. The range of estimated incidental take observed (2008–17) was 1.1 to 3.3 percent, and averaged 1.9 percent. Incidental take associated with treaty harvest rates on A-Index steelhead was estimated to about 8.1 percent. Thus, average harvest rates for UCR steelhead have likely averaged about 10 percent in the zone 1 to 6 fisheries in the lower Columbia River. These harvest rates are substantial reductions compared to those that occurred before the 1990s.

NMFS signed the 2018–27 *U.S. v. Oregon* Management Agreement of the Columbia River Basin, based on information reviewed in both the recently completed Final EIS and the associated biological opinion (NMFS 2018a). The agreement supports salmon and steelhead fishing opportunities for the states of Oregon, Washington, and Idaho; ensures fair sharing of harvestable fish between tribal and non-tribal fisheries in accordance with treaty fishing rights and *U.S. v. Oregon*; protects and conserves ESA-listed and non-listed species; and ensures NMFS fulfills its treaty and trust responsibilities to Columbia Basin tribes.

Annual ESA Section 10 permit reports show that the estimated take of UCR steelhead in mainstem and tributary fisheries above Priest Rapids Dam is relatively minimal (Jeromy Jording, pers. comm. 2018). Reports indicate that, over the past five years, total incidental and directed mortalities in state fisheries above Priest Rapids Dam have averaged 87 adults and 540 juvenile UCR steelhead per year. In addition, the estimated maximum indirect mortality rates for all UCR steelhead handled by activities recently approved under the Colville Tribe's Tribal Resource Management Plan (TRMP) are as follows: 4 to 12 percent for Okanogan River basin activities (which encounter 60 percent of all returns to the Okanogan); and 5 to 12 percent of natural-origin, or 5 to 50 percent of hatchery-origin steelhead handled at Wells Dam, with the chances of mortality increasing with number of fish handled and processed. The approved activities include fishery, hatchery, RM&E, predator control, and kelt-reconditioning activities in the Okanogan River basin and at Wells Dam on the Upper Columbia River.

These levels of exploitation are expected to continue for the foreseeable future and will continue to somewhat reduce the productivity and abundance of UCR steelhead.

2.10.2.4 Tributary Habitat

2.10.2.4.1 DPS Overview

Tributary habitat conditions in the subbasins within the UCR steelhead DPS (i.e., the Wenatchee, Entiat, Methow, and Okanogan subbasins) are good in high elevation reaches, but degraded in lower elevation stream reaches, particularly near valley bottoms (UCSRB 2007). The ability of tributary habitats in the Wenatchee, Entiat, Methow, and Okanogan subbasins to support the viability of UCR steelhead is generally limited by one or more of the following factors: (1) reduced stream complexity and channel structure; (2) reduced floodplain condition and connectivity; (3) degraded riparian condition; (4) diminished stream flow; (5) impaired fish passage; (6) excess fine sediment; and (7) elevated summer water temperatures (UCSRB 2007). The combination, intensity, and relative impact of these factors vary locally throughout each subbasin, depending on historical and current land use activities and natural conditions.

Human activities that have contributed to these limiting factors include dams, water diversions, stream channelization and diking, roads and railways, timber harvest, grazing, and urban and rural development (UCSRB 2015). In addition, natural disturbance has recently had a large effect on habitat in the Upper Columbia. For instance, the 2014 Carlton Complex fire, the largest fire ever recorded in Washington, burned approximately 253,377 acres and will likely result in higher runoff rates, higher impacts (e.g., increased runoff and erosion leading to increased sediment load and streambed scouring) from rain and snow events, and increased sedimentation, with associated adverse effects on salmon productivity (UCSRB 2015).

Land use practices and regulatory mechanisms have improved from historical practices and regulations (UCSRB 2007), and new development appears to be a relatively minor factor in landscape change in the region, based on a study in a representative area (UCSRB 2015). In addition, many habitat restoration actions have been, and are being, implemented in these subbasins through the individual and combined efforts of federal, tribal, state, local, and private entities, including the CRS Action Agencies (UCSRB 2007; BPA et al. 2013, 2016). The CRS Action Agencies have been implementing tributary habitat improvement actions as part of mitigation for the CRS since 2007. These actions have included protecting and improving stream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, and removing barriers to spawning and rearing habitat. The actions are targeted toward addressing the limiting factors identified above (BPA et al. 2013, 2016). Cumulative metrics for these action types for UCR steelhead from the years 2007–15 are shown in Table 2.10-6.

Table 2.10-6. Tributary Habitat Restoration Metrics: UCR Steelhead, 2007–15 (BPA et al. 2016).

Action Type*	**Amount completed**
Acre-feet/year of water protected *(by efficiency improvements and water purchase/lease projects)*	39,908.6
Acres protected *(by land purchases or conservation easements)*	250.0
Acres treated *(to improve riparian habitat, such as planting native vegetation or control of noxious weeds)*	1,435.00
Miles of enhanced or newly accessible habitat *(by providing passage or removing barriers)*	201.0
Miles of improved stream complexity *(by adding wood or boulder structures or reconnecting existing habitat, such as side channels)*	28.2
Miles protected *(by land purchases or conservation easements)*	11.2
Screens installed or addressed *(for compliance with criteria or by elimination/consolidation of diversions)*	82

* Several of these categories (acres protected, acres treated, miles of enhanced stream complexity, miles protected) also encompass actions directed at reducing sediments and reconnecting floodplains.

NMFS determined, based on best available science, that the actions implemented by the Action Agencies and other entities have and will continue to improve habitat in the targeted populations as these projects mature, and that fish population abundance and productivity will respond positively.[111] Benefits of some of these actions will continue to accrue over several decades (see Appendix A). RM&E, including IMWs and CHaMP sampling, have been underway in this DPS to help confirm improvements in habitat productivity and fish population response and the magnitude of the changes. Available empirical evidence supports our view that these actions are improving habitat capacity and productivity, as well as population abundance and productivity (see Appendix A; NMFS 2014; Hillman et al. 2016; Griswold and Phillips 2018; Haskell et al. 2018).

The best available scientific and technical information also indicates that there is additional potential to improve habitat productivity in these populations (UCSRB 2007; NMFS 2016a; UCRTT 2017). Density dependence has been observed in UCR steelhead populations (ISAB 2015), which also indicates that improvements in tributary habitat capacity or productivity, if targeted at limiting life stage and limiting factors, would be likely to improve overall population abundance and productivity.

In summary, while tributary habitat conditions are likely improving in some areas as a result of habitat improvement actions and improved land use practices, in general tributary habitat conditions are still degraded and continue to negatively affect UCR steelhead abundance, productivity, spatial structure, and diversity. In addition, the potential exists to further improve tributary habitat capacity and productivity in this DPS, although the potential varies by population.

More detail on baseline tributary habitat conditions for the four populations that constitute this DPS is provided below.

2.10.2.4.2 Methow River Subbasin

In the Methow subbasin, upper portions of major tributaries contain a high proportion of intact habitat. The primary habitat conditions in the Methow subbasin that currently limit abundance, productivity, spatial structure, and diversity of steelhead are mostly found in the middle and lower mainstem and lower portions of major tributaries. In these areas, road building, residential development, and agricultural practices have diminished stream complexity, wood and gravel recruitment, floodwater retention, and water quality, negatively affecting the ability of these habitats to support steelhead. Late summer and winter instream flow conditions also often reduce migration, spawning, and rearing habitat for salmonids. This is partly natural (a result of watershed-specific weather and geomorphic conditions) but is exacerbated by irrigation withdrawals (NMFS 2016a; UCRTT 2017).

[111] In most cases, near-term benefits would be expected in abundance and productivity. Depending on the population and the scale and type of action, benefits to spatial structure and diversity might also accrue, either in the near term or over time. In addition, while we expect abundance, productivity, spatial structure, and diversity to respond positively to strategically implemented tributary habitat improvement actions, other factors also influence these viability parameters (e.g., ocean conditions) and any resulting trends. Throughout this tributary habitat discussion, when we discuss improvements in abundance and productivity, it is implied that spatial structure and diversity might also respond positively, and that other factors, as noted here, might influence any resulting trends.

Restoration actions in this subbasin have included protection and restoration of flow, screening of irrigation diversions, improving access to habitat, improving stream complexity and floodplain connectivity, and protecting and restoring riparian areas (BPA et al. 2013, 2016). These actions have been targeted at addressing limiting factors. Best available science indicates that the actions have and will continue to improve habitat function for the Methow River population, and that fish population abundance and productivity will respond positively. Benefits of some of these actions will continue to accrue over several decades (see Appendix A). This population must achieve at least viable status under the ESA recovery plan (UCSRB 2007).

2.10.2.4.3 Entiat River Subbasin

While most of the Entiat subbasin is in public ownership, the lower basin, including more than 70 percent of the stream length accessible to salmon and steelhead, is privately owned. Historical land uses of mining, water diversion, and timber harvest have reduced habitat diversity, connectivity, water quantity and quality, and riparian function in many areas. The primary habitat conditions in the Entiat subbasin that currently limit steelhead include reduced stream channel configuration and complexity from logging, and flood control measures that straightened and removed large woody debris from the channel. These historical and ongoing activities have led to low instream habitat diversity, including few pools; lack of large wood accumulations; and disconnected side channels, wetlands, and floodplains. The result is a reduction in resting and rearing areas for both adult and juvenile steelhead throughout the Entiat River (NMFS 2016a; UCRTT 2017).

Restoration actions in this subbasin have included protection and restoration of stream flow, screening of irrigation diversions, improvements to passage barriers, improved stream channel complexity and floodplain connectivity, and riparian area protection and improvements (BPA et al. 2013, 2016). These actions have been targeted at addressing limiting factors. Best available science indicates that the actions have and will continue to improve habitat function for the Entiat River population, and that fish population abundance and productivity will respond positively. Benefits of some of these actions will continue to accrue over several decades (see Appendix A). This population must achieve at least viable status under the ESA recovery plan (UCSRB 2007).

2.10.2.4.4 Wenatchee River Subbasin

In the Wenatchee River subbasin, although less than 25 percent of the subbasin is privately owned, nearly two-thirds of the lineal area of anadromous streams, primarily lower gradient streams, is bordered by private lands. The Wenatchee subbasin was also affected historically by mining, intense livestock grazing, water diversions, timber harvest, and roadbuilding. These land uses have reduced habitat diversity, connectivity, water quantity and quality, and riparian function in many areas within the basin. However, some headwater areas are in relatively pristine condition and serve as strongholds for listed species. The primary habitat conditions in the Wenatchee River basin that currently limit abundance, productivity, spatial structure, and diversity of steelhead include a lack of habitat diversity and quantity, excessive sediment load, obstructions, a lack of channel stability, low flows, and high summer temperatures. Habitat diversity is affected by channel confinement, loss of floodplain connectivity and off-channel habitat, reduced quantities of large wood, and a lack of riparian vegetation. The mainstem, and many of its tributaries, also lack high-quality pools and spawning areas associated with pool tail-outs. The lack of pools in many areas is probably directly related to the loss of riparian vegetation, removal of large wood, and channel confinement (NMFS 2016a; UCRTT 2017).

Restoration actions in this subbasin have included actions to protect and restore stream flow, screen irrigation diversions, improve passage, improve stream channel complexity and floodplain connectivity, and protect and improve riparian areas (BPA et al. 2013, 2016). These actions have been targeted at addressing limiting factors, and best available science indicates that they have and will continue to improve habitat function for the Wenatchee River population, and that fish population abundance and productivity will respond positively. Benefits of some of these actions will continue to accrue over several decades (see Appendix A). This population must achieve at least viable status under the ESA recovery plan (UCSRB 2007).

2.10.2.4.5 Okanogan River Subbasin

In the Okanogan River subbasin, many factors, including beaver trapping, mining, grazing, and diversion of water for irrigation and other purposes have contributed to habitat degradation. At present, barriers, poor water quality and low late-summer instream flows (mainstem and tributary) limit the survival, distribution, and productivity of steelhead. Summer water temperatures often exceed lethal tolerance levels for salmonids along the Okanogan River mainstem. These high temperatures are partially due to natural phenomena but are exacerbated by various anthropogenic activities, including dam operations, irrigation, and land management. Elevated water temperatures and low flows in summer and fall may limit adult run timing as well as juvenile salmonid rearing in the mainstem and in several tributaries. Lack of stream flow and the presence of Conconully and Enloe Dams are barriers to fish passage, although there is debate whether anadromous salmonids historically passed the natural waterfalls that existed before construction of Enloe Dam (NMFS 2016a; UCRTT 2017).

Restoration actions in this subbasin have included actions to protect and restore stream flow, screen irrigation diversions, improve passage, improve stream channel complexity and floodplain connectivity, and protect and improve riparian areas (BPA et al. 2013, 2016). These actions have been targeted at addressing limiting factors, and best available science indicates that they have and will continue to improve habitat function for the Okanogan River population, and that fish population abundance and productivity will respond positively. Benefits of some of these actions will continue to accrue over several decades (see Appendix A). This population must achieve at least viable status under the ESA recovery plan (UCSRB 2007).

2.10.2.4.6 DPS Summary

In summary, while some degraded areas in the UCR steelhead DPS are likely on an improving trend as a result of ongoing habitat improvement actions and improved land-use practices, in general,tributary habitat conditions are still degraded and continue to negatively affect the abundance, productivity, spatial structure, and diversity of the populations in this DPS. In addition, there remains potential for improvement in habitat productivity in all populations in this DPS (UCSRB 2007; NMFS 2016a; UCRTT 2017).

2.10.2.5 Estuary Habitat

The estuary provides important migratory habitat for UCR steelhead. Since the late 1800s, 68–70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening combined with flow regulation and other modifications (Kukulka and Jay 2003; Bottom et al. 2005; Marcoe and Pilson 2017). Disconnection of tidal wetlands and floodplains has reduced the production of wetland macrodetritus supporting salmonid food webs (Simenstad et al. 1990; Maier and Simenstad 2009), both in shallow water and for larger juveniles migrating in the mainstem (ERTG 2018).

Restoration actions in the estuary, such as those highlighted in the latest five-year review, have improved access and connectivity to floodplain habitat. From 2004 through 2017, the Action Agencies implemented 58 projects including dike and levee breaching or lowering, tide-gate removal, and tide-gate upgrades that reconnected 5,412 acres of historical tidal floodplain habitat to the mainstem. This represents a 2.5 percent net increase in the connectivity of habitats that produce prey used by yearling steelhead (Johnson et al. 2018). In addition, about 2,500 acres of functioning floodplain habitat were acquired for conservation.

Floodplain habitat restoration can affect juvenile salmonid performance directly (for fish that move onto the floodplain) and indirectly (for fish that stay in the mainstem). Wetland food production supports foraging and growth within the wetland (Johnson et al. 2018), but these prey items (primarily chironomid insects and corophiid amphipods; PNNL and NMFS 2018) are also exported to the mainstem where they become available to salmon and steelhead migrating in these locations. Thus, while most yearling steelhead may not directly enter a tidal wetland channel, they derive indirect benefits from wetland habitats; improved opportunities for feeding on prey that drift into the mainstem are likely to contribute to survival at ocean entry.

Habitat quality and the food web in the estuary are also degraded because of past and continuing releases of toxic contaminants (Fresh et al. 2005; LCREP 2007), from both estuarine and upstream sources. Historically, levels of contaminants in the Columbia River were low, except for some metals and naturally occurring substances (Fresh et al. 2005). Today, levels in the estuary are much higher, as the estuary receives contaminants from more than 100 sources that discharge into a river and numerous sources of runoff (Fuhrer et al. 1996). With Portland and other cities on its banks, the Columbia River below Bonneville Dam is the most urbanized section of the river. Sediments in the river at Portland are contaminated with various toxic compounds, including metals, PAHs, PCBs, chlorinated pesticides, and dioxin (ODEQ 2008). Contaminants have been detected in aquatic insects, resident fish species, salmonids, river mammals, and osprey, reinforcing that contaminants are widespread throughout the estuarine food web (Fuhrer et al. 1996; Tetra Tech 1996; LCREP 2007).

Exposure to toxic contaminants can either kill aquatic organisms outright or have sublethal effects that compromise their health and behavior. Sublethal concentrations increase stress and decrease fitness, predisposing organisms to disease, slowing development, and disrupting physiological processes, such as reproduction and smoltification. Acute lethal effects of toxic contaminants, such as fish kills from accidental discharges or spills, are generally rare, but some researchers have described direct mortality of salmonids, including high levels of pre-spawning mortality in Puget Sound coho salmon due to road runoff (McCarthy et al. 2008), synergistic toxicity of agricultural pesticide mixtures causing death in juvenile salmon (Laetz et al. 2009), and increased egg mortality due to PAH exposure (Heintz et al. 1999; Carls et al. 2015).

Sublethal effects are more likely a significant threat to juvenile salmon in the Columbia River estuary. Exposure can reduce immune function and fitness, impair growth and development, and disrupt olfaction; salmonids depend on olfaction for migration, imprinting, and homing; detecting predators, prey, and potential mates; and spawning cues. These sublethal effects can interact with other factors like infectious disease, parasites, predation, exhaustion, and starvation by suppressing salmonid immune systems and impairing necessary behaviors, such as swimming, feeding, responding to stimuli, and avoiding predators (LCREP 2007).

Toxic contaminants can also affect salmon via the food web, especially through prey such as aquatic and terrestrial insects. Insect bodies accumulate contaminants, which salmon in turn ingest when they consume insects. Additionally, many toxic contaminants are specifically designed to kill insects and plants, reducing the availability of insect prey or modifying the surrounding vegetation and habitats. Changes in vegetative habitat can shift the composition of biological communities; create favorable conditions for invasive, pollution-tolerant plants and animals; and further shift the food web from macrodetrital to microdetrital sources. Overall, more work is needed on contaminant uptake and impacts on salmon of different populations and life-history types.

2.10.2.6 Predation

A variety of avian and fish predators consume juvenile UCR steelhead on their migration from tributary rearing areas to the ocean. Pinnipeds eat returning adults in the estuary, including the tailrace of Bonneville Dam. This section discusses predation rates and describes management measures to reduce the effects of the growth of predator populations within the action area.

2.10.2.6.1 Predation in the Lower Columbia River Estuary

Avian Predators

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, are having a significant impact on the survival of juvenile salmonids (including UCR steelhead) in the Columbia River. Caspian terns on Rice Island, an artificial dredged-material disposal island in the estuary, consumed about 5.4-14.2 million juveniles per year in 1997 and 1998, or 5 to 15 percent of all the smolts reaching the estuary (Roby et al. 2017). Efforts began in 1999 to relocate the tern colony 13 miles closer to the ocean at East Sand Island where the tern diet would diversify to include marine forage fish. During 2001-15, estimated consumption by terns on East Sand Island averaged 5.1 million smolts per year, about a 59 percent reduction compared to when the colony was on Rice Island. Management efforts are ongoing to further reduce salmonid consumption by terns in the lower Columbia River and similar efforts are in progress to reduce the nesting population of double-crested cormorants in the estuary.

Based on PIT-tag recoveries at East Sand Island, average annual tern and cormorant predation rates for this DPS were about 17.2 and 5.1 percent, respectively, before efforts to manage the size of these colonies (Evans et al. 2018a).[112] The Corps has been implementing the Caspian Tern and Double-crested Cormorant Management Plans, but, in terms of effectiveness, has seen mixed results due to the dispersal of both terns and cormorants to other locations within the estuary. Average predation rates on UCR steelhead have decreased to nine percent for terns nesting on East Sand Island, but in 2017 this improvement was offset to some unknown degree by terns roosting farther upstream on Rice Island (Evans et al. 2018a). Due to failures of the cormorant colony in 2016 and 2017, there are no estimates of predation rates since management of that colony began (Appendix C). substantial numbers of cormorants have relocated to the Astoria-Megler Bridge (preliminary report of 1,737 in 2018) and hundreds more are observed on the Longview Bridge, navigation aids, and transmission towers in the lower river (Anchor QEA et al. 2017). Smolts may constitute a larger proportion of the diet of cormorants nesting at these sites than if the birds were foraging from East Sand Island. Thus, the success of the East Sand Island tern and cormorant management plans at meeting their underlying goals of reducing salmonid predation is uncertain at this time.

An important question in predator management is whether mortality due to predation is an additive or compensatory source of mortality. Most importantly, do reductions in smolt predation rates by Caspian terns or double-crested cormorants result in higher adult returns because avian predation adds to the other sources of smolt mortality or are the smolts eaten by birds destined to die before returning as adults regardless of the level of predation? The latter case could occur because avian predation could be compensated for by sources of mortality in the ocean phase of the life cycle so that adult returns are unchanged. Haeseker (2015) and Evans et al. (2018b) have begun modeling the degree to which double-crested cormorant and Caspian tern predation, respectively, are additive versus compensatory sources of mortality.

Given the magnitude of bird predation on juvenile steelhead observed in the Columbia Basin, and that smolts eaten by birds in the lower river have survived hydrosystem passage, it is likely that some of the smolts consumed by birds could otherwise have survived to adulthood. Therefore, even if avian predation is partially compensatory, we expect that limiting the size of these tern and cormorant colonies will contribute to increased SARs for UCR steelhead.

Pinniped Predators

Numbers of pinnipeds that are predators of adult salmonids have increased considerably in the Pacific Northwest since the MMPA was enacted in 1972 (Carretta et al. 2013). CSLs, SSLs, and

[112] See Appendix C for 95 percent credible intervals and other details about these estimates.

harbor seals consume salmonids from the mouth of the Columbia River and tributaries up to the tailrace of Bonneville Dam. A small number of California sea lions have also been observed in Bonneville Reservoir in recent years.The ODFW has been counting the number of individual CSL hauling out at the East Mooring Basin in Astoria, Oregon, since 1997. Adult UCR steelhead are migrating through the lower river during July–September. Although there has been no clear trend in peak monthly counts of CSL at the East Mooring Basin during July and August in recent years, numbers increased from less than 500 in September 2008–14 to more than 1,000 in September 2015–16 (Wright 2018).

Estimates of steelhead predation by pinnipeds in the lower Columbia River estuary (i.e., downstream of the Bonneville tailrace) are not available for the summer time period, when UCR steelhead are present. Instead, monitoring efforts have focused on CSL predation on SR spring/summer Chinook salmon during January–May (Wargo-Rub 2017).

Fish Predators

The native northern pikeminnow is a significant predator of juvenile salmonids in the Columbia River (reviewed in ISAB 2015). Before the start of the NPMP in 1990, this species was estimated to eat about 8 percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River (including the hydrosystem reach) each year. Williams et al. (2017) compared current estimates of northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. The Sport Reward Fishery removed an average of 188,636 piscivorous pikeminnow (> 228 mm fork length) per year during 2013–17 (Williams 2013, 2014; Williams et al. 2015, 2016, 2017).

The removal of the larger, piscivorous individuals from northern pikeminnow populations will result in a sustained survival improvement for migrating juvenile steelhead only if it is not offset by a compensatory response by the remaining northern pikeminnow or other piscivorous fishes, such as walleye or smallmouth bass. Signs of a compensatory response can include increased numbers of other predators, improved condition factors, or diet shifts. Williams et al. (2017) did not observe increases in numbers of pikeminnow, but did report an increasing trend in condition factor. This could be an intra-specific compensatory mechanism or just a response to beneficial environmental conditions. Similarly, Williams et al. (2017) documented increased numbers of smallmouth bass in parts of the lower Columbia River, which could be related to the NPMP or could be due to factors such as alterations in other parts of the food web or environmental conditions, such as warmer temperature that affect this species' consumption rates. Williams et al. (2017) concluded that given these analytical constraints, data collected during 2017 provided ambiguous indicators of a compensatory response from the piscivorous fish community. Given the numbers of fish, bird, and marine mammal predators in the Columbia River and the ocean, we so not expect that all of the steelhead that are "saved" from predation by pikeminnows survive to adulthood. However, a 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity of steelhead populations, including UCR steelhead.

An average of 37 adult and 197 juvenile steelhead per year were killed and/or handled in the Sport Reward Fishery, system-wide (i.e., in the lower Columbia River and the hydrosystem reach), during 2013–17 (Williams et al. 2013, 2014; Williams et al. 2015, 2016, 2017). Although it was not practical for the field crews to identify these fish to DPS, we assume that some were UCR steelhead.

Non-native fishes such as walleye, smallmouth bass, and channel catfish are present in the slower-moving, off-channel habitats below Bonneville Dam, but yearling UCR steelhead, which mostly stay in the mainstem migration channel, are not likely to encounter large numbers of these species. The Oregon and Washington Departments of Fish and Wildlife have removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids.

2.10.2.6.2 Predation in the Hydrosystem Reach

The following paragraphs describe predation in the mainstem Columbia River from the tailrace of Bonneville Dam to confluences of the Wenatchee, Entiat, Methow, and Okanogan Rivers.

Avian Predators

UCR steelhead survival is affected in the mainstem by avian predators that inhabit the dams and reservoirs. The 2008 FCRPS biological opinion required that the Action Agencies implement avian predation control measures to increase survival of juvenile salmonids in the lower Snake and Columbia Rivers through effective monitoring, hazing, and deterrents at each project. All CRS projects have been using several effective strategies, including: wire arrays that crisscross the tailrace areas, spike strips along the concrete, water sprinklers at juvenile bypass outfalls, pyrotechnics, propane cannons, and limited amounts of lethal take. Zorich et al. (2012) estimated that, compared to the number of smolts consumed at John Day Dam in 2009 and 2010, 84–94 percent fewer smolts were consumed by gulls in 2011. At The Dalles Dam, 81 percent fewer smolts were consumed in 2011 than in 2010. Zorich et al. (2012) attribute the observed changes in predation rates between years to variation in the number of foraging gulls, but imply that deterrence activities provide some (unquantifiable) level of protection.[113]

Juvenile UCR steelhead migrating through the mid-Columbia River are vulnerable to predation by terns nesting on islands in McNary Reservoir, in the Hanford Reach, and in Potholes Reservoir. Smolts come within foraging range of other nesting sites on the plateau (principally the Blalock Islands in John Day Reservoir) as they continue their downstream migration. Annual predation rates on UCR steelhead moving through this reach by terns nesting on Goose Island (Potholes Reservoir) averaged 15.7 percent during 2007–2013 (Collis et al. 2018).

[113] "For continued protection against avian predation we recommend the current passive deterrents avian lines be maintained and expanded where possible and active deterrents, such as hazing from boats or other novel methods, continue to be deployed as necessary to minimize foraging by piscivorous water birds at the Corps' dams" (Zorich et al. 2012).

The objective of the IAPMP (USACE 2014), is to reduce predation rates to less than 2 percent per listed ESU/DPS per tern colony per year. The primary management activities have been to keep terns from nesting on Goose Island in Potholes Reservoir (managed by Reclamation) and on Crescent Island in McNary Reservoir (managed by the Corps) using passive dissuasion, hazing, and revegetation. The Corps has been successful at preventing terns from nesting on Crescent Island since 2015 and similar efforts by Reclamation are in progress at Goose Island in Potholes Reservoir. As a result, predation rates on UCR steelhead by Caspian terns nesting at these two sites have declined from up to 15.7 percent to <1.0 percent (Collis et al. 2018; Appendix C).

However, the number of tern nests at the Blalock Islands in John Day Reservoir was ten times higher in 2015 than the year before, and resightings of colored leg-banded terns indicated that large numbers had moved there from Crescent Island. Annual predation rates on UCR steelhead at this site averaged 5.2 percent in 2015–17 (Collis et al. 2018). Terns have also moved to the interior plateau from East Sand Island in the estuary, and came from alternative Corps-constructed colony sites in southeastern Oregon and northeastern California in 2015 when those areas experienced severe drought (Collis et al. 2016).

Gull predation was not considered in the IAPMP and there are no regional plans to manage these colonies. PIT-tag recoveries indicate that predation rates on smolts from this DPS by gulls on Miller Rock Island ranged from 10.1–13.2 percent during 2015–16 (Roby et al. 2016, 2017).

Pinniped Predators

Pinniped presence in the Bonneville tailrace has increased in the last six years (Tidwell et al. 2017). SSLs, in particular, aggregate at the base of the dam in the fall when UCR steelhead are present. Between July 21 and December 31, 2017, Tidwell et al. (2018) documented an average of 14.5 SSLs at Bonneville Dam and during many sampling periods, counted more than 20 individuals. A small number of California sea lions have also been observed in Bonneville Reservoir in recent years.

Due to the repeated entry of sea lions into the adult ladders at Bonneville Dam, the Corps began constructing physical exclusion devices in 2006 to block pinnipeds, but allow fish passage. These SLEDs are installed at all eight ladder entrances at Bonneville Dam when UCR steelhead are present (Tidwell et al. 2017). In addition, the Corps has installed smaller physical exclusion gratings on the 16 FOGs along the face of Powerhouse 2 that allow fish to enter the collection channel and pass via the Washington shore ladder. The SLEDs and FOGs successfully prevent pinnipeds from entering the adult fish ladders.

Adjusted consumption estimates for all steelhead at Bonneville Dam by pinnipeds is 1.54 percent (Tidwell et al. 2018). Based on the timing of the observations in the study, that number is a reasonable estimate for UCR steelhead.

Fish Predators

Native pikeminnow are significant predators of juvenile salmonids in the hydrosystem reach, followed by non-native smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011, 2015). In addition to the Sport Reward Fishery in the lower Columbia River estuary and throughout the hydrosystem reach, the Action Agencies conduct a Dam Angling Program to remove large pikeminnow from the tailraces of The Dalles and John Day Dams. Angling crews removed an average of 5,913 northern pikeminnow from these two projects per year during 2013–17 (Williams 2013, 2014; Williams et al. 2015, 2016, and 2017). They reported killing or handling zero adult or juvenile steelhead during the five-year period.

Juvenile salmonids are also consumed by large numbers of non-native fishes, including walleye, smallmouth bass, and channel catfish, in the reservoirs of the hydrosystem reach. As described for the lower Columbia River estuary: (1) yearling UCR steelhead mostly stay in the mainstem migration channel and are not likely to encounter large numbers of these species, and (2) both the Oregon and Washington Departments of Fish and Wildlife have removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids.

2.10.2.7 Research and Monitoring Activities

The primary effects of the past and ongoing CRS-related RM&E program on UCR steelhead are associated with the capturing and handling of fish. The RM&E program is a collaborative, regionally coordinated approach to fish and habitat status monitoring, action effectiveness research, critical uncertainty research, and data management. The information derived from the program facilitates effective adaptive management through better understanding the effects of the ongoing CRS action. Capturing, handling, and releasing fish generally leads to stress and other sublethal effects, but fish sometimes die from such treatment. The mechanisms by which these activities affect fish have been well documented and are detailed in Section 8.1.4 of the 2008 biological opinion (NMFS 2008a). Some RM&E actions also involve sacrificial sampling of fish. We estimated the number of UCR steelhead that have been handled or killed each year during the implementation of RM&E under the 2008 RPA as the average annual take reported for 2013–17:

- Average annual estimates for handling and mortality of UCR steelhead associated with the Smolt Monitoring Program and the CSS was: (1) zero hatchery and zero wild adults handled; (2) zero hatchery and zero wild adults died; (3) 1,288 hatchery and 414 wild juveniles handled; and (4) six hatchery and one wild juvenile died.
- The estimated handling and mortality of UCR steelhead associated with the ISEMP Program was: (1) zero hatchery and one wild adult handled; (2) zero hatchery and zero wild adults died; (3) 43 hatchery and 1,972 wild juveniles handled; and (4) zero hatchery and 51 wild juveniles died.
- Estimates for UCR steelhead handling and mortality for all other fish RM&E programs are as follows: (1) 33 hatchery and 14 wild adults handled; (2) zero hatchery and zero

wild adults died; (3) 2,584 hatchery and 1,643 wild juveniles handled; and (4) four hatchery and 12 wild juveniles died.

The combined observed mortality associated with these elements of the RM&E program has, on average, affected less than one percent of the wild (i.e., natural origin) adult run or juvenile production of the UCR steelhead DPS (Bellerud 2018). However, we estimate that more than one percent of the wild juveniles was handled in the combined RM&E programs. Based on the history of these programs, we assume that up to 1 percent of the handled juveniles (i.e., < 0.03 percent of juveniles) died after they were released. This relatively small effect is deemed worthwhile because it allows the Action Agencies and NMFS to evaluate the effects of CRS operations, including modifications to facilities, operations, and mitigation actions.

In addition, northern pikeminnow are tagged as part of the Sport Reward Fishery and their rate of recapture is used to calculate exploitation rates. Northern pikeminnow are collected for tagging using boat electrofishing in select reaches of the Columbia River. During 2017, boat electrofishing operations in the Columbia River extended upstream from RM 47 (near Clatskanie, Oregon) to RM 394 (Priest Rapids Dam), and in the Snake River from RM 10 (Ice Harbor Dam) to RM 41 (Lower Monumental Dam) and from RM 70 (Little Goose Dam) to RM 156 (upstream of Lower Granite Dam). Researchers conducted four sampling events consisting of 15 minutes of boat electrofishing effort in shallow water within each 0.6-mile reach during April-July.

A side effect of the electrofishing effort is that salmon and steelhead may be exposed to the electrofishing field, with the potential for injury, stress, and fatigue and even cardiac or respiratory failure (Snyder 2003). Some adult and juvenile UCR steelhead are likely to be present in shallow shoreline areas during the April-July time period. Most sampling occurs in darkness (1800-0500 hours). Operators shut off the electrical field if salmonids are seen and because most stunned fish quickly recover and swim away, they cannot be identified to species (i.e., Chinook, coho, chum, or sockeye salmon or steelhead). Barr (2018) reported encountering an annual average of 1,463 adult and 78,425 juvenile salmonids in the lower and middle Columbia River each year during 2013-17 electrofishing operations based on visual estimation methods. It is likely that some of these were UCR steelhead.

2.10.2.8 Critical Habitat

The environmental baseline for the PBFs of UCR steelhead critical habitat are reflected in the same impacts discussed above (e.g., mainstem flows, passage, water quality, predation, etc.) and summarized in Table 2.10-6. Across the action area, widespread development and other land use activities have disrupted watershed processes (e.g., erosion and sediment transport, storage and routing of water, plant growth and successional processes, input of nutrients and thermal energy, nutrient cycling in the aquatic food web, etc.), reduced water quality, and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and/or current land use or water management activities have adversely affected the quality and quantity of stream and side channel areas (e.g., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for steelhead production have been weakened.

Habitat quality in tributary streams in the upper Columbia portion of the Interior Columbia recovery domain varies from good in higher elevation stream reaches to degraded in lower elevation reaches, especially near valley bottoms. These areas are subject to heavy agricultural and urban development. Human activities that have contributed to these factors include dams, water diversions, stream channelization and diking, roads and railways, timber harvest, grazing, and urban and rural development (UCSRB 2015). Natural disturbances that have had a large effect on habitat include wildfires with subsequent effects on runoff and sedimentation in areas used for spawning and rearing.

The general effects of mainstem and tributary dams on the functioning of critical habitat include:

- Lost access to historical spawning areas behind dams built without fish passage facilities (obstructions);
- Juvenile and adult passage survival at dams with passage facilities (reduced safe passage in the migration corridor);
- Altered flows and seasonal timing (reduced water quantity);
- Altered seasonal temperatures and elevated dissolved gas (reduced water quality);
- Sediment transport and turbidity (reduced water quality); and
- Altered food webs, including both predators and prey (reduced prey production and increased numbers of predators, including non-natives).

Habitat quality in migratory corridors in this area has been severely affected by the development and operation of the CRS dams and reservoirs in the mainstem Columbia River, Bureau of Reclamation tributary projects, and privately owned dams in the Snake and Upper Columbia River basins. Hydroelectric development has modified natural flow regimes of the rivers, resulting in warmer late summer/fall water temperatures, changes in fish community structure that lead to increased rates of piscivorous and avian predation on juvenile salmon and steelhead, and delayed migration for both adult and juvenile salmonids. Physical features of dams, such as turbines, also kill outmigrating fish. In-river survival is inversely related to the number of hydropower projects encountered by emigrating juveniles. Additionally, development and operation of extensive irrigation systems and dams for water withdrawal and storage in tributaries have altered hydrological cycles (NMFS 2016a).

Many stream reaches designated as critical habitat are listed on Oregon and Washington's Clean Water Act Section 303(d) lists for water temperature. Many areas that were historically suitable rearing and spawning habitat are now unsuitable due to high summer stream temperatures. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water for agricultural or municipal use all contribute to elevated stream temperatures.

Furthermore, contaminants, such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste, are common in some areas of critical habitat (NMFS 2016a). They can negatively impact critical habitat and the organisms associated with these areas.

The large numbers of avian predators nesting on man-made or enhanced structures (dredge material deposits that created Rice Island and increased the size of East Sand Island in the lower Columbia River, as well as bridges, aids to navigation, and transmission towers) constitute unnaturally high predation in the juvenile migration corridor. Similarly, sea-lion predation on adult UCR steelhead in the tailrace of Bonneville Dam is excessive predation associated with a man-made structure. Predation associated with sea lions in the estuary is a natural phenomenon and is not excessive predation in the context of an effect on the functioning of critical habitat.

In the mainstem of the Columbia and Snake Rivers, the altered habitats in project reservoirs reduce smolt migration rates and create more favorable habitat conditions for fish predators, including native northern pikeminnow and nonnative walleye and smallmouth bass. The effects of the non-native species and pikeminnows, to the extent the latter's predation rates are enhanced by reservoir and tailrace conditions, are also examples of excessive predation in the juvenile migration corridor.

Restoration activities addressing habitat quality and complexity, migration barriers, and water quality have improved the baseline condition for PBFs; however, the conservation role of critical habitat is to provide PBFs that support populations that can contribute to conservation of the DPS. More restoration is needed before the PBFs can fully support the conservation of UCR steelhead.

Table 2.10-7. Physical and biological features (PBFs) of designated critical habitat for UCR steelhead.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBF
Freshwater spawning sites	Water quantity and quality and substrate to support spawning, incubation and larval development	● Reduced stream complexity and channel structure (loss of substrate, natural cover, vegetation, and forage) ● Reduced floodplain condition and connectivity (loss of side channels, natural cover, vegetation, and forage) ● Degraded riparian condition (elevated temperatures; loss of natural cover, side channels, vegetation, and forage) ● Diminished stream flow (degraded water quantity, elevated temperatures, loss of juvenile and adult mobility) ● Impaired fish passage (obstructions, water withdrawals) ● Excess fine sediment in spawning gravel (degraded water quantity)
Freshwater rearing sites	Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and	● Impaired fish passage (obstructions, water withdrawals)

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBF
	mobility, water quality and forage, natural cover	● Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) ● Elevated water temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices) ● Reduced floodplain condition and connectivity (loss of side channels, natural cover, vegetation, and forage)
Freshwater migration corridors	Free of obstruction and excessive predation, Adequate water quality and quantity and natural cover	● Delay and mortality of some juveniles and adults at up to five PUD-owned and four CRS dams on the mainstem Columbia River ● Concerns about increased opportunities for predators, especially birds and pinnipeds (construction of dredge material islands in the lower river and other human-built structures used by terns and cormorants for nesting)
Estuarine areas	Free of obstruction and excessive predation with water quality , quantity and salinity, natural cover, juvenile and adult forage	● Disconnection of much of the historical tidally influenced wetlands and riverine floodplain below Bonneville Dam (reduced water quantity, natural cover, side channels, and forage), and the presence of toxic contaminants (reduced water quality and forage).
Nearshore marine areas[1]	Free of obstruction and excessive predation with water quality, quantity and forage	● Concerns about increased opportunities for pinniped predators, adequate forage.

2.10.2.9 Future Anticipated Impacts of Completed Federal Formal Consultations

The environmental baseline also includes the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, including the consultation on the operation and maintenance of the Bureau of Reclamation's upper Snake River projects. NMFS' most recent five-year review evaluated new information regarding the status and trends of UCR steelhead, including recent biological opinions issued for actions likely to affect the UCR steelhead DPS and key emergent or ongoing habitat concerns (NMFS 2016a). Since the beginning of 2015 through 2017, we completed 400 formal consultations (114 in 2015, 95 in 2016 and 191 in 2017) that addressed effects to UCR steelhead (PCTS data query July 31, 2018). These numbers do not include the many projects implemented under programmatic consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed salmonids. Some of the completed consultations are large (large action area, multiple species) such as the Mitchell Act consultation, the consultation on the operation and maintenance of the Bureau of Reclamation's upper Snake River projects, and the consultation on the 2018–27 *U.S. v. Oregon* Management Agreement. Many of the completed actions are for a single activity within a single subbasin.

Some of the projects will improve access to blocked habitat and riparian condition, and increase channel complexity and instream flows. For example, under BPA's Habitat Improvement Programmatic consultation, BPA implemented 29 projects in the Columbia River basin that improved fish passage in 2017, and 99 projects that involved river, stream, floodplain, and wetland restoration. These projects will benefit the viability of the affected populations by improving abundance, productivity, and spatial structure. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more, and typically less, than a few weeks).

Other types of federal projects, including grazing allotments, dock and pier construction, and bank stabilization, will be neutral or have short- or even long-term adverse effects on viability. All of these actions have undergone section 7 consultation, and the actions or the RPA were found to meet the ESA standards for avoiding jeopardy.

Consultations on flow management and irrigation projects typically minimize or avoid negative impacts associated with water use and water management. The estimated effect of water management actions in the Columbia River basin upstream of Bonneville Dam are displayed in Figure 2.10-3, and are expected to continue.

Similarly, future federal restoration projects will improve the functioning of the PBFs safe passage, spawning gravel, substrate, water quantity, water quality, cover/shelter, food, and riparian vegetation. Projects implemented for other purposes will be neutral or have short- or even long-term adverse effects on some of these same PBFs. However, all of these actions, including any RPAs, have undergone section 7 consultation and were found to meet the ESA standards for avoiding adverse modification of critical habitat.

2.10.3 Effects of the Action

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

The proposed action is an ongoing action that has been modified over time to reflect capital improvements, as well as changes in operation based on existing conditions and improved information on how CRS operations affect UCR steelheadand other listed species and their critical habitats. The current proposed action includes operational measures (e.g., flood risk management, navigation, fish passage, and hydropower generation) and non-operational measures (e.g., support for conservation hatchery programs, predation management, habitat improvement actions) that will be implemented beginning in 2019. The proposed action, however, is of limited duration. The Action Agencies are developing an EIS in accordance with NEPA that will assess and update the approach for long-term system operations, maintenance, and configuration as well as evaluate measures to avoid, offset, or minimize impacts to resources affected by the management of the CRS, including ESA-listed species and designated critical habitat. A court order currently requires the Action Agencies to issue Records of Decision on or before September 24, 2021.[114] Based on scoping, the range of alternatives being examined is broad and includes potential large-scale changes in the action. Thus, there is substantial uncertainty regarding what system operations, maintenance, and configuration the Action Agencies will propose at the conclusion of the NEPA process. Likewise, it is unknown what measures intended to avoid, offset, or minimize adverse effects will ultimately be included in the final preferred alternative.

Accordingly, our analysis of effects for UCR steelhead and their critical habitat extends from 2019 into the future, but emphasizes the evaluation of effects that are reasonably certain to occur as a result of implementing the proposed action pending completion of the EIS and our issuance of a subsequent biological opinion addressing the effects of the final preferred alternative. To the extent our consideration of potential effects beyond that time period assumes the current proposed action remains in place, it is intended, in part, to inform the evaluation of alternatives in the EIS.

The effects of the proposed action for UCR steelhead are generally consistent with the effects caused by a continuation of the CRS operations as described in the environmental baseline, with the exception of the addition of the following:

- Implementation of the flexible spring spill operation.
- A 0.5-ft increase in operating range at John Day and lower Snake River reservoirs (relevant for UCR species because of flow effects in the Columbia River downstream of the confluence with the Snake River); and
- The potential for reduction of spill at mainstem projects (August 15 to 31) of 2020 pending consensus among parties.

2.10.3.1 Effects to Species

The Action Agencies will operate the run-of-river lower Snake and Columbia River projects in accordance with the annual Water Management Plan and Fish Passage Plan (including all appendices). These projects are operated for multiple purposes, including fish and wildlife conservation, irrigation, navigation, power, recreation, and, in the case of John Day Dam, limited flood risk management.

The Action Agencies propose to implement the flexible spring spill operation at the lower Columbia River and lower Snake River dams in an attempt to improve juvenile survival through the dams and improve adult returns. Beginning in the spring of 2019, the four lower Snake River

[114] The Presidential Memorandum on Promoting the Reliable Supply and Delivery of Water in the West, issued on October 19, 2018, required the development of an expedited schedule for completion of the NEPA process. The Council on Environmental Quality has confirmed a revised schedule that calls for completing the Draft EIS in February 2020, the Final EIS in June 2020 and Records of Decision by September 30, 2020. These dates are consistent with, but earlier than, the court-ordered deadlines.

dams and the four Columbia River Dams will operate up to 120 percent TDG Gas Cap spill for a minimum of sixteen hours per day, and each project may operate under “performance spill” for up to eight hours per day. The eight hours of performance spill may be split into two separate blocks with one beginning in the AM hours, and one in the PM hours. These performance spill blocks provide more flow through turbine units. Higher powerhouse flow allows for power marketing flexibility and can also work to alleviate passage concerns for adult migrants that can have difficulty passing during high spill at some projects. The Gas Cap spill periods are intended to increase spillway passage and reduce powerhouse encounter rates for downstream migrating juvenile salmonids. Spring spill operations will occur April 3–June 20 at the four lower Snake River projects, and April 10–June 15 at the four lower Columbia River projects. Daily spill caps to meet the up to 120 percent tailrace target will be coordinated with NMFS and adjusted daily as necessary. Target spill levels for spring 2019 at each project are defined in (Table 2.10-8). Gas Cap Spill operations are proposed to increase from up to 120 to up to 125 percent TDG Gas Cap levels starting in 2020.

Table 2.10-8. Initial 2019 juvenile fish passage spill operations at Columbia River and Snake River Dams as described in the proposed action.

PROJECT	GAS CAP SPILL (16 hours per day)[1, 2, 3, 5]	PERFORMANCE STANDARD SPILL (8 hours per day)[2, 4, 5]
Lower Granite	120% Gas Cap	20 kcfs
Little Goose	120% Gas Cap	30%
Lower Monumental	120% Gas Cap (uniform spill pattern)	30 kcfs (bulk spill pattern)
Ice Harbor	120% Gas Cap	30%
McNary	120% Gas Cap	48%
John Day	120% Gas Cap	32%
The Dalles	120% Gas Cap[6]	40%
Bonneville	120% Gas Cap[7] (no downstream forebay)	100 kcfs

[1]Uncertainty remains about how the system will respond to these new operations, therefore existing adaptive management processes will be employed to help address any unintended consequences that may arise in-season as a result of implementing these proposed spill operations.
[2]Spill may be temporarily reduced at any project if necessary to ensure navigation safety or transmission reliability.
[3]120% Gas Cap spill is spill to the maximum level that meets, but does not exceed, the TDG criteria allowed under state laws.

[4]Performance standard spill would occur with some flexibility. The 8 hours would be split into two blocks, an a.m. block and a p.m. block. An a.m. block is defined as beginning in the a.m. (but may end in the p.m.) and a p.m. block is defined as beginning in the p.m. Only Little Goose would be set to at least 4 hours in the a.m. (beginning near dawn and not to exceed 5 hours in the a.m.) and no more than 4 hours in the p.m. (generally near dusk) to help with adult passage issues. All other projects could spill up to 5 hours of performance standard spill either in the a.m. or p.m. time period with the remaining hours occurring in the alternate time period (not to exceed 8 hours in a day).
[5]No ponding above current MOP/MIP assumptions: Snake River - MOP 1.5-foot range to provide 1 foot of usable space; John Day - MIP2foot range to provide 1.5 feet of usable space.
[6]Gas cap fish passage spill restricted to spillbays 1-8.
[7]Spill up to the 120% Gas Cap, not to exceed 150 kcfs.

System-wide water management operations involving upstream water storage projects will continue under the proposed action. Thus, the seasonal alterations described in the environmental baseline will continue (decreased spring and early summer flows, increased winter flows) to affect the mainstem migration and rearing corridor, estuary, and plume. The effects of these flows on the physical environment and to UCR steelhead juveniles and adults are discussed below.

2.10.3.1.1 Water Quality

The existence and operation of the federal hydrosystem will continue to affect water quality parameters in the mainstem migration corridor, as described in the environmental baseline. This includes delayed spring warming, delayed fall cooling, and reduced temperature variability on a daily basis due to the thermal inertia of the reservoirs.

TDG levels will continue to exceed the state-approved standards whenever high flows or lack of load result in lack of market or lack of turbine capacity spill. These events will continue to occur most frequently in May and June, but may also occur in other months.

The available information indicates that supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). For UCR steelhead smolts, the proposed flexible spill operation (up to 120 or 125 percent TDG) would increase the exposure of spring migrating juveniles to elevated TDG levels from the tailrace of McNary Dam to at least 35 miles downstream of Bonneville Dam. Individuals from all populations would be exposed similarly. Smolts typically migrate at depths which effectively reduce TDG exposure due to pressure compensation mechanisms (Weitkamp et al. 2003). However, the proposed flexible spill operation would likely result in a slight increase in the incidence and severity of GBT symptoms and a very small (not measurable through reach survival studies) increase in mortality.

The majority of adult UCR steelhead migrate after the spring spill period and will not be affected by the proposed flexible spring spill operation. Less than 1 percent of the DPS holds up in the larger rivers over the winter and then continues upstream through the dams in the spring (Keefer et al. 2016). Thus only a very small portion of the DPS — those holding overwinter and continuing their migration the following year — could be exposed to the increased spill associated with the flexible spring spill operation. Adults also migrate at depths which reduce the effective exposure to TDG through depth compensation mechanisms. The proposed flexible spill operation would likely result in a slight increase in the incidence and severity of GBT symptoms and a very small (not measurable) increase in mortality for those adults that are exposed.

The Action Agencies also propose to continue using best management practices to reduce and minimize the effects of oil and grease spills. These actions should result in continued reductions in contaminants, as described in the environmental baseline.

2.10.3.1.2 Sediment Transport

The existence and operation of the federal hydrosystem will continue to affect sediment transport, as described in the environmental baseline. These dams will continue to trap sediment and increase water transparency, especially during the spring freshet, which hypothetically increases the exposure of UCR steelhead juveniles to predators and results in higher mortality rates than would be the case in a system with normative flows.

2.10.3.1.3 Adult Migration/Survival

Average adult survival rates through the lower Columbia River dams, as described in the environmental baseline, are expected to continue as a result of the proposed action because very few adults from all populations are in the rivers before June 20. Thus, only a very small proportion of the migrating adults will experience tailrace conditions influenced by the increased spill levels during the flexible spring spill operation. Keefer et al. (2016) estimated that mean annual fallback rates were about 6 to 9 percent at the lower Columbia River dams. Fallback rates, which are associated at many dams with higher spill levels, will likely increase slightly at several of the eight mainstem dams, but this effect will be small because of the scarcity of adults present. In addition, adaptive management processes will be used to identify and remedy excessive fallback, if it occurs, as was done for adult delays at Little Goose Dam in recent years. Thus, the survival for UCR steelhead is expected to continue to average about 92 percent from Bonneville to McNary Dam.

Increasing the operating range by 6 inches at John Day Dam (MIP 2-foot range) will have little effect on velocity and, thus, is not expected to measurably affect adult migration timing or survival rates.

Potential spill reduction starting in August (15-31) of 2020, pending consensus among parties, would likely have negligible effects on adults (fallback related impacts) because sufficient volumes of water are provided to allow volitional passage for downstream migrating adults.

2.10.3.1.4 Juvenile Migration/Survival

The Action Agencies propose to continue to provide beneficial spill (conventional and surface passage), juvenile bypass system, and other operations for juvenile passage at the four lower Columbia River dams described in the environmental baseline. Increased spill levels resulting from the flexible spring spill operation are expected to have little effect on tailrace conditions at Bonneville, The Dalles, or McNary Dams, but could cause small eddies to form at John Day

Dam under low flow conditions. The latter would be likely to reduce the survival of juvenile steelhead passing through the spillway by a small amount. Overall, increased spill levels at the four lower Columbia River mainstem dams would generally be expected to slightly increase the survival rates of in-river migrating smolts.

The COMPASS model, developed by NMFS' NWFSC (Zabel et al. 2008), is a tool for comparatively assessing the likely effect of alternative hydropower structures and/or operations on the passage and survival of juvenile yearling Chinook salmon and steelhead smolts migrating through the lower Snake and Columbia Rivers. Information from both PIT tags (detection efficiencies and project and reach survival estimates) and acoustic tags (route-specific passage and survival estimates and dam survival estimates) are used to calibrate the model. The COMPASS model predicts that the combined effect of the 6-in increase in operating range at John Day Dam and the flexible spring spill operation (up to 120 percent TDG) is expected to stay the same for juvenile UCR steelhead. Juvenile survival from McNary pool to Bonneville tailrace is not expected to change.

These modeling results support our qualitative expectations that passage conditions and survival rates for juvenile UCR steelhead in the lower Columbia River will not change in biologically significant ways (i.e., that would affect the abundance or productivity of any UCR steelhead population) as a result of the proposed action. However, CSS hypothesizes that spill to state water quality limits would reduce latent mortality for SR spring/summer Chinook salmon by reducing the number of powerhouse encounters. If this proves to be true for UCR steelhead, an additional increase in adult returns (though to a smaller extent because they would be exposed to fewer dams with higher spill levels) is also possible.

Potential spill reduction starting in August (15-31) of 2020, pending consensus among parties, would not affect juvenile UCR steelhead which migrate in the spring.

2.10.3.1.5 Transportation

No juvenile UCR steelhead smolts will be transported as a result of the proposed action. Any changes to transportation operations in 2020 would not affect UCR steelhead because juveniles only migrate downstream of the collector projects.

2.10.3.1.6 Estuary Habitat

The Action Agencies will continue to implement the CEERP (Ebberts et al. 2018; BPA and USACE 2018). Program goals are to increase the capacity and quality of estuarine ecosystems and to improve access to these resources for juvenile salmonids. Floodplain reconnections are expected to continue to increase the production and availability of commonly consumed prey (chironomid insects and corophiid amphipods; PNNL and NMFS 2018) to UCR steelhead as they migrate through the estuary.

NMFS agrees with ISAB's assessment findings (ISAB 2014) that it has been difficult to quantify the survival benefits of estuary habitat restoration, but the Action Agencies' assessment method, including review by the ERTG,[115] is useful to prioritize projects. For the interim period, the Action Agencies' proposed commitment is to reconnect an average of 300 acres of floodplain per year, a goal that they have a record of meeting in 2008-17 (BPA et al. 2018b), rather than to achieve a specific survival improvement. NMFS also agrees with the ISAB that the Action Agencies' assessment method, including review by the ERTG (Krueger et al. 2017), remains useful for prioritizing projects and for optimizing project design (number of breaches and channels, etc.) to site conditions. Thus, NMFS expects that the proposed implementation of the estuary program during the interim period will continue to partially mitigate for effects of flow management that, combined with dikes and levees, have cut much of the floodplain off from the mainstem river. The trend of increasing connected area (Johnson et al. 2018) is expected to continue, providing benefits (flux of insect and amphipod prey to the mainstem migration corridor) to juvenile UCR steelhead. These benefits are likely to increase as habitat quality matures.

The Action Agencies also propose continued implementation of their estuary habitat monitoring program, the component of the CEERP that provides the basis for adaptive management. This includes action effectiveness monitoring at each restoration site. A set of "standard" indicators (photo points, water surface elevation, and salinity) are measured at all sites (Level 3); core indicators (plant species composition, percent cover, and biomass) are measured at a subset of the sites (Level 2); and intensive indicators (juvenile salmonid species composition, density, diet, and growth, along with structures and controlling factors) are measured at a smaller number of sites (Level 1; Johnson et al. 2018). Monitoring will continue at recently constructed sites and will be initiated for sites constructed during the period of this biological opinion. Johnson et al. (2018) evaluated the action effectiveness monitoring data collected since 2012 and found they generally indicated that the restoration of physical and biological processes was underway at these sites. Continued implementation and evaluation of this monitoring program either will confirm that these floodplain reconnections are enhancing conditions for yearling salmonids such as UCR steelhead as they migrate through the mainstem, or provide sufficient information to the Action Agencies that site selection or project design will improve through adaptive management.

2.10.3.1.7 Tributary Habitat

For the UCR steelhead DPS, the Action Agencies will implement tributary habitat improvements in order to achieve the metrics outlined in Table 2.10-9 for the single MPG in the DPS. Actions will be strategically identified, prioritized, and implemented to ameliorate specific limiting factors in specific populations, and will accomplish the specific metrics identified for the DPS.

[115]As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss with ERTG and regional partners relevant climate change science in an effort to understand whether their planned estuary projects are resilient to climate change (i.e., sea level rise, temperatures, and mainstem flow levels). In addition, the Action Agencies' annual update of their restoration and monitoring plans for the estuary will document any needed adjustments in design, location, or other elements of a given project to address climate change impacts, both during and beyond the interim period.

The habitat actions that produce these metrics will be completed or in process before completion of the Action Agencies' NEPA process.

The Action Agencies determined this commitment is feasible based on performance and accomplishments under the 2008 FCRPS biological opinion. In addition, the Action Agencies have committed to continuing to improve the strategic implementation of the program, to convene a tributary habitat program steering committee, to report on implementation using metrics that will allow NMFS to evaluate implementation of the program, and to conduct RM&E to assess tributary habitat conditions, limiting factors, and action effectiveness, and to inform associated critical uncertainties.

Table 2.10-9. Proposed tributary habitat metrics (2019–2021) for the single major population group in the Upper Columbia River Steelhead DPS

Upper Columbia River Steelhead DPS Major Population Group[1,2]	**Metrics**					
	Flow Protected (CFS)	**Flow Enhanced (Acre feet)**	**Entrainment Screening (# screens)**	**Habitat Access (Miles)**	**Stream Complexity (Miles)**	**Riparian Habitat Improved (Acres)**
Upper Columbia River /East Slope Cascades Steelhead	5	850	0	0	12	80

[1] The habitat actions that produce these metrics will be completed or in process by the end of the biological opinion period.
[2] The Action Agencies may use surpluses within an MPG from one metric category to augment other metric categories where the biological benefits are comparable.

For an overview of how NMFS analyzed the effects of tributary habitat improvement actions for this biological opinion, see Appendix A. In brief, we reviewed and re-affirmed the strong technical foundation for the tributary habitat program (i.e., that strategically implementing actions to alleviate the factors that limit the function of tributary habitat will improve habitat function and, ultimately, the freshwater survival of salmon and steelhead). We evaluated new RM&E information and found that it also supported the foundation of the program. We determined that the methods we were using to evaluate the effects of tributary habitat actions were based on best available science. For steelhead, we evaluated the effects of actions qualitatively within the context of our understanding of limiting factors, the effects of the types of habitat improvement actions being proposed, population extinction risk, habitat improvement potential, and our ESA recovery plan framework. Life-cycle models for UCR steelhead are in development and were not used for this analysis; however, we expect to be able to use them to evaluate habitat actions implemented during the term of this biological opinion as part of the baseline for the next CRS biological opinion. We considered short-term negative effects that could result from implementation of habitat improvement actions. We also considered certainty of implementation and effects, as well as the strategic framework within which the Action Agencies were committing to implement the program. In addition, we considered the adequacy of the RM&E and adaptive management framework proposed to guide and refine

implementation of the habitat improvement actions and inform our understanding of their effects, and the adequacy of the proposed reporting on actions implemented.

In this DPS, the Action Agencies have committed to continuing to implement actions to protect and enhance flow, to improve stream complexity, and to improve riparian habitat. Limiting factors in this MPG include diminished stream flow, reduced stream complexity and channel structure, and degraded riparian conditions (see Section 2.10.2.4), so the actions will be targeted at addressing these identified limiting factors. Effects of these types of actions, and the time frame in which effects would be expected to accrue, are summarized in Table 2.10-10. In general, these actions will have a long-term benefit to UCR steelhead, although the benefit for actions implemented during the interim period pending completion of the NEPA process, will be particularly small, given the scope of the actions proposed. The positive changes noted in the table below may contribute to improvements in all four VSP parameters for the targeted populations[116] (for additional information on action effectiveness, see Appendix A).

Table 2.10-10. Effects and timing of effects of proposed tributary habitat improvement actions for UCR steelhead.

Action Type	Effects of action and timing of effects
Flow protection and enhancement	Reduced flows can affect adult and juvenile salmonids by blocking fish migration, stranding fish, reducing rearing habitat availability, and increasing summer water temperatures (NMFS 2017a). Flow protection or enhancement reduces these impacts, and the literature shows an obvious and clear relationship between increased flows and increases in fish and macroinvertebrate production (Hillman et al. 2016). The response is most dramatic in stream reaches that were previously dewatered or too warm to support fish because of water withdrawals, and the most successful projects are those in which acquired flows are held in trust long term or in perpetuity (Sabaton et al. 2008; Roni et al. 2014). Studies of fish movements following increases in instream flows show rapid fish colonization of newly accessible habitats and the success of these projects (Roni et al. 2008) For example, ongoing studies in the Lemhi River show increased spawner and juvenile abundance of both Chinook salmon and steelhead following enhancement of instream flows in tributaries (Uthe et al. 2017; Appendix A of Griswold and Phillips 2018). The effects of flow augmentation on habitat conditions depends on the amount of flow within the channel and how much water is added. Augmented flow in dewatered channels or streams too warm to support fish will have the greatest effects on habitat condition. In addition, augmenting flood flows can improve floodplain connectivity and off-channel conditions (Hillman et al. 2016).
Improved stream complexity	Stream complexity created by large wood, boulders, coarse substrate, undercut banks, and overhanging vegetation (in concert with adequate flow regimes and other habitat-forming processes) is an essential feature of productive salmon habitat. Functioning floodplains and side-channels with hydrologic connectivity are also key feature of productive salmon habitat because they provide rearing, resting, and refuge habitat; increase availability of prey; and enhance other stream and watershed processes

[116] In most cases, near-term benefits would be expected in abundance and productivity. Depending on the population and the scale and type of action, benefits to spatial structure and diversity might also accrue, either in the near term or over time. In addition, while we expect abundance, productivity, spatial structure, and diversity to respond positively to strategically implemented tributary habitat improvement actions, other factors also influence these viability parameters (e.g., ocean conditions) and any resulting trends. Throughout this tributary habitat discussion, when we discuss improvements in abundance and productivity, it is implied that spatial structure and diversity might also respond positively, and that other factors, as noted here, might influence any resulting trends.

Action Type	Effects of action and timing of effects
	(NMFS 2013b, 2017a). Habitat improvement actions commonly implemented to enhance stream complexity include placement of large wood, boulders, and cover structures; gravel addition; floodplain reconnection; side channel and pond construction and reconnection, levee removal and setback; channel re-meandering; and, more recently, the construction of beaver enhancement structures (Roni et al. 2014; Hillman et al. 2016). These actions can be expected to aid in reestablishment of hydrologic regimes, increase availability of rearing habitat, improve access to rearing habitat, increase the hydrologic capacity of side channels, increase channel diversity and complexity, provide resting areas for salmonids, provide flood-water attenuation, and enhance native plant communities (NMFS 2013b). The placement of instream structures includes a wide variety of actions that can affect many different habitat factors, so salmonid responses documented in the literature are quite diverse, ranging from small negative responses to large increases in abundance, growth, and survival. Most studies indicate a positive response (increased abundance and density) for salmonids. The lack of response or decrease in abundance identified in some studies was often because the projects did not address upstream watershed processes (e.g., sediment, water quality, etc.), the actions did not address the factors limiting fish, duration of monitoring was too short to demonstrate a positive effect, or the treatments resulted in little change in physical habitat. Salmonids have also been shown to respond rapidly to reconnected or constructed floodplains, side channels, and wetlands. These habitats provide critical rearing habitat for juvenile Chinook and coho salmon and steelhead. Studies indicate that these actions increase salmonid abundance, individual growth rates, overwinter survival, and smolt production (Hillman et al. 2016). While benefits of actions to improve stream complexity may be rapid in terms of fish occupying restored habitats, they also will continue to accrue over some time as habitat continues to respond.
Riparian Habitat Improvement	Riparian vegetation provides numerous functions including shading, stabilizing streambanks, controlling sediments, contributing large wood, and regulating the flow of nutrients. Riparian habitat improvement through riparian planting and silvicultural treatment, invasive species control, and riparian fencing and grazing management can lead to increased shade, bank stability, reduction of fine sediment, reduced temperatures, and improvement of water quality (Roni et al. 2014; Hillman et al. 2016; NMFS 2017a). Benefits of riparian planting actions take more than 50 years to fully accrue, although some benefits begin to accrue after five to ten years (Justice et al. 2017; Pess and Jordan et al. in press). Few studies have examined the response of instream habitat or fish to riparian planting or thinning, in part because of the long lag time between tree growth and any change in channel conditions or delivery of large wood. However, a retrospective study (Lennox et al. 2011) found that project age was positively correlated with both riparian vegetation and instream anadromous fish habitat at revegetated sites. Modeling work in the Grande Ronde River basin indicates that riparian enhancement actions should reduce water temperatures and increase juvenile salmonid abundance up to 377 percent in the Upper Grande Ronde and 61 percent in Cather Creek (McCullough et al. 2016). Justice et al. (2017) utilized a stream temperature model to explore potential benefits of channel and riparian restoration on stream temperatures in the Upper Grande Ronde River and Catherine Creek Basins in Oregon. They focused on streams that had been degraded by intensive land use leading to reduced riparian vegetation and widened channels and concluded that restoration of such streams could more than make up for expected increase in summer stream temperature through 2080. Studies of fish response to livestock exclusion projects have shown variable results. Some have shown increases in salmonid abundance while others have shown no response. Those showing no response were linked to short duration of monitoring,

Action Type	Effects of action and timing of effects
	small size of enclosures, and upstream habitat processes that limited habitat conditions in the project area (Hillman et al. 2016).

All four of these populations must achieve at least viable status for ESA recovery (UCSRB 2007), and there is potential for improvement in tributary habitat productivity in all four populations in the DPS. As noted above, actions will be strategically identified, prioritized, and implemented to ameliorate specific limiting factors in specific populations. Actions implemented to ameliorate limiting factors for any population in the MPG would provide localized habitat benefits and potential improvements in abundance and productivity for the targeted population. To the extent that actions are implemented consistent with best available science and modeling information about the value (in terms of increased biological benefit) to be gained from implementing the appropriate actions in the appropriate location and at the appropriate scale, benefits would be enhanced (Appendix A; also see e.g., Hillman et al. 2016; Pess and Jordan et al. in press).[117]

In terms of the extent of benefits, life-cycle modeling of proposed tributary habitat actions for this DPS was not available. Benefits to habitat and populations in this DPS as a result of tributary habitat improvement actions implemented during the interim period pending completion of the NEPA process are likely to be particularly small for this DPS given the scope of actions proposed. In almost all cases, we would not expect implementation of habitat actions for only a few years to yield significant improvements, because it is not feasible to implement actions of sufficient scope and scale in that time frame to yield substantial effects. It is important to put results of the habitat actions to be implemented in the relatively short time frame of the interim period pending completion of the NEPA process into the context of the effects of longer-term implementation of habitat actions.

The Action Agencies have well-developed partnerships with local implementing groups in the Upper Columbia. The Action Agencies, in coordination with the Upper Columbia Regional Technical Team, utilized the Upper Columbia Biological Strategy to document biological considerations for the protection and improvement of habitat, primarily in the Methow and

[117] Ultimately, implementation should be focused where short-term efforts might yield the highest benefit in terms of reducing both short- and long-term risk, reducing climate vulnerability, and moving toward ESA recovery. NMFS' focal population concept (Cooney, in press (a)) may inform decisions about which populations have the highest potential to benefit DPS status in the near term from directed habitat actions. However, in this case there are only four populations in the DPS, and all four are required to be at least viable to achieve ESA recovery. Thus there is less utility in focusing near-term efforts on a subset of populations, and any of the four is likely an appropriate focus of near-term tributary habitat effort. Nevertheless, NMFS will work with the Action Agencies during implementation of the proposed action to evaluate opportunities for greater alignment of implementation efforts with recovery plan priorities and focal population concepts to the extent they are not currently aligned. In conversations with NMFS, the Action Agencies indicated that their tributary habitat focus during the interim period pending completion of the NEPA process was likely to continue to be on populations where they focused effort under the 2008 biological opinion. The Action Agencies carried out actions in all four populations of this DPS under the 2008 biological opinion.

Wenatchee Rivers, and to a lesser degree in the Entiat River. This strategy provides a scientific basis for habitat action prioritization to guide the design, selection, and implementation of reach-based projects that achieve the highest biological benefit and ensure project goals will be met. The Regional Technical Team is currently working to update the Biological Strategy. This on-the-ground infrastructure, combined with the Action Agencies commitments to work with NMFS to continue to enhance strategic implementation of the program, provides confidence that appropriate actions will be implemented in appropriate locations.

Summation: Tributary Habitat Benefits

Implementation of the tributary habitat actions analyzed in this biological opinion, if implemented as anticipated and as described in the proposed action (i.e., in a manner consistent with scientifically sound identification and prioritization of limiting factors and geographic locations and principles of watershed restoration), will provide benefits to the targeted populations.

This biological opinion covers a proposed action with a limited duration, and thus the improvements from tributary habitat actions will be small, as a large scope and scale of actions are required to achieve significant change at the population level. While it is possible that effects of some actions, such as actions to improve stream flow or remove barriers to passage, could be immediate, for other actions, benefits will take several years to fully accrue (and will take 50 years or more for actions such as restoring riparian areas). In addition, fish response in terms of improved viability will not begin until the progeny of fish spawning in new habitat conditions begin to return, and can only be detected over multiple life cycles. Therefore, it is unlikely that the benefits of these actions will be realized before the Action Agencies complete the NEPA process.

2.10.3.1.8 Hatcheries

Conservation hatchery actions for UCR steelhead that are included in the proposed action and covered under this biological opinion include production of up to 200,000 steelhead smolts by the Winthrop steelhead hatchery program, as part of an integrated conservation (and mitigation) program operated by the USFWS. If the Winthrop NFH program is successful in efforts to develop a Methow-specific broodstock, the effect will be an improvement upon the current baseline.

The kelt reconditioning program operated by the Yakama Confederated Tribes (UCKRP) will continue at the same level as it has been in recent years, and will not collect and capture more than 500 adults. (The program's annual collection rarely exceeds 100 fish.) Based on survival rates in recent years Yakama Nation expects to continue releasing 30 to 75 fish to the Methow and Columbia River. The UCKRP is monitoring post-release movement, survival and reproductive success of reconditioned kelts, and preliminary data suggests that these long-term reconditioning efforts are improving kelt returns (Abrahamse and Murdoch 2017). At a minimum, this program may be having a positive effect on the productivity of the Methow population, but no recent evidence has been provided to-date for determining or quantifying the effect of the program on any UCR steelhead population.

2.10.3.1.9 Predation Management in the Lower Columbia River Estuary

Avian Predators

The Action Agencies propose continued implementation of the Caspian Tern Nesting Habitat Management Plan (USACE 2015a) and the Double-crested Cormorant Management Plan (USACE 2015b). Tern habitat on East Sand Island will continue to be maintained at no less than one acre for the period covered by this interim consultation. Management actions for double-crested cormorants on East Sand Island will be limited to passive dissuasion and hazing, except that limited egg take (up to 500 eggs) may be requested from USFWS each year to preclude cormorants from nesting in new or different areas on East Sand Island. These ongoing actions are likely to continue current levels of predation by birds nesting on East Sand Island, which, in the case of Caspian terns, has been shown to be an improvement compared to the pre-colony management period. Due to the dispersal of the colony in 2016 and 2017, predation rates for East Sand Island cormorants are not available for the management period. Colony size and predation rate data from 2018 and during the interim period will be needed to evaluate whether this program is meeting its management goals.

In addition, the Action Agencies propose to synthesize colony size and predation rate data collected under the tern and cormorant management plans. The intent of the synthesis report is to summarize data on predation by piscivorous waterbirds on ESA-listed salmonids in the Columbia River basin before, during, and after the management actions, in order to assess their effectiveness on a basinwide scale. For example, the dispersal of double-crested cormorants from East Sand Island to nest sites on the Astoria-Megler Bridge in recent years, and observations of thousands of Caspian terns roosting on Rice Island in 2017, indicate that the numbers of avian predators in the estuary, and their effects on the viability of salmonids such as UCR steelhead, are still in flux. The synthesis report will help managers assess whether to recommend that the Action Agencies or other regional parties consider additional measures for implementation over the long term.

Ongoing annual monitoring will include estimates of double-crested cormorant abundance, nesting density, and PIT-tag detection on East Sand Island. The average estimated three-year peak colony size will be used to evaluate management activities relative to plan objectives (2019–2021); the management plan will be considered successful when the average three-year peak colony size estimate does not exceed 5,939 nesting pairs while no management actions are conducted. Annual PIT detection will continue for 5 to 10 years to assess overall trends in predation rates (through the 2023 breeding season, at minimum), accounting for annual variability in predation impacts.

These measures are likely to effectively constrain double-crested cormorant predation of UCR steelhead at Corps-managed sites in the estuary at current levels. The proposed RM&E will provide NMFS and the Action Agencies with the data needed to quantify those levels as management activities continue.

Fish Predators

The Action Agencies will continue to implement the NPMP, including the Sport Reward Fishery in the lower Columbia River estuary as described under the environmental baseline. We expect that this ongoing measure will continue the 30 percent reduction in predation rates achieved under the 2008 RPA. We estimate that the numbers of steelhead, including some from the UCR steelhead DPS, handled and/or killed in the Sport Reward Fishery, system-wide, will be no more than 100 adults and 600 juveniles per year during the interim period.

2.10.3.1.10 Predation Management in the Hydrosystem Reach

Avian Predators

The Corps will continue to implement and improve, as needed, avian predator deterrent programs at lower Columbia and Snake River dams. At each dam, bird numbers will be monitored, feeding birds will be hazed, and passive predation deterrents, such as irrigation sprinklers and bird wires, will be deployed. Hazing, including launching long-range pyrotechnics at concentrations of feeding birds near the spillway and powerhouse discharge areas and the juvenile bypass outfall areas, will also continue. These measures will continue to reduce predation on juvenile UCR steelhead, although the amount of protection has not been quantified (Zorich et al. 2012).

The Action Agencies propose to continue to address Caspian tern predation at lands that they manage on the Columbia plateau: Crescent Island (Corps) and Goose Island (Reclamation). The Corps has excluded tern use on Crescent Island via revegetation since 2015, but will continue to monitor that site to ensure that conditions remain unfavorable for nesting. If tern use does resume during the interim period, the Corps will work with NMFS and USFWS to address concerns, perform any necessary environmental compliance, and seek permits and funding for active hazing, if warranted. If no nesting of concern to the Corps and NMFS is identified, the Corps will discontinue monitoring after three years. These measures are likely to preclude use of Crescent Island by Caspian terns during the interim period.

Reclamation has excluded Caspian terns from Goose Island using ropes and flagging, and is currently experimenting with revegetation. They propose to maintain the ropes and flagging and to monitor for tern presence on a regular basis between late February and early July. If terns resume nesting despite these activities and efforts to establish vegetative cover, and if the number of terns exceeds metrics identified in the IAPMP (more than 40 nesting pairs on Goose Island or more than 200 pairs at sites across the interior Columbia Basin; USACE 2014), Reclamation will work with NMFS to identify management actions and tools that can be put in place to dissuade tern use of the island before the next nesting season (e.g., permits from USFWS for hazing and egg take). These measures are likely to preclude use of Goose Island by Caspian terns during the interim period.

Pinniped Predators

The Corps will continue to install, and improve as needed, sea-lion excluder gates at all adult fish ladder entrances at Bonneville Dam each year. In addition, the Corps and Bonneville will continue to support land- and water-based harassment efforts by ODFW, WDFW, and CRITFC to keep sea lions away from the area downstream of Bonneville Dam. The Corps will continue estimating sea lion abundance, spatial distribution, temporal distribution, predation attempts, and predation rates in the Bonneville Dam tailrace annually from early August through May 31. Collection of predation data will occur when sea lion abundance is greater than or equal to 20 animals. Through the FPOM and Sea Lion Task Force, the Corps will continue to use adaptive management to address changing circumstances as they relate to supporting sea lion harassment efforts and monitoring of sea lion predation at Bonneville Dam. These ongoing measures are expected to maintain current levels of sea lion predation on UCR steelhead in the Bonneville tailrace, which is estimated at 1.54 percent. If pinnipeds are observed at The Dalles Dam, the Corp may respond with hazing at adult fish ladder entrances.

Fish Predators

The Action Agencies will continue to implement the Northern Pikeminnow Sport Reward Fishery in the hydrosystem reach and the Dam Angling Program at The Dalles and John Day Dams, as described under the environmental baseline. These ongoing measures will continue the reduction in predation rates achieved under the 2008 RPA. We estimate that the 2013-2017 annual average numbers of steelhead, including UCR steelhead, which will be handled and/or killed in the Sport Reward Fishery will continue as described above (Predation Management in the Lower Columbia River Estuary). In addition, we estimate that no more than ten adult and 20 juvenile steelhead, including some from the UCR steelhead DPS, will be caught in the Dam Angling Program per year during the interim period.

2.10.3.1.11 Research and Monitoring Activities

The Action Agencies' RM&E program will be similar to the current program, or will be implemented at a reduced scale. Thus, the level of injury and mortality discussed in the environmental baseline, primarily from the capture and handling of fish, is likely to continue at a similar or reduced level. We estimate that, on average, the following number of UCR steelhead will be affected each year during the interim period:

- Projected estimates of UCR steelhead handling and mortality during activities associated with the Smolt Monitoring Program and CSS: (1) zero hatchery and one wild adult handled; (2) one hatchery and one wild adult killed; (3) 13,888 hatchery and 35,396 wild juveniles handled; and (4) 842 hatchery and 985 wild juveniles killed.
- Projected estimates of UCR steelhead handling and mortality during activities associated with Fish Status Monitoring:[118] (1) zero hatchery and zero wild adults handled; (2) zero

[118] Fish Status Monitoring is intended to include individuals handled/killed during status and trend, "fish-in/fish out," and habitat effectiveness monitoring projects.

hatchery and zero wild adults killed; (3) 9,002 hatchery and 12.692 wild juveniles handled; and (4) 90 hatchery and 127 wild juveniles killed.

- Projected estimates of UCR steelhead handling and mortality for all other RM&E programs: (1) 210 hatchery and 78 wild adults handled; (2) two hatchery and one wild adult killed; (3) 3,703 hatchery and 10,207 wild juveniles handled; (4) 37 hatchery and 102 wild juveniles killed.

The combined observed mortality associated with these elements of the RM&E program will, on average, affect less than 1 percent of the wild (i.e., natural origin) adult returns or juvenile production for the UCR steelhead DPS (Bellerud 2018). Although we estimate that 33.08 percent of the wild juvenile production will be handled each year, on average, we expect that only up to 1 percent of these will die after release (in this case, 0.33 percent of juveniles handled). This relatively small effect is deemed worthwhile because it will allow the Action Agencies and NMFS to continue to evaluate the effects of CRS operations, including modifications to facilities, operations, and mitigation actions.

Electrofishing operations for the NPMP during the interim period are expected to continue at the same level of effort as in recent years (four 15-minute sampling events per 0.6-mile reach between RM 47 near Clatskanie, Oregon, and Priest Rapids Dam on the Columbia River during April-July; a total of 550 hours system-wide). Some adult and juvenile UCR steelhead are likely to be present in shallow shoreline areas during electrofishing activities and may be stunned and even killed. However, because the operator releases the electrical field as soon as salmonids are observed and most of these fish quickly recover and swim away, we are unable to use observations from past operations to estimate the number of fish from this DPS that will be affected. Information obtained through electrofishing supports management of the NPMP, which is reported to have reduced salmonid predation by about 30 percent (Williams et al. 2017). This level of take is anticipated to occur for the duration of this proposed action, pending completion of the NEPA process.

2.10.3.1.12 Effects to Critical Habitat

Implementation of the proposed flexible spring spill operation is likely to affect passage at the four lower Columbia River dams. The increased spill will affect the freshwater migration corridor for juveniles, and for a very small number (less than 1 percent) of adult UCR steelhead that overwinter and continue their migration in the spring. Implementation will also affect the volume and timing of flow in the Columbia River, which has the potential to alter habitat in the hydrosystem reach and Columbia River estuary. The PBFs that will be affected by the proposed action are described in Table 2.10-11.

Table 2.10-11. Effects of the proposed action on the physical and biological features (PBFs) essential for the conservation of the UCR steelhead DPS.

Physical and Biological Feature (PBF)	Effects of the Proposed Action
Freshwater spawning sites and freshwater rearing sites	● The principal effect of habitat improvements in spawning and rearing areas ● Used by UCR steelhead will be that about 850 acre-feet of flow will be enhanced and 80 acres of riparian habitat will be improved across the Wenatchee, Entiat, Methow, and Okanogan subbasins. This will improve water quality, floodplain connectivity, and natural cover at the local scale in HUC5 watersheds with these PBFs.
Freshwater migration corridors	● Continuation of decreased survival through the CRS dams and reservoirs, although the flexible spring spill operation is likely to slightly improve direct juvenile survival to below Bonneville Dam (safe passage) ● Increase in TDG levels up to the state-approved limits (up to 120 or 125 percent TDG) at the CRS run-of-river projects) will result in only a slight increase in the incidence and severity of GBT symptoms (water quality in the juvenile and adult migration corridor) (water quality in the juvenile and adult migration corridor) ● Increased spill levels resulting from the flexible spring spill operation can degrade tailrace conditions (especially at John Day Dam under low flow conditions) slightly increasing the risk of bird and fish predation (safe passage). ● The proposed spill operation is not likely to affect passage time for juvenile UCR steelhead in the reach from McNary to Bonneville Dam (safe passage). ● Continuation of altered seasonal flows (decreased spring and early summer flows and increased winter flows) due to system-wide storage operations, including those at CRS reservoirs (reduced water quantity in the juvenile migration corridor) ● Continuation of delayed spring warming, delayed fall cooling, and reduced daily temperature variability due to the thermal inertia of the CRS reservoirs (reduced water quality in juvenile and adult migration corridors) ● Increasing the operating range by 6 inches at John Day Dam (MIP 2-foot range) will slightly increase travel times and exposure to predators (obstructions and excessive predation in juvenile migration corridors), but is more than offset by increased spill levels ● Sediment will continue to accumulate behind CRS dams, reducing turbidity in the migration corridor during the spring smolt outmigration, which could affect the safe passage PBF by increasing the risk of predation ● Ongoing implementation of the Action Agencies' predator management programs will continue (safe passage)
Estuarine areas	● This PBF will continue to improve with the proposed reconnection of an average of 300 acres of floodplain habitat per year during implementation of this proposed action (increased access to forage) ● Because estuary bird colonies and predation rates are in flux, it is not clear whether the continued tern and cormorant colony management is likely to continue any existing survival benefits thus we expect the predation risk to remain unchanged.

2.10.4 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation (50 CFR 402.02). Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Nonfederal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. These projects also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth management programs (planning and regulation); a variety of stream and riparian habitat projects; watershed planning and implementation; acquisition of water rights for instream purposes and sensitive areas; instream flow rules; stormwater and discharge regulation; TMDL implementation to achieve water quality standards; hydraulic project permitting; and increased spill and bypass operations at hydropower facilities. NMFS has determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. These activities are likely to have beneficial cumulative effects that will significantly improve conditions for salmon and steelhead, including CR chum salmon.

In 1998–2004, two PUDs (Chelan County and Douglas County) worked cooperatively with various state and federal fisheries agencies, including NWFS, USFWS, WDFW, three Native American tribes, and an environmental organization, American Rivers, to develop the first hydropower habitat conservation plans (HCPs) for salmon and steelhead. Under the HCPs, the two PUDs commit to a 50-year program to ensure that their projects have no net impact on mid-Columbia salmon and steelhead runs. This will be accomplished through a combination of fish bypass systems, spill at the hydropower projects, off-site hatchery programs and evaluations, and habitat restoration work in mid-Columbia tributary streams. The PUDs must meet minimum targets for either combined juvenile and adult survival or for juvenile-only survival through our reservoirs and past our dams. The minimum combined survival target is 91 percent and juvenile-only survival target is 93 percent. The PUDs have met or exceeded those levels for all spring migrating salmon and steelhead species at both the Rocky Reach, Rock Island and Wells Development hydropower projects. Subsequently, FERC completed consultation on the renewal of the FERC license for the Wells Development Project (Douglas PUD) that carries those same commitments forward. Also, in the mid-Columbia reach, FERC completed consultations on licenses to operate for two Grant PUD projects in 2008: Wanapum Development and Priest Rapids Development. The licenses and ESA consultations contain commitments for UCR spring-run Chinook salmon survival, consistent with current recovery planning.

NMFS has also noted that some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects are activities that occurred in the recent past and were included in the environmental baseline. Some of these activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the action area, nonfederal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. All of these activities can contaminate local or larger areas with hydrocarbon-based materials. Continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations.

Overall, we anticipate that projects to restore and protect habitat and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area.

2.10.5 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.10.3) to the environmental baseline (Section 2.10.2) and the cumulative effects (Section 2.10.4), taking into account the status of the species and critical habitat (Section 2.10.1), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat for the conservation of the species.

2.10.5.1 Species

The extant UCR steelhead DPS is comprised of a single MPG that includes natural-spawned steelhead originating below natural and manmade barriers in the Wenatchee, Entiat, Methow, and Okanogan Rivers. The DPS also includes six artificial propagation programs: Wenatchee River, Wells Hatchery (in the Methow and Okanogan Rivers), Winthrop NFH, Omak Creek, and the Ringold steelhead hatchery programs.

For UCR steelhead, the most recent status review (NWFSC 2015; NMFS 2016a) noted improved abundance for all four extant populations (Wenatchee, Entiat, Methow, and Okanogan Rivers), and reduced productivity for the Entiat River population, but still recommended overall viability ratings of high risk for each population, except the Wenatchee River population, which was rated as maintained. The risk factors of most importance include: (1) continued degraded conditions in tributary spawning and rearing areas, (2) long-term risk associated with high levels of hatchery-origin fish spawning in each population, and (3) continued mortality of juveniles and adults in the hydrosystem reach (both FERC-licensed projects and the CRS).

The proposed action will continue to affect UCR steelhead within the action area, as described in the Status and Environmental Baseline sections (altered flows and water quality, highly modified/inundated habitat, exposure to predators, predator hazing and reduction programs, reduced juvenile and adult passage survival compared to an undeveloped system, tributary and estuary habitat improvements, and research and monitoring activities). However, some aspects of the proposed action will affect UCR steelhead differently than recent operations:

- Increased spill levels at the lower Columbia River dams during the flexible spring spill operation
- Increasing the operating range of John Day Reservoir by 6 inches (MIP 2-foot range).
- The potential for reduction of spill at mainstem projects (August 15 to 31) of 2020 pending consensus among parties

Passage through the four lower Columbia River dams is improved for both life stages; survival rates will continue to average about 92 percent for adults (Bonneville to McNary Dam) and The net effect of the proposed flexible spring spill operation and the increased operational range for John Day pool is not expected to change juvenile travel times compared to operations under the environmental baseline. However, if the flexible spring spill operation reduces latent mortality for this species, as hypothesized by the CSS for Snake River spring/summer Chinook salmon, it could slightly increase the abundance and productivity of the DPS.

The Action Agencies propose continued implementation of the avian, pinniped, and fish predation management programs in the estuary and mainstem hydrosystem reach. Predators consume large numbers of juvenile UCR steelhead as they migrate between the Upper Columbia River basin and the ocean. The continued implementation of these programs is expected to reduce further, or at least maintain, the ongoing benefits of reduced predation rates.

Some degraded habitat in the Upper Columbia River tributaries is likely on an improving trend because of ongoing restoration efforts and improved land use practices. Overall, however, tributary habitat conditions continue to negatively affect the abundance, productivity, spatial structure, and diversity of the populations in this DPS, and there is potential for improvement. Implementation of the tributary habitat actions analyzed in this biological opinion, if implemented as anticipated (i.e., in a manner consistent with scientifically sound identification and prioritization of limiting factors and geographic locations and principles of watershed restoration), will provide benefits to the targeted populations. The status of the Wenatchee River population is maintained, which means that the population does not meet the criteria for a viable population but does support ecological functions and preserve options for recovery of the DPS. The other populations are considered at high risk.

This biological opinion covers a proposed action with a limited duration, and, thus, the improvements from tributary habitat actions will be small, as large amounts of actions are required to achieve significant change at the population level. While it is possible that effects of some habitat improvement actions (e.g., removal of passage barriers) could be immediate, for other actions, benefits will take several years to fully accrue (and will take 50 years or more for actions such as restoring riparian areas). In addition, fish response in terms of improved viability will not begin until the progeny of fish spawning in new habitat conditions begin to return, can only be detected over multiple life cycles, and will be influenced by the backdrop of ecosystem variability. The proposed tributary habitat improvement program is consistent with recommendations in the recovery plan and will support the improving status of the DPS.

All populations in the single MPG migrate downstream through the estuary; according to the status review and the recovery plan, degraded habitat in this reach is a key factor limiting survival and recovery, including floodplain connectivity and function. For the interim period, the Action Agencies propose to reconnect an average of 300 acres of floodplain habitat per year, a continuation of the average rate of implementation during 2008-17. Reconnected areas produce commonly consumed prey that drift into the mainstem where they are encountered by juvenile UCR steelhead. The opportunity to feed during transit of the lower Columbia River is likely to contribute to survival at ocean entry.

As a general matter, the effects of the proposed action are very similar to a short-term continuation of the same effects caused by the current operations and maintenance of the CRS, as well as the associated measures implemented to avoid, minimize, or offset adverse effects. Therefore, we do not anticipate large changes in mortality caused by the CRS or substantial new risks to UCR steelhead or their habitat, and we do not expect considerable changes in the effects on reproduction, numbers, or distribution. However, we do anticipate additional improvements in habitat conditions in the estuary and tributaries that will accrue over time.

The environmental baseline includes the past and present impacts of hydropower, changes in tributary and mainstem habitat (both beneficial and adverse), harvest, and hatcheries on UCR steelhead. The baseline provides important context for assessing the effects of the action described above.

Improvements in mainstem passage and survival resulting from past federal efforts at the lower Columbia River dams and from improvements at the five FERC-licensed “Mid-Columbia” river dams (i.e., 24-hour spill, surface passage routes, improved juvenile bypass systems, etc.) are expected to continue. The continuation of these actions should continue to positively affect the productivity and abundance of UCR steelhead.

Harvest and hatcheries will continue to affect the status of UCR steelhead. The hatchery programs for UCR steelhead serve the dual purpose of providing fish for fisheries, as well as supplemental spawners to help rebuild depressed natural populations. Although the issue is complex, existing hatchery programs remain a threat for several UCR steelhead populations. The concerns are discussed in the environmental baseline above, and includes a discussion of critical uncertainties where information is lacking regarding the relative proportion and distribution of hatchery-origin spawners in natural spawning areas at the population scale. Improvements stemming from recent consultations in hatchery operations and management include development of Methow-specific broodstock for use in the Wells Complex Steelhead Program to reduce the effects of hatchery fish on (Methow and Okanogan Rivers) spawning grounds. They also include changes to management of adult hatchery-origin steelhead returning to the Wenatchee River basin to reduce pHOS and genetic risk, and changes in the use of water at Leavenworth National Fish Hatchery, which provides more stream flow in Icicle Creek in summer months — reducing the potential for dewatering and, therefore, risks to the Wenatchee River population. These improvements would be expected to lessen threats to genetic diversity over time and should also lead to improvements in productivity of the naturally spawning populations.

Continued implementation of the kelt reconditioning program (operated by the Confederated Tribes and Bands of the Yakama Nation) should continue to benefit UCR steelhead by increasing the productivity.

The largest harvest-related effects on UCR steelhead result from the tribal and nontribal mainstem Columbia River fisheries. The recent *U.S. v. Oregon* consultation addressed this fishery, and that the harvest rate should continue to average around 10 percent (8 percent in tribal fall season fisheries and 2 percent in the non-treaty fall season fishery) for the foreseeable future.

Improvements, including tributary hydrosystem modification and habitat restoration (e.g., in the estuary), coupled with significant harvest reductions from historic levels, have allowed for progress in improving UCR steelhead abundance, productivity, spatial structure and diversity. However, these improvements also occur in the context of natural fluctuations in environmental conditions, such as cyclical changes in ocean circulation and the unusually warm ocean conditions seen predominating during 2015, which can temporarily adversely affect survival and adult returns of all salmonid species, even if freshwater habitat conditions are improving.

The status of UCR steelhead is also likely to be affected by climate change. Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycle. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream-flow patterns in freshwater and changes to food webs in freshwater, estuarine, and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management actions may help alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations, increased riparian vegetation to control water temperatures, etc.).

Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life-history types that will be successful in the future are neither static nor predictable. Therefore, maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the UCR steelhead DPS. Because of its location in the Columbia River basin, the DPS is likely to be more affected by climate-related effects in tributary streams (altered seasonal flows and temperatures) that support spawning and early rearing. Emerging research using complex life-cycle modeling indicates a potentially strong link between SST and survival of Snake River spring/summer Chinook salmon populations. However, the apparent link between SST and survival is presumably caused by food web interactions, relationships which could be disrupted by major transformations of community dynamics, as well as ocean acidification and other factors under a changing climate. The degree to which SST is linked to survival of UCR steelhead, and how that relationship interacts with other variables throughout the UCR steelhead life cycle, will likely be an important area of future research.

When evaluating the effects of the action, those effects must be taken together with the effects on UCR steelhead of future state or private activities, not involving federal activities that are reasonably certain to occur within the action area. NMFS anticipates that human development activities will continue to have adverse effects on UCR steelhead in the action area. Many of these activities and their effects occurred in the recent past and were included in the environmental baseline but are also reasonably certain to occur in the future. Within the action area, nonfederal actions are likely to include changes associated with human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Habitat restoration efforts led by state and local agencies, tribes, environmental organizations, and local communities are likely to continue. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives that, in some cases, are identified through ESA recovery plans. Larger, more regionwide, restoration and conservation efforts are either underway or planned throughout the Columbia River basin. These state and private actions have helped restore habitat, improve fish passage, and reduce pollution. While these efforts are reasonably certain to continue to occur, funding levels may vary on an annual basis.

Other environmental baseline conditions have shown little change or have declined. The most notable of these are: (1) increased numbers of sea lions in the lower Columbia River since the late 1990s, and an estimated 1.54 percent predation rate on UCR steelhead in the tailrace of Bonneville Dam in recent years; (2) relatively high rates of predation on UCR steelhead by large numbers of piscivorous birds in the estuary and on the interior Columbia plateau; and (3) continued exposure to chemicals and toxic substances throughout the mainstem migration corridor, lower Columbia River, and estuary. We expect that these effects will continue largely unchanged for the foreseeable future.

The recovery plan (UCSRB 2007) outlines specific objectives for each of the four populations. The recovery plan addresses the underlying limiting factors and threats for UCR steelhead, including hydropower projects, predation, harvest and hatchery effects, tributary habitat, and ocean conditions. The recovery plan identifies recovery actions to be implemented, generally within a 10 to 30-year period. Effective implementation requires that the recovery efforts of diverse private, local, state, tribal, and federal parties across two states be coordinated at multiple levels. The proposed action will not result in reductions to UCR steelhead reproduction, numbers, or distribution that would impede the ability to successfully carry out the identified recovery measures and actions over the time frames considered in the recovery plan.

After reviewing and analyzing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, and considering the interim nature of this proposed action pending the decision to implement a new action as a result of the NEPA process, it is NMFS' biological opinion that the proposed action is not likely to reduce appreciably the likelihood of both survival and recovery of UCR steelhead.

2.10.5.2 Critical Habitat

The rangewide status of critical habitat designated for UCR steelhead is described in Section 2.1 of this biological opinion. Across the entire designated area, widespread development and other land use activities have disrupted watershed processes (e.g., erosion and sediment transport, storage and routing of water, plant growth and successional processes, input of nutrients and thermal energy, nutrient cycling in the aquatic food web, etc.), reduced water quality, and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and/or current land use or water management activities have adversely affected the quality and quantity of stream and side channel areas (e.g., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for salmon and steelhead production have been weakened.

The environmental baseline includes a broad range of past and present actions and activities that have affected the conservation value of critical habitat for UCR steelhead. These include the effects of hydropower, changes in tributary and mainstem habitat (both positive and negative), and hatcheries on freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine areas, and nearshore marine areas. Despite a long-term trend in degradation of these habitats, there have been localized improvements in their conservation value through the combined efforts of federal, state, and local agencies; tribes; and other stakeholders. Tributary dams and other barriers have been removed, estuarine habitats restored and reconnected to the floodplain, and water quality has improved. Despite significant losses to predators in the migration corridor, the combined efforts of multiple parties has reduced the effect of predation, and the Action Agencies propose to continue predator management activities.

Specific effects on the functioning of critical habitat in the migration corridor have included increased passage times and reduced juvenile and adult survival at CRS run-of-river dams. The proposed flexible spring spill program is likely to slightly improve the direct survival of juvenile steelhead to below Bonneville Dam. Levels of TDG will increase to state water quality limits during the flexible spill operation, but result in only slight increases in the incidence and severity of GBT symptoms. Seasonal flows and temperatures will continue to be altered with negative effects on water quantity and quality. Increased numbers of predators, including birds and native and non-native fishes that prey on yearling steelhead, are present in the hydrosystem reach (excessive predation in the juvenile migration corridor). The reduced levels of predation by Caspian terns nesting on Goose and Crescent Islands on the interior Columbia plateau, and northern pikeminnows in project tailraces and reservoirs that were achieved under the 2008 RPA will be maintained by the continued implementation of the respective predator management plans (reduction in the level of excessive predation).

In the lower Columbia River estuary, the proposed habitat restoration program will continue to reconnect the historical floodplain, increasing the availability of wetland-derived prey to yearling steelhead migrating to the ocean (improved forage in estuarine areas). In addition, the Action Agencies will provide a total of over 850 acre-feet of instream flow and will improve a total 80 acres of riparian habitat in subbasins used by UCR steelhead for spawning and rearing. This will improve the functioning of critical habitat at the local scale in some HUC5 watersheds (improvements in water quantity in spawning and rearing areas and forage and natural cover in rearing areas). The benefits of instream flow will improve the function of critical habitat during the implementation period of this opinion; the benefits of the riparian improvement will increase over time as the habitat improvements mature.

Considering the ongoing and future effects of the environmental baseline and cumulative effects and in light of the status of critical habitat, the proposed action will not appreciably reduce the value of designated critical habitat for the conservation of UCR steelhead.

2.10.6 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, and considering the interim nature of the proposed action, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of UCR steelhead or destroy or adversely modify its designated critical habitat.

2.11 Upper Columbia River Spring-run Chinook Salmon

This section applies the analytical framework described in section 2.1 to the UCR spring-run Chinook salmon ESU and provides NMFS' finding regarding whether the proposed action is likely to jeopardize the continued existence of UCR spring-run Chinook salmon ESU or destroy or adversely modify its critical habitat.

2.11.1 Rangewide Status of the Species and Critical Habitat

The status of the UCR spring-run Chinook salmon ESU is determined by the level of extinction risk that the listed species faces, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The condition of critical habitat throughout the designated area is determined by the current function of the PBFs that help to form that conservation value.

2.11.1.1 Status of the Species

The summary that follows describes the status of UCR spring-run Chinook salmon, and its designated critical habitat. More detailed information on the status and trends of these listed resources, and their biology and ecology, are in the listing regulations and critical habitat designations published in the Federal Register.

The UCR spring-run Chinook salmon ESU was originally listed as endangered under the ESA in 1998 (64 FR 14308), and the status was affirmed in 2005 and 2012. In 2016, the five-year review for UCR spring-run Chinook salmon concluded that the species should maintain its endangered listing classification (NWFSC 2015; NMFS 2016a). Critical habitat for the UCR spring-run Chinook salmon ESU was designated on September 2, 2005 (70 FR 52630).

Adult UCR spring-run Chinook salmon begin returning from the ocean in April and May, with the run into the Columbia River peaking in mid-May. They enter the Upper Columbia River tributaries from April through July. After migration, they hold in freshwater tributaries until spawning occurs in the late summer, peaking in mid-to-late August. Juvenile spring Chinook salmon spend a year in freshwater before migrating to saltwater in the spring of their second year of life. Most UCR spring-run Chinook salmon return as adults after two or three years in the ocean. Some precocious males, or jacks, return after one winter at sea. A few other males mature sexually in freshwater without migrating to the sea. The run, however, is dominated by four- and five-year-old fish that have spent two and three years at sea, respectively. Fecundity ranges from 4,200 to 5,900 eggs, depending on the age and size of the female.

2.11.1.1.1 Spatial Structure and Diversity

The UCR Chinook salmon ESU is composed of a single MGP which includes all naturally spawned populations of Chinook salmon in all river reaches accessible to Chinook salmon in Columbia River tributaries upstream of the Rock Island Dam and downstream of Chief Joseph

Dam (excluding the Okanogan River),[119] and the progeny of six artificial propagation programs (Twisp River, Chewuch River, Methow, Winthrop NFH, Chiwawa River, and White River). The North Cascades MPG is comprised of three extant populations: the Wenatchee River, the Methow River, and the Entiat River populations. All three populations spawn in tributaries to the Columbia River, upstream of the confluence of the Snake River to the Columbia River; they pass the four lower Columbia River dams (Bonneville, The Dalles, John Day and McNary Dams), operations of which are part of the proposed action. All three populations spawn upstream of Priest Rapids, Wanapum, and Rock Island Dams on the Columbia River (the operation of these dams is not part of the proposed action). Historically, UCR spring-run Chinook salmon likely included three MPGs (Figure 2.11-1). Two of these MPGs were eliminated by the completion of Grand Coulee and Chief Joseph Dams (UCSRB 2007; NWFSC 2015).

The composite spatial structure/diversity risks for all three of the extant natural populations in this MPG are rated at high (Table 2.11-1). The natural processes component of this risk is low for the Wenatchee and Methow River populations, and moderate for the Entiat River population. All three of the extant populations in this MPG are rated at high risk for diversity, driven primarily by chronically high proportions of hatchery-origin spawners in natural spawning areas and a lack of genetic diversity among the natural-origin spawners (ICTRT 2008; NWFSC 2015).

[119] On July 11, 2014, NMFS designated the Okanogan River as a "Nonessential Experimental Population of UCR spring-run Chinook salmon (79 FR 40004).

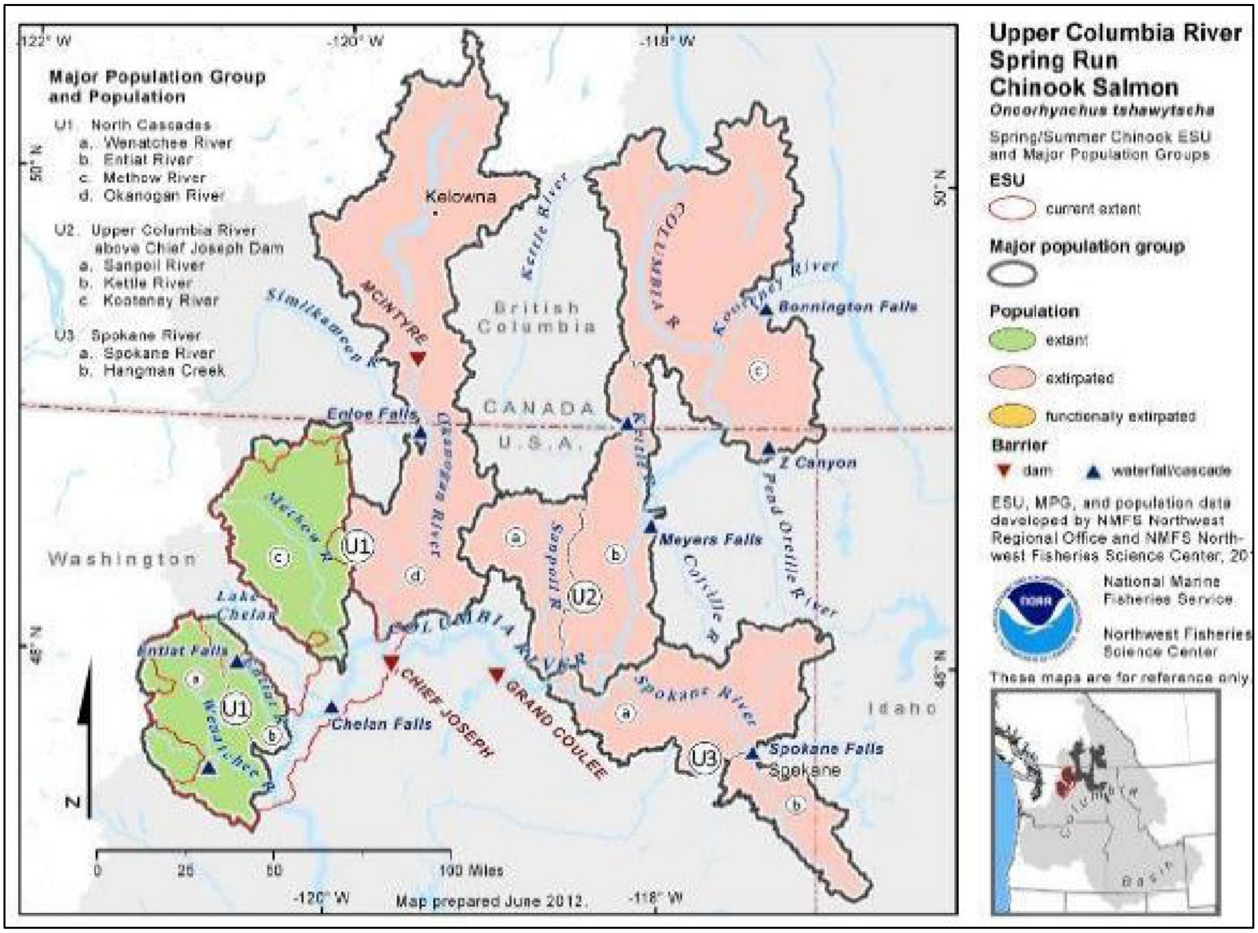


Figure 2.11-1. Map of the UCR Spring Chinook salmon ESU spawning and rearing areas, illustrating natural populations and both extant and historical MPGs (NWFSC 2015).

Table 2.11-1. UCR spring-run Chinook salmon ESU population viability status summary. Current abundance and productivity (A/P) estimates are geometric means. The range in annual abundance, standard error, and number of qualifying estimates for production are in parentheses. Upward arrows = current estimates increased from prior review. Oval = no change since prior review (NWFSC 2015). The Wenatchee, Entiat, and Methow River populations are considered a high risk for both A/P and composite spatial structure/diversity (SS/D), as noted in the table.

Population	Abundance and productivity metrics				Spatial structure and diversity metrics			Overall viability rating
	ICTRT minimum threshold	Natural Spawning Abundance	ICTRT Productivity	Integrated A/P Risk	Natural Processes Risk	Diversity Risk	Integrated SS/D Risk	
Wenatchee River 2005-2014	2,000	545 ↑ (311-1,030)	0.60 ↑ (0.27,15/20)	High	Low	High	High	High Risk
Entiat River 2005-2014	500	166 ↑ (78-354)	0.94 ↑ (0.18, 12/20)	High	Moderate	High	High	High Risk
Methow River 2005-2014	2,000	379 ↑ (189-929)	0.46 ○ (0.31, 16/20)	High	Low	High	High	High Risk

2.11.1.1.2 Abundance and Productivity

Overall abundance and productivity (A/P) continue to be rated at high risk for each of the three extant populations in this ESU (Table 2.11-1 and Figure 2.11-2) (NWFSC 2015). The 10-year geometric mean abundance of adult natural-origin spawners has increased for each population relative to the levels reported in the 2011 status review, but natural-origin escapements remain below the corresponding ICTRT thresholds. The combinations of current abundance and productivity for each population result in a high-risk rating when compared to the ICTRT viability curves (NWFSC 2015). Since the last status review in 2015, observations of coastal ocean conditions suggested that the 2015–17 outmigrant year classes experienced below average ocean survival during a marine heatwave and its lingering effects, which led researchers to predict a corresponding drop in adult returns through 2019 (Werner et al. 2017). The negative impacts on juvenile salmonids had subsided by spring 2018, but other aspects of the ecosystem (e.g., temperatures below the 50-m surface layer) had not returned to normal (Harvey et al. 2019).

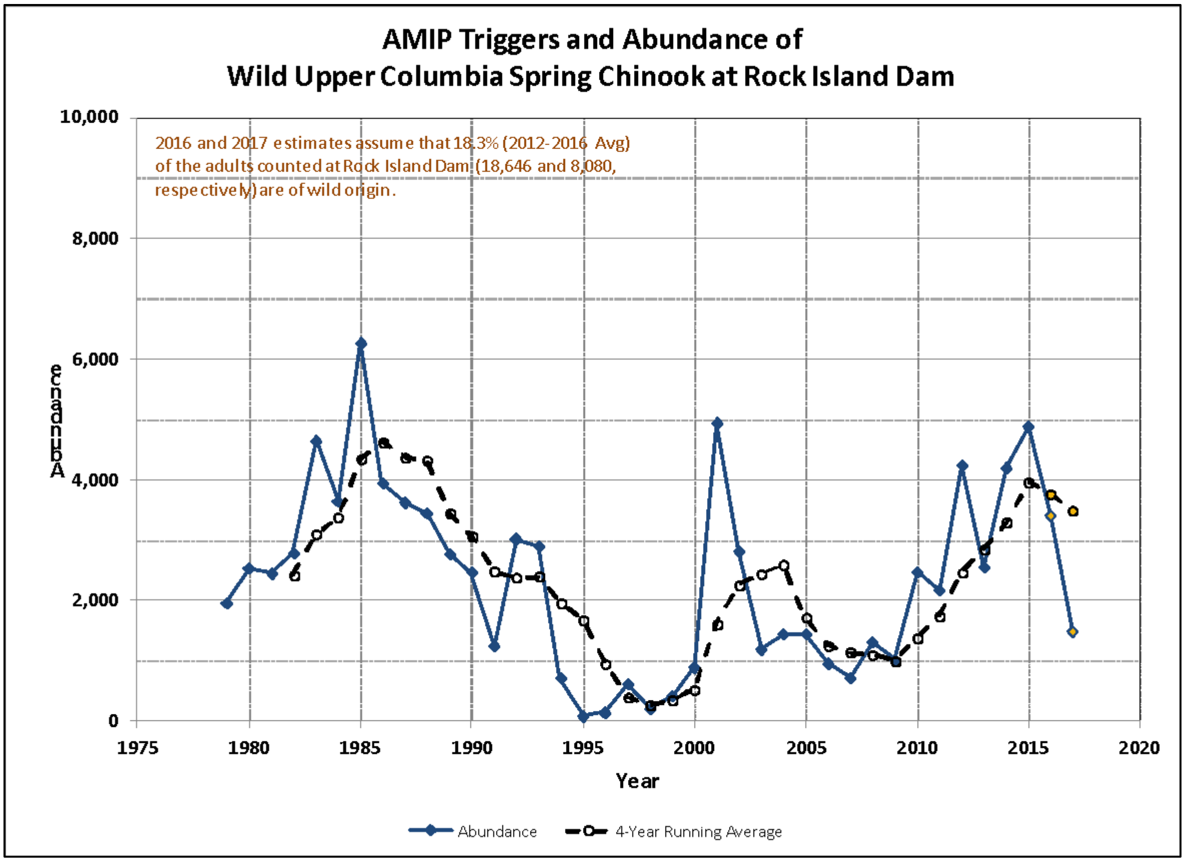


Figure 2.11-2. Abundance of wild adult UCR spring-run Chinook salmon at Rock Island Dam in the Upper Columbia River**.**

2.11.1.1.3 Recovery Plan

The recovery plan for this species (UCSRB 2007) describes measures that could provide sufficient improvement in the abundance, productivity, spatial structure, and diversity of the species to achieve recovery (i.e., delisting the species). The plan calls for meeting or exceeding the same basic spatial structure and diversity criteria adopted from the ICTRT viability report for recovery (NWFSC 2015). None of the three populations are currently viable with respect to abundance and productivity, and they all have a greater than 25 percent chance of extirpation in 100 years (UCSRB 2007).

2.11.1.1.4 Limiting Factors

Understanding the limiting factors and threats that affect UCR spring-run Chinook salmon provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting the species is to ensure that the underlying limiting factors and threats have been addressed. Limiting factors identified in the recovery plan (UCSRB 2007) for this species include:

- Effects related to the hydropower system (including FERC-licensed projects) in the mainstem Columbia River, including reduced upstream and downstream fish passage survival, altered ecosystem structure and function, altered flows, and degraded water quality;

- Degradation of floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream flow, and water quality in tributaries;
- Degraded estuarine and nearshore marine habitat;
- Hatchery-related effects;
- Persistence of non-native (exotic) fish species that continues to affect conditions for listed species; and
- Harvest in Columbia River fisheries.

2.11.1.2 Status of Critical Habitat

This Section examines the rangewide status of UCR spring-run Chinook salmon designated critical habitat. Critical habitat includes the stream channels within designated stream reaches and a lateral extent defined by the ordinary high-water line (33 CFR 319.11).

For UCR spring-run Chinook salmon, NMFS ranked watersheds within designated critical habitat at the scale of the fifth-field HUC_5 in terms of the conservation value they provide.[120] The conservation rankings are high, medium, or low. To determine the conservation value of each watershed to species viability, NMFS' CHARTS evaluated the quantity and quality of habitat features (for example, spawning gravels, wood and water condition, and side channels), the relationship of the area compared to other areas within the species' range, and the significance to the species of the population occupying that area (NMFS 2005a). Thus, even a location that has poor quality of habitat could be ranked with a high conservation value if it were essential due to factors such as limited availability (e.g., one of a very few spawning areas), a unique contribution of the population it served (e.g., a population at the extreme end of geographic distribution), or if it serves another important role (e.g., obligate area for migration to upstream spawning areas).

The PBFs identified when critical habitat was designated are essential to the conservation of UCR spring-run Chinook salmon because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration, and foraging). Designated areas support one or more life stages (spawning, rearing, and/or migration) and contain the PBFs essential to the conservation of the species (Table 2.11-2). These areas include rearing sites with overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks and migration corridors free of artificial obstruction with sufficient water quantity and quality.

[120] The conservation value of a site depends upon: "(1) the importance of the populations associated with a site to the ESU [or DPS] conservation, and (2) the contribution of that site to the conservation of the population through demonstrated or potential productivity of the area" (NMFS 2005a).

Table 2.11-2. Physical and biological features (PBFs) of critical habitats designated for UCR spring-run Chinook salmon and components of the PBFs.

Physical and Biological Feature	Components of the PBF
Freshwater spawning sites	● Water quantity and quality and substrate to support spawning, incubation, and larval development
Freshwater rearing sites	● Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility ● Water quality and forage supporting juvenile development ● Natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks
Freshwater migration corridors	● Free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival
Estuarine areas	● Free of obstruction and excessive predation with: - Water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater - Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels - Juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation
Nearshore marine areas[1]	● Free of obstruction and excessive predation with: - Water quality and quantity conditions and forage including aquatic invertebrates and fishes, supporting growth and maturation - Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels
Offshore marine areas	● Not designated

[1] The designated nearshore marine area includes only the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

The complex life cycle of UCR spring-run Chinook salmon gives rise to complex habitat needs, particularly in freshwater. The gravel used for spawning must be a certain size and largely free of fine sediments to allow successful incubation of the eggs and later emergence or escape from the gravel as alevins. Eggs also require cool, clean, and well-oxygenated waters for proper development. Juveniles need abundant food sources, including insects, crustaceans, and other small fish. They need instream places to hide from predators (mostly birds and larger fish), such as under logs, root wads, and boulders, as well as beneath overhanging vegetation. They also need refuge from periodic high flows in side channels and off-channel areas and from warm summer water temperatures in cold-water springs and deep pools. Returning adults generally do not feed in freshwater, but instead rely on limited energy stored to migrate, mature, and spawn. Like juveniles, the returning adults also require cool water that is free of contaminants and migratory corridors with adequate passage conditions (timing, water quality/quantity) to allow access to the various habitats required to complete their life cycle (NMFS 2005a).

In the following paragraphs, we discuss the current status of the functioning of the PBFs of critical habitat in the Interior Columbia and Lower Columbia River Estuary recovery domains.

2.11.1.2.1 Interior Columbia Recovery Domain

Critical habitat has been designated for UCR spring-run Chinook salmon in the Interior Columbia recovery domain, which encompasses all of the Columbia River basin accessible to anadromous salmon and steelhead above Bonneville Dam. Habitat quality in tributary streams within this domain varies from excellent in wilderness and roadless areas, to poor in areas subject to heavy agricultural and urban development. Critical habitat throughout much of the Interior Columbia recovery domain has been degraded by intense agriculture, alteration of stream morphology (i.e., through channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining, and urbanization. Reduced summer stream flows, impaired water quality, and reduction of habitat complexity are common problems for critical habitat in developed areas (NMFS 2016a).

Habitat quality of migratory corridors in this area has been severely affected by the development and operation of the CRS dams and reservoirs in the mainstem Columbia River, Bureau of Reclamation tributary projects, and privately owned dams in the upper Columbia River basin. Hydroelectric development has modified natural flow regimes of the rivers, resulting in warmer late summer/fall water temperatures, changes in fish community structure that lead to increased rates of piscivorous and avian predation on juvenile salmon and steelhead, and delayed migration for both adult and juvenile salmonids. Physical features of dams, such as turbines, also kill out-migrating fish. In-river survival is inversely related to the number of hydropower projects encountered by emigrating juveniles. Additionally, development and operation of extensive irrigation systems and dams for water withdrawal and storage in tributaries have altered hydrological cycles (NMFS 2016a).

Many stream reaches designated as critical habitat are listed on the Oregon and Washington Clean Water Act Section 303(d) lists for water temperature. Many areas that were historically suitable rearing and spawning habitat are now unsuitable due to high summer stream temperatures. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water for agricultural or municipal use all contribute to elevated stream temperatures. Furthermore, contaminants, such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste, are common in some areas of critical habitat (NMFS 2016a). They can negatively impact critical habitat and the organisms associated with these areas.

2.11.1.2.2 Lower Columbia River Estuary Recovery Domain

Critical habitat also has been designated for UCR spring-run Chinook salmon in the lower Columbia River estuary. The estuary is broadly defined to include the entire reach where tidal forces and river flows interact, regardless of the extent of saltwater intrusion. This encompasses areas from Bonneville Dam (RM 146) to the mouth of the Columbia River. It also includes the tidally influenced portions of tributaries below Bonneville Dam, including the lower 26 miles of the Willamette River. This region experiences ocean tides that extend from the mouth of the Columbia River up to Bonneville Dam.

Historically, the downstream half of the Columbia River estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. The mouth of the Columbia River was about four miles wide. Winter and spring floods, low flows in late summer, large woody debris floating downstream, and a shallow bar at the mouth of the Columbia River maintained a dynamic environment. Today, navigation channels have been dredged, deepened, and maintained, jetties and pile-dike fields have been constructed to stabilize and concentrate flow in navigation channels, marsh and riparian habitats have been filled and diked, and causeways have been constructed across waterways. These actions have decreased the width of the mouth of the Columbia River to two miles and increased the depth of the Columbia River channel at the bar from less than 20 to more than 55 feet (NMFS 2008a).

Over time, more than 50 percent of the original marshes and spruce swamps in the estuary have been converted to industrial, transportation, recreational, agricultural, or urban uses. More than 3,000 acres of intertidal marsh and spruce swamps have been converted to other uses since 1948. Many wetlands along the shore in the upper reaches of the estuary were converted to industrial and agricultural lands after levees and dikes were constructed. Furthermore, water storage and release patterns from reservoirs upstream of the estuary have changed the seasonal pattern and volume of discharge. The peaks of spring/summer floods have been reduced, and the amount of water discharged during winter has increased (NMFS 2008a).

In addition, model studies indicate that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of suspended particulate matter to the lower river and estuary by about a third (as measured at Vancouver, Washington) and have reduced fine sediment transport by 50 percent or more. The significance of these changes for UCR spring Chinook salmon is unclear, although estuarine habitat provides food for yearling migrants that move rapidly downstream to the ocean (Johnson et al. 2018; PNNL and NMFS 2018).

NMFS (2005b) identified the PBFs for UCR spring-run Chinook salmon in estuaries: Estuarine areas free of obstruction with water quality, quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.

These features are essential to conservation because, without them, juvenile UCR spring Chinook salmon cannot reach the ocean in a timely manner and use the variety of habitats that allow them to avoid predators, compete successfully, and complete the behavioral and physiological changes needed for life in the ocean. Similarly, these features are essential to the conservation of adult salmonids because these features in the estuary provide a final source of abundant forage that will provide the energy stores needed to make the physiological transition to freshwater, migrate upstream, avoid predators, and develop to maturity upon reaching spawning areas (NMFS 2005b).

2.11.1.3 Climate Change Implications for UCR Spring-run Chinook Salmon and Critical Habitat

One factor affecting the rangewide status of UCR spring Chinook salmon and aquatic habitat is climate change. The USGCRP)[121] reports average warming of about 1.3ºF from 1895 to 2011, and projects an increase in average annual temperature of 3.3ºF to 9.7ºF by 2070 to 2099 (CCSP 2014). Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004; Scheuerell and Williams 2005; Zabel et al. 2006; ISAB 2007). According to the ISAB,[122] these effects pose the following impacts into the future:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season;
- With a smaller snowpack, watersheds will see their runoff diminished earlier in the season, resulting in lower stream-flows in the June through September period. River flows in general and peak river flows are likely to increase during the winter due to more precipitation falling as rain rather than snow; and
- Water temperatures are expected to rise, especially during the summer months when lower stream-flows co-occur with warmer air temperatures.

These changes will not be spatially homogeneous across the entire Pacific Northwest. Low-lying areas are likely to be more affected. Climate change may have long-term effects that include, but are not limited to, depletion of important cold-water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, premature emergence of fry, and increased competition among species.

Climate change is predicted to cause a variety of impacts to Pacific salmon and their ecosystems (Mote et al. 2003; Crozier et al. 2008a; Martins et al. 2012; Wainwright and Weitkamp 2013). The complex life cycles of anadromous fishes, including salmon, rely on productive freshwater, estuarine, and marine habitats for growth and survival, making them particularly vulnerable to environmental variation. Ultimately, the effects of climate change on salmon and steelhead

[121] http://www.globalchange.gov

[122] The Independent Scientific Advisory Board (ISAB) serves the National Marine Fisheries Service (NOAA Fisheries), Columbia River Indian Tribes, and Northwest Power and Conservation Council by providing independent scientific advice and recommendations regarding scientific issues that relate to the respective agencies' fish and wildlife programs. https://www.nwcouncil.org/fw/isab/

across the Pacific Northwest will be determined by the specific nature, level, and rate of change and the synergy between interconnected terrestrial/freshwater, estuarine, nearshore, and ocean environments.

The primary effects of climate change on Pacific Northwest salmon and steelhead include:

- Direct effects of increased water temperatures on fish physiology;
- Temperature-induced changes to stream-flow patterns;
- Alterations to freshwater, estuarine, and marine food webs; and
- Changes in estuarine and ocean productivity.

While all habitats used by Pacific salmon will be affected, the impacts and certainty of the change vary by habitat type. Some effects (e.g., increasing temperature) affect salmon at all life stages in all habitats, while others are habitat specific, such as stream-flow variation in freshwater, sea-level rise in estuaries, and upwelling in the ocean. How climate change will affect each stock or population of salmon also varies widely depending on the level or extent of change and the rate of change, and the unique life-history characteristics of different natural populations (Crozier et al. 2008b). For example, a few weeks difference in migration timing can have large differences in the thermal regime experienced by migrating fish (Martins et al. 2011). Current research looking at species-specific vulnerability to climate change will help guide future species recovery planning efforts, including for UCR spring-run Chinook salmon.

2.11.1.3.1 Temperature Effects

Like most fishes, salmon are poikilotherms (cold-blooded animals); therefore, increasing temperatures in all habitats can have pronounced effects on their physiology, growth, and development rates (see review by Whitney et al. 2016). Increases in water temperatures beyond their thermal optima will likely be detrimental through a variety of processes, including increased metabolic rates (and therefore food demand), decreased disease resistance, increased physiological stress, and reduced reproductive success. All of these processes are likely to reduce survival (Beechie et al. 2013; Wainwright and Weitkamp 2013; Whitney et al. 2016).

By contrast, increased temperatures at ranges well below thermal optima (i.e., when the water is cold) can increase growth and development rates. Examples of this include accelerated emergence timing during egg incubation stages, or increased growth rates during fry stages (Crozier et al. 2008a; Martins et al. 2011). Temperature is also an important behavioral cue for migration (Sykes et al. 2009), and elevated temperatures may result in earlier-than-normal migration timing. While there are situations or stocks where this acceleration in processes or behaviors is beneficial, there are also others where it is detrimental (Martins et al. 2012; Whitney et al. 2016).

2.11.1.3.2 Freshwater Effects

Climate change is predicted to increase the intensity of storms, reduce winter snow pack at low and middle elevations, and increase snowpack at high elevations in northern areas. Middle and lower-elevation streams will have larger fall/winter flood events and lower late-summer flows, while higher elevations may have higher minimum flows. How these changes will affect freshwater ecosystems largely depends on their specific characteristics and location, which vary at fine spatial scales (Crozier et al. 2008b; Martins et al. 2012). For example, within a relatively small geographic area (the Salmon River basin in Idaho), survival of some Chinook salmon populations was shown to be determined largely by temperature, while in others it was determined by flow (Crozier and Zabel 2006). Certain salmon populations inhabiting regions that are already near or exceeding thermal maxima will be most affected by further increases in temperature and, perhaps, the rate of the increases, while the effects of altered flow are less clear and likely to be basin-specific (Crozier et al. 2008b; Beechie et al. 2013). However, river flow is already becoming more variable in many rivers, and is believed to negatively affect anadromous fish survival more than other environmental parameters (Ward et al. 2015). It is likely this increasingly variable flow is detrimental to multiple salmon and steelhead populations, and likely multiple other freshwater fish species in the Columbia River basin as well.

Stream ecosystems will likely change in response to climate change in ways that are difficult to predict (Lynch et al. 2016). Changes in stream temperature and flow regimes will likely lead to shifts in the distributions of native species and provide "invasion opportunities" for exotic species. This will result in novel species interactions, including predator-prey dynamics, where juvenile native species may be either predators or prey (Lynch et al. 2016; Rehage and Blanchard 2016). How juvenile native species will fare as part of "hybrid food webs," which are constructed from natives, native invaders, and exotic species, is difficult to predict (Naiman et al. 2012).

2.11.1.3.3 Estuarine Effects

In estuarine environments, the two big concerns associated with climate change are rates of sea-level rise and temperature warming (Wainwright and Weitkamp 2013; Limburg et al. 2016). Estuaries will be affected directly by sea-level rise: as sea level rises, terrestrial habitats will be flooded and tidal wetlands will be submerged (Kirwan et al. 2010; Wainwright and Weitkamp 2013; Limburg et al. 2016). The net effect on wetland habitats depends on whether rates of sea-level rise are sufficiently slow that the rates of marsh plant growth and sedimentation can compensate (Kirwan et al. 2010).

Due to subsidence, sea-level rise will affect some areas more than others, with the largest effects expected for the lowlands, like southern Vancouver Island and central Washington coastal areas (Verdonck 2006; Lemmen et al. 2016). The widespread presence of dikes in Pacific Northwest estuaries will restrict inward estuary expansion as sea levels rise, likely resulting in a near-term loss of wetland habitats for salmon (Wainwright and Weitkamp 2013). Sea-level rise will also result in greater intrusion of marine water into estuaries, resulting in an overall increase in salinity, which will also contribute to changes in estuarine floral and faunal communities (Kennedy 1990). While not all anadromous fish species are generally highly reliant on estuaries for rearing, extended estuarine use may be important in some populations (Jones et al. 2014), especially if stream habitats are degraded and become less productive.

2.11.1.3.4 Marine Effects

In marine waters, increasing temperatures are associated with observed and predicted poleward range expansions of fish and invertebrates in both the Atlantic and Pacific Oceans (Lucey and Nye 2010; Asch 2015; Cheung et al. 2015). Rapid poleward species shifts in distribution in response to anomalously warm ocean temperatures have been well documented in recent years, confirming this expectation at short time scales. Range extensions were documented in many species from southern California to Alaska during unusually warm water associated with "the blob" in 2014 and 2015 (Bond et al. 2015; Di Lorenzo and Mantua 2016) and past strong El Niño events (Pearcy 2002; Fisher et al. 2015).

Exotic species benefit from these extreme conditions to increase their distributions. Green crab (*Carcinus maenas*) recruitment increased in Washington and Oregon waters during winters with warm surface waters, including 2014 (Yamada et al. 2015). Similarly, Humboldt squid (*Dosidicus gigas*) dramatically expanded their range during warm years of 2004–09 (Litz et al. 2011). The frequency of extreme conditions, such as those associated with El Niño events or "blobs," is predicted to increase in the future (Di Lorenzo and Mantua 2016).

Expected changes to marine ecosystems due to increased temperature, altered productivity, or acidification, will have large ecological implications through mismatches of co-evolved species and unpredictable trophic effects (Cheung et al. 2015; Rehage and Blanchard 2016). These effects will certainly occur, but predicting the composition or outcomes of future trophic interactions is not possible with current models. Interestingly, Daly and Brodeur (2015) showed that bioenergetic demand increased during warm-ocean conditions suggesting that, at a minimum, bottom-up drivers of growth and survival may become more important in the future.

Wind-driven upwelling is responsible for the extremely high productivity in the California Current ecosystem (Bograd et al. 2009; Peterson et al. 2014). Minor changes to the timing, intensity, or duration of upwelling, or the depth of water-column stratification, can have dramatic effects on the productivity of the ecosystem (Black et al. 2014; Peterson et al. 2014). Current projections for changes to upwelling are mixed: some climate models show upwelling unchanged, but others predict that upwelling will be delayed in spring, and more intense during summer (Rykaczewski et al. 2015). Should the timing and intensity of upwelling change in the future, it may result in a mismatch between the onset of spring ecosystem productivity and the timing of salmon entering the ocean (Tomaro et al. 2012), and a shift toward food webs with a strong sub-tropical component (Bakun et al. 2015).

Columbia River anadromous fish also use coastal areas of British Columbia and Alaska and mid-ocean marine habitats in the Gulf of Alaska, although their fine-scale distribution and marine ecology during this period are poorly understood (Morris et al. 2007; Pearcy and McKinnell 2007). Increases in temperature in Alaskan marine waters have generally been associated with increases in productivity and salmon survival (Mantua et al. 1997; Martins et al. 2012), thought to result from temperatures that have been below thermal optima (Gargett 1997). Warm ocean temperatures in the Gulf of Alaska are also associated with intensified downwelling and increased coastal stratification, which may result in increased food availability to juvenile salmon along the coast (Hollowed et al. 2009; Martins et al. 2012). Predicted increases in freshwater discharge in British Columbia and Alaska may influence coastal current patterns (Foreman et al. 2014), but the effects on coastal ecosystems are poorly understood.

In addition to becoming warmer, the world's oceans are becoming more acidic as increased atmospheric CO_2 is absorbed by water. The North Pacific is already acidic compared to other oceans, making it particularly susceptible to further increases in acidification (Lemmen et al. 2016). Laboratory and field studies of ocean acidification show it has the greatest effects on invertebrates with calcium-carbonate shells and relatively little direct influence on finfish; see reviews by Haigh et al. (2015) and Mathis et al. (2015). Consequently, the largest impact of ocean acidification on salmon will likely be its influence on marine food webs, especially its effects on lower trophic levels, which are largely composed of invertebrates (Haigh et al. 2015; Mathis et al. 2015). Marine invertebrates fill a critical gap between freshwater prey and larval and juvenile marine fishes, supporting juvenile salmon growth during the important early-ocean residence period (Daly et al. 2009, 2014).

2.11.1.3.5 Uncertainty in Climate Predictions

There is considerable uncertainty in the predicted effects of climate change on the globe as a whole, and on the Pacific Northwest in particular, and there is also the question of indirect effects of climate change and whether human "climate refugees" will move into the range of salmon and steelhead, increasing stresses on their respective habitats (Dalton et al. 2013; Poesch et al. 2016).

Many of the effects of climate change (e.g., increased temperature, altered flow, coastal productivity, etc.) will have direct impacts on the food webs that species rely on in freshwater, estuarine, and marine habitats to grow and survive. Such ecological effects are extremely difficult to predict even in fairly simple systems, and minor differences in life-history characteristics among stocks of salmon may lead to large differences in their response (e.g., Crozier et al. 2008b; Martins et al. 2011, 2012). This means it is likely that there will be "winners and losers," meaning some salmon populations may enjoy different degrees or levels of benefit from climate change while others will suffer varying levels of harm.

Climate change is expected to impact anadromous fish during all stages of their complex life cycle. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream-flow patterns in freshwater and changes to food webs in freshwater, estuarine, and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty.

2.11.2 Environmental Baseline

The "environmental baseline" includes the past and present impacts of all federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

For UCR spring-run Chinook salmon, we focus our description of the environmental baseline on where UCR spring-run Chinook salmon juveniles and adults are exposed to the effects of the proposed action, including tributary habitats where the Action Agencies propose to implement habitat restoration actions.

To determine the upstream extent of UCR spring-run Chinook salmon distribution and thus exposure, we reviewed information relative to the distribution of UCR spring-run Chinook salmon in the Columbia Basin. The area where UCR spring-run Chinook salmon experience the greatest exposure to the effects of the proposed action is the Columbia River from Chief Joseph Dam downstream to the plume, excluding the Okanogan River subbasin. The area includes tributaries and their confluences in this reach to the extent that they are affected by flow management, and habitat mitigation actions in the Columbia River basins.

2.11.2.1 Mainstem Habitat

Mainstem habitat in the middle and lower reaches of the Columbia River has been substantially altered by basinwide water management operations, the construction and operation of mainstem hydroelectric projects, the growth of native avian and pinniped predator populations, the introduction of non-native species (e.g., fishes and invertebrates), and other human practices that have degraded water quality.

2.11.2.1.1 Seasonal Flows

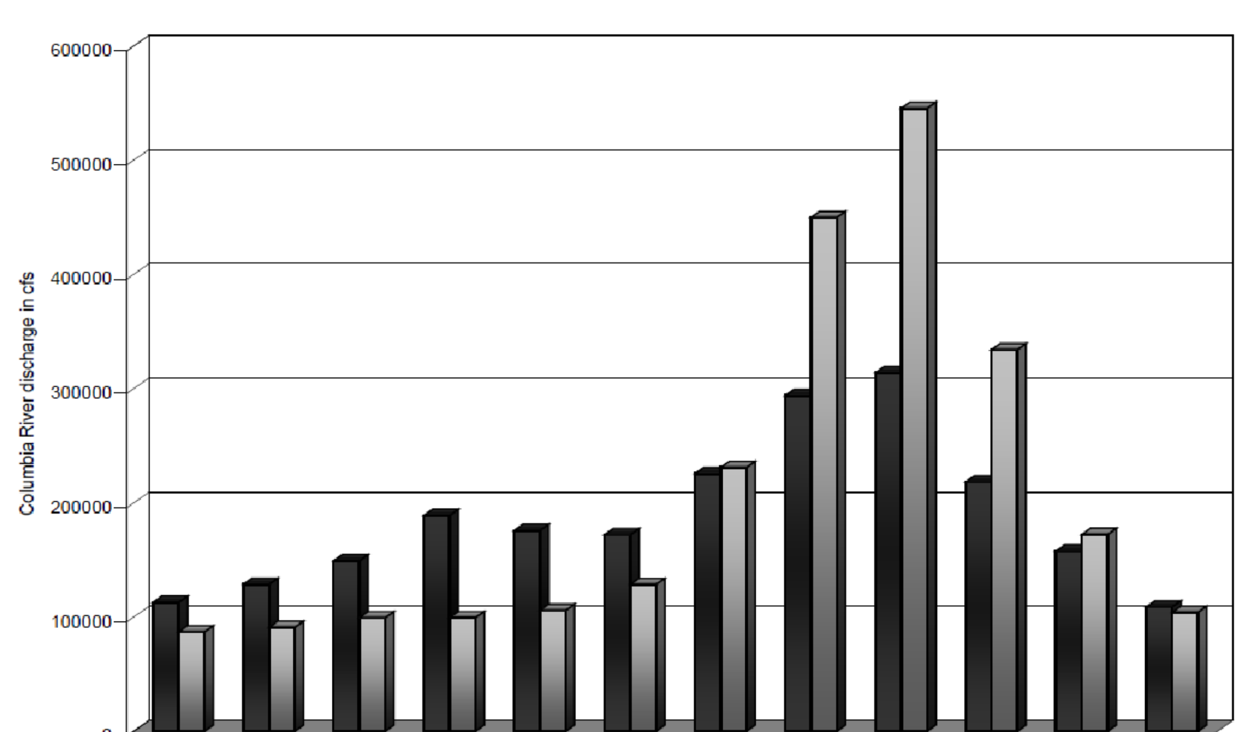
On the mainstem of the Columbia River, hydropower projects (including the CRS), water storage projects (including reservoirs in Canada operated under the Columbia River Treaty), and the withdrawal of water for irrigation and urban uses have significantly degraded salmon and steelhead habitats (Bottom et al. 2005; Fresh et al. 2005; NMFS 2013a). The volume of water discharged by the Columbia River varies seasonally according to runoff, snowmelt, and hydropower demands. Mean annual discharge is estimated to be 265 kcfs, but may range from lows of 71–106 kcfs to highs of 530 kcfs (Hamilton 1990; NMFS 1998; Prahl et al. 1998; USACE 1999). Naturally occurring maximum flows on the river occur in May, June, and July as a result of snowmelt in the headwater regions. Minimum flows occur from September to March, with periodic peaks due to heavy winter rains (Holton 1984). Interannual variability in stream flow is strongly correlated with two recurrent climate phenomena, the ENSO and the PDO (Newman et al. 2016).

Water storage projects (dams and reservoirs) and water management activities have reduced flows at Bonneville Dam, representing basinwide effects in the lower Columbia River (McNary

Reservoir to the mouth of the Columbia River) (Figure 2.11-3) (NMFS 2008b). On average, this reduction can range from nearly 15 kcfs in August to over 230 kcfs in May (see Figure 2.11-3). Proportional flow reductions of similar magnitude also occur in the middle Columbia River reach (Chief Joseph tailrace to the Columbia River's confluence with the Snake River within McNary Reservoir).

Recognizing that the flow versus survival relationships for some interior basin ESUs/DPSs displayed a plateau over a wide range of flows but declined markedly as flows dropped below some threshold (NMFS 1995b, 1998), NMFS and the CRS Action Agencies have attempted to manage Columbia and Snake River water resources to maintain seasonal flows above threshold objectives given the amount of runoff in a given year. This has been accomplished by avoiding excessive reservoir drafts going into spring to minimize the flow reductions needed for refill, and by drafting the storage reservoirs during summer to augment flows.[123] These flow objectives have guided preseason reservoir planning and in-season flow management. Nonetheless, since the development of the hydrosystem, average monthly flows at Bonneville Dam have been substantially lower during May–July and higher in October–March compared to an unregulated system. Reduced flows have increased travel times for outmigrating juvenile salmonids and reduced access to high-quality estuarine habitats during spring and early summer.

[123] Even though several million acre feet of water is released annually from storage during the summer months to augment flows (and from Dworshak Dam, to reduce mainstem temperatures), these volumes do not offset the consumption of water in the basin in July and August.



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Current	113017	128641	149403	189076	175921	172150	225689	293948	313930	218523	157935	109020
Natural	87115	91029	99387	99496	106033	128580	231047	450040	545561	334238	172430	104310

Figure 2.11-3. Comparison of monthly discharge (flow) in the Columbia River between current conditions (black) and normative flows (gray). These data show that pre-development flows were lower in the winter and higher in the summer months.

Table 2.11-3 depicts the FOP for spring spill during 2017 and 2018. There was a substantial increase in spill over the dam spillways in the spring during 2018 in response to a court order requiring additional spill.

Table 2.11-3. Summary of 2017 and 2018 Fish Operations Plan (FOP) spring spill levels at lower Columbia River projects.

Project	2017 Spring Spill Operations (Day/Night)	2018 Operations
McNary	40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay
John Day	**April 10-April 28:** 30%/30% **April 28-June 15:** 30%/30% and 40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay
The Dalles	40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay
Bonneville	100 kcfs/100 kcfs	120% TDG tailrace (gas cap) to a cap of 150 kcfs because of erosion concerns (no next forebay)

2.11.2.1.2 Water Quality

Water quality in the action area is impaired as a result of chemical contamination from municipal, agricultural, industrial, and urban land uses (NMFS 2017a). Common toxic contaminants found in the Columbia River system include PCBs, PAHs, PBDEs, DDT and other legacy pesticides, current use pesticides, pharmaceuticals and personal care products, and trace elements (LCREP 2007). The LCREP (2007) report noted widespread presence of PCBs and PAHs, both geographically and in the food web. Urban and industrial portions of the lower river contribute significantly to contaminant levels in juvenile salmon; juvenile salmon are absorbing toxic contaminants during their time rearing and feeding in the lower Columbia River (LCREP 2007). Likewise, juvenile salmon are accumulating DDT in their tissues and are exposed to estrogen-like compounds in the lower river, likely associated with pharmaceuticals and personal care products. Concentrations of copper are present at levels that could interfere with crucial salmon behaviors.

Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute municipal and industrial waste discharges to the lower Columbia River. Industrial and municipal wastes from the Portland/Vancouver metro areas, including the superfund-designated reach in the lower Willamette River, also contribute to degraded water quality in the lower river. Legacy and active mining areas scattered around the basin deliver high background concentrations of metals. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river.

Outside of urban areas, the majority of residences and businesses rely on septic systems. Common water-quality issues with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff. Under these environmental conditions, fish in the action area are stressed. Stress may lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival).

Our understanding of the effects on aquatic life of many contaminants, alone or in combination with other chemicals (potential for synergistic effects), is incomplete, especially when considering the exposure of rearing juveniles to multiple contaminants that may have synergistic or antagonistic effects, or when considering their interactions with other stressors or food-web mediated effects, and effects in complex mixtures (NMFS 2017a). Together, these contaminants are likely affecting the productivity and abundance of UCR spring Chinook salmon, especially during the rearing and juvenile migration life stages. Effects can be direct or indirect and lethal or, more likely, sublethal. The interaction of co-occurring stressors may have a greater impact on salmon than if they occur in isolation (Dietrich et al. 2014).

Water temperatures in the Columbia River are a concern; the Columbia River is included on the Clean Water Act §303(d) list of impaired waters established by Oregon and Washington because of temperature-standard exceedances. Temperature conditions in the Columbia River basin area are affected by many factors, including:

- Natural variation in weather and river flow.
- Construction of the dam and reservoir system (the large surface areas of reservoirs and resulting slower river velocities contribute to warmer late summer/fall water temperatures);
- Increased temperatures of tributaries;
- Water managed for irrigated agriculture;
- Point source discharges such as cities and industries; and
- Climate change (Overman 2017; EPA 2018).

Temperatures in the middle Columbia River are affected by Grand Coulee Dam, completed in 1942. Thermal inertia from the large mass of water in the reservoir (total storage capacity of 9.6 million acre-feet, active capacity of about 5.2 million acre-feet) results in delayed warming in the spring (cooler temperatures) and delayed cooling in the late summer and fall (warmer temperatures). Even in the extremely warm year of 2015, the average temperature of Grand Coulee outflows was less than 68°F (Figure 2.11-4) (NMFS 2016a), indicating little risk from this environmental parameter to spring migrating UCR spring Chinook salmon smolts. Cooler spring (April and May) temperatures in the middle Columbia River would reduce exposure to high temperatures and would be expected to enhance the survival of spring migrating smolts and adult spring-run Chinook salmon. Warmer August and September temperatures would have little effect on adult UCR spring Chinook salmon because they should already have migrated into their natal tributaries by this time of year.

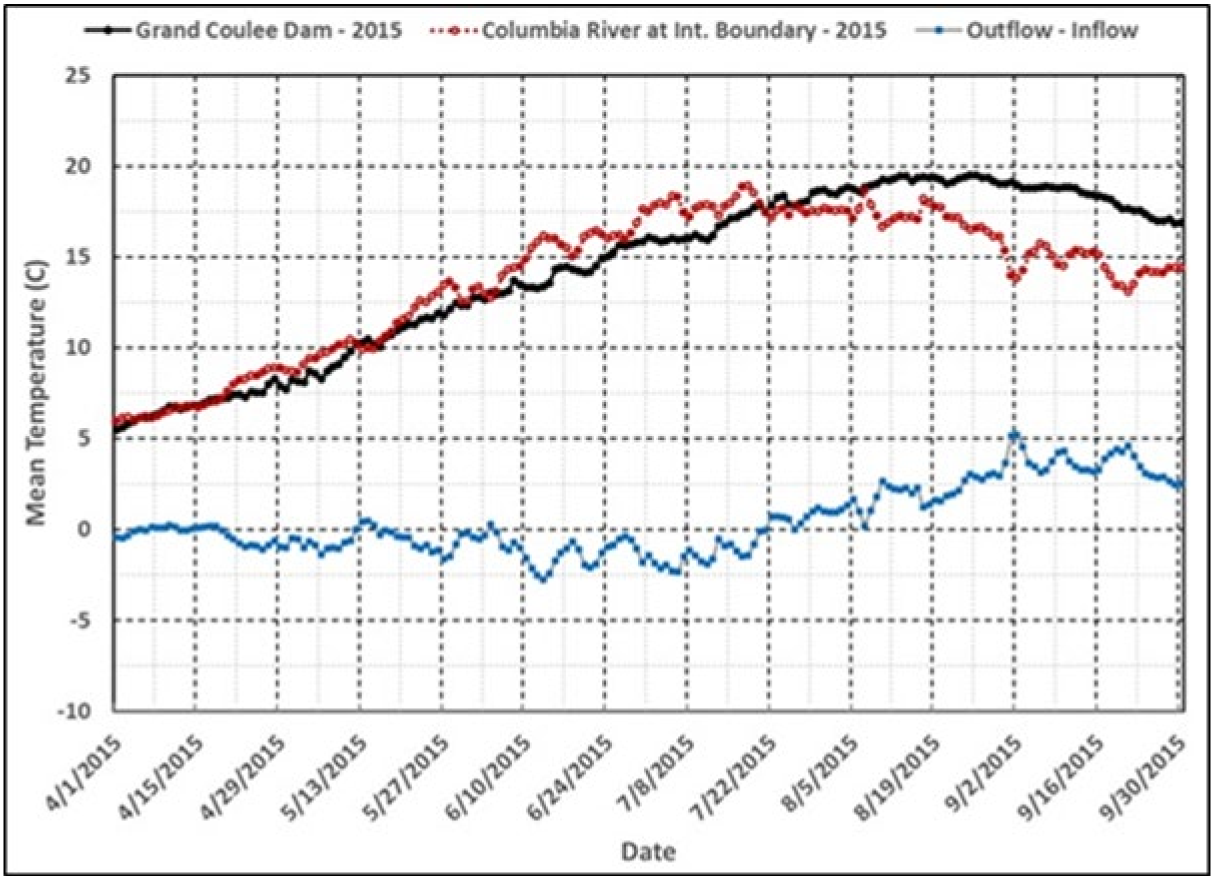


Figure 2.11-4. Outflow temperatures at Grand Coulee Dam compared to upstream Columbia River temperatures at the international boundary. Blue line indicates the difference (inflow – outflow) in temperature. Source: USBR Hydromet Data.

The EPA is working with federal and state agencies, the tribes, and other stakeholders to develop water-quality improvement plans (total maximum daily loads) for temperature in the Columbia River and lower Snake River. As part of the 2015 biological opinion on EPA's approval of water-quality standards, including temperature (NMFS 2015a), EPA committed to work with federal, state, and tribal agencies to identify and protect thermal refugia and thermal diversity in the lower Columbia River and its tributaries.

Comparisons of long-term temperature monitoring in the migration corridor before and after impoundment reveal a change in the thermal regime of the Snake River that influences temperatures downstream of its confluence with the Columbia River. Using historical flows and environmental records for the 35-year period 1960–1995, Perkins and Richmond (2001) compared water temperature records in the lower Snake River with and without the run-of-river dams and found three notable differences between the current versus unimpounded river:

- Maximum summer water temperature has been slightly reduced;
- Water temperature variability has decreased; and

- Post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall, a phenomenon termed thermal inertia.

Dams in the middle and lower reaches of the Columbia River likely have similar effects.

These hydrosystem effects (which stem from both upstream storage projects and run-of-river mainstem projects) continue downstream and, along with tributaries, influence temperature conditions in the lower Columbia River. At a macro scale, water temperature affects salmonid distribution, behavior, and physiology (Groot and Margolis 1991); at a finer scale, temperature influences migration swim speed of salmonids (Salinger and Anderson 2006), timing of river entry (Peery et al. 2003), susceptibility to disease and predation (Groot and Margolis 1991), and at temperature extremes, survival. The thermal inertia of large upper basin storage projects has largely reduced the risk of encountering elevated temperatures in the mainstem mid-Columbia and lower Columbia Rivers during spring, except for juvenile and adult UCR spring-run Chinook salmon migrating at the end of their respective runs (late May and June).

TDG levels also affect mainstem water quality and habitat. To facilitate the downstream movement of juvenile salmonids, state regulatory agencies issue waivers for TDG as measured in the forebay and tailrace (NMFS 1995b). Specifically, water that passes over the spillway at a mainstem dam can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). Historically, TDG supersaturation was a major contributor to juvenile salmon mortality; to reduce TDG supersaturation, the Corps installed spillway improvements, typically “flip lips,” at the base of the spillway at each federal mainstem run-of-river dam, except The Dalles Dam, and at Chief Joseph Dam. The FERC-licensed Wanapum Dam in the mid-Columbia reach also uses these structures to control TDG. Biological monitoring (smolts sampled from the juvenile bypass systems at many mainstem dams) shows that the incidence of observable GBT symptoms remains between 1–2 percent when TDG concentrations in the upper water column do not exceed 120 percent of saturation in CRS project tailraces. When those levels are exceeded, there is a corresponding increase in the incidence of signs of GBT symptoms. Fish migrating at depth avoid exposure to the higher TDG levels due to pressure compensation mechanisms (Weitkamp et al. 2003).[124] Under recent operations (2008–18), exposure to excessive high (>120 percent) TDG levels has been restricted to lack of market or lack of turbine capacity spill events associated with high flow conditions and/or lack of load — which have most often occurred between mid-May and mid-June, affecting most yearling spring Chinook salmon smolts and adults.

The most extensive urban development in the lower Columbia River basin has occurred in the Portland/Vancouver area. Common water-quality issues, both in areas with urban development

[124] Roughly, for each meter below the surface an aquatic organism is located, there is a corresponding reduction in the effective TDG the organism experiences of about 10 percent. Thus, if TDG levels are at 120 percent, an organism two meters below the surface would effectively experience 100 percent TDG saturation.

and rural residential septic systems, include warmer water temperatures, lowered dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff (LCREP 2007). Similar effects are likely to be proportionally associated with smaller urban areas as well (e.g., Lewiston, Idaho; Tri-Cities, Washington; The Dalles and Hood River, Oregon). While it is not clear what the magnitude of effects are to juvenile or adult Chinook salmon from exposure to these factors (see previous discussion relating to chemical contaminants), they are likely to negatively affect fitness and survival to some extent.

2.11.2.1.3 Oil and Grease Management

Oils, greases, and other lubricants (derived from animal, fish, vegetable, petroleum, or marine-mammal origin) are used at each of the CRS projects (and all other dams in the Columbia River Basin), including, but not limited to, the following: hydropower turbines, hydraulic systems, lubricating systems, gear boxes, machining coolant systems, heat transfer systems, transformers, circuit breakers, and electrical systems. Leakage of oils, greases, or other lubricants into rivers has the potential to affect salmon and steelhead (avoidance, exposure to toxic compounds, or even, in some circumstances death). In response to increased concerns regarding the releases of oils and greases from lower Columbia and lower Snake River dams (and Dworshak and Chief Joseph Dams), the Corps has taken steps to minimize these risks. For equipment in contact with the water, the Corps has developed best management practices to avoid accidental releases and to minimize the adverse effects in the case of an accidental release. The Corps has also begun using, where feasible, environmentally acceptable lubricants and, in some cases, has replaced greased equipment with greaseless equipment. The Corps has also developed and is implementing oil accountability plans, with enhanced inspection protocols and annual reporting.

The extent to which leaked grease or oil, occurring under the environmental baseline in the Clearwater River (Dworshak Dam), Upper Columbia River (Chief Joseph), lower Snake River, or lower Columbia River, has affected the behavior, health, or survival of juvenile or adult UCR spring-run Chinook salmon in the past is unknown, but effects, if any, are likely to be small given that these river systems are extremely large (thousand to hundreds of thousands of cubic feet per second of water). For comparison, a large leak of 100 gallons per day is the equivalent of 0.00016 cubic feet per second and the average annual discharge of the Columbia River has ranged from roughly 125,000 to 250,000 cubic feet per second since about 1940 (ISAB 2000). Nevertheless, to the extent past leakages have potentially affected passage or survival, these effects would be encompassed by annual juvenile or adult reach survival estimates. Similarly, any delayed effects manifesting after passing either upstream of downstream through the mainstem Snake or Columbia Rivers, would be captured in population productivity (recruit-per-spawner) estimates.

Recent actions (adoption of best management practices, use of environmentally acceptable lubricants, use of greaseless equipment, etc.) would further reduce the potential for negative effects stemming from these materials and slightly improve conditions for juvenile and adult migrants.

2.11.2.1.4 Sediment Transport

The series of dams and reservoirs have also blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is less than one-third of nineteenth-century levels (Simenstad et al. 1982, 1990; Sherwood et al. 1990; Weitkamp 1994; NRC 1996; NMFS 2008a). Similarly, Bottom et al. (2005) estimated that the delivery of suspended sediment to the lower river and estuary has been reduced by about 60 percent (as measured at Vancouver, Washington), and fine sediment transport reduced by 50 percent or more. These estimates reflect the combined total of all activities throughout the Columbia River basin on sediment transport. Similar reductions would be expected throughout the mainstem action area. The overall reduction in sediment has altered the development of habitat along the margins of the river, and likely increased the risk of predation (birds and fishes) to migrating juveniles (Bottom et al. 2005).

Industrial harbor and port development are also significant influences on the lower Snake and lower Columbia Rivers (Bottom et al. 2005; Fresh et al. 2005; NMFS 2013a). Since 1878, the Corps has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the Willamette River as a navigation channel. Originally dredged to a 20-foot minimum depth, the federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The navigation channel supports many ports on both sides of the river, resulting in several thousand commercial ships traversing the river every year. The dredging, along with diking, draining, and fill material placed in wetlands and shallow habitat, also disconnects the river from its floodplain, resulting in the loss of shallow-water rearing habitat and the ecosystem functions that floodplains provide (e.g., supply of prey, refuge from high flows, temperature refugia, etc.; Bottom et al. 2005).

2.11.2.2 Adult Migration/Survival

Adults must migrate from the ocean, upstream through the estuary, and pass between seven and nine mainstem dams and reservoirs to reach their spawning areas; all populations of UCR spring-run Chinook salmon must pass the four lower Columbia River dams and between three and five mid-Columbia River PUD dams. Factors that affect the survival rates of migrating adults include harvest (either reported or unreported), dam passage (adults must find and ascend ladders and reascend the ladders if they accidentally fall back over the spillway), straying, pinniped predation, and temperature and flow conditions that can increase the energetic demands of migrating fish (NMFS 2008a).

PIT-tag detectors placed near the exits of adult ladders at the mainstem dams provide a unique ability to monitor the upstream survival of adults that were tagged as juveniles. Starting with the number of adults detected at Bonneville Dam, minimum survival estimates can be derived from detectors at upstream dams. Termed "conversion rates," these survival estimates are adjusted for reported harvest and the expected rate of straying of natural-origin adults.[125] Figure 2.11-5 depicts minimum estimated survival rates from Bonneville to McNary Dam (three reservoirs and

[125] Using only known-origin fish adjusted for reported harvest and natural stray rates.

dams) during 2008–17, years that include recent hydropower operations and harvest rates within the "zone 6" fishery (as designated in the *U.S. v. Oregon* Management Agreement). Figure 2.11-5 also shows minimum estimated survival rates from McNary to Priest Rapids Dam (McNary Reservoir and the free-flowing Hanford reach of the Columbia River) or to Wells Dams (McNary to Priest Rapids Dam and an additional four reservoirs and dams) for fish released as juveniles upstream of Wells Dam and detected as adults at McNary Dam (2008–17).

From Figure 2.11-5, the ten-year average minimum survival estimates for UCR spring-run Chinook salmon from Bonneville to McNary Dam is 91.5 percent (range of 80.4 to 105.1 percent). The average minimum survival estimate for UCR spring-run Chinook salmon released upstream of Wells Dam as juveniles was 94.7 percent (range of 91.2 to 97.9 percent) to Priest Rapids and 90.2 percent (range of 85.4 to 96.3 percent) to Wells Dam during this period. Comparing the McNary to Priest Rapids Dam reach to the McNary to Wells Dam reach indicates that average survival from 2008–17 was about 95.4 percent (100 – (94.7 – 90.2)) through the Priest Rapids Reservoir; Wanapum, Rock Island, and Rocky Reach Dams and reservoirs; and Wells Dam reaches.

These survival estimates account for total losses from the dams and reservoirs, as well as any losses in these reaches resulting from any flow effects, temperature, disease, or other natural causes. Expressed on a "per project" basis ($1/3^{rd}$ root of 91.5 percent), about 97.1 percent of adult UCR spring-run Chinook salmon are surviving passage through each project (dam and reservoir) in the lower Columbia River after accounting for reported harvest and natural stray rates. From Priest Rapids to Wells Dam, per project survival rates are averaging around 98.8 percent ($1/4^{th}$ root of 95.5). These relatively high survival rates indicate that upstream passage conditions are not substantially impaired for adult UCR spring-run Chinook salmon migrating through impounded reaches of the middle and lower Columbia Rivers.

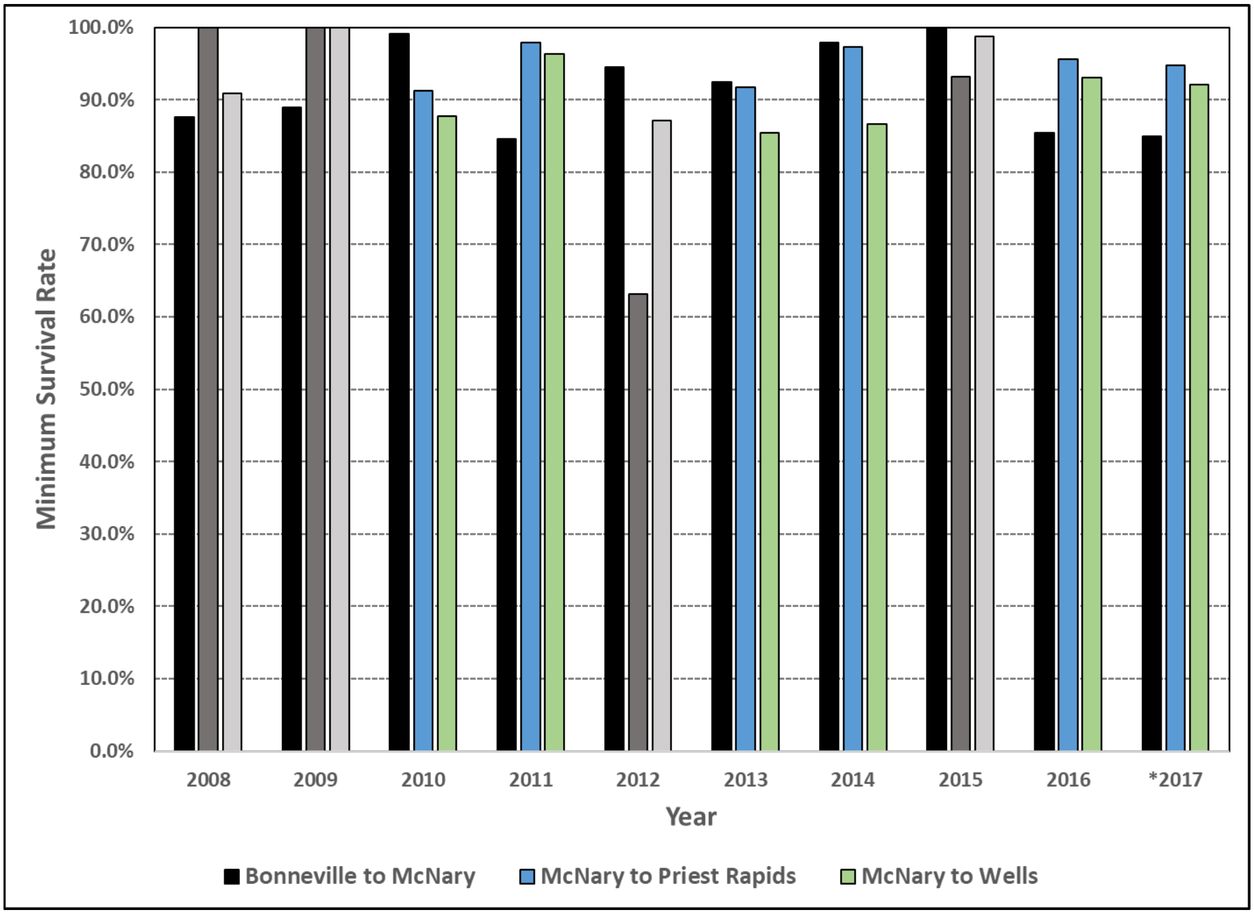


Figure 2.11-5. Minimum survival estimates from Bonneville to McNary Dams (of known-origin PIT-tagged adult UCR spring-run Chinook salmon, natural- and hatchery-origin combined), McNary to Priest Rapids Dam and McNary to Wells Dam (of known-origin PIT-tagged UCR adult Chinook salmon released upstream of Wells Dam as juveniles) from 2008–17. Note: Grayed bars indicate that either too few PIT-tagged adults were available to make a reliable estimate (2008 and 2009) or McNary to Priest Rapids Dam estimates were lower than McNary to Wells Dam — which is impossible unless adults were passing Priest Rapids Dam without being detected. Source: NMFS, using data from PITAGIS and Columbia River Data Access in Real Time.

2.11.2.2.1 Juvenile Migration/Survival

The mainstem dams and reservoirs continue to substantially alter the mainstem migration corridor habitat. The reservoirs have increased the cross-sectional area of the river, reducing water velocity, altering the food web, and creating habitat for native and non-native species which are predators, competitors, or food sources for migrating juvenile yearling Chinook salmon. The travel times of migrating smolts are increased through the reservoirs, increasing exposure to both native and nonnative predators, and some juveniles are injured or killed as they pass through the dams (turbines, bypass systems, spill bays, or surface passage routes) (NMFS 2008a, 2008b).

However, overall passage conditions and resulting juvenile survival rates in the migration corridor have improved substantially since 1999, when the species was listed. This is most likely the result of improved structures and operations and predator-management programs at the

Corps' and FERC-licensed mainstem projects (24-hour spill, surface passage routes, improved juvenile bypass systems, etc.).

Tables 2.11-4 and 2.11-5 depict the hydrosystem spillway operations for the five middle Columbia River PUD-owned dams (Douglas, Chelan, and Grant County) and the Action Agency-operated dams in the lower Columbia River, respectively. The spillways represent just one of several routes of passage through the dams. For example, the Wells project is constructed as a hydropower combine and utilizes modified spillway bays to efficiently pass juvenile salmon and steelhead past the project in a non-turbine route of passage.

Table 2.11-4. Summary of recent spring spill levels at middle Columbia River projects.

Project	Recent Spring Spill Operations (Day/Night)
Wells	7% or more Uses of up to five surface bypass entrances (modified spillway bays)
Rocky Reach	9%
Rock Island	10%
Wanapum	20 kcfs
Priest Rapids	27 kcfs

Table 2.11-5. Summary of 2017 and 2018 Fish Operations Plan (FOP) spring spill levels at lower Columbia River projects.

Project	2017 Spring Spill Operations (Day/Night)	2018 Operations
McNary	40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay
John Day	**April 10-April 28:** 30%/30% **April 28-June 15:** 30%/30% and 40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay
The Dalles	40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay
Bonneville	100 kcfs/100 kcfs	120% TDG tailrace (gas cap) to a cap of 150 kcfs because of erosion concerns (no next forebay)

Performance standards testing at the mid-Columbia PUD FERC-licensed projects indicates that recent average juvenile survival rates to Priest Rapids tailrace are about 73.7 percent for juveniles from the Okanogan and Methow Rivers (five reservoirs and dams), 76.4 percent for juveniles from the Entiat River (four reservoirs and dams), and 81.1 percent for juveniles from the Wenatchee River (three reservoirs and dams). This equates to average per project (reservoir and dam) juvenile survival rates of about 93 to 96 percent.

Widener et al. (2017) estimates that hatchery-origin juvenile UCR spring-run Chinook salmon survival rates from McNary to Bonneville Dam (three reservoirs and dams) have ranged from 62.6 to 105.6 percent (2008–17, an average of 84.0 percent).[126] In 2018, the estimate was 74.9 percent, slightly less than the 2008-17 average.

Together, these survival rates represent a substantial improvement in migration conditions and survival rates for juvenile UCR spring-run Chinook salmon migrating through the impounded reaches of the middle and lower Columbia River compared to the 1970s to the mid-2000s.

2.11.2.2.2 Transportation

Turbine intake screens, part of the juvenile bypass systems,[127] divert UCR yearling Chinook salmon smolts away from turbine units and into a system of channels and flumes before delivering them to either the tailrace below the dam (bypassed) or, as was the case for McNary Dam, into raceways where they can be loaded onto barges, taken to below Bonneville Dam (transported), and released to continue their migration to the ocean. Some UCR spring-run Chinook salmon smolts were collected at McNary Dam and transported to below Bonneville Dam until 2012, when the Corps terminated transportation of juveniles. This decision was incorporated into the 2014 FCRPS biological opinion (NMFS 2014).

2.11.2.3 Hatcheries

The Leavenworth National Fish Hatchery Complex consists of three large hatchery facilities: Leavenworth National Fish Hatchery, Entiat National Fish Hatchery, and Winthrop National Fish Hatchery, which are operated by the USFWS.[128] The three hatcheries serve as mitigation facilities to compensate for the lack of access and loss of spawning and rearing habitat caused by the construction of Grand Coulee Dam, and were authorized as part of the Grand Coulee Fish Maintenance Project in 1937. At the time, it was estimated that 85–90 percent of the fish counted at Rock Island Dam originated upstream from Grand Coulee Dam, and about half of historical UCR spring-run Chinook salmon habitat was taken out of production by construction of the Grand Coulee Dam (UCSRB 2007).

Under current settlement agreements and stipulations (FERC processes), the three upper-Columbia PUDs fund other hatchery programs within the upper Columbia Basin, which are operated by the PUDs, WDFW, and the tribes. These agreements determine the levels of hatchery production needed to mitigate for the construction and continued operation of the PUD dams, and contribute to the rebuilding and recovery of natural-origin populations in their native

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[126] Survival estimates higher than 100 percent are possible. To calculate the 2008–17 average, 1.00 was used for the survival value in 2013, rather than the 1.056 estimated value.
[127] All of the powerhouses at the four lower Columbia River mainstem dams have juvenile bypass systems, with the exception of The Dalles Dam and Bonneville Dam, Powerhouse 1; Rocky Reach Dam is the only mid-Columbia PUD project which has a conventional screening system on some of its turbine units.
[128] The facility planned for the Okanogan River was never constructed.

habitats, while maintaining genetic and ecological integrity, and supporting harvest (UCSRB 2007). Although these hatchery programs emphasize use of local stocks, they may also affect diversity and productivity of natural-origin stocks. For example, the programs may affect the age-at-return of spring Chinook salmon, resulting in a higher proportion of younger hatchery fish spawning in the wild (NMFS 2004b). More recently, the objective for the hatchery component of the No Net Impact standard for these FERC-licensed projects is to contribute to the rebuilding and recovery of natural populations in their native habitats, while maintaining genetic and ecological integrity, and supporting harvest.

The hatchery programs that affect the UCR spring-run Chinook salmon ESU have changed over time and these changes have likely reduced adverse effects on ESA-listed species. Specifically, the hatchery programs funded by the PUDs were reduced in size starting in 2012 because of a revised calculation of their mitigation responsibility based on increased survivals through the upper Columbia dams. Reducing hatchery production has reduced pHOS (proportion of hatchery fish on spawning grounds) and associated genetic risk. It has also reduced the number of natural-origin fish removed for the hatchery broodstocks. And, as a result of site-specific consultations now completed (*U.S. v. Oregon* 2018), several additional reform measures have been implemented such as genetically linking the two spring Chinook salmon programs in the Methow River subbasin. Information about other reform measures are included in the following hatchery summaries, organized by subbasin.

2.11.2.3.1 Entiat Subbasin - Entiat Basin Spring Chinook Salmon Program at Entiat National Fish Hatchery

Ford et al. (2004) found that the similarity of natural Entiat River spring-run Chinook salmon and Entiat NFH samples indicated that Entiat NFH spring Chinook salmon were spawning successfully and had introgressed into, or may have replaced, the natural Entiat River population. However, the sample size was small and only covered a limited number of years when spawning escapement of hatchery fish was very high (UCSRB 2007). The Entiat NFH continued releasing out-of-basin spring Chinook salmon until the program was discontinued in 2007, which has increased the proportion of natural-origin spawners in this subbasin. The only hatchery-origin spawners returning to the Entiat River now would be strays from other programs within close proximity (NMFS 2018a; NWFSC 2015).

2.11.2.3.2 Wenatchee Subbasin

The Wenatchee spring Chinook salmon population is affected by several hatchery programs that release spring Chinook salmon within the subbasin (UCSRB 2007). The Chiwawa River program is integrated with the local population and included in the ESU. The White River program has been discontinued.

<u>Leavenworth National Fish Hatchery Spring Chinook Salmon Program</u>

Leavenworth NFH has released spring Chinook salmon into Icicle Creek since 1940, except for brood years 1967 and 1968. Beginning in 1985, broodstock consisted of Leavenworth program adult returns that volunteer into the hatchery on Icicle Creek, and program broodstock are now segregated from the natural population in the Wenatchee River basin. Past tagging studies have indicated that fish from the Leavenworth NFH generally have low stray rates (<1 percent) (Pastor 2004). However, based on expanded carcass recoveries from spawning ground surveys (2001–04), the Leavenworth NFH and other out-of-basin strays have comprised 3–27 percent of the spawner composition upstream from Tumwater Canyon (WDFW, unpublished data). Outside of the Wenatchee subbasin, Leavenworth NFH fish have been recovered at Wells Dam on the Columbia River, at the Methow Hatchery on the Methow River, at the Pelton Dam on the Deschutes River, and in the Umpqua River sport fishery (Cooper 2006). The proportion of Leavenworth NFH fish on spawning grounds upstream of Tumwater Canyon has contributed to a high-risk rating for diversity for the Wenatchee River population. This has led to a recent reduction in Leavenworth NFH releases, and an increase in mark rates and removals of Leavenworth NFH fish at Tumwater Dam (NMFS 2018a). There has also been a recent change in the use of water at Leavenworth NFH, which has provided more stream flow in Icicle Creek in summer months, reducing the potential for dewatering; therefore, reducing risks to the UCR spring-run Chinook salmon ESU (NMFS 2018a).

Chiwawa River Spring Chinook Salmon Program

The Chiwawa spring Chinook salmon program was initiated as an integrated supplementation program using Chiwawa River spring Chinook salmon for broodstock. The broodstock management strategy, aimed at increasing proportionate natural influence, has been relatively successful (NMFS 2018a), and the program does not appear to have altered the spatial distribution of the population. Releases were reduced under the new 2013 biological opinion for the program from about 364,000 yearling Chinook salmon smolts to 205,000 (NMFS 2013b).

Nason Creek River Spring Chinook Salmon Program

The artificial propagation of about 250,000 Nason Creek spring Chinook salmon yearling smolts per year serves as mitigation for the Priest Rapids Hydroelectric Project. The program is an integrated supplementation program using local spring Chinook salmon returning to Nason Creek, and is intended to increase the number of adults on the spawning grounds and subsequently lead to an increase in natural production (NMFS 2018a). Implementation of this program, combined with a reduction in the production level of the Chiwawa program, is helping reduce the risks associated with hatchery programs and allow them to be implemented in a manner more consistent with HSRG, ISAB, and Independent Scientific Review Panel guidance (NMFS 2016a).

2.11.2.3.3 Methow Subbasin

Methow Composite Spring Chinook Salmon Program at the Winthrop National Fish Hatchery

The original intent of the Winthrop NFH was to provide spring Chinook salmon for harvest. Since the listing of spring Chinook salmon, the program's use of Carson stock has been phased out and replaced with Methow Composite stock in order to contribute to the recovery of the Methow River population (UCSRB 2007). By switching to the Methow composite stock, the

Winthrop NFH program links hatchery fish to natural-origin Chinook salmon, decreasing genetic risks (NMFS 2018a).

Methow Composite Stock Spring Chinook Salmon Program at the Methow Hatchery

In 1991, Douglas PUD began funding artificial propagation programs of spring Chinook salmon in the Methow River basin as mitigation for Wells Dam (UCSRB 2007). The Methow Composite spring Chinook salmon program at the Methow Hatchery has been successful in returning adult hatchery Chinook salmon to the spawning grounds. The effects on diversity are intended to be managed by incorporating natural-origin Chinook salmon into broodstock annually, and by recent reductions in hatchery releases (NMFS 2016a). However, achieving this objective has often been difficult because of low returns of naturally produced fish to the subbasin and tributary traps, which are relatively ineffective at capturing adults.

Chewuch River Spring Chinook Salmon Program

The Chewuch River stock was maintained at Methow Hatchery from 1992 to 1997. These first smolt releases to the Chewuch were the progeny of naturally produced Chinook salmon collected at Fulton Dam on the Chewuch River and elsewhere within the Chewuch River. Starting in 1998, the program transitioned to the Methow Composite stock (Methow River and Chewuch River stocks). The program currently releases 61,000 smolts from Chewuch Pond.

2.11.2.3.4 Okanogan Subbasin

Spring Chinook salmon were extirpated from the Okanogan subbasin before the 1930s. Although there has not been a formal mitigation program for spring Chinook salmon, there has been an experimental spring Chinook salmon propagation program in the Okanogan subbasin through a cooperative agreement between NMFS, USFWS, Colville Tribes, and WDFW. An active recovery program using Methow composite stock has been recently initiated (Biological Opinion for 10j release completed in 2014).

Chief Joseph Hatchery

There is also a release of 700,000 spring Chinook salmon at Chief Joseph (initially Carson stock) with the intent, over time, to only use fish that return to the hatchery for brood.

2.11.2.3.5 Hatchery Summary

For UCR spring-run Chinook salmon, the proportions of natural-origin contributions to spawning in the Wenatchee and Methow River populations have trended downwards since 1990, reflecting the large increase in releases and subsequent returns from the directed supplementation programs in those two drainages (Hillman et al. 2015). This is true despite implementing measures to reduce risk. Conversely, there is no longer a direct hatchery supplementation program in the Entiat River (Entiat NFH program discontinued in 2007), and the upward trend in proportional natural-origin fish since then can be attributed to that closure. The NMFS most recent five-year status review for UCR spring-run Chinook salmon concluded that the extent to which hatchery effects continue to present risks to the persistence of the ESU remains unchanged (NMFS

2016a). However, many recent changes in the management of these programs have occurred under various reforms and ESA consultations, though observed benefits will not be fully realized for a few generations of fish.

Hatchery programs can provide short-term demographic benefits, such as increases in abundance, during periods of low natural abundance. They also can help preserve genetic resources until limiting factors can be addressed. However, the long-term use of artificial propagation may pose risks to natural productivity and diversity. The magnitude and type of the risk depends on the status of affected populations and on specific practices in the hatchery program. Hatchery programs can affect naturally produced populations of salmon and steelhead in a variety of ways: competition (for spawning sites and food) and predation effects, disease effects, genetic effects (outbreeding depression), broodstock collection and facility effects (hatchery-influenced selection) (NMFS 2018a). The lack of scientific knowledge about density dependence of Columbia River salmonids during their time in the estuary and ocean is an important information gap in hatchery management, because understanding density dependence might help explain abundance patterns of natural salmonid populations. Although hatcheries are an integral part of the hydrosystem mitigation programs for the upper Columbia River basin, they are not intended to be a substitute for healthy, abundant spawning and rearing habitat (UCSRB 2007).

2.11.2.4 Harvest

UCR spring-run Chinook salmon are not targeted by ocean fisheries within the U.S. Exclusive Economic Zone and the coastal and inland marine waters of the west coast states (Washington, Oregon, and California). The harvest of upriver spring Chinook salmon, including those from the UCR, is assumed to be zero, or close to it, based on the timing for when ocean fisheries are prosecuted, allowing spring-run Chinook salmon to enter freshwater areas before ocean salmon fisheries begin. These low levels of catch of all spring-run Chinook salmon have similarly been verified from these same sampling activities (NMFS 2018a).

Fisheries in the Columbia River basin, particularly in the mainstem Columbia River, are managed pursuant to fishing plans developed by the parties to *U.S. v. Oregon*. Parties to this process include the federal government, the states of Oregon, Washington, and Idaho, and the four Columbia River Treaty Tribes and the Shoshone-Bannock Tribes. The majority of harvest on UCR spring-run Chinook salmon occurs in Columbia River mainstem tribal gillnet and dip net fisheries targeting spring and summer-run Chinook salmon. The 2008 *U.S. v. Oregon* Agreement allowed for the incidental take of 5.5 percent to 17.0 percent of the total run of UCR spring Chinook salmon in spring fisheries, depending upon abundance of upriver spring Chinook salmon. The range of estimated incidental take observed (2008–17) was 8.8 to 16.7 percent and averaged 12.1 percent. These harvest rates are substantial reductions compared to those that occurred before the 1990s. These levels of exploitation are expected to continue for the foreseeable future, and will continue to somewhat reduce the productivity and abundance of UCR spring-run Chinook salmon.

NMFS recently signed the 2018–2027 *U.S. v. Oregon* Management Agreement of the Columbia River Basin. Under the new management agreement, incidental harvest of UCR spring Chinook salmon is limited to 17 percent of the estimated run size at the mouth of the Columbia River, but is not expected to exceed 14.6 percent. The agreement supports salmon and steelhead fishing opportunities for the states of Oregon, Washington, and Idaho, and ensures fair sharing of harvestable fish between tribal and non-tribal fisheries in accordance with Treaty fishing rights and *U.S. v. Oregon*. NMFS biological opinion addressing the effects of the 2018–2027 Management Agreement concluded that the effects to UCR Chinook salmon were not likely to jeopardize the continued existence of the ESU.

2.11.2.5 Tributary Habitat

2.11.2.5.1 ESU Overview

Tributary habitat conditions in the subbasins within the UCR spring-run Chinook salmon ESU (i.e., the Wenatchee, Entiat, and Methow subbasins) are generally good in high elevation reaches but degraded in lower elevation reaches, particularly near valley bottoms (UCSRB 2007). The ability of habitat in these upper Columbia subbasins to support the viability of UCR spring-run Chinook salmon is generally limited by one or more of the following factors: (1) reduced stream complexity and channel structure, (2) reduced floodplain condition and connectivity, (3) degraded riparian condition, (4) diminished stream flow, (5) impaired fish passage, (6) excess fine sediment, and (7) elevated summer water temperatures (UCSRB 2007). The combination, intensity, and relative impact of these factors vary locally throughout each subbasin, depending on historical and current land use activities and natural conditions.

Human activities that have contributed to these limiting factors include dams, water diversions, stream channelization and diking, roads and railways, timber harvest, grazing, and urban and rural development (UCSRB 2015). In addition, natural disturbance has recently had a large effect on habitat in the upper Columbia River basin. For instance, the 2014 Carlton Complex fire, the largest ever recorded in Washington, burned approximately 253,377 acres and will likely result in higher runoff rates, higher impacts (e.g., increased runoff and erosion leading to increased sediment load and streambed scouring) from rain and snow events, and increased sedimentation, with associated adverse effects on salmon productivity (UCSRB 2015).

Land use practices and regulatory mechanisms have improved from historical practices and regulations (UCSRB 2007), and new development appears to be a relatively minor factor in landscape change in the region, based on a study in a representative area (UCSRB 2015). In addition, many habitat restoration actions have been and are being implemented in these subbasins through the individual and combined efforts of federal, tribal, state, local, and private entities, including the CRS Action Agencies (UCSRB 2007; BPA et al. 2013, 2016). The CRS Action Agencies have been implementing tributary habitat improvement actions as part of mitigation for the CRS since 2007. These actions have included protecting and improving stream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, and removing barriers to spawning and rearing habitat actions targeted toward addressing the limiting factors identified above (BPA et al. 2013, 2016). Cumulative metrics for these action types for UCR spring-run Chinook salmon from the years 2007-2015 are shown in Table 2.11-6.

Table 2.11-6. Tributary habitat restoration metrics: UCR spring-run Chinook Salmon, 2007-2015 (BPA et al. 2016).

Action Type*	**Amount completed**
Acre-feet/year of water protected *(by efficiency improvements and water purchase/lease projects)*	23,708.8
Acres protected *(by land purchases or conservation easements)*	283.5
Acres treated *(to improve riparian habitat, such as planting native vegetation or control of noxious weeds)*	356.6
Miles of enhanced or newly accessible habitat *(by providing passage or removing barriers)*	110.4
Miles of improved stream complexity *(by adding wood or boulder structures or reconnecting existing habitat, such as side channels)*	21.8
Miles protected *(by land purchases or conservation easements)*	8.32
Screens installed or addressed *(for compliance with criteria or by elimination/consolidation of diversions)*	10

* Several of these categories (acres protected, acres treated, miles of enhanced stream complexity, miles protected) also encompass actions directed at reducing sediments and reconnecting floodplains.

NMFS determined, based on best available science, that the actions implemented by the Action Agencies and other entities have and will continue to improve habitat in the targeted populations as these projects mature, and that fish population abundance and productivity will respond positively. Benefits of some of these actions will continue to accrue over several decades (see Appendix A). RM&E, including IMWs and CHaMP sampling, have been underway in this ESU to help confirm improvements in habitat productivity and fish population response and the magnitude of the changes. Available empirical evidence supports our view that these actions are improving habitat capacity and productivity, as well as population abundance and productivity (see Appendix A; NMFS 2014; Hillman et al. 2016; Griswold and Phillips 2018; Haskell et al. 2018).

For the Wenatchee population, NMFS used life-cycle modeling to evaluate how actions implemented to date affect the baseline. Some life-cycle modeling results are also available for the Entiat population, but this model did not incorporate the same life-cycle modeling framework for mainstem, ocean, and other effects that was used for the suite of models described elsewhere in this biological opinion and in Zabel and Jordan (in press). Results of these evaluations are summarized below and the models and results are described in more detail elsewhere in this chapter and in supporting documents (Jorgenson, in press; Pess and Jordan et al. in press; Saunders et al. 2017).

The best available scientific and technical information also indicates that there is additional potential to improve habitat productivity in these populations (UCSRB 2007, 2015; UCRTT 2017). Density dependence has been observed to varying degrees in UCR spring-run Chinook salmon populations (UCSRB 2007; ISAB 2015), which also indicates that improvements in tributary habitat capacity or productivity, if targeted at limiting life stages and limiting factors, would be likely to improve overall population abundance and productivity. The Entiat exhibits strong and unambiguous density dependence. In the Methow, freshwater productivity for spring Chinook salmon is likely to be limited by rearing habitat or food in some tributaries but not in the Methow subbasin overall (ISAB 2018).

More detail on baseline tributary habitat conditions for the three populations that constitute this ESU is provided below.

2.11.2.5.2 Methow Subbasin

In the Methow subbasin, upper portions of major tributaries contain a high proportion of intact habitat. The primary habitat conditions in the Methow Basin that currently limit abundance, productivity, spatial structure, and diversity of salmon and steelhead are mostly found in the middle and lower mainstem and lower portions of major tributaries. In these areas, road building, residential development, and agricultural practices have diminished stream complexity, wood and gravel recruitment, floodwater retention, and water quality, negatively affecting the ability of these habitats to support spring-run Chinook salmon. Late summer and winter instream flow conditions also often reduce migration, spawning, and rearing habitat for salmonids. This is partly natural (a result of watershed-specific weather and geomorphic conditions) but is exacerbated by irrigation withdrawals (NMFS 2016a; UCRTT 2017).

Restoration actions in this subbasin have included protection and restoration of flow, screening of irrigation diversions, improving access to habitat, improving stream complexity and floodplain connectivity, and restoring riparian areas (BPA et al. 2013, 2016). These actions have been targeted at addressing limiting factors, and best available science indicates that they have and will continue to improve habitat function for the Methow population, and that fish population abundance and productivity will respond positively. Benefits of some of these actions will continue to accrue over several decades (see Appendix A). This population must achieve at least viable status under the ESA recovery plan (UCSRB 2007).

2.11.2.5.3 Entiat Subbasin

While most of the Entiat subbasin is in public ownership, the lower basin is privately owned, including more than 70 percent of the stream length accessible to salmon and steelhead. Historical land uses of mining, water diversion, and timber harvest reduced habitat diversity, connectivity, water quantity and quality, and riparian function in many areas. The primary habitat conditions in the Entiat subbasin that currently limit salmon and steelhead include reduced stream channel configuration and complexity from logging, and flood control measures that straightened and removed large woody debris from the channel. These historical and ongoing activities have led to low instream habitat diversity, including few pools, lack of large wood accumulations, and disconnected side channels, wetlands, and floodplains. The result is a reduction in resting and rearing areas for both adult and juvenile salmon throughout the Entiat River (NMFS 2016a; UCRTT 2017).

Restoration actions in this subbasin have included protection and restoration of streamflow, improvements to passage barriers, improved stream channel complexity and floodplain connectivity, and riparian area improvements (BPA et al. 2013; BPA et al. 2016). These actions have been targeted toward addressing limiting factors, and best available science indicates that they have and will continue to improve habitat function for the Entiat population, and that fish population abundance and productivity will respond positively. Benefits of some of these actions will continue to accrue over the next several decades (see Appendix A). This population must achieve at least viable status under the ESA recovery plan (UCSRB 2007).

A life-cycle model for the Entiat River basin developed under the ISEMP examined potential benefits of habitat improvement for spring Chinook salmon in the Entiat River basin.[129] The model was used to examine scenarios of (1) current habitat conditions, (2) current and proposed habitat improvement actions (side-channel habitat creation and addition of large wood and boulders), and (3) habitat improvement and two percent increase in juvenile Chinook salmon survival (based on influence of habitat structures on overwinter survival). The model results indicated that implementation of actions to increase instream habitat complexity in 2012 and 2014 resulted in very small (less than 1 percent) increases in rearing capacity across modeled sites, and a small increase in the number of Chinook salmon adults predicted to return to the Entiat River (ISAB 2018; Saunders et al. 2017).

2.11.2.5.4 Wenatchee Subbasin

In the Wenatchee basin, although less than 25 percent of the subbasin is privately owned, nearly two-thirds of the lineal area of anadromous streams, primarily lower gradient streams, is

[129] This model did not incorporate the same life-cycle model framework for mainstem, ocean, and other effects that was used for the suite of models described elsewhere in this biological opinion (Zabel and Jordan, in press).

bordered by private lands. The Wenatchee subbasin was also affected historically by mining, intense livestock grazing, agriculture, water diversions, timber harvest, and railroad and road building. These land uses have reduced habitat diversity, connectivity, water quantity and quality, and riparian function in many areas within the basin. However, some headwater areas are in relatively pristine condition and serve as strongholds for listed species. The primary habitat conditions in the Wenatchee Basin that currently limit abundance, productivity, spatial structure, and diversity of salmon and steelhead include a lack of habitat diversity and quantity, excessive sediment load, obstructions, a lack of channel stability, low flows, and high summer temperatures. Habitat diversity is affected by channel confinement, loss of floodplain connectivity and off-channel habitat, reduced quantities of large wood, and a lack of riparian vegetation. The mainstem and many of its tributaries also lack high-quality pools and spawning areas associated with pool tail-outs. The lack of pools in many areas is probably directly related to the loss of riparian vegetation, removal of large wood, and channel confinement (NMFS 2016a; UCRTT 2017).

Restoration actions in this subbasin have included actions to protect streamflow, improve access, improve stream complexity, protect intact habitat areas, and improve riparian areas (BPA et al. 2013, 2016). These actions have addressed limiting factors, and best available science indicates that they have and will continue to improve habitat function for the Wenatchee population and that fish population abundance, productivity, spatial structure, and diversity will respond positively.[130] Benefits of some of these actions will continue to accrue over the next several decades (see Appendix A). This population must achieve at least viable status under the ESA recovery plan (UCSRB 2007).

NMFS used a life-cycle model to project the effects of tributary habitat actions implemented in the 2009 through 2015 period on abundance of natural-origin spawners and on population extinction risk for the Wenatchee population. In this case, the estimated effects of the habitat actions in the 2009 through 2015 period were not detectable compared to conditions prior to completion of the actions (Jorgensen et al. 2013, 2017; Jorgensen, in press; Pess and Jordan et al. in press). However, there were only two habitat actions completed during this period that were located in spawning and rearing areas and that were quantifiable into changes in habitat capacity (about a 1 percent increase in two subbasins; Pess and Jordan et al. in press). Other completed actions that could not be quantified into changes to habitat capacity such as conservation easements, which are directed at preserving existing functional habitats, are also expected to benefit this population now and into the future.

2.11.2.5.5 ESU Summary

[130] In most cases, the most immediate benefits would be expected in abundance and productivity. Depending on the population and the scale and type of action, benefits to spatial structure and diversity might also accrue. In addition, while we expect abundance, productivity, spatial structure, and diversity to respond positively to strategically implemented tributary habitat improvement actions, other factors also influence these viability parameters (e.g., ocean conditions) and any resulting trends.

In summary, while some degraded areas in the UCR spring-run Chinook salmon ESU are likely on an improving trend due to ongoing habitat improvement actions and improved land-use practices, in general tributary habitat conditions are still degraded and continue to negatively affect spring-run Chinook salmon abundance, productivity, spatial structure, and diversity. In addition, there remains additional potential for improvement in habitat productivity in all populations in this ESU (UCSRB 2007; NMFS 2016a; UCRTT 2017; ISAB 2018).

2.11.2.6 Estuary Habitat

The estuary provides important migration habitat for yearling UCR spring-run Chinook salmon. Since the late 1800s, 68-70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening combined with flow regulation and other modifications (Kukulka and Jay 2003; Bottom et al. 2005; Marcoe and Pilson 2017). Disconnection of tidal wetlands and floodplains has reduced the production of wetland macrodetritus supporting salmonid food webs (Simenstad et al. 1990; Maier and Simenstad 2009), both in shallow water and for larger juveniles migrating in the mainstem (ERTG 2018).

Restoration actions in the estuary such as those highlighted in the latest five-year review have improved access and connectivity to floodplain habitat. From 2004 through 2017, the Action Agencies implemented 58 projects including dike and levee breaching or lowering, tide gate removal, and tide gate upgrades that reconnected 5,412 acres of historical tidal floodplain habitat to the mainstem. This represents a 2.5 percent net increase in the connectivity of habitats that produce prey used by yearling Chinook salmon (Johnson et al. 2018). In addition, about 2,500 acres of functioning floodplain habitat were acquired for conservation.

Floodplain habitat restoration can affect juvenile salmonid performance directly (for fish that move onto the floodplain) and indirectly (for fish that stay in the mainstem). Wetland food production supports foraging and growth within the wetland (Johnson et al. 2018), but these prey items (primarily chironomid insects and corophiid amphipods; PNNL and NMFS 2018) are also exported to the mainstem and off-channel habitats behind islands and other landforms where they become available to salmon and steelhead migrating in these locations. Thus, while most yearling Chinook salmon may not directly enter a tidal wetland channel, they derive indirect benefits from wetland habitats. Improved opportunities for feeding on prey that drift into the mainstem are likely to contribute to survival at ocean entry.

Habitat quality and the food web in the estuary are also degraded because of past and continuing releases of toxic contaminants (Fresh et al. 2005; LCREP 2007), from both estuarine and upstream sources. Historically, levels of contaminants in the Columbia River were low, except for some metals and naturally occurring substances (Fresh et al. 2005). Today, levels in the estuary are much higher, as the estuary receives contaminants from more than 100 sources that discharge into a river and numerous sources of runoffs (Fuhrer et al. 1996). With Portland and other cities on its banks, the Columbia River below Bonneville Dam is the most urbanized section of the river. Sediments in the river at Portland are contaminated with various toxic compounds, including metals, PAHs, PCBs, chlorinated pesticides, and dioxin (ODEQ 2008).

Contaminants have been detected in aquatic insects, resident fish species, salmonids, river mammals, and osprey, reinforcing that contaminants are widespread throughout the estuarine food web (Fuhrer et al. 1996; Tetra Tech 1996; LCREP 2007).

Exposure to toxic contaminants can either kill aquatic organisms outright or have sublethal effects that compromise their health and behavior. Sublethal concentrations increase stress and decrease fitness, predisposing organisms to disease, slowing development, and disrupting physiological processes, such as reproduction and smoltification. Acute lethal effects of toxic contaminants, such as fish kills from accidental discharges or spills, are generally rare, but some researchers have described direct mortality of salmonids including high levels of pre-spawning mortality in Puget Sound coho salmon due to road runoff (McCarthy et al. 2008), synergistic toxicity of agricultural pesticide mixtures causing death in juvenile salmon (Laetz et al. 2009), and increased egg mortality due to PAH exposure (Heintz et al. 1999; Carls et al. 2015).

Sublethal effects are more likely a significant threat to juvenile salmon in the Columbia River estuary. Exposure can reduce immune function and fitness, impair growth and development, and disrupt olfaction; salmonids depend on olfaction for migration, imprinting, homing, and detecting predators, prey, potential mates, and spawning cues. These sublethal effects can interact with other factors like infectious disease, parasites, predation, exhaustion, and starvation by suppressing salmonid immune systems and impairing necessary behaviors such as swimming, feeding, responding to stimuli, and avoiding predators (LCREP 2007).

Toxic contaminants can also affect salmon via the food web, especially through prey such as aquatic and terrestrial insects. Insect bodies accumulate contaminants, which salmon in turn ingest when they consume insects. Additionally, many toxic contaminants are specifically designed to kill insects and plants, reducing the availability of insect prey or modifying the surrounding vegetation and habitats. Changes in vegetative habitat can shift the composition of biological communities, create favorable conditions for invasive, pollution-tolerant plants and animals, and further shift the food web from macrodetrital to microdetrital sources. Overall, more work is needed on contaminant uptake and impacts on salmon of different populations and life-history types.

2.11.2.7 Predation

A variety of avian and fish predators consume juvenile UCR spring-run Chinook salmon on their migration from tributary rearing areas to the ocean. Many native (e.g., northern pikeminnow, trout, etc.) and non-native fish predators (e.g., smallmouth bass, walleye, brook trout, etc.) are known to consume rearing and migrating juvenile Chinook salmon in tributary streams and in the mainstem Columbia River. Many avian predators (e.g., Caspian terns, cormorants, pelicans, herons, kingfishers, etc.) and mammals (e.g., river otters, mink, raccoons, black bears, etc.) are also known to consume juvenile Chinook salmon, and in some cases adults (UCSRB 2007). Pinnipeds eat returning adults in the estuary, including the tailrace of Bonneville Dam. In the following paragraphs we discuss predation rates and describe management measures to reduce the effects of the growth of predator populations within the action area.

2.11.2.7.1 Predation in the Lower Columbia River Estuary

Avian Predators

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, are having a significant impact on the survival of juvenile salmonids (including UCR spring-run Chinook salmon) in the Columbia River. Caspian terns on Rice Island, an artificial dredged-material disposal island in the estuary, consumed about 5.4-14.2 million juveniles per year in 1997 and 1998, or 5-15 percent of all the smolts reaching the estuary (Roby et al. 2017). Efforts began in 1999 to relocate the tern colony 13 miles closer to the ocean at East Sand Island where the tern diet would diversify to include marine forage fish. During 2001-15, estimated consumption by terns on East Sand Island averaged 5.1 million smolts per year, about a 59 percent reduction compared to when the colony was on Rice Island. Management efforts are ongoing to further reduce salmonid consumption by terns in the lower Columbia River and similar efforts are in progress to reduce the nesting population of double-crested cormorants in the estuary.

Based on PIT-tag recoveries at East Sand Island, average annual tern and cormorant predation rates for this ESU were about 3.9 and 3.1 percent, respectively, before efforts to manage the size of these colonies (Evans et al. 2018a). The Corps has been implementing the Caspian Tern and Double-crested Cormorant Management Plans, but, in terms of effectiveness, has seen mixed results due to the dispersal of both terns and cormorants to other locations within the estuary. Average predation rates on UCR spring-run Chinook salmon have decreased to 1.6 percent for terns nesting on East Sand Island, but in 2017 this improvement was offset to some unknown degree by terns roosting farther upstream on Rice Island (Evans et al. 2018a). Due to failures of the cormorant colony in 2016 and 2017, there are no estimates of predation rates since management of that colony began (Appendix C). Substantial numbers of cormorants have relocated to the Astoria-Megler Bridge (preliminary report of 1,737 in 2018) and hundreds more are observed on the Longview Bridge, navigation aids, and transmission towers in the lower river (Anchor QEA et al. 2017). Smolts may constitute a larger proportion of the diet of cormorants nesting at these sites than if the birds were foraging from East Sand Island. Thus, the success of the East Sand Island tern and cormorant management plans at meeting their underlying goals of reducing salmonid predation is uncertain at this time.

An important question in predator management is whether mortality due to predation is an additive or compensatory source of mortality. Most importantly, do reductions in smolt predation rates by Caspian terns or double-crested cormorants result in higher adult returns because avian predation adds to the other sources of smolt mortality or are the smolts eaten by birds destined to die before returning as adults regardless of the level of predation? The latter case could occur because avian predation could be compensated for by sources of mortality in the ocean phase of the life cycle so that adult returns are unchanged. Haeseker (2015) and Evans et al. (2018b) have begun modeling the degree to which double-crested cormorant and Caspian tern predation, respectively, are additive versus compensatory sources of mortality.

Given the magnitude of bird predation on juvenile salmon observed in the Columbia Basin, and that smolts eaten by birds in the lower river have survived hydrosystem passage, it is likely that some of them could otherwise have survived to adulthood. Therefore, even if avian predation is partially compensatory, we expect that limiting the size of these tern and cormorant colonies will contribute to increased SARs for UCR spring-run Chinook salmon.

Pinniped Predators

Numbers of pinnipeds that are predators of adult salmonids have increased considerably in the Pacific Northwest since the MMPA was enacted in 1972 (Carretta et al. 2013). CSLs, SSLs, and harbor seals consume salmonids from the mouth of the Columbia River and its tributaries up to the tailrace of Bonneville Dam. A small number of California sea lions have also been observed in Bonneville Reservoir in recent years. The ODFW has been counting the number of individual CSL hauling out at the East Mooring Basin in Astoria, Oregon, since 1997. Up to 50 percent of the mortality of adult spring-run Chinook salmon destined for tributaries above Bonneville occurred within the 10-mile reach just below the dam, which is part of the lower gorge. An authorization from NMFS under the MMPA has allowed the states of Oregon and Washington to implement hazing and removal measures in an effort to improve the survival of adult salmonids in the lower river.

Based on pinniped count data and spring Chinook salmon survival estimates, increasing pinniped abundance in the Columbia River estuary has resulted in an increased loss of UCR spring-run Chinook salmon in recent years. Rub et al. (2018) conducted a five-year mark-recapture tagging study to examine the behavior and survival of spring Chinook salmon returning to the Interior Columbia River basin (above Bonneville) amid increasing pinniped abundance. Using spring Chinook salmon that were known to originate above Bonneville Dam through genetic testing, these researchers found that survival ranged from 0.46 to 0.80 annually over the five-year study and survival was lowest during the most recent two years of study. It is important to note that while mortality due to harvest was accounted for, effects from capture, handling, disease, and straying effects were not accounted for in these estimates. These researchers found strong evidence that the recent increases in spring Chinook salmon loss estimates were a function of the large increase in pinnipeds counted from 2012 to 2015. This study provided estimates that were consistent with bioenergetics modeling and provides strong evidence that increasing numbers of pinnipeds within the Columbia River are associated with reductions in the survival of returning adult Chinook salmon, most likely due to predation.

Chinook salmon populations exhibit a range of migration timings due to their different migration strategies adapted in response to phenology of migration, spawning and juvenile rearing habitat conditions. For UCR spring-run Chinook salmon, survival is typically lowest overall for fish migrating earlier in the run. Research has consistently found that the highest proportional impact of predation losses were experienced by fish that returned to the dam during late winter and early spring compared to those that followed. In 2013–2015, survival was especially low for early migrants, corresponding with a period of increased CSL presence in the estuary (Keefer et al. 2012). Early migrating spring Chinook salmon populations experienced a 22 percent reduction survival in 2013-2015 relative to a baseline period of 1998 to 2012, and survival of later-migrating populations declined by only 4–16 percent (Figure 2.11-6) (Sorel et al 2017). The current information indicates salmon populations with relatively early migration timing are more at risk since the relative predator density (number of predators/number of prey) has been highest early in the spring and pinnipeds appear effective at capturing prey even at relatively low prey density.

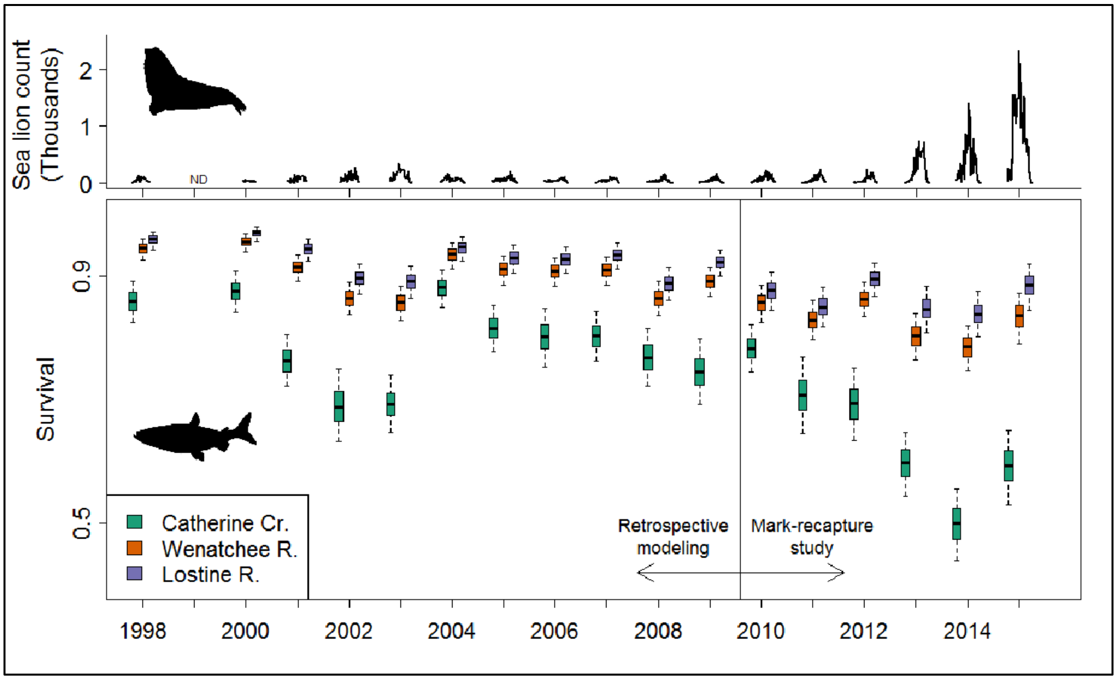

Figure 2.11-6. Daily counts of California sea lions hauled out at the East Mooring Basin in Astoria from 1 January to 30 June of 1998–2015. Sea lion counts were unavailable for 1999. Bottom Panel: Modeled population- and year-specific survival rates of adult spring-summer Chinook salmon (only the Wenatchee River population is from the UCR spring-run Chinook salmon ESU) during their migration from the mouth of the Columbia River (near Astoria) to Bonneville Dam. The boxplots represent medians, interquartile ranges, and 5th and 95th percentiles of survival rate estimates. We used the model of survival based on the mark-recapture study conducted in 2010–2015 to retrospectively model survival rates as a function of California sea lion counts Sorel et al. 2017).

Later migrating UCR spring-run Chinook salmon from the Okanogan, Methow, and Wenatchee populations are at relatively low risk compared to the early migrating Entiat populations which are at high risk (Figure 2.11-7).

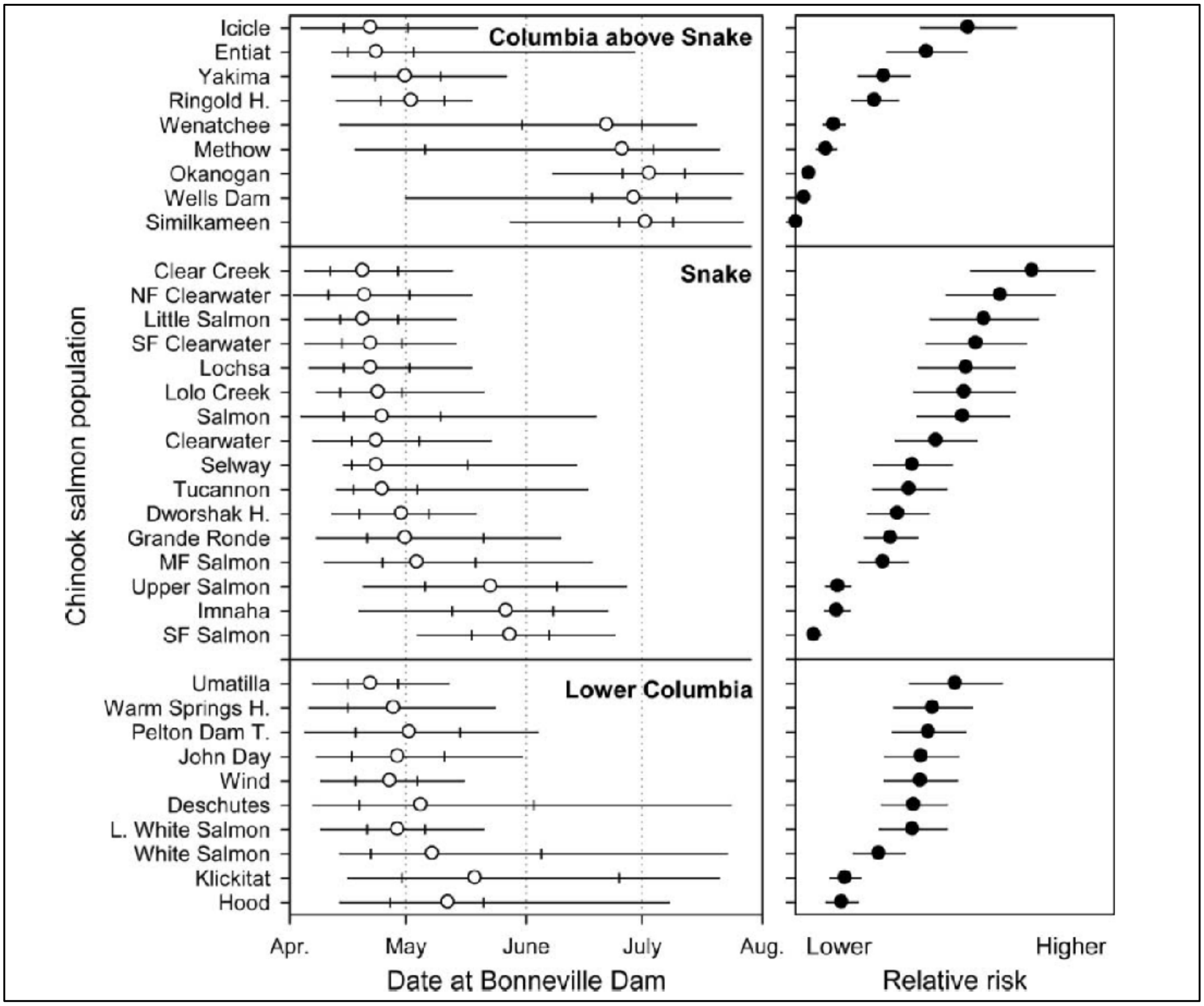

Figure 2.11-7. Left panel: Migration timing distributions calculated using 5,229 radio-tagged spring and summer Chinook salmon from 32 upriver populations in the lower Columbia River, Snake River, and Columbia River upstream from the Snake River confluence, 1996–1998 and 2000–2004. Distributions show 5th, 25th, 50th, 75th, and 95th percentiles. Right panel: the relative risk (±1 SE) of predation by pinnipeds, estimated by multiplying weekly mean predation rate estimates from the pinniped observation study by population-specific migration timing distributions.

Within the Columbia River, UCR spring-run Chinook salmon losses due to pinniped predation are greatest directly downstream of Bonneville Dam and up to 50 percent of the mortality of adult spring-run Chinook salmon occurred within the 10-mile reach just below the dam (Rub et al. 2018). The dam structure provides a predation advantage as fish congregate in search of ladder entrances and these delays can concentrate fish and predators making fish more vulnerable to predation (Stansell 2004). Biologists have been estimating spring Chinook salmon consumption by pinnipeds directly below (2km) Bonneville Dam since 2002 (Tidwell et al 2017).

Based on tailrace predation monitoring efforts conducted from 2002-2017 at the Bonneville Dam tailrace, pinniped predation on spring Chinook salmon has been variable, but has generally increased in recent years and we assume that predation has increased for UCR spring-run Chinook salmon at a similar rate. Tidwell et al (2017) reports that an estimated 4,951 adult spring Chinook salmon (all ESU's) were consumed by both pinniped species in 2017, which equates to 4.5 percent of the adult spring Chinook salmon that passed. Consumption rates of spring Chinook salmon in the last three years have ranged from 4.3-5.9 percent and are the highest consumption rates since monitoring begun in 2002 (Table 2.11-7).

Table 2.11-7. Consumption of spring Chinook salmon by pinnipeds at Bonneville Dam tailrace from January 1 through June 15, 2002 to 2017. Passage counts of Chinook salmon includes both adult and jack salmon.

Year	Bonneville Dam Spring Chinook Passage	Chinook Salmon Consumption Estimate	% Run
2002	316,468	880	0.3 %
2003	247,059	2,313	0.9 %
2004	210,569	3,307	1.5 %
2005	102,741	2,742	2.6 %
2006	130,014	2,580	1.9 %
2007	101,068	3,403	3.3 %
2008	143,139	4,500	3.0 %
2009	181,174	4,360	2.3 %
2010	257,036	5,909	2.2 %
2011	218,092	3,634	1.6 %
2012	165,681	1,960	1.2 %
2013	117,165	2,710	2.3 %
2014	214,177	4,576	2.1 %
2015	233,794	10,622	4.3 %
2016	148,360	9,222	5.9 %
2017	105,583	4,951	4.5 %

Fish Predators

The native northern pikeminnow is a significant predator of juvenile salmonids in the Columbia River (reviewed in ISAB 2015). Before to the start of the NPMP in 1990, this species was estimated to eat about 8 percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River (including the hydrosystem reach) each year. Williams et al. (2017) compared current estimates of northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. The Sport Reward Fishery removed an average of 188,636 piscivorous pikeminnow (> 228 mm fork length) per year during 2013-17 (Williams 2013, 2014; Williams et al. 2015, 2016, 2017).

The removal of the larger, piscivorous individuals from northern pikeminnow populations will result in a sustained survival improvement for migrating juvenile Chinook salmon only if it is not offset by a compensatory response by the remaining northern pikeminnow or other piscivorous fishes such as walleye or smallmouth bass. Signs of a compensatory response can include increased numbers of other predators, improved condition factors, or diet shifts. Williams et al. (2017) did not observe increases in numbers of pikeminnow, but did report an increasing trend in condition factor. This could be an intra-specific compensatory mechanism or just a response to beneficial environmental conditions. Similarly, Williams et al. (2017) documented increased numbers of smallmouth bass in parts of the lower Columbia River, which could be related to the NPMP or could be due to factors such as alterations in other parts of the food web or environmental conditions such as warmer temperature that affect this species' consumption rates. Williams et al. (2017) concluded that given these analytical constraints, data collected during 2017 provided ambiguous indicators of a compensatory response from the piscivorous fish community. Given the numbers of fish, bird, and marine mammal predators in the Columbia River and the ocean, we do not expect that all of the Chinook salmon that are "saved" from predation by pikeminnows survive to adulthood. However, a 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity of Chinook salmon populations, including UCR spring Chinook salmon.

An average of 27 adult, 15 jack, and 67 juvenile Chinook salmon per year were killed and/or handled in the Sport Reward Fishery, system-wide (i.e., in the lower Columbia River and the hydrosystem reach), during 2013-17 (Williams et al. 2013, 2014; Williams et al. 2015, 2016, 2017). Although it was not practical for the field crews to identify these fish to ESU, we assume that some were UCR spring Chinook salmon.

2.11.2.7.2 Predation in the Hydrosystem Reach

The following paragraphs describe predation in the mainstem Columbia River from the tailrace of Bonneville Dam to confluences of the Wenatchee, Entiat, and Methow Rivers.

Avian Predators

UCR spring-run Chinook salmon survival is affected in the mainstem by avian predators that inhabit the dams and reservoirs. The 2008 FCRPS biological opinion required that the Action Agencies implement avian predation control measures to increase survival of juvenile salmonid in the lower Snake and Columbia Rivers through effective monitoring, hazing, and deterrents at each project. All CRS projects have been using several effective strategies including wire arrays that crisscross the tailrace areas, spike strips along the concrete, water sprinklers at juvenile bypass outfalls, pyrotechnics, propane cannons, and limited amounts of lethal take. Zorich et al. (2012) estimated that, compared to the numbers of smolts consumed at John Day Dam in 2009 and 2010, 84-94 percent fewer smolts were consumed by gulls in 2011. At The Dalles Dam, 81 percent fewer smolts were consumed in 2011 than in 2010. Zorich et al. (2012) attribute the observed changes in predation rates between years to variation in the number of foraging gulls, but imply that deterrence activities provide some (unquantifiable) level of protection.[131]

Juvenile UCR spring-run Chinook salmon migrating through the mid-Columbia River are vulnerable to predation by terns nesting on islands in McNary Reservoir, in the Hanford Reach, and in Potholes Reservoir. Smolts come within foraging range of other nesting sites on the plateau (principally Blalock Islands in John Day Reservoir) as they continue their downstream migration. The objective of the IAPMP (USACE 2014), is to reduce predation rates to less than 2 percent per listed ESU/DPS per tern colony per year. The primary management activities have been to keep terns from nesting on Goose Island in Potholes Reservoir (managed by Reclamation) and on Crescent Island in McNary Reservoir (managed by the Corps) using passive dissuasion, hazing, and revegetation. The Corps has been successful at preventing terns from nesting on Crescent Island since 2015 and similar efforts by Reclamation are in progress at Goose Island in Potholes Reservoir. However, the number of tern nests at the Blalock Islands in John Day Reservoir was ten times higher in 2015 than the year before and resightings of colored leg-banded terns indicated that large numbers had moved there from Crescent Island. Terns have also moved to sites on the interior plateau from East Sand Island in the estuary and from alternative Corps-constructed colony sites in southeastern Oregon and northeastern California in 2015 when those areas experienced severe drought (Roby et al. 2017). Nonetheless, the numbers of pairs of Caspian terns nesting on the Columbia plateau in 2017 represented a 23 percent drop from the pre-management period and average annual predation rates on UCR spring Chinook salmon at each of these colonies were below 2 percent in 2015-2016 (Roby et al. 2016, 2017; Appendix C).

Gull predation was not considered in the IAPMP and there are no regional plans to manage these colonies. PIT-tag recoveries indicate that predation rates on smolts from this ESU by gulls on Miller Rock Island ranged from 2.5-3.5 percent during 2015-2016 (Roby et al. 2016, 2017).

Pinniped Predators

Pinniped presence in the Bonneville tailrace has increased in the last six years (Appendix B). Rub et al. (2018) found up to 50 percent of the mortality from pinnipeds of adult spring-run Chinook salmon (all ESUs) destined for tributaries above Bonneville Dam occurred within the 10-mile reach just below the dam. Hydroelectric dams can delay upstream fish passage and congregate fish searching for ladder entrances (Kareiva et al. 2000; Quinones et al. 2015). Such delays can make fish vulnerable to predation by pinnipeds (Stansell 2004; Naughton et al. 2011). Tidwell et al (2017) reports that an estimated 4,951 adult spring Chinook salmon (all ESU's) were consumed by both pinniped species in 2017, which equates to 4.5 percent of the adult spring Chinook salmon that passed. Consumption rates of spring Chinook salmon in the last three years (2015–17) have ranged from 4.3 to 5.9 percent, and are the highest consumption rates

[131] "For continued protection against avian predation we recommend the current passive deterrents avian lines be maintained and expanded where possible and active deterrents such as hazing from boats or other novel methods continue to be deployed as necessary to minimize foraging by piscivorous water birds at the Corps' dams" (Zorich et al. 2012).

since monitoring begun in 2002 (Appendix B). A small number of California sea lions have also been observed in Bonneville Reservoir in recent years.

Based on evidence of high rates of predation on UCR spring-run Chinook salmon (and other ESUs), NMFS has provided the states of Oregon and Washington with a Letter of Authorization under the MMPA to haze and remove CSL through June 30, 2021. In 2017, the states trapped and euthanized 24 individually identifiable CSL that were having a significant negative impact on ESA-listed salmonids at Bonneville Dam (Brown et al. 2017).

Fish Predators

Native pikeminnow are significant predators of juvenile salmonids in the hydrosystem reach, followed by non-native smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011, 2015). In addition to the Sport Reward Fishery in the lower Columbia River estuary and throughout the hydrosystem reach, the Action Agencies conduct a Dam Angling Program to remove large pikeminnow from the tailraces of The Dalles and John Day Dams. Angling crews removed an average of 5,913 northern pikeminnow from these two projects per year during 2013–17 (Williams 2013, 2014; Williams et al. 2015, 2016, 2017). They also reported an average of one adult and zero juvenile Chinook salmon killed and/or handled per year.

Juvenile salmonids are also consumed by large numbers of non-native fishes, including walleye, smallmouth bass, and channel catfish, in the reservoirs of hydrosystem reach. As described for the lower Columbia River estuary: (1) yearling UCR spring Chinook salmon mostly stay in the mainstem migration channel and are not likely to encounter large numbers of these species, and (2) both the Oregon and Washington Departments of Fish and Wildlife have removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids.

2.11.2.8 Life-Cycle Models

Life-cycle models were used to assess the effect of continuing to operate the hydropower system in accordance with the 2017 FOP, the future effect of recent habitat restoration actions (where they could be quantified), the effect of continuing hatchery production (in accordance with the most recent Hatchery Genetic Management Plans (HGMPs), and the effect of recent, seasonally variable increases in sea lion predation (earlier migrating populations suffer higher mortality rates) in the lower Columbia River from the mouth to Bonneville Dam (see Methods Section). The estimates of projected (in 24 years) median geomean abundance and productivity of populations under the environmental baseline (and resulting estimates of quasi-extinction at the 30 and 50 adult levels) includes improvements in productivity and abundance that occurred in past decades as the result of both positive (e.g., hydrosystem improvements, reduced harvest, pikeminnow and avian predator management actions, etc.) and negative (e.g. continuing negative effects of hydropower projects, land use practices, etc.) factors which have affected the recruit-per-spawner estimates in the time series available for each population.

Model results projecting out 24 years was selected as a reasonable timeframe to assess near-term extinction and is consistent with past CRS biological opinions. Quasi-extinction Thresholds represent levels at which populations may be too small to reliably reproduce. Because the exact population levels at which this condition occurs for Chinook salmon populations is unknown (and is likely variable due to a number of factors), past biological opinions (e.g., NMFS 2008a) provided QET projections for 50, 30, 10, and 1 individual (for four consecutive years) because of concern about populations with extremely low numbers. In this consultation, NMFS presents QET projections for 30 and 50 adults (for four consecutive years) as a useful means of illustrating differences resulting from factors affecting the abundance and productivity of the modeled populations.

Within the UCR spring-run Chinook salmon ESU (North Cascades MPG), only one population (Wenatchee River) has sufficient information available to support life-cycle modeling. This population is also affected by ongoing hydrosystem actions and by increased sea-lion predation, and inhabits a subbasin in which the spawning and rearing habitat is degraded. This population has not been targeted for habitat restoration actions, and will continue to be substantively influenced by hatchery produced fish. Model projections (median geomean abundance and quasi-extinction (QET) estimates for thresholds of 30 and 50 adults for four consecutive years in 24 years) are presented in Table 2.11-8. Based on these model projections, median abundance is projected to be near 532 adults for Wenatchee River population in 24 years. The median probability of the population falling below a QET of 50 adults for four consecutive years is projected to be less than 1 percent.

Table 2.11-8. Life-cycle model estimates of median abundance and Quasi-Extinction Risk (QET) thresholds of 30 and 50 (5th and 95th percentiles) in 24 years under the Environmental Baseline.

North Cascades MPG	Abundance			QET = 30			QET = 50		
Population	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**
Wenatchee River	532	93	1,385	0	0	0	0.001	0	0.010

2.11.2.9 Research and Monitoring Activities

The primary effects of the past and ongoing CRS-related RM&E program on UCR spring Chinook salmon are associated with the capturing and handling of fish. The RM&E program is a collaborative, regionally coordinated approach to fish and habitat status monitoring, action effectiveness research, critical uncertainty research, and data management. The information derived from the program facilitates effective adaptive management through better understanding the effects of the ongoing CRS action. Capturing, handling, and releasing fish generally leads to stress and other sublethal effects, but fish sometimes die from such treatment. The mechanisms by which these activities affect fish have been well documented and are detailed in Section 8.1.4 of the 2008 biological opinion (NMFS 2008a). Some RM&E actions also involve sacrificial sampling of fish. We estimated the number of UCR spring Chinook salmon that have been handled or killed each year during implementation of RM&E under the 2008 RPA as the average annual take reported for 2013–17:

- Average annual estimates for handling and mortality of UCR spring Chinook salmon associated with the Smolt Monitoring Program and the CSS were: (1) zero hatchery adults and zero wild adults handled; (2) zero hatchery and zero wild adults died; (3) 1,625 hatchery juveniles and 803 wild juveniles handled; and (4) five hatchery juveniles and five wild juveniles died.
- The estimated handling and mortality of UCR spring Chinook salmon associated with the ISEMP Program was: (1) zero hatchery adults and one wild adult handled; (2) zero hatchery adults and one wild adult died; (3) 20 hatchery juveniles and 3,010 wild juveniles handled; and (4) zero hatchery juveniles and 91 wild juveniles died.
- Estimates for UCR spring Chinook salmon handling and mortality for all other fish RM&E programs are as follows: (1) 73 hatchery adults and 38 wild adults handled; (2) zero hatchery adults and zero wild adult died; (3) 1,242 hatchery juveniles and 901 wild juveniles handled; and (4) four hatchery juveniles and 19 wild juveniles died.

The combined take (i.e., handling, including injury, and incidental mortality) associated with the RM&E program has, on average, affected less than 1 percent of the wild (i.e., natural-origin) portion of the adult run or the juvenile production for the UCR spring Chinook salmon ESU. This relatively small effect is deemed worthwhile because it allows the Action Agencies and NMFS to evaluate the effects of CRS operations, including modifications to facilities, operations, and mitigation actions.

In addition, northern pikeminnow are tagged as part of the Sport Reward Fishery and their rate of recapture is used to calculate exploitation rates. Northern pikeminnow are collected for tagging using boat electrofishing in select reaches of the Columbia River. During 2017, boat electrofishing operations in the Columbia River extended upstream from RM 47 (near Clatskanie, Oregon) to RM 394 (Priest Rapids Dam), and in the Snake River from RM 10 (Ice Harbor Dam) to RM 41 (Lower Monumental Dam) and from RM 70 (Little Goose Dam) to RM 156 (upstream of Lower Granite Dam). Researchers conducted four sampling events consisting of 15 minutes of boat electrofishing effort in shallow water within each 0.6-mile reach during April-July.

A side effect of the electrofishing effort is that salmon and steelhead may be exposed to the electrofishing field, with the potential for injury, stress, and fatigue and even cardiac or respiratory failure (Snyder 2003). Some adult and juvenile UCR spring-run Chinook salmon are likely to be present in shallow shoreline areas during the April-July time period. Most sampling occurs in darkness (1800-0500 hours). Operators shut off the electrical field if salmonids are seen and because most stunned fish quickly recover and swim away, they cannot be identified to species (i.e., Chinook, coho, chum, or sockeye salmon or steelhead). Barr (2018) reported encountering an annual average of 1,463 adult and 78,425 juvenile salmonids in the lower and middle Columbia River each year during 2013-17 electrofishing operations based on visual estimation methods. It is likely that some of these were UCR spring-run Chinook salmon.

All three mid-Columbia PUDs (Grant, Chelan and Douglas) have achieved adult and juvenile survival standards for UCR spring-run Chinook salmon. As a condition of their federal license, all PUDs must evaluate adult and juvenile survival at 10-year intervals to ensure that standards are maintained; this requires a monitoring program.

2.11.2.10 Critical Habitat

The environmental baseline for the PBFs for UCR spring-run Chinook salmon critical habitat are reflected in the same impacts discussed above (e.g., mainstem flows, passage, water quality, predation, etc.) and summarized in Table 2.11-8. Across the action area, widespread development and other land use activities have disrupted watershed processes (e.g., erosion and sediment transport, storage and routing of water, plant growth and successional processes, input of nutrients and thermal energy, nutrient cycling in the aquatic food web, etc.), reduced water quality, and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and/or current land use or water management activities have adversely affected the quality and quantity of stream and side channel areas (e.g., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for spring-run Chinook salmon production have been weakened.

Habitat quality in tributary streams in the upper Columbia portion of the Interior Columbia recovery domain varies from good in higher elevation stream reaches to degraded in lower elevation reaches, especially near valley bottoms. These areas are subject to heavy agricultural and urban development. Human activities that have contributed to these factors include dams, water diversions, stream channelization and diking, roads and railways, timber harvest, grazing, and urban and rural development (UCSRB 2015). Natural disturbances that have had a large effect on habitat include wildfires with subsequent effects on runoff and sedimentation in areas used for spawning and rearing.

The general effects of mainstem and tributary dams on the functioning of critical habitat include:

- Lost access to historical spawning areas behind dams built without fish passage facilities (does not apply to Chief Joseph and Grande Coulee Dams)(obstructions);
- Altered juvenile and adult passage survival at dams with passage facilities (obstructions);
- Altered flows and seasonal timing (reduced water quantity);
- Altered seasonal temperatures and elevated dissolved gas (reduced water quality);
- Reduced sediment transport and turbidity (reduced water quality); and
- Altered food webs, including both predators and prey (reduced prey production and increased numbers of predators, including non-natives).

Habitat quality of migratory corridors in this area has been severely affected by the development and operation of the CRS dams and reservoirs in the mainstem Columbia River, Bureau of

Reclamation tributary projects, and privately owned dams in the Snake and Upper Columbia River basins. Hydroelectric development has modified natural flow regimes of the rivers, resulting in warmer late summer/fall water temperatures, changes in fish community structure that lead to increased rates of piscivorous and avian predation on juvenile salmon and steelhead, and delayed migration for both adult and juvenile salmonids. Physical features of dams, such as turbines, also kill outmigrating fish. In-river survival is inversely related to the number of hydropower projects encountered by emigrating juveniles. Additionally, development and operation of extensive irrigation systems and dams for water withdrawal and storage in tributaries have altered hydrological cycles (NMFS 2016a).

Many stream reaches designated as critical habitat are listed on Oregon and Washington's Clean Water Act Section 303(d) lists for water temperature. Many areas that were historically suitable rearing and spawning habitat are now unsuitable due to high summer stream temperatures. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water for agricultural or municipal use all contribute to elevated stream temperatures. Furthermore, contaminants, such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste, are common in some areas of critical habitat (NMFS 2016a). They can negatively impact critical habitat and the organisms associated with these areas.

The large numbers of avian predators nesting on man-made or enhanced structures (dredge material deposits that created Rice Island and increased the size of East Sand Island in the lower Columbia River as well as bridges, aids to navigation, and transmission towers) constitute excessive predation in the lower Snake and Columbia River portions of the juvenile migration corridor. Similarly, sea-lion predation on adult UCR spring-run Chinook salmon in the tailrace of Bonneville Dam is excessive predation associated with a man-made structure. Predation associated with sea lions in the estuary is a natural phenomenon and is not excessive predation in the context of an effect on the functioning of critical habitat.

In the mainstem of the Columbia River, the altered habitats in project reservoirs reduce smolt migration rates and create more favorable habitat conditions for fish predators, including native northern pikeminnow and nonnative walleye and smallmouth bass. The effects of the non-native species and pikeminnows, to the extent the latter's predation rates are enhanced by reservoir and tailrace conditions, are also examples of excessive predation in the juvenile migration corridor.

Restoration activities addressing habitat quality and complexity, migration barriers (24-hour spill, new and improved spillway designs, etc.), and water quality have improved the baseline condition for PBFs; however, the conservation role of critical habitat is to provide PBFs that support populations that can contribute to conservation of the ESU. More restoration is needed before the PBFs can fully support the conservation of UCR spring-run Chinook salmon.

Table 2.11-9. Physical and biological features (PBFs) of designated critical habitat for UCR spring Chinook salmon.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBF
Freshwater spawning sites	Water quantity and quality and substrate to support spawning, incubation and larval development	● Reduced stream complexity and channel structure (loss of substrate, natural cover, vegetation, and forage) ● Reduced floodplain condition and connectivity (loss of side channels, natural cover, vegetation, and forage) ● Degraded riparian condition (elevated temperatures; loss of natural cover, side channels, vegetation, and forage) ● Diminished stream flow (degraded water quantity, elevated temperatures, and loss of juvenile and adult mobility) ● Impaired fish passage (obstructions, water withdrawals) ● Excess fine sediment in spawning gravel (degraded water quantity)
Freshwater rearing sites	Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility, water quality and forage, natural cover	● Impaired fish passage (obstructions, water withdrawals) ● Reduced riparian function (urban and rural development, forest and agricultural practices, and channel manipulations) ● Elevated water temperatures and toxics accumulations (water withdrawals, urban and rural development, and forest and agricultural practices) ● Reduced floodplain condition and connectivity (loss of side channels, natural cover, vegetation, and forage)
Freshwater migration corridors	Free of obstruction and excessive predation, Adequate water quality and quantity and natural cover	● Delay and mortality of some juveniles and adults at up to 9 mainstem dams ● Concerns about increased opportunities for predators, especially birds and pinnipeds (construction of dredge material islands in the lower river and other human-built structures used by terns and cormorants for nesting)
Estuarine areas	Free of obstruction and excessive predation with water quality , quantity and salinity, natural cover, juvenile and adult forage	● Disconnection of much of the historical tidally influenced wetlands and riverine floodplain below Bonneville Dam (reduced water quantity, natural cover, side channels, and forage) and the presence of toxic contaminants (reduced water quality and forage).
Nearshore marine areas	Free of obstruction and excessive predation with water quality, quantity and forage	● Concerns about increased opportunities for pinniped predators, adequate forage.

2.11.2.11 Future Anticipated Impacts of Completed Federal Formal Consultations

The environmental baseline also includes the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, including the consultation on the operation and maintenance of the Bureau of Reclamation's upper Snake River projects. NMFS' most recent five-year review evaluated new information regarding the status and trends of UCR spring-run Chinook salmon, including recent biological opinions issued for actions likely to affect the UCR spring-run Chinook salmon ESU and key emergent or ongoing habitat concerns (NMFS 2016a). Since the beginning of 2015 through 2017, we completed 395 formal consultations (109 in 2015, 95 in 2016 and 191 in 2017) that addressed effects to UCR spring-run Chinook salmon (PCTS data query July 31, 2018). These numbers do not include the many projects implemented under programmatic consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed salmonids. Some of the completed consultations are large (large action area, multiple species) such as the Mitchell Act consultation and the consultation on the 2018–2027 *U.S. v. Oregon* Management Agreement. Many of the completed actions are for a single activity within a single subbasin.

In 1998–2004, two PUDs (Chelan County and Douglas County) worked cooperatively with various state and federal fisheries agencies, including NWFS, USFWS, WDFW, three Native American tribes, and an environmental organization, American Rivers, to develop the first hydropower habitat conservation plans (HCPs) for salmon and steelhead. Under the HCPs, the two PUDs commit to a 50-year program to ensure that their projects have no net impact on mid-Columbia salmon and steelhead runs. This will be accomplished through a combination of fish bypass systems, spill at the hydropower projects, off-site hatchery programs and evaluations, and habitat restoration work in mid-Columbia tributary streams. The PUDs must meet minimum targets for either combined juvenile and adult survival or for juvenile-only survival through our reservoirs and past our dams. The minimum combined survival target is 91 percent and juvenile-only survival target is 93 percent. The PUDs have met or exceeded those levels for all spring migrating salmon and steelhead species at both the Rocky Reach, Rock Island and Wells Development hydropower projects. Subsequently, FERC completed consultation on the renewal of the FERC license for the Wells Development Project (Douglas PUD) that carries those same commitments forward. Also, in the mid-Columbia reach, FERC completed consultations on licenses to operate for two Grant PUD projects in 2008: Wanapum Development and Priest Rapids Development. The licenses and ESA consultations contain commitments for UCR spring-run Chinook salmon survival, consistent with current recovery planning.

Some of the projects will improve access to blocked habitat and riparian condition, and increase channel complexity and instream flows. For example, under BPA's Habitat Improvement Programmatic consultation, BPA implemented 29 projects in the Columbia River basin that improved fish passage in 2017, and 99 projects that involved river, stream, floodplain, and wetland restoration. Many of these projects will benefit the viability of the affected populations by improving abundance, productivity, and spatial structure either through direct benefits to spawning and rearing habitat, or indirectly by improving ecosystem function in migratory corridors. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more, and typically less, than a few weeks).

Other types of federal projects, including grazing allotments, dock and pier construction, and bank stabilization, will be neutral or have short- or even long-term adverse effects on viability. All of these actions have undergone section 7 consultation, and the actions or the RPA were found to meet the ESA standards for avoiding jeopardy.

Similarly, future federal restoration projects that have completed ESA consultation will improve the functioning of the PBFs safe passage, spawning gravel, substrate, water quantity, water quality, cover/shelter, food, and riparian vegetation. Projects implemented for other purposes will be neutral or have short- or even long-term adverse effects on some of these same PBFs. However, all of these actions, including any RPAs, have undergone section 7 consultation and were found to meet the ESA standards for avoiding adverse modification of critical habitat.

2.11.3 Effects of the Action

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

The proposed action is an ongoing action that has been modified over time to reflect capital improvements, as well as changes in operation based on existing conditions and improved information on how CRS operations affect UCR Chinook salmon and other listed species and their critical habitats. The current proposed action includes operational measures (e.g., flood risk management, navigation, fish passage, and hydropower generation) and non-operational measures (e.g., support for conservation hatchery programs, predation management, habitat improvement actions) that will be implemented beginning in 2019. The proposed action, however, is of limited duration. The Action Agencies are developing an EIS in accordance with NEPA that will assess and update the approach for long-term system operations, maintenance, and configuration as well as evaluate measures to avoid, offset, or minimize impacts to resources affected by the management of the CRS, including ESA-listed species and designated critical habitat. A court order currently requires the Action Agencies to issue Records of Decision on or before September 24, 2021.[132] Based on scoping, the range of alternatives being examined is broad and includes potential large-scale changes in the action. Thus, there is substantial uncertainty regarding what system operations, maintenance, and configuration the Action Agencies will propose at the conclusion of the NEPA process. Likewise, it is unknown what measures intended to avoid, offset, or minimize adverse effects will ultimately be included in the final preferred alternative.

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[132] The Presidential Memorandum on Promoting the Reliable Supply and Delivery of Water in the West, issued on October 19, 2018, required the development of an expedited schedule for completion of the NEPA process. The Council on Environmental Quality has confirmed a revised schedule that calls for completing the Draft EIS in February 2020, the Final EIS in June 2020 and Records of Decision by September 30, 2020. These dates are consistent with, but earlier than, the court-ordered deadlines.

Accordingly, our analysis of effects for UCR spring-run Chinook salmon and their critical habitat extends from 2019 into the future, but emphasizes the evaluation of effects that are reasonably certain to occur as a result of implementing the proposed action pending completion of the EIS and our issuance of a subsequent biological opinion addressing the effects of the final preferred alternative. To the extent our consideration of potential effects beyond that time period assumes the current proposed action remains in place, it is intended, in part, to inform the evaluation of alternatives in the EIS.

The effects of the proposed action for UCR Chinook salmon are generally consistent with the effects caused by a continuation of the CRS operations as described in the environmental baseline section, with the exception of the addition of the following:

- Implementation of the flexible spring spill operation
- A 0.5-ft increase in operating range at John Day reservoir; and
- The potential for reduction of spill at mainstem projects (August 15 to 31) of 2020 pending consensus among parties

2.11.3.1 Effects to the Species

The Action Agencies will operate the run-of-river lower Snake and lower Columbia River projects (McNary, John Day, The Dalles, and Bonneville Dams) in accordance with the annual Water Management Plan and Fish Passage Plan (including all appendices). These projects are operated for multiple purposes, including fish and wildlife conservation, irrigation, navigation, power, recreation, and, in the case of John Day Dam, limited flood risk management.

The proposed action is an ongoing action that has been modified over time to reflect capital improvements, as well as changes in operation based on existing conditions and improved information on how CRS operations affect UCR spring-run Chinook salmon and other listed species and their critical habitats. The current proposed action includes operational measures (e.g., flood risk management, navigation, fish passage, and hydropower generation) and non-operational measures (e.g., support for conservation hatchery programs, predation management, habitat improvement actions) that will be implemented beginning in 2019.

The Action Agencies propose to increase spill at the lower Columbia and lower Snake River dams during the spring spill period in an effort to improve juvenile survival through the dams (and improve adult returns). The Action Agencies propose to implement the flexible spring spill operation with a few limitations at some projects to due to concerns about concrete erosion and adult passage. Performance spill was developed using a combination of 2008 CRS biological opinion prescribed spill and performance standard testing guidelines, and the spill volume varies at some projects from what was prescribed in the 2017 FOP.

System-wide water management operations involving upstream water storage projects will continue under the proposed action. Thus, the seasonal alterations described in the environmental baseline will continue (decreased spring and early summer flows, increased winter flows) to affect the mainstem migration and rearing corridor, estuary, and plume. The effects of these flows on the physical environment and to UCR spring-run Chinook salmon juveniles and adults are discussed below.

2.11.3.1.1 Water Quality

The existence and operation of the federal hydrosystem will continue to affect water quality parameters in the mainstem migration corridor as described in the environmental baseline. This includes delayed spring warming, delayed fall cooling, and reduced temperature variability on a daily basis due to the thermal inertia of the reservoirs.

TDG levels will continue to exceed the state-approved standards whenever high flows or lack of load result in lack of market or lack of turbine capacityspill. These events occur most frequently in May and June, but may also occur in other months.

The available information indicates that supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). The proposed flexible spill operation (up to 120 or 125 percent TDG) would increase the exposure of spring migrating juveniles to elevated TDG levels from McNary reservoir near the confluence with the Snake River to at least 35 miles downstream of Bonneville Dam. Individuals from all populations would be exposed similarly. Smolts typically migrate at depths which effectively reduce TDG exposure due to pressure compensation mechanisms (Weitkamp et al. 2003). However, the proposed flexible spill operation would likely result in a slight increase in the incidence and severity of GBT symptoms and a very small (not measurable through reach survival studies) increase in mortality.

Adult UCR spring Chinook salmon typically migrate between Bonneville and Priest Rapids Dam during the period that the flexible spill operation would occur (April through June). Adults also migrate at depths which reduce the effective exposure to TDG through depth compensation mechanisms. The proposed flexible spill operation would likely result in a slight increase in the incidence and severity of GBT symptoms and a very small (not measurable) increase in mortality.

The Corps proposes to continue a program of best management practices to avoid accidental releases of oil and grease, and to minimize any adverse effects from equipment in contact with the water. The Corps will also implement oil accountability plans with enhanced inspection protocols and prepare annual oil accountability reports. The adoption of these practices should continue the slight, but positive improvement in conditions for juvenile and adult migrants, but would not be expected to detectably affect reach survival estimates. Any impacts, given dilution, are likely to be very small, if not negligible.

2.11.3.1.2 Sediment Transport

The existence and operation of the federal hydrosystem will continue to affect sediment transport as described in the environmental baseline. These dams will continue to trap sediment and increase water transparency, especially during the spring freshet, which hypothetically increases the exposure of UCR spring-run Chinook salmon juveniles to predators (Gregory 1993;Gregory and Levings 1998; Sontag 2013) and results in higher mortality rates than would be the case in a system with more normative flows.

2.11.3.1.3 Adult Migration/Survival

Average adult survival rates through the lower Columbia River dams, as described in the environmental baseline, are expected to continue as a result of the proposed action. Tailrace conditions at these projects should generally be unaffected and not reduce survival for UCR spring-run Chinook salmon, except potentially at John Day Dam during low flow conditions, by the increased spill levels resulting from the flexible spring spill operation during a portion of the spring spill period. It is possible that fallback rates — which are associated at many dams with higher spill levels — will increase slightly at the lower mainstem dams, but this effect should not be substantial at the proposed spill levels. In addition, adaptive management processes can be used to identify and remedy excessive fallback, if it occurs. Thus, survival rates for UCR spring-run Chinook salmon are expected to continue to average about 92 percent from Bonneville to McNary Dam.

Increasing the operating range by 6 inches (average of 3 inches) at John Day Dam (MIP 2-foot range) will have little effect on velocity and thus is not be expected to substantially affect adult migration timing or survival rates. COMPASS modeling indicates the pool raise alone will increase juvenile travel time slightly, but this small change, in addition to the flexible spring spill operation (up to 120 percent TDG), is expected to result in a net reduction in travel time of 11.2 hours for UCR Chinook salmon.

Potential spill reduction starting in August (15-31) of 2020, pending consensus among parties, would likely have negligible effects on adults (fallback related impacts) because sufficient volumes of water are provided to allow volitional passage for downstream migrating adults.

2.11.3.1.4 Juvenile Migration/Survival

The Action Agencies propose to continue to provide beneficial spill (conventional and surface passage), juvenile bypass system, and other operations for juvenile passage at the four lower Columbia River dams. Surface passage structures exist at all four lower Columbia dams and three of them have juvenile bypass systems. The Dalles Dam does not have a juvenile bypass system because of low powerhouse passage rates. Increased spill levels resulting from the flexible spring spill operation are expected to have little effect on tailrace conditions at Bonneville, The Dalles, or McNary Dams, but could cause small eddies to form at John Day Dam under low flow conditions; however, the existing passage and survival data indicate this is not expected to reduce survival. This is primarily because the increase in spill is expected to shift fish from the much lower survival turbine routes to the higher survival spillway routes at John Day Dam.

Potential spill reduction starting in August (15-31) of 2020, pending consensus among parties, would not affect juvenile UCR steelhead which migrate in the spring.

COMPASS Model Results

The COMPASS model, developed by NMFS' NWFSC (Zabel et al. 2008), is a tool for comparatively assessing the likely effect of alternative hydropower structures and/or operations on the passage and survival of juvenile yearling Chinook salmon and steelhead smolts migrating through the lower Snake and Columbia Rivers. Information from both PIT tags (detection efficiencies and project and reach survival estimates) and acoustic tags (route-specific passage and survival estimates and dam survival estimates) are used to calibrate the model.

For UCR spring-run Chinook salmon, COMPASS estimates that the increased spill levels at the lower Columbia River dams resulting from the proposed Action (flexible spill up to 120 percent TDG) will, compared to operations under the environmental baseline, on average:

- Reduce average travel times from McNary tailrace to Bonneville tailrace by about 0.5days to 5.4 days;
- Increase average juvenile survival from McNary tailrace to Bonneville tailrace by about 0.9 percent to 73.6 percent;
- Increase average juvenile survival from Rock Island tailrace to Bonneville tailrace, a reach that includes McNary pool, by 0.6 percent to 51.9 percent; and
- Increase the average number of spill passage events (the inverse of the CSS's PITph metric) by 0.3 to 3.9 out of nine total dams (Wells to Bonneville Dam).

Although the modeling suggests that migration travel times could be reduced substantially (nearly half a day), the results support our qualitative expectations that juvenile survival rates for UCR spring-run Chinook salmon in the lower Columbia River would not change in biologically significant ways (i.e., enough to affect the abundance or productivity of any UCR spring-run Chinook salmon population) as a result of the proposed operation. The CSS hypothesizes that flexible spring spill would reduce latent mortality by reducing the number of powerhouse encounters. If this proves to be true, an additional small increase in adult returns is possible. The CSS report (2017) predicts that SARs will improve by about 23 percent for SR Chinook salmon, which pass eight mainstem CRS dams. If this hypothesis proves to be true, we expect UCR spring-run Chinook salmon would experience about half of that benefit since they pass four CRS dams.

2.11.3.1.5 Estuary Habitat

The Action Agencies will continue to implement the CEERP (Ebberts et al. 2018; BPA and USACE 2018). Program goals are to increase the capacity and quality of estuarine ecosystems and to improve access to these resources for juvenile salmonids. Floodplain reconnections are expected to continue to increase the production and availability of commonly consumed prey (chironomid insects and corophiid amphipods; PNNL and NMFS 2018) to UCR spring-run Chinook salmon as they migrate through the estuary.

NMFS agrees with ISAB's assessment findings (ISAB 2014) that it has been difficult to quantify the survival benefits of estuary habitat restoration, but the Action Agencies' assessment method, including review by the ERTG,[133] is useful to prioritize projects. For the interim period, the Action Agencies' proposed commitment is to reconnect an average of 300 acres of floodplain per year, a goal that they have a record of meeting in 2008-17 (BPA et al. 2018b), rather than to achieve a survival improvement. NMFS also agrees with the ISAB that the Action Agencies' assessment method, including review by the ERTG (Krueger et al. 2017), remains useful for prioritizing projects and for optimizing project design (number of breaches and channels, etc.) to site conditions. Thus, NMFS expects that the proposed implementation of the estuary program during the interim period will continue to partially mitigate for effects of flow management that, combined with dikes and levees, have cut much of the floodplain off from the mainstem river. The trend of increasing connected area (Johnson et al. 2018) is expected to continue during the interim period, providing benefits (flux of insect and amphipod prey to the mainstem migration corridor) to juvenile UCR spring-run Chinook salmon. These benefits are likely to increase as habitat quality matures.

The Action Agencies also propose continued implementation of their estuary habitat monitoring program, the component of CEERP that provides the basis for adaptive management. This includes action effectiveness monitoring at each restoration site. A set of "standard" indicators (photo points, water surface elevation, and salinity) are measured at all sites (Level 3); core indicators (plant species composition, percent cover, and biomass) are measured at a subset of the sites (Level 2); and intensive indicators (juvenile salmon species composition, density, diet, and growth, along with structures and controlling factors) are measured at a smaller number of sites (Level 1; Johnson et al. 2018). Monitoring will continue at recently constructed sites and will be initiated for sites constructed during the interim period. Johnson et al. (2018) evaluated the action effectiveness monitoring data collected since 2012 and found they generally indicated that the restoration of physical and biological processes was underway at these sites. Continued implementation and evaluation of this monitoring program either will confirm that these floodplain reconnections are enhancing conditions for yearling salmonids, such as UCR spring-run Chinook salmon, as they migrate through the mainstem, or provide sufficient information to the Action Agencies that site selection or project design will improve through adaptive management.

2.11.3.1.6 Tributary Habitat

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[133] As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss with ERTG and regional partners relevant climate change science in an effort to understand whether their planned estuary projects are resilient to climate change (i.e., sea level rise, temperatures, and mainstem flow levels). In addition, the Action Agencies' annual update of their restoration and monitoring plans for the estuary will document any needed adjustments in design, location, or other elements of a given project to address climate change impacts, both during and beyond the interim period.

For the UCR spring-run Chinook salmon ESU, the Action Agencies will implement tributary habitat improvements in order to achieve the metrics outlined in Table 2.11-10 for the single MPG in the ESU. Actions will be strategically identified, prioritized, and implemented to ameliorate specific limiting factors in specific populations, and will accomplish specific metrics defined for the single MPG. The habitat actions that produce these metrics will be completed or in process before completion of the Action Agencies' NEPA process.

The Action Agencies determined this commitment is feasible based on performance and accomplishments under the 2008 FCRPS biological opinion. In addition, the Action Agencies have committed to continuing to improve the strategic implementation of the program, to convene a tributary habitat program steering committee, to report on implementation using metrics that will allow NMFS to evaluate implementation of the program, and to conduct RM&E to assess tributary habitat conditions, limiting factors, and action effectiveness, and to inform associated critical uncertainties.

Table 2.11-10. Proposed tributary habitat metrics (2019–21) for the single major population group (MPG) in the UCR spring-run Chinook salmon ESU.

Upper Columbia River Spring Chinook Salmon ESU Major Population Group[1,2]	**Metrics**					
	Flow Protected (CFS)	**Flow Enhanced (Acre feet)**	**Entrainment Screening (# screens)**	**Habitat Access (Miles)**	**Stream Complexity (Miles)**	**Riparian Habitat Improved (Acres)**
North Cascades MPG	5	850	1	0	12	80

[1] The habitat actions that produce these metrics will be completed or in process by the end of the interim timeline for this biological opinion.
[2] The Action Agencies may use surpluses within an MPG from one metric category to augment other metric categories where the biological benefits are comparable.

For an overview of how NMFS analyzed the effects of tributary habitat improvement actions for this biological opinion, see Appendix A. In brief, we reviewed and reaffirmed the strong technical foundation for the tributary habitat program (i.e., that strategically implementing actions to alleviate the factors that limit the function of tributary habitat will improve habitat function and, ultimately, the freshwater survival of salmon and steelhead). We evaluated new RM&E information and found that it also supported the foundation of the program. We determined that the methods we were using to evaluate the effects of tributary habitat actions were based on best available science, as described in the Appendix A. We evaluated the effects of those actions quantitatively for some populations and qualitatively for all populations within the context of our understanding of limiting factors, the effects of the types of habitat improvement actions being proposed, population extinction risk, habitat improvement potential, and our recovery plan framework. We considered short-term negative effects that could result from implementation of habitat improvement actions. We also considered certainty of implementation and effects, as well as the strategic framework within which the Action Agencies were committing to implement the program. In addition, we considered the adequacy of the RM&E and adaptive management framework that is proposed to guide and refine

implementation of the habitat improvement actions and inform our understanding of their effects, and the adequacy of the proposed reporting on actions implemented.

In this ESU, the Action Agencies have committed to continuing to implement actions to protect and enhance flow, to improve stream complexity, to improve riparian habitat, and to reduce entrainment. Limiting factors in this MPG include diminished stream flow, reduced stream complexity and channel structure, degraded riparian conditions, and habitat access, including irrigation diversions (see Section 2.11.2.3), so the actions will be targeted toward addressing these identified limiting factors. Effects of these types of actions, and the time frame in which effects would be expected to accrue, are summarized in Table 2.11-11. In general, these actions will have a long-term benefit to UCR Chinook salmon, although the benefit for actions implemented during the interim period pending completion of the NEPA process will be particularly small, given the scope of the actions proposed. The positive changes noted in the table below may contribute to improvements in all four VSP parameters for the targeted populations[134] (for additional information on action effectiveness, see Appendix A).

Table 2.11-11. Effects and timing of effects of proposed tributary habitat improvement actions for UCR steelhead.

Action Type	Effects of action and timing of effects
Flow protection and enhancement	Reduced flows can affect adult and juvenile salmonids by blocking fish migration, stranding fish, reducing rearing habitat availability, and increasing summer water temperatures (NMFS 2017a). Flow protection or enhancement reduces these impacts, and the literature shows an obvious and clear relationship between increased flows and increases in fish and macroinvertebrate production (Hillman et al. 2016). The response is most dramatic in stream reaches that were previously dewatered or too warm to support fish because of water withdrawals, and the most successful projects are those in which acquired flows are held in trust long term or in perpetuity (Sabaton et al. 2008; Roni et al. 2014). Studies of fish movements following increases in instream flows show rapid fish colonization of newly accessible habitats and the success of these projects (Roni et al. 2008) For example, ongoing studies in the Lemhi River show increased spawner and juvenile abundance of both Chinook salmon and steelhead following enhancement of instream flows in tributaries (Uthe et al. 2017; Appendix A of Griswold and Phillips 2018). The effects of flow augmentation on habitat conditions depends on the amount of flow within the channel and how much water is added. Augmented flow in dewatered channels or streams too warm to support fish will have the greatest effects on habitat condition. In addition, augmenting flood flows can improve floodplain connectivity and off-channel conditions (Hillman et al. 2016).
Improved stream complexity	Stream complexity created by large wood, boulders, coarse substrate, undercut banks, and overhanging vegetation (in concert with adequate flow regimes and other habitat-forming processes) is an essential feature of productive salmon habitat, providing the features needed for adequate spawning and rearing. Functioning floodplains and side-channels with hydrologic connectivity are also key features of productive salmon habitat because they provide rearing, resting, and refuge habitat; increase availability of prey; and enhance other

[134] In most cases, near-term benefits would be expected in abundance and productivity. Depending on the population and the scale and type of action, benefits to spatial structure and diversity might also accrue, either in the near term or over time. In addition, while we expect abundance, productivity, spatial structure, and diversity to respond positively to strategically implemented tributary habitat improvement actions, other factors also influence these viability parameters (e.g., ocean conditions) and any resulting trends. Throughout this tributary habitat discussion, when we discuss improvements in abundance and productivity, it is implied that spatial structure and diversity might also respond positively, and that other factors, as noted here, might influence any resulting trends.

Action Type	Effects of action and timing of effects
	stream and watershed processes (NMFS 2013b, NMFS 2017a). Habitat improvement actions commonly implemented to enhance stream complexity include placement of large wood, boulders, and cover structures; gravel addition; floodplain reconnection; side channel and pond construction and reconnection, levee removal and setback; channel re-meandering; and, more recently, the construction of beaver enhancement structures (Hillman et al. 2016; Roni et al. 2014). These actions can be expected to aid in reestablishment of hydrologic regimes, increase availability of rearing habitat, improve access to rearing habitat, increase the hydrologic capacity of side channels, increase channel diversity and complexity, provide resting areas for salmonids, provide flood water attenuation, and enhance native plant communities (NMFS 2013b). The placement of instream structures includes a wide variety of actions that can affect many different habitat factors, so salmonid responses documented in the literature are quite diverse, ranging from small negative responses to large increases in abundance, growth, and survival. Most studies of this type of actions indicate a positive response (increased abundance and density) for salmonids. The lack of response or decrease in abundance identified in some studies was often because the projects did not address upstream watershed processes (e.g., sediment, water quality, etc.), the actions did not address the factors limiting fish, duration of monitoring was too short to demonstrate a positive effect, or the treatments resulted in little change in physical habitat. Salmonids have also been shown to respond rapidly to reconnected or constructed floodplains, side channels, and wetlands. These habitats provide critical rearing habitat for juvenile Chinook, coho, and steelhead. Studies indicate that these actions increase salmonid abundance, individual growth rates, overwinter survival, and smolt production (Hillman et al. 2016). While benefits of actions to improve stream complexity may be rapid in terms of fish occupying restored habitats, they also will continue to accrue over some time as habitat continue to respond.
Riparian Habitat Improvement	Riparian vegetation provides numerous functions including shading, stabilizing streambanks, controlling sediments, contributing large wood, and regulating the flow of nutrients. Riparian habitat improvement through riparian planting and silvicultural treatment, invasive species control, and riparian fencing and grazing management can lead to increased shade, bank stability, reduction of fine sediment, reduced temperatures, and improvement of water quality (NMFS 2017a, Hillman et al. 2016, Roni et al. 2014). Benefits of riparian planting actions take more than 50 years to fully accrue, although some benefits begin to accrue after five to ten years (Justice et al. 2017; Pess and Jordan et al. in press). Few studies have examined the response of instream habitat or fish to riparian planting or thinning, in part because of the long lag time between tree growth and any change in channel conditions or delivery of large wood. However, a retrospective study (Lennox et al. 2011) found that project age was positively correlated with both riparian vegetation and instream anadromous fish habitat at revegetated sites. Modeling work in the Grande Ronde River basin indicates that riparian enhancement actions should reduce water temperatures and increase juvenile salmonid abundance up to 377 percent in the Upper Grande Ronde and 61 percent in Catherine Creek (McCullough et al. 2016). Justice et al. (2017) utilized a stream temperature model to explore potential benefits of channel and riparian restoration on stream temperatures in the Upper Grande Ronde River and Catherine Creek Basins in Oregon. They focused on streams that had been degraded by intensive land use leading to reduced riparian vegetation and widened channels and concluded that restoration of such streams could more than make up for expected increase in summer stream temperature through 2080. Studies of fish response to livestock exclusion projects have shown variable results. Some have shown increases in salmonid abundance while others have shown no response. Those showing no response were linked to short duration of monitoring, small size of enclosures, and upstream habitat processes that limited habitat conditions in the project area (Hillman et al. 2016).

Action Type	Effects of action and timing of effects
Entrainment	Diversion of water from rivers can negatively affect salmon and steelhead populations. For example, open, unmodified water diversions can act as a source of injury or mortality to resident or migratory fishes from entrainment and impingement, and can cause habitat degradation and fragmentation. Fish-protection devices, such as exclusion screens, can physically or behaviorally deter fish from approaching or being entrained into water diversions. Most monitoring of screening projects is compliance monitoring rather than effectiveness monitoring, with a focus on whether installation or upgrading screens has reduced entrainment of fish into irrigation or water withdrawal systems. In one evaluation, however, Walters et al. (2012) conducted modeling which indicated that an extensive program to screen diversions in the Lemhi River had potentially significantly reduced mortality of out-migrating Chinook salmon smolts. Screening irrigation or water withdrawal systems and reconnecting spawning and rearing streams often provide immediate and important survival and carrying capacity benefits (Hillman et al. 2016).

All three of these populations must achieve at least viable status for ESA recovery (NMFS 2017a), and there is potential for improvement in tributary habitat productivity in all three of these populations. As noted above, actions will be strategically identified, prioritized, and implemented to ameliorate specific limiting factors in specific populations. Actions implemented to ameliorate limiting factors for any population in the MPG would provide localized habitat benefits and potential improvements in abundance and productivity for the targeted population. To the extent that actions are implemented consistent with best available science and modeling information about the value (in terms of increased biological benefit) to be gained from implementing the appropriate actions in the appropriate location and at the appropriate scale, benefits would be enhanced (Appendix A; also see e.g., Hillman et al. 2016; Pess and Jordan et al. in press).[135]

In terms of the extent of benefits, life-cycle modeling of proposed tributary habitat actions for this ESU was not available. Benefits to habitat and populations in this ESU as a result of tributary habitat improvement actions implemented during the interim period pending completion of the NEPA process are likely to be particularly small for this ESU given the scope of actions proposed. In almost all cases, we would not expect implementation of habitat actions for only a few years to yield significant improvements, because it is not feasible to implement actions of sufficient scope and scale in that time frame to yield substantial effects. It is important

[135] Ultimately, implementation should be focused where short-term efforts might yield the highest benefit in terms of reducing both short- and long-term risk, reducing climate vulnerability, and moving toward ESA recovery. NMFS' focal population concept (Cooney, in press (a)) may inform decisions about which populations have the highest potential to benefit ESU status in the near term from directed habitat actions. However, in this case there are only three populations in the ESU, and all three are required to be at least viable to achieve ESA recovery. Thus there is less utility in focusing near-term efforts on a sub-set of populations, and any of the three is likely an appropriate focus of near-term tributary habitat effort. Nevertheless, NMFS will work with the Action Agencies during implementation of the proposed action to evaluate opportunities for greater alignment of implementation efforts with recovery plan priorities and focal population concepts to the extent they are not currently aligned. In conversations with NMFS, the Action Agencies indicated that their tributary habitat focus during the interim period pending completion of the NEPA process was likely to continue to be on populations where they focused effort under the 2008 biological opinion. The action agencies carried out actions in all four populations of this DPS under the 2008 biological opinion.

to put results of the habitat actions to be implemented in the relatively short time frame of the interim period pending completion of the NEPA process into the context of the effects of longer-term implementation of habitat actions.

The Action Agencies have well-developed partnerships with local implementing groups in the Upper Columbia. In the Upper Columbia, the Action Agencies, in coordination with the Upper Columbia Regional Technical Team (UCRTT), utilized the Upper Columbia Biological Strategy (UCRTT 2013) to document biological considerations for the protection and improvement of habitat, primarily in the Methow and Wenatchee Rivers, and to a lesser degree in the Entiat River. This strategy is the guiding document used by the UCRTT to evaluate proposed projects, and it provides a scientific basis for a formal process to design, select, and prioritize habitat improvement actions in an effort to achieve the highest biological benefit and ensure project goals are met. The UCRTT intends to update the strategy on a periodic basis as new information becomes available (see UCRTT 2017). This on-the-ground infrastructure, combined with the Action Agencies commitments to work with NMFS to continue to enhance strategic implementation of the program, provides confidence that appropriate actions will be implemented in appropriate places.

Summary of Effects to Tributary Habitat

Implementation of the tributary habitat actions analyzed in this biological opinion, if implemented as anticipated, and as described in the proposed action (i.e., in a manner consistent with scientifically sound identification and prioritization of limiting factors and geographic locations and principles of watershed restoration), will provide benefits to the targeted populations.

This biological opinion covers a proposed action with a limited duration, and thus the improvements from tributary habitat actions will be small, as a large scope and scale of actions are required to achieve significant change at the population level. While it is possible that effects of some actions, such as actions to improve stream flow or remove barriers to passage, could be immediate, for other actions, benefits will take several years to fully accrue (and will take 50 years or more for actions such as restoring riparian areas). In addition, fish response in terms of improved viability will not begin until the progeny of fish spawning in new habitat conditions begin to return, and can only be detected over multiple life cycles. Therefore, it is unlikely that the benefits of these actions will be realized before the Action Agencies complete the NEPA process.

2.11.3.1.7 Hatcheries

The proposed action will continue to fund production levels at their mitigation hatcheries, including improvements to several of these programs described in the environmental baseline.

Hatchery production goals for UCR spring-run Chinook salmon that are included in the proposed action and covered under this biological opinion include:

1. Up to 400,000 Methow spring Chinook salmon smolts produced at the Winthrop NFH as part of an integrated conservation (and mitigation) program operated by the USFWS.
2. Up to 200,000 Chinook spring Chinook salmon smolts produced at the Chief Joseph Hatchery/Winthrop NFH as part of an isolated conservation (reintroduction) program on the Okanogan River operated by the Colville Tribe and the USFWS.

While the Winthrop NFH program for the Methow River population is now using Methow composite stock, the percentage of hatchery fish on spawning grounds remains high. A continuation of this program is beneficial in terms of maintaining population abundance levels, but this comes at a cost to the productivity and long-term stability of the natural population.

The first group of yearling smolts were acclimated and released in the Okanogan River basin in 2015. PIT-tag detection data indicates that at least a small percentage of these fish returned to the basin in 2016, 2017 and 2018. If the reintroduction efforts are successful, this program could help lower the ESU's risk of extinction and contribute to its recovery.

2.11.3.1.8 Predation Management in the Lower Columbia River Estuary

Avian Predators

The Action Agencies propose continued implementation of the Caspian Tern Nesting Habitat Management Plan (USACE 2015a) and the Double-crested Cormorant Management Plan (USACE 2015b). Tern habitat on East Sand Island will continue to be maintained at no less than one acre for the period covered by this interim consultation. Management actions for double-crested cormorants on East Sand Island will be limited to passive dissuasion and hazing, except that limited egg take (up to 500 eggs) may be requested from USFWS each year to preclude cormorants from nesting in new or different areas on East Sand Island. These ongoing actions are likely to continue current levels of predation by birds nesting on East Sand Island, which, in the case of Caspian terns, has been shown to be an improvement compared to the pre-colony management period. Due to the dispersal of the colony in 2016 and 2017, predation rates for East Sand Island cormorants are not available for the management period.[136]

In addition, the Action Agencies propose to synthesize colony size and predation rate data collected under the tern and cormorant colony-management plans. The intent of the synthesis report is to summarize data on predation by piscivorous waterbirds on ESA-listed salmonids in the Columbia River basin before, during, and after the management actions, in order to assess their effectiveness on a basinwide scale. For example, the dispersal of double-crested cormorants from East Sand Island to nest sites on the Astoria-Megler Bridge in recent years and observations of thousands of Caspian terns roosting on Rice Island indicate that the numbers of avian predators in the estuary, and their effects on the viability of salmonids such as UCR spring-run Chinook salmon, are still in flux. The synthesis report will help managers assess whether to

[136] Predation rate data were obtained for the cormorant colony in 2018, but the final report is not yet available.

recommend that the Action Agencies or other regional parties consider additional measures for implementation after the interim period.

Ongoing annual monitoring will include estimates of double-crested cormorant abundance, nesting density, and PIT-tag detection on East Sand Island. The average estimated three-year peak colony size will be used to evaluate management activities relative to plan objectives (2019–2021); the management plan will be considered successful when the average three-year peak colony size estimate does not exceed 5,939 nesting pairs while no management actions are conducted. Annual PIT-tag detection will continue for 5 to 10 years to assess overall trends in predation rates (through the 2023 breeding season, at minimum), accounting for annual variability in predation impacts. These measures are likely to be effective in evaluating predation on listed salmonids, such as UCR spring-run Chinook salmon, by double-crested cormorants nesting on East Sand Island.

Fish Predators

The Action Agencies will continue to implement the NPMP, including the Sport Reward Fishery in the lower Columbia River estuary as described under the environmental baseline. We expect that this ongoing measure will continue the 30 percent reduction in predation rates achieved under the 2008 RPA. We estimate that numbers of Chinook salmon, including some from the UCR spring-run Chinook salmon ESU, handled and/or killed in the Sport Reward Fishery, system-wide, will be no more than 100 adults (including jacks) and 200 juveniles per year during the interim period.

2.11.3.1.9 Predation Management in the Hydrosystem Reach

Avian Predators

The Corps will continue to implement and improve, as needed, avian predator deterrent programs at lower Columbia River dams. At each dam, bird numbers will be monitored, feeding birds will be hazed, and passive predation deterrents, such as irrigation sprinklers and bird wires, will be deployed. Hazing, including launching long-range pyrotechnics at concentrations of feeding birds near the spillway and powerhouse discharge areas, and juvenile bypass outfall areas, will also continue. These measures will continue to reduce predation on juvenile UCR spring-run Chinook salmon, although the amount of protection has not been quantified (Zorich et al. 2012).

The Action Agencies propose to continue to address Caspian tern predation at lands that they manage on the Columbia plateau: Crescent Island (Corps) and Goose Island (Reclamation). The Corps has excluded tern use on Crescent Island via revegetation since 2015, but will continue to monitor that site to ensure that conditions remain unfavorable for nesting. If tern use does resume during the interim period, the Corps will work with NMFS and USFWS to address concerns, perform any necessary environmental compliance, and seek permits and funding for active hazing, if warranted. If no nesting of concern to the Corps' and NMFS is identified, the Corps will discontinue monitoring after three years. These measures are likely to preclude use of Crescent Island by Caspian terns during the interim period.

Reclamation has excluded Caspian terns from Goose Island using ropes and flagging, and is currently experimenting with revegetation. They propose to maintain the ropes and flagging and to monitor for tern presence on a regular basis between late February and early July. If terns resume nesting despite these activities and efforts to establish vegetative cover, and if the number of terns exceeds metrics identified in the IAPMP (more than 40 nesting pairs on Goose Island or more than 200 pairs at sites across the interior Columbia Basin; USACE 2014), Reclamation will work with NMFS to identify management actions and tools that can be put in place to dissuade tern use of the island before the next nesting season (e.g., permits from USFWS for hazing and egg take). These measures are likely to preclude use of Goose Island by Caspian terns during the interim period.

Pinniped Predators

The Corps will continue to install, and improve as needed, sea-lion excluder gates at all adult fish ladder entrances at Bonneville Dam each year. In addition, the Corps and BPA will continue to support land- and water-based harassment efforts by ODFW, WDFW, and CRITFC to keep sea lions away from the area downstream of Bonneville Dam. The Corps will continue estimating sea lion abundance, spatial distribution, temporal distribution, predation attempts, and predation rates in the Bonneville Dam tailrace annually from early August through May 31. Collection of predation data will occur when sea lion abundance is greater than or equal to 20 animals. The Corps will continue to use adaptive management, including recommendations from the Fish Passage Operations and Management Coordination Team and the Sea Lion Task Force, to address changing circumstances as they relate to supporting sea lion harassment efforts and monitoring of sea lion predation at Bonneville Dam. These ongoing measures are expected to maintain current levels of sea-lion predation on UCR spring-run Chinook salmon in the Bonneville tailrace. In the last ten years, pinnipeds have consumed 1.2–5.9 percent of spring Chinook salmon annually at Bonneville Dam (Tidwell et al. 2017); this rate is expected to be the same, or lower, for the later migrating UCR Chinook salmon and will continue with the proposed action. If pinnipeds are observed at The Dalles Dam, the Corp may respond with hazing at adult fish ladder entrances.

Fish Predators

The Action Agencies will continue to implement the Northern Pikeminnow Sport Reward Fishery in the hydrosystem reach and the Dam Angling Program at The Dalles and John Day Dams, as described under the environmental baseline. These ongoing measures will continue the reduction in predation rates achieved under the 2008 RPA. We estimate that the 2013-17 annual average numbers of Chinook salmon, including UCR Chinook salmon, which will be handled and/or killed in the Sport Reward Fishery will continue as described above (Predation Management in the Lower Columbia River Estuary). In addition, we estimate that no more than ten adult (including jacks) and 20 juvenile Chinook salmon, including some from the UCR spring-run Chinook salmon ESU, will be caught in the Dam Angling Program per year during the interim period.

2.11.3.1.10 Research and Monitoring Activities

The Action Agencies' RM&E program will be similar to the current program, or will be implemented at a reduced scale. Thus, the level of injury and mortality discussed in the environmental baseline, primarily from the capture and handling of fish, is likely to continue at a similar or reduced level. We estimate that, on average, the following number of UCR spring Chinook salmon will be affected each year during the interim period:

- Projected estimates of UCR spring Chinook salmon handling and mortality during activities associated with the Smolt Monitoring Program and CSS: (1) zero hatchery and one wild adult handled; (2) one hatchery and one wild adult killed; (3) 177,985 hatchery and 11,904 wild juveniles handled; and (4) 5,866 hatchery and 169 wild juveniles killed.
- Projected estimates of UCR spring Chinook salmon handling and mortality during activities associated with Fish Status Monitoring:[137] (1) zero hatchery or wild adults handled; (2) zero hatchery or wild adults killed; (3) 26,787 hatchery and 16,144 wild juveniles handled; and (4) 268 hatchery and 161 wild juveniles killed.
- Projected estimates of UCR spring Chinook salmon handling and mortality for all other RM&E programs: (1) 95 hatchery and 1,754 wild adults handled; (2) one hatchery and 18 wild adults killed; (3) 38,901 hatchery and 13,822 wild juveniles handled; (4) 389 hatchery and 138 wild juveniles killed.

The combined observed mortality associated with these elements of the RM&E program will, on average, affect less than 1 percent of the wild (i.e., natural origin) adult returns or juvenile production for the UCR spring Chinook salmon ESU (Bellerud 2018). Although we estimate that 37.03 percent of the wild adults and 8.83 percent of the wild juvenile production will be handled each year, on average, we expect that only up to 1 percent of these will die after release (in this case, 0.37 percent of adults and 0.09 percent of juveniles handled). These relatively small effects are deemed worthwhile because they will allow the Action Agencies and NMFS to continue to evaluate the effects of CRS operations, including modifications to facilities, operations, and mitigation actions.

Electrofishing operations for the NPMP during the interim period are expected to continue at the same level of effort as in recent years (four 15-minute sampling events per 0.6-mile reach between RM 47 near Clatskanie, Oregon, and Priest Rapids Dam on the Columbia River during April-July; a total of 550 hours system-wide). Some adult and juvenile UCR spring-run Chinook salmon are likely to be present in shallow shoreline areas during electrofishing activities and may be stunned and even killed. However, because the operator releases the electrical field as soon as salmonids are observed and most of these fish quickly recover and swim away, we are unable to

[137] Fish Status Monitoring is intended to include individuals handled/killed during status and trend, "fish-in/fish out," and habitat effectiveness monitoring projects.

use observations from past operations to estimate the number of fish from this ESU that will be affected. Information obtained through electrofishing supports management of the NPMP, which is reported to have reduced salmonid predation by about 30 percent (Williams et al. 2017). This level of take is anticipated to occur for the duration of this proposed action, pending completion of the NEPA process.

2.11.3.1.11 Life-Cycle Modeling

Life-cycle models were used to develop projections of median abundance and probabilities of falling below a Quasi-Extinction Risk threshold of 30 and 50 adults for four consecutive years to assess projected population responses to quantifiable factors evaluated in the environmental baseline: continued implementation of recent hydrosystem actions (consistent with the 2017 FOP), habitat restoration actions, effects of recent hatchery production (where applicable), and the effect of increased sea-lion predation (see environmental baseline discussion).

In this section, we discuss the model results used to quantitatively project the effects of the proposed action on the abundance and QET parameters for a period of 24 years. The life-cycle model (which includes the COMPASS juvenile passage and survival model) projects the estimated direct survival effect from the up to 120 percent (and up to 125 percent) flexible spring spill operation and three scenarios to consider the potential productivity increases (as hypothesized by the CSS) if increased spill levels were to reduce latent mortality for inriver migrating smolts, thus increasing adult returns (productivity) (see Methods Section). [138]

Assumptions relating to the continued implementation of the tributary habitat actions included: (1) tributary habitat projects would continue to be implemented in strategic locations within the populations identified in Table 5 of the 2014 biological opinion, (2) the habitat projects would address the same limiting factors in the same general reaches as in the 2012–16 program, and (3) the Action Agencies could annually implement at least the minimum level of habitat improvements achieved in recent years (a conservative assumption).

The NWFSC also considered three latent mortality reduction scenarios that were deemed to roughly represent the ranges of potential outcomes (increased productivity) indicated by the CSS (2017) for the up to 120 percent flexible spill operation compared to recent or biological opinion spill operations: 10 percent (1.10 multiplier), 25 percent (1.25 multiplier), and 50 percent (1.50 multiplier).

As previously noted, within the North Cascades MPG, only one population has sufficient information available to support life-cycle modeling. Model projections are displayed in Figure

[138] Comparing model results (24-year projections of geomean abundance and QETs of 30 and 50 adults for four consecutive years) of different hydropower operations (and associated hypothesis about how these operations might reduce latent mortality) and mitigation actions (i.e. habitat restoration, changes in hatchery operations etc.) is important for understanding how different actions or key uncertainties might affect these parameters, and by extension, the populations being modeled. Consideration of modeling information is but one element of NMFS's effects analysis, which considers the full scope of the likely effects of the proposed action, including, future hydropower operations.

2.11-7 and in Table 2.11-12. In general, the proposed action results in slightly higher mean abundance projections for the Wenatchee River population (552). This is most likely a result of slightly improved passage conditions in the lower Columbia River. The projected probability of falling below QETs of 50 remains extremely low (less than 1 percent) for this population.

As a sensitivity analysis, Figure 2.11-8 and Table 2.11-12 also displays the projected results of increasing productivity an additional 10, 25, or 50 percent, which roughly bounds the benefits hypothesized by the CSS (2017 and 2018) to result from increasing spill under the up to 120 percent (or up to 125 percent) flexible spill operation. In general, an increase in productivity of 10 percent modestly improves the projected median abundance (645) of the Wenatchee River population and slightly decreases the projected probability of falling below QETs of 50 adults. Increasing productivity by 50 percent would result in substantially increased projected median abundance estimates (in 24 years) for the Wenatchee River population (914), and would reduce the projected probability of falling below QETs of 50 adults to zero. Increasing productivity by 25 percent results in intermediate increases in projected abundance and persistence.

Analysis of the up to 125 percent gas cap flexible spill operation indicated there is little difference between this operation and the estimates for the up to 120 percent gas cap flexible spill operation assuming direct survival improvements only, or 10, 25, and 50 percent improvements in productivity that could result from increased spill (Figure 2.11-8). Simply put, Life Cycle Modeling indicates that assumptions about improved productivity (from potential latent mortality reductions) dominates projected estimates of abundance or probabilities of falling below QETs of 30 or 50 adults.

Table 2.11-12. Life-cycle model projections of median abundance and Quasi-Extinction Risk thresholds of 30 and 50 (5th and 95th percentiles) for populations of naturally produced fish in 24 years under the Environmental Baseline (italicized text), Proposed Action (up to 120 % flexible spill operation), and assuming a 10% 25%, or 50% increase in survival resulting from hypothesized reductions in latent mortality.

Upper Columbia MPG	**Abundance**			**QET = 30**			**QET = 50**		
Population	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**
Wenatchee River									
Env. Baseline	***532***	*93*	*1,385*	***0***	*0*	*0*	***0.001***	*0*	*0.010*
Prop. Action 120% Flex Gas Cap	**552**	106	1,492	**0**	0	0	**0.001**	0	0.007
PA + 10%	**645**	124	1,757	**0**	0	0	**0.001**	0	0.006
PA + 25%	**736**	156	2,002	**0**	0	0	**0.001**	0	0.004
PA + 50%	**914**	157	2,209	**0**	0	0	**0**	0	0.002

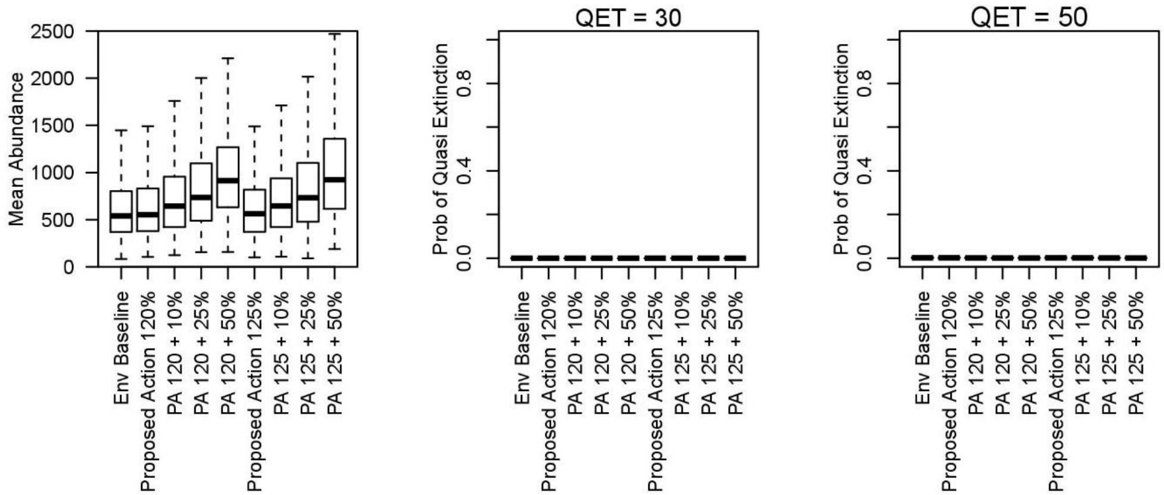


Figure 2.11-8. Life-cycle model projections of median abundance and Quasi-Extinction Risk thresholds of 30 and 50 adults for four consecutive years for the Wenatchee River population (Upper Columbia River steelhead) of naturally produced fish in 24 years under (from left to right) the Environmental Baseline; the Proposed Action (up to 120% flexible spill hydro operation), and Proposed Action assuming 10, 25, or 50 percent increases in survival resulting from hypothesized potential reductions in latent mortality; and the Proposed Action (up to 125% flexible spill hydro operation), and Proposed Action assuming 10, 25, or 50 percent increases in survival resulting from hypothesized reductions in latent mortality. Boxes represent the 25th, 50th, and 75th percentiles; whiskers represent the 5th and 95th percentiles.

2.11.3.2 Effects to Critical Habitat

Implementation of the proposed operation is likely to affect passage at the four lower Columbia River dams. The flexible spring spill operation will affect the freshwater migration corridor for juvenile and adult UCR spring-run Chinook salmon. Implementation will also affect the volume and timing of flow in the Columbia River, which has the potential to alter habitat in the hydrosystem reach and Columbia River estuary. The PBFs that will be affected by the proposed action are described in Table 2.11-14.

Table 2.11-13. Effects of the proposed action on the physical and biological features (PBFs) essential for the conservation of the UCR spring-run Chinook salmon ESU.

Physical and Biological Feature (PBFs)	Effects of the Proposed Action
Freshwater spawning sites and freshwater rearing sites	● The principal effect of habitat improvements in spawning and rearing areas used by UCR spring-run Chinook salmon will be that about 850 acre-feet of flow will be enhanced and 80 acres of riparian habitat will be improved across the Wenatchee, Entiat, and Methow subbasins. This will improve water quality, floodplain connectivity, and natural cover at the local scale in HUC5 watersheds with these PBFs.
Freshwater migration corridors	● Increase in TDG levels up to the state-approved limits (up to 120 or 125 percent TDG) at the CRS run-of-river projects) will result in only a slight increase in the incidence and severity of GBT symptoms (water quality in the juvenile and adult migration corridor) (water quality in the juvenile and adult migration corridor) ● Increased spill levels resulting from the flexible spring spill operation (up to 120 or 125 percent) can degrade tailrace conditions (especially at John Day Dam under low flow conditions) increasing the risk of increased bird and fish predation (safe passage). ● The proposed operation will decrease travel time and exposure to predators for about half a day for juveniles in the McNary to Bonneville reach (safe passage and excessive predation in the juvenile migration corridor) ● Continuation of altered seasonal flows (decreased spring and early summer flows and increased winter flows) due to system-wide storage operations including those at CRS reservoirs (reduced water quantity in the juvenile migration corridor) ● Continuation of delayed spring warming, delayed fall cooling, and reduced daily temperature variability due to the thermal inertia of the CRS reservoirs (reduced water quality in juvenile and adult migration corridors) ● Sediment will continue to accumulate behind CRS dams, reducing turbidity in the migration corridor during the spring smolt outmigration, which could affect the safe passage PBF by increasing the risk of predation ● Ongoing implementation of the Action Agencies' predator management programs will continue to reduce excessive predation in the juvenile and adult migration corridors (safe passage) ● Improvements in the migratory corridor will continue: these include juvenile fish passage systems and enhanced operations at each dam, including spillway improvements, improvements to the juvenile transport system, screened juvenile bypass systems, surface passage routes, etc.).
Estuarine areas	● This PBF will continue to improve with the proposed reconnection of an average of 300 acres of floodplain habitat per year during implementation of this proposed action (increased access to forage) ● Because estuary bird colonies and predation rates are in flux, it is not clear whether the continued tern and cormorant colony management is likely to continue any existing survival benefits, thus we expect the predation risk to remain unchanged.

2.11.4 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation (50 CFR 402.02). Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult, if not impossible, to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline.

Non-federal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat, and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. These projects also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth-management programs (planning and regulation), a variety of stream and riparian habitat projects, watershed planning and implementation, acquisition of water rights for instream purposes and sensitive areas, instream flow rules, stormwater and discharge regulation, TMDL implementation to achieve water quality standards, hydraulic project permitting, and increased spill and bypass operations at hydropower facilities. NMFS determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. These activities are likely to have beneficial cumulative effects that will significantly improve conditions for the salmon and steelhead, including UCR spring-run Chinook salmon.

NMFS also noted that some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects are from activities that occurred in the recent past and were included in the environmental baseline. Some of these activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the action area, nonfederal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations.

Overall, we anticipate that projects to restore and protect habitat, restore access and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area.

2.11.5 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.11.3) to the environmental baseline (Section 2.11.2), and the cumulative effects (Section 2.11.4), taking into account the status of the species and critical habitat (Section 2.11.1), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat for the conservation of the species.

2.11.5.1 Species

The UCR spring-run Chinook salmon ESU includes naturally spawned spring-run Chinook salmon originating from Columbia River tributaries upstream of the Rock Island Dam and downstream of Chief Joseph Dam (excluding the Okanogan River subbasin). It also includes spring-run Chinook salmon from six artificial propagation programs. The ESU is comprised of three extant populations within one MPG. NMFS' most recent status review reaffirmed the ESU as endangered (NMFS 2016a; NWFSC 2015). Abundance has improved for all three extant populations (Wenatchee, Entiat, and Methow Rivers), and productivity has improved for the Wenatchee and Entiat River populations; despite these improvements, the overall viability ratings of high risk is warranted for each of the three populations. The risk factors of most importance include: (1) continued degraded conditions in tributary spawning and rearing areas, (2) long-term risk associated with high levels of hatchery-origin fish spawning in each subbasin, and (3) continuing mortalities due to dams and reservoirs (both federal and FERC-licensed projects) in the mainstem migration and rearing corridor. Since the last status review in 2015, observations of coastal ocean conditions suggested that the 2015–17 outmigrant year classes experienced below average ocean survival during a marine heatwave and its lingering effects, which led researchers to predict a corresponding drop in adult returns through 2019 (Werner et al. 2017). The negative impacts on juvenile salmonids associated with the marine heatwave had subsided by spring 2018, but other aspects of the ecosystem (e.g., temperatures below the 50-m surface layer) had not returned to normal (Harvey et al. 2019).

The proposed action will continue to affect UCR spring-run Chinook salmon within the action area, as described in the environmental baseline section (passage through the four federal dams and up to five FERC-licensed dams, flows, highly modified/inundated habitat, exposure to predators, predator hazing and reduction programs, water quality, survival, research and monitoring, etc.). Passage through the four lower Columbia River dams (Bonneville to McNary) has improved for both juveniles and adults, but survival rates will continue to average about 91.5 percent for adults and 73.6 percent (accounting for both natural and dam-related losses) for juveniles. The proposed flexible spring spill operation is predicted to reduce juvenile travel time by about half a day and is hypothesized by CSS to significantly reduce latent mortality. The latter has the potential to improve abundance and productivity for all UCR spring-run Chinook salmon populations.

The proposed flexible spring spill operation will increase exposure of both juveniles and adults to higher TDG levels in the lower Columbia River from the confluence with the Snake River to about 35 miles downstream of Bonneville Dam. The duration of this exposure should be limited for juveniles, which quickly move through the project tailraces where TDG is higher. Adults spend more time in the tailraces searching for ladder entrances and therefore will be affected to a greater extent. However, because most adults and juveniles stay at least 1 meter below the surface where TDG concentration is reduced by depth compensation, the effects of the increased exposure are likely to be minor in nature (e.g., increased incidence of GBT symptoms). Implementing these spill levels at John Day Dam during low flow conditions could result in degraded conditions for tailrace egress (large eddies that increase exposure to predators), but the resulting reduction in juveniles passing through the powerhouse routes will result in no net reduction in survival rates for juvenile UCR spring-run Chinook salmon at this project.

The proposed increased operating range by 6 inches (average of 3 inches) at John Day Dam (to MIP 2-foot range) will likely result in slightly increased variability in daily flows, and will slightly increase travel times (hours), increasing exposure to predators in this reservoir reach. These changes in operating range will have little effect on water velocity, and, thus, are not expected to affect adult migration timing or survival rates. The combined effect of increased spill and reservoir operations is expected to reduce travel time for this ESU through the lower Columbia reach by 0.47 days (about 11 hrs).

The Action Agencies propose to continue to implement estuary habitat improvement actions, which should continue to benefit UCR spring-run Chinook salmon smolts rearing or migrating through the estuary. The Action Agencies also propose to continue tributary habitat restoration activities to address limiting factors and contribute to improving habitat conditions for UCR spring-run Chinook salmon populations in the Wenatchee, Entiat, and Methow Rivers. They also propose to implement avian, pinniped, and fish predation-management programs in the estuary and mainstem hydrosystem reach so that any reduced predation rates achieved under the 2008 biological opinion and associated RPA from the mouth of the estuary to upstream to the upper extent of McNary Reservoir will continue during the interim period. These actions are expected to improve tributary and estuary habitat conditions for the three populations and reduce predation rates in the mainstem migration corridor, although the effects are likely to be small considering the limited duration of the proposed action.

The Action Agencies propose to continue to fund federal hatchery programs: Leavenworth National Fish Hatchery and Winthrop NF, which are operated by the USFWS. Terminating Chinook salmon production at Entiat NFH in 2007 should continue to improve productivity and abundance of the natural population, as well as diversity. By switching to the Methow composite stock, the Winthrop NFH program should improve the diversity and productivity of naturally produced spring Chinook salmon in the Methow River population. Actions taken to reduce the proportion of Leavenworth NFH fish on spawning grounds upstream of Tumwater Canyon (improved marking for removal, etc.) should improve the productivity and abundance of naturally produced Chinook salmon in the Wenatchee River (NMFS 2018a).

RM&E activities will continue to negatively affect a small fraction of juvenile and adult UCR spring-run Chinook salmon (handled, tagged/marked, or killed) in order to assess the status of UCR spring-run Chinook salmon populations (VSP parameters) and the efficacy of proposed hydropower, estuary habitat, tributary habitat, hatchery-funded, and predator-management measures.

The environmental baseline conditions in the action area (mainstem rearing and migration corridor and estuary) remain degraded, but have generally improved over the past two decades. The most notable improvements include: (1) changes to the configuration and operation of dams in the mainstem migration corridor (i.e., 24-hour spill, surface passage routes, improved juvenile bypass systems, etc.), which substantially improved passage conditions for migrating smolts at both the four federal and five FERC-licensed mainstem dams; (2) improved conditions in the estuary, particularly improvements in floodplain connectivity resulting from recent Action Agency-funded restoration efforts, should improve conditions for yearling Chinook salmon smolts that use these areas, and enhance the amount of prey available for the those smolts migrating more quickly through the estuary to the plume; (3) incremental improvements in tributary habitat conditions from implementation of past habitat actions, consistent with scientifically sound identification and prioritization of limiting factors and geographic locations and principles of watershed restoration; (4) improvements in hatchery operations and management, including changes to broodstock at Winthrop NFH (Methow River population) to better link hatchery fish genetically to natural-origin fish, and improving rearing practices to minimize early maturation that could contribute to residualization of smolts (all three populations); and (5) continuing sliding-scale harvest management, which has resulted in substantially lower average harvest rates than occurred before 1990.

Other environmental baseline conditions have shown little change or have declined. The most notable of these include: (1) pinniped predation from the mouth of the Columbia River to Bonneville Dam has increased substantially from the last biological opinion, and has become a substantial factor affecting the productivity and abundance of UCR spring-run Chinook salmon; (3) relatively high rates of avian predation, especially in the estuary, on UCR spring-run Chinook salmon, but it is still unknown whether management efforts to reduce cormorant numbers and further reduce Caspian tern numbers in the estuary will stop or reverse this trend; (4) continued exposure to chemicals and toxic substances throughout the mainstem migration corridor, lower

Columbia River, and estuary remains a concern; and (5) though there is considerable uncertainty related to the scale of the changes over the coming decades, and the response of UCR spring-run Chinook salmon, climate change is a concern because it will affect temperature and seasonal precipitation patterns in freshwater habitat and conditions in the ocean — which will likely have negative impacts to stream type Chinook salmon species like UCR spring-run Chinook salmon. Climate change could continue to pose a threat to species survival/recovery, but the type of habitat actions proposed in the tributaries and the estuary should, at a minimum, not make the problem any worse and should continue to provide some benefit compared to if they did not occur in the action area.

As mentioned in the previous paragraph, the status of UCR spring-run Chinook salmon is likely to be affected by climate change. Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycle. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream-flow patterns in freshwater and changes to food webs in freshwater, estuarine, and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management actions may help alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations, increased riparian vegetation to control water temperatures, etc.).

Improvements including tributary hydrosystem modification and habitat restoration (e.g., in the estuary), coupled with significant harvest reductions from historic levels, have allowed for progress in improving UCR spring-run Chinook salmon abundance, productivity, spatial structure, and diversity for some populations. However, these improvements also occur in the context of natural fluctuations in environmental conditions, such as cyclical changes in ocean circulation and the unusually warm ocean conditions seen predominating during 2015, which can temporarily adversely affect survival and adult returns of all salmonid species, even if freshwater habitat conditions are improving.

Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life-history types that will be successful in the future are neither static nor predictable. Therefore, maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the UCR spring-run Chinook salmon ESU. The ESU is likely to be affected by climate-related effects in the estuary, and in tributary streams (altered seasonal flows and temperatures) that support spawning and early rearing. Emerging research using complex life-cycle modeling indicates a potentially strong link between sea-surface temperature and survival of SR spring/summer Chinook salmon populations. However, the apparent link between SST and survival is presumably caused by food web interactions, relationships which could be disrupted by major transformations of community dynamics, as well as ocean acidification and other factors under a changing climate. The degree to which SST is linked to survival of UCR spring-run Chinook salmon, and how that relationship interacts with other variables throughout the UCR spring-run Chinook salmon life cycle, will likely be an important area of future research.

When evaluating the effects of the action, those effects must be taken together with the effects on UCR spring-run Chinook salmon of future state or private activities, not involving federal activities that are reasonably certain to occur within the action area. NMFS anticipates that human development activities will continue to have adverse effects on UCR spring-run Chinook salmon in the action area. Many of these activities and their effects occurred in the recent past and were included in the environmental baseline but are also reasonably certain to occur in the future. Within the action area, nonfederal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Habitat restoration efforts led by state and local agencies, tribes, environmental organizations, and local communities are likely to continue. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives that, in some cases, are identified through ESA recovery plans. Larger, more regionwide, restoration and conservation efforts are either underway or planned throughout the Columbia River basin. These state and private actions have helped restore habitat, improve fish passage, and reduce pollution. While these efforts are reasonably certain to continue to occur, funding levels may vary on an annual basis.

The recovery plan (UCSRB 207) outlines specific objectives for each of the three populations. The recovery plan addresses the underlying limiting factors and threats for UCR spring-run Chinook salmon, including hydropower projects, predation, harvest and hatchery effects, tributary habitat, and ocean conditions. The recovery plan identifies recovery actions to be implemented, generally over a 25-year period. Effective implementation requires that the recovery efforts of diverse private, local, state, tribal, and federal parties across two states be coordinated at multiple levels. Since the plan’s adoption, partners have made progress in several key areas, including: removing barriers to migration and opening habitat to spawning and rearing fish; improving irrigation efficiency and screening irrigation intakes; restoring riparian habitat to improve water quality and quantity; and enhancing instream habitat for fish in the Wenatchee, Entiat and Methow River basins. The proposed action will not result in reductions to UCR spring-run Chinook salmon reproduction, numbers, or distribution that would impede the ability to successfully carry out the identified recovery measures and actions over the time frames considered in the recovery plan.

After reviewing and analyzing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, and considering the interim nature of this proposed action pending the decision to implement a new action as a result of the NEPA process , it is NMFS’ biological opinion that the proposed action is not likely to reduce appreciably the likelihood of both survival and recovery of UCR spring-run Chinook salmon.

2.11.5.2 Critical Habitat

The designated critical habitat for UCR spring-run Chinook salmon consists of river reaches of the Columbia River and its tributaries upstream of the Rock Island Dam and downstream of Chief Joseph Dam, excluding the Okanogan River subbasin. Across subbasins with PBFs for UCR spring-run Chinook salmon in the Interior Columbia recovery domain, widespread development and other land use activities have disrupted watershed processes (e.g., erosion and sediment transport, storage and routing of water, plant growth and successional processes, input of nutrients and thermal energy, nutrient cycling in the aquatic food web, etc.), reduced water quality, and diminished habitat quantity, quality, and complexity. Past and/or current land use or water management activities have adversely affected the quality and quantity of stream and side channel areas (e.g., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity. As a result, the important watershed processes and functions that once created healthy ecosystems for salmon production have weakened.

The environmental baseline includes a broad range of past and present actions and activities that have affected the conservation value of critical habitat for UCR spring-run Chinook salmon. These include the effects of hydropower, changes in tributary and mainstem habitat (both positive and negative), and hatcheries on freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine areas, and nearshore marine areas. Despite a long-term trend in degradation of these habitats, there have been localized improvements in their conservation value through the combined efforts of federal, state, and local agencies; tribes; and other stakeholders. Tributary dams and other barriers have been removed, estuarine habitats restored and reconnected to the floodplain, and water quality has improved. Ongoing implementation of the Action Agencies' predator-management programs will continue the current functioning of critical habitat relative to excessive predation in the juvenile and adult migration corridors (safe passage).

The proposed operation of the CRS will continue to affect the functioning of critical habitat in the migration corridor. Despite recent improvements to the dams and their operations,[139] the CRS will continue to increase passage times and reduce survival of juvenile and adult UCR spring-run Chinook salmon compared to an unmanaged system (affecting the safe passage PBF). Increased spill levels at the lower Columbia River dams under the flexible spring spill operation will have very small but positive effects on safe passage in the juvenile migration corridor (reduced travel time and increased survival). Seasonal flows and temperatures will continue to be altered with negative effects on water quantity and quality. Increased numbers of predators, including birds and native and non-native fishes that prey on yearling Chinook salmon, are present in the hydrosystem reach (excessive predation in the juvenile migration corridor). The reduced levels of predation by Caspian terns on the interior Columbia plateau, and northern pikeminnows in project tailraces and reservoirs that were achieved under the 2008 RPA will be

[139] Improvements include juvenile fish passage systems and enhanced operations at each dam including spillway improvements, improvements to the juvenile transport system, screened juvenile bypass systems, surface passage routes, etc.). These improvements will continue under the proposed action.

maintained by the continued implementation of the respective predator-management plans (reduction in the level of excessive predation).

In the lower Columbia River estuary, the proposed habitat restoration program will continue to reconnect the historical floodplain, increasing the availability of wetland-derived prey to yearling Chinook salmon migrating to the ocean (improved forage in estuarine areas). In addition, the Action Agencies will provide a total of over 850 acre-feet of instream flow and will improve a total 80 acres of riparian habitat in subbasins used by UCR spring-run Chinook salmon for spawning and rearing. Habitat improvement actions will strategically target current habitat-related threats to UCR spring-run Chinook salmon viability during the interim period pending the decision to implement a new action as a result of the NEPA process. This will improve the functioning of critical habitat at the local scale in some HUC_5 watersheds (improvements in spawning gravel, water quality, water quantity, cover/shelter, food, riparian vegetation, and space in spawning and rearing areas).

Considering the ongoing and future effects of the environmental baseline and cumulative effects and in light of the status of critical habitat, the proposed action will not appreciably reduce the value of designated critical habitat for the conservation of UCR spring-run Chinook salmon.

2.11.6 Conclusion

After reviewing and analyzing the current status of UCR spring-run Chinook salmon and its designated critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, and considering the interim nature of this proposed action pending the decision to implement a new action as a result of the NEPA process, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of UCR spring-run Chinook salmon or destroy or adversely modify its designated critical habitat.

2.12 Snake River Fall Chinook Salmon

2.12.1 Rangewide Status of the Species and Critical Habitat

The status of Snake River fall Chinook salmon is determined by the level of extinction risk that the listed species faces, based on parameters considered in documents such as the recovery plan, status reviews, and listing decisions (NMFS 1992, 2005b, 2016e; Ford 2011). The species status also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. This informs the description of the species' current likelihood of both survival and recovery. The condition of critical habitat throughout the designated area is determined by the current function of the PBFs that help to form that conservation value.

2.12.1.1 Status of Species

Table 2.12-1 provides a summary of listing and recovery plan information, status summary and limiting factors for SR fall Chinook salmon. More information can be found in the recovery plan (NMFS 2017d) and most recent status review (NMFS 2016e) for this species. These documents are available on the NMFS West Coast Region website.[140]

Snake River fall Chinook salmon were originally listed as threatened in 1992 (57 FR 14653). The status was affirmed in 2005 and updated in 2014. Critical habitat was designated in 1993. Historically, the SR fall Chinook salmon most likely included one MPG with two large populations (NMFS 2016e, 2017d). One population, located upstream of the Hells Canyon Complex of dams in the middle Snake River, was extirpated in the early 1960s (Figure 2.12-1). The remaining, ESA-listed population inhabits a geographically large and complex area with five major spawning groups (NMFS 2016d). The spawning groups are located in the mainstem Snake River below Hells Canyon Dam and the Tucannon, Grande Ronde, Imnaha, Salmon, and Clearwater River subbasins. Fall-run Chinook salmon from four artificial propagation programs are included in this ESU: Lyons Ferry Hatchery Program, Fall Chinook Acclimation Ponds Program, Nez Perce Tribal Hatchery Program, and Oxbow Hatchery Program (NMFS 2017e).

Waples et al. (1993) identified several factors which adversely affected SR fall Chinook salmon and led to their proposed listing under the ESA: (1) the range of the species was substantially reduced by dams (blocked access to the historically most-productive habitat in the middle Snake River and habitat in the Clearwater River, and inundated habitat in the lower Snake River); (2) abundance was only a small fraction of the historical abundance (presumably stemming from spawning and rearing habitat loss, reduced survival through dams, high harvest rates, and a recent drought); and (3) stray hatchery fish of non-Snake River origin posed a serious threat to the genetic integrity of the species.

[140] https://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/salmon_and_steelhead_listings /chinook/snake_river_fall/snake_river_fall_run_chinook.html. Last accessed August 2018.

Table 2.12-1. Recent status and limiting factors information for Snake River fall Chinook salmon from the status review (NMFS 2016e). HCC= Hells Canyon complex.

<table>
<tr><th>Status Summary</th><th>Limiting Factors</th></tr>
<tr><td>This ESU includes one MPG with one extant population of naturally spawned fall-run Chinook salmon originating from the mainstem Snake River below Hells Canyon Dam and from the Tucannon River, Grande Ronde River, Imnaha River, Salmon River, and Clearwater River subbasins. It also includes fall-run Chinook salmon from four artificial propagation programs: Lyons Ferry Hatchery Program, Fall Chinook Acclimation Ponds Program, Nez Perce Tribal Hatchery Program, and Oxbow Hatchery Program.

The overall current risk rating for the extant SR fall Chinook salmon population is viable (i.e., low risk). This risk rating is based on a low risk rating for abundance/productivity and a moderate risk rating for spatial structure/diversity. Overall, the abundance of SR fall Chinook salmon (including natural-origin fish) has increased substantially in recent years. Continued high levels of hatchery-origin spawners in natural spawning areas, and the potential for selective pressure imposed by current hydropower operations (yearling versus subyearling life history pattern) and cumulative harvest impacts contribute to the moderate risk rating for spatial structure/diversity.</td><td>● Hydropower Projects and Mainstem Habitat:
– Blocked access to middle Snake River
– Inundation of spawning and rearing habitat in lower Snake River reach
– Adult fish: upstream passage and impaired homing ability (of transported fish)
– Juvenile fish passage: increased mortality, injuries or stress due to passage through dams, slowed migration
– Altered mainstem habitat quality
– Altered temperature regime
– Altered hydrologic regime (seasonal, daily, and hourly flows)
– Elevated TDG levels in winter and spring (below Hells Canyon, Dworshak, and lower Snake and Columbia River dams)
– Increased exposure to native and nonnative predators
– Potential stranding and entrapment of juveniles
– Increased sediment (above HCC)
– Excessive nutrients (above HCC)
– Low dissolved oxygen (below HCC)
– Pollutants (agricultural and industrial chemicals)
– Toxic pollutants
● Tributary Habitat
– Reduced habitat complexity, floodplain connectivity, and channel stability
– Lack of habitat quantity and diversity
– Degraded riparian conditions
– Low late-summer flows (in tributaries)
– High summer temperatures (in tributaries)
– Increased fine sediment
– Excessive nutrients
– Low dissolved oxygen
– Excessive pollutants (agricultural and industrial chemicals)
– Toxic pollutants
● Estuary Habitat and Plume
– Altered flow regime
– Reduced access to off-channel rearing habitat (May to July)
– Reduced productivity resulting from sediment and nutrient-related changes
– Excessive contaminants
● Harvest and Hatcheries
– Loss of adults
– Long-term effects of high proportions of hatchery-origin fish on spawning grounds</td></tr>
</table>

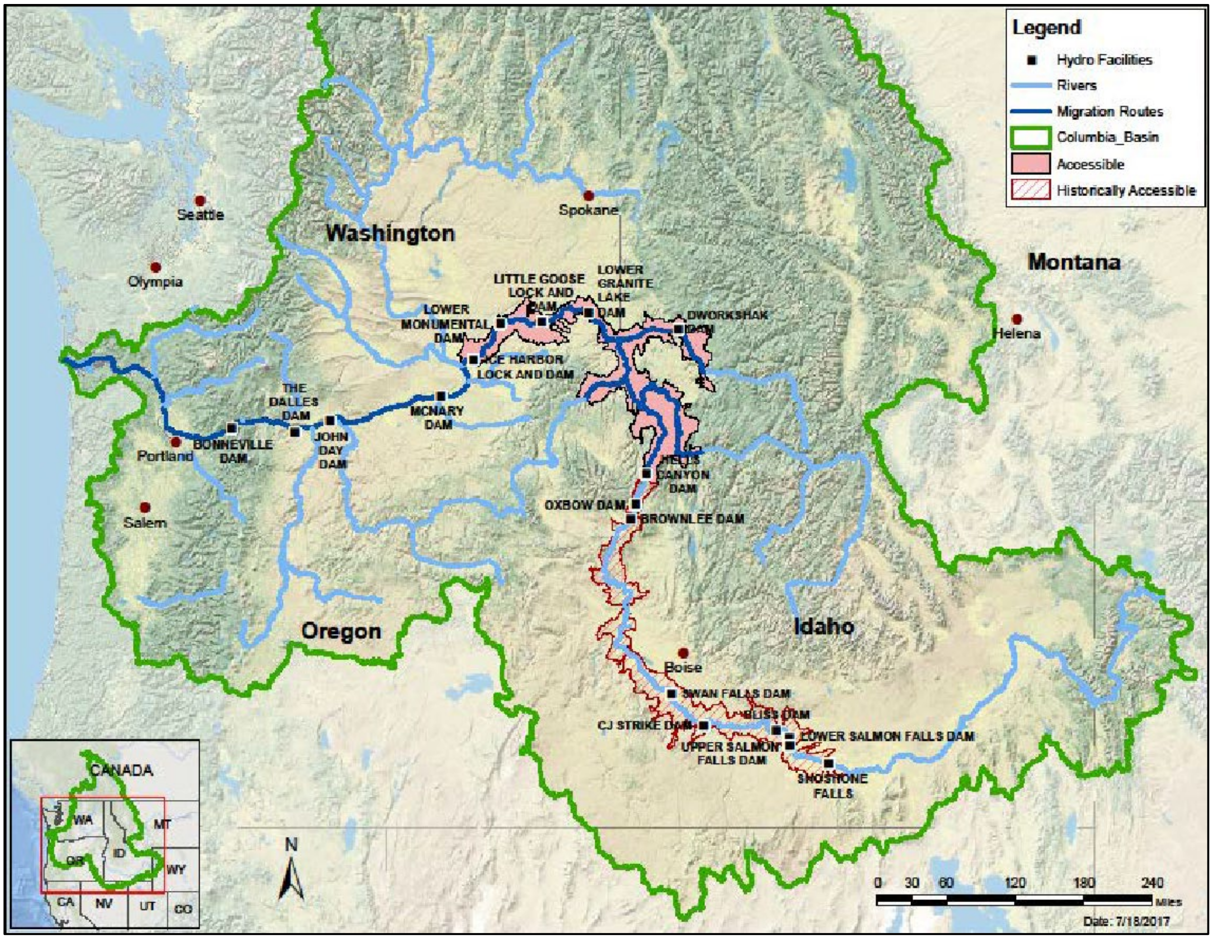


Figure 2.12-1. Snake River fall Chinook salmon current and historical spawning range. The areas shaded pink denote habitat that is currently occupied; the red hatched areas denote habitat that was accessible historically, but is now blocked by the Hells Canyon Project and other dams on the mainstem Snake River. Source: NMFS 2017d.

2.12.1.1.1 Life History

Most SR fall Chinook salmon production historically came from large mainstem reaches that supported a subyearling, or "ocean-type," life history strategy. Adults migrated up the Columbia and Snake Rivers from July–August through November and spawned from late September–early October through November. Eggs developed rapidly in the relatively warm lower mainstem reaches of several tributary rivers, which facilitated emergence during late winter and early spring and accelerated growth such that juveniles could become smolts and migrate to the ocean in May and June (NMFS 2017d). This life history strategy allowed fall Chinook salmon to avoid high summer temperatures and losses associated with over-summering and over-wintering that affect other Chinook salmon ESUs with a yearling, or "stream-type," life history strategy.

At present, the subyearling life history strategy contributes most of the natural-origin adult returns to the ESU, and the timing of adult migration and spawning plus egg incubation, fry emergence, and juvenile emigration is similar to historical patterns. However, a yearling life history strategy is also supported, mostly for juveniles from the cooler Clearwater River subbasin,[141] which overwinter in the lower Snake River reservoirs or other cool-water refuge areas and migrate downstream the following spring (NMFS 2017d).

2.12.1.1.2 Major Factors Affecting Status - 1850s to 1990

Several factors were responsible for the precipitous collapse of Snake River fall Chinook salmon in the 19th and 20th centuries. First, Chinook salmon were harvested at very high rates starting in the 1880s, and harvest rates continued at high levels through the 1980s. Second, the development of mainstem dams in the middle Snake River from the 1900s to the 1960s (Swan Falls Dam, the Hells Canyon Complex of dams, and others) inundated[142] and blocked access to the most productive spawning and rearing habitat, thereby eliminating one of the two large populations that are thought to have contributed to the historical structure of this ESU. They also affected water quality within and downstream of the dams (altered seasonal thermal regime, elevated TDG levels in the winter and spring, lowered dissolved oxygen levels in the late summer and fall, etc.). The construction of Lewiston Dam on the Clearwater River blocked access to habitat upstream of river mile 6 starting in 1927, extirpating fall Chinook salmon within that subbasin. Third, the development of mainstem dams in the lower Snake and Columbia Rivers (1938 to 1975) greatly altered mainstem migration and rearing habitat and substantially impacted the survival of juvenile migrants. The dams likely impacted the survival of migrating adults as well, at least in some years, and affected water quality (increased TDG levels, altered thermal regime, decreased sediment transport, etc.). Fourth, the construction and operation of dams (water storage and hydropower projects) and water conveyance systems for irrigation and other purposes (starting in the late 1800s) throughout the Columbia River basin have substantially affected seasonal flows; dam operations increased November to March flows and decreased May to July flows in the mainstem Snake and Columbia Rivers and the Columbia estuary and plume. Sixth, land use practices (agriculture, grazing, mining, timber harvest, etc.) throughout the basin negatively affected important water-quality parameters (nutrients, fine sediments, toxic contaminants) and channel complexity, especially in the middle Snake River[143] and the lower reaches of the five Snake River tributaries used for spawning and rearing. Lastly, strays from non-Snake River origin hatcheries on the spawning grounds posed a serious threat to the genetic integrity of the species (Waples et al. 1993; NMFS 2016e, 2017d).

These factors substantially reduced the amount and quality of available spawning, rearing, and migration corridor habitat; reduced the productivity of SR fall-run Chinook salmon in all freshwater life history stages; and resulted in extremely low abundance by 1990, when only 78

[141] Cool water has been released from Dworshak Dam since the mid-1990s in order to reduce summer temperatures that can impair passage conditions for migrating adult salmon and steelhead. This action retards the growth and delays the migration of juveniles rearing in the Clearwater River in July and August, but maintains thermal conditions, especially in Lower Granite, Little Goose, and Lower Monumental Reservoirs that allow juvenile Chinook to survive the summer and early-fall periods, overwinter, and migrate the following spring.
[142] Higher water levels in shoreline areas covered historically productive spawning habitat for fall Chinook salmon.
[143] Currently, water quality in the middle Snake River is highly degraded (excessive nutrients, excessive algal growth, anoxic or hypoxic conditions in spawning gravels, and increased sediment loads) and not sufficient to support fall Chinook salmon production.

naturally produced adults were counted passing Lower Granite Dam.[144] As a result, SR fall Chinook salmon were listed as threatened under the ESA on April 22, 1992 (57 FR 14653).

2.12.1.1.3 2016 Status Review

Based on substantial improvements in the abundance and productivity of the ESU, the most recent five-year status review (NMFS 2016e) recommended that the overall risk rating for SR fall Chinook salmon be reduced from moderate risk (i.e., maintained) to low risk (i.e., viable), based on a low risk rating for abundance/productivity and a moderate risk rating for spatial structure/diversity.

The 10-year (2005–14) geometric mean natural-origin abundance for spawner escapement was 6,418. Figure 2.12-2 depicts the estimated number of natural-origin adults passing Lower Granite Dam (1975–2017). The estimated average number of recruits per spawner is 1.5 for brood years 1990–2009. This is lower than the proposed recovery plan productivity criterion of 1.7 and reflects uncertainty due to the high numbers of hatchery-origin fish on the spawning grounds. Thus, while the recent abundance estimates shown in Figure 2.12-2 exceed the approximately 4,200 spawners needed to achieve a "very low" (i.e., highly viable) risk rating, the associated estimate of productivity is below that needed to reduce viability risk to less than 1 percent.

[144] This compares to an estimated historic average of about 500,000 returning adults (NMFS 2017d).

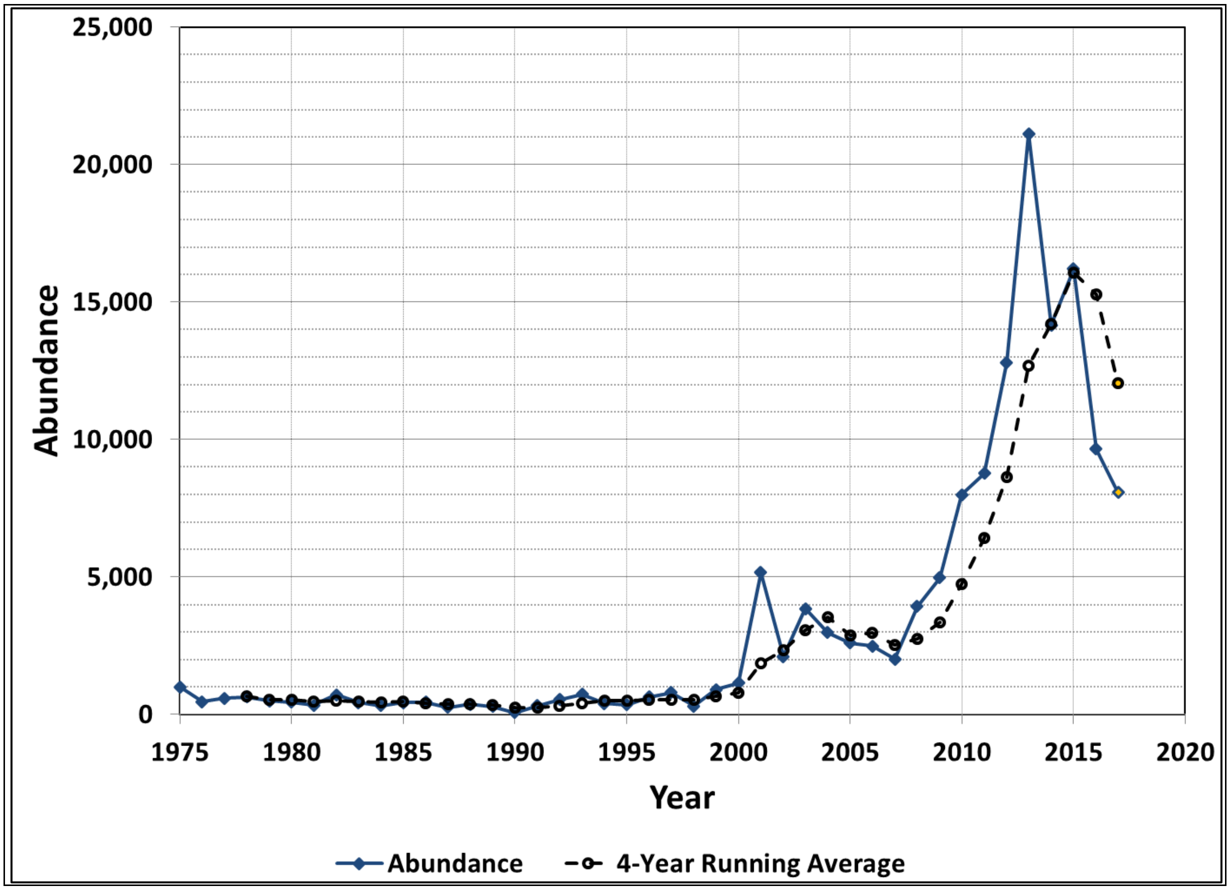


Figure 2.12-2. Estimated annual abundance (and 4-year running average abundance) of natural-origin adult Snake River fall Chinook salmon passing Lower Granite Dam (1975–2017).

In addition, observations of coastal ocean conditions suggest that the 2015–17 outmigrant year classes experienced below-average ocean survival (NWFSC 2015, 2017). These variations in conditions affecting early ocean survival indicate that despite efforts to address key threats in freshwater, the future status of SR fall Chinook salmon is somewhat uncertain.

NMFS (2016e) gave the ESU a rating for moderate risk for spatial structure/diversity, “driven by changes in major life history patterns, shifts in phenotypic traits, and high levels of genetic homogeneity in samples from natural-origin returns.” The rating also reflected risk associated with the high levels of hatchery-origin spawners in natural spawning areas and “the potential for selective pressure imposed by current hydropower operations and cumulative harvest impacts.”

The recovery plan considered several recovery scenarios, but identified the scenario aimed at achieving highly viable status (50 percent probability of a less than 1 percent risk of extinction in 100 years) for the extant population, using the upper Hells Canyon major spawning area (below Hells Canyon Dam to the mouth of the Salmon River) as a Natural Production Emphasis Area (NPEA) as the most likely scenario to achieve recovery. The relatively low hatchery contributions targeted in the NPEA are expected to provide “an opportunity to gain more direct information on intrinsic productivity without the masking effect common when high levels of hatchery-origin spawners are present” (NMFS 2017d).

The recovery plan (NMFS 2017d) acknowledges that "uncertainty remains regarding the driving factors for the recent increases in fall Chinook salmon abundance and productivity, and whether those increases will persist into the future across a range of changing environmental conditions. There is also uncertainty about the long-term effects of the high proportions of hatchery-origin spawners on species productivity and diversity." The recovery plan identifies ten management strategies (with associated ongoing actions that should continue and potential additional actions that should be considered for future implementation) for recovering the SR fall Chinook salmon ESU:

1. Develop tools, including life-cycle models, for evaluating and improving our understanding of the combined and relative effects of limiting factors and recovery actions across the life cycle.
2. Maintain and improve spawning, incubation, rearing, and migration conditions by continuing ongoing actions and implementing additional actions as appropriate in the lower mainstem Snake and Columbia Rivers and lower Snake tributaries.
3. Address loss of off-channel habitat in the estuarine floodplain and altered food web by continuing ongoing actions and implementing additional actions identified in the Estuary Module, FCRPS biological opinion (NMFS 2008a, 2010, 2014) and the recovery plan, as appropriate.
4. Continue ongoing actions and implement additional actions as appropriate to gain a better understanding of potential impacts from climate change during freshwater, estuarine, and ocean life stages, and to support SR fall Chinook salmon adaptation and resilience in response to climate change.
5. Implement harvest management programs in a manner that protects and restores SR fall Chinook salmon.
6. Continue ongoing actions and implement additional actions as appropriate to reduce predation and competition and address other ecological interactions that affect SR fall Chinook salmon.
7. Continue ongoing actions and implement additional actions that will improve ESU viability by reducing the impacts of hatchery-origin fish on natural-origin SR fall Chinook salmon.
8. Continue RM&E to gain a better understanding of potential negative impacts from exposure to toxic pollutants and develop actions to reduce potential effects of toxic contaminants on natural-origin SR fall Chinook salmon.
9. Evaluate feasibility of providing adult and juvenile fish passage to and from spawning and rearing areas above the Hells Canyon Complex.
10. Restore habitat conditions that can support SR fall Chinook salmon spawning and rearing above the Hells Canyon Complex by encouraging local governments and stakeholders to implement actions to reduce nutrients and sediment to improve mainstem habitat.

2.12.1.2 Status of Critical Habitat

This section of the opinion examines the rangewide status of designated critical habitat for SR fall Chinook salmon. Critical habitat includes the stream channels within designated stream reaches and a lateral extent defined by the ordinary high-water line (33 CFR 319.11).

NMFS determines the rangewide status of critical habitat by examining the condition of the PBFs that were identified when critical habitat was designated (Table 2.12-2). These features are essential to the conservation of the listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration, and foraging). Designated areas support one or more life stages (spawning, rearing, and/or migration) and contain the PBFs essential to the conservation of the species (for example, overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks and migration corridors free of artificial obstruction, with sufficient water quantity and quality).

Table 2.12-2. Physical and biological features (PBFs) of critical habitats designated for SR fall Chinook salmon and components of the PBFs.

Physical and Biological Features	Component of the PBF
Spawning and juvenile rearing areas	Spawning gravel Water quality Water quantity Food Riparian vegetation Space
Juvenile migration corridors	Substrate Water quality Water quantity Water temperature Water velocity Cover/shelter Food Riparian vegetation Space Safe passage
Adult migration corridors	Substrate Water quality Water quantity Water velocity Cover/shelter Riparian vegetation Space Safe passage
Areas for growth and development to adulthood	Ocean areas – not designated

The life cycle of SR fall Chinook salmon gives rise to complex habitat needs, particularly in freshwater. The gravel used for spawning must be a certain size and largely free of fine sediments to allow successful incubation of the eggs and later emergence or escape from the gravel as alevins. Eggs also require cool, clean, and well oxygenated waters for proper development. Juveniles need abundant food sources, including insects, crustaceans, and other small fish. They need instream places to hide from predators (mostly birds and larger fish), such as under logs, root wads, and boulders, as well as beneath overhanging vegetation. They also need refuge from periodic high flows in side channels and off-channel areas and from warm summer water temperatures in cold-water springs and deep pools. Returning adults generally do not feed in freshwater, but instead, rely on limited stored energy to migrate, mature, and spawn. Like juveniles, the returning adults also require cool water that is free of contaminants and migratory corridors with adequate passage conditions (timing, water quality/quantity) to allow access to the various habitats required to complete their life cycle (NMFS 2005b).

In the following paragraphs, we discuss the current status of the functioning PBFs of critical habitat in the Interior Columbia and Lower Columbia River Estuary recovery domains.

2.12.1.2.1 Interior Columbia Recovery Domain

The value of PBFs in the upper Hells Canyon reach (spawning and rearing), and to a lesser extent in the lower Hells Canyon reach, have been greatly improved by Idaho Power Company's voluntary implementation of: (1) a fall Chinook salmon flow program which provides stable spawning and incubation flows from October to March; and (2) the Juvenile Fall Chinook Salmon Entrapment Management Plan, with operations to reconnect high-priority entrapment sites to the river for at least two hours each day. The value of PBFs continues to be negatively affected by elevated nutrients entering Brownlee Reservoir and associated low dissolved oxygen levels in the late summer and fall exiting Hells Canyon Dam, an altered thermal regime (warmer than historical temperatures) which could negatively affect the survival of adult migrants and the condition of their gametes, and pollutants and toxic contaminants.

The value of PBFs in the other major spawning and rearing areas is primarily affected by loss of habitat complexity and connectivity, reduced late summer/fall flows, water-quality issues, toxic contaminants, and predation by both native and nonnative predators. The spawning habitat in the lower Clearwater River can also be negatively affected by high TDG levels from spill events at Dworshak Dam during the winter and spring.

The value of PBFs through the freshwater migration corridor has substantially improved in the past two decades, especially for juvenile migrants, because of structural and operational changes (surface passage routes, improved juvenile bypass systems, predator management, flow management, improvements to adult fishways, release of cool water from Dworshak Dam from June or July through September, etc.). However, the value of PBFs continues to be affected by the mainstem dams and reservoirs (altered habitat), basinwide water use activities (reduced May and June flows), both native and nonnative predators in this altered habitat, and impaired water quality (elevated TDG levels stemming from voluntary and lack of market or lack of turbine capacityspill, elevated late summer and fall temperatures, and pollutants and toxic contaminants).

2.12.1.2.2 Lower Columbia River Estuary Recovery Domain

Critical habitat has also been designated for SR fall Chinook salmon in the lower Columbia River estuary. The estuary is broadly defined to include the entire reach where tidal forces and river flows interact, regardless of the extent of saltwater intrusion. This encompasses areas from Bonneville Dam (RM 146) to the mouth of the Columbia River. It also includes the tidally influenced portions of tributaries below Bonneville Dam, including the lower 26 miles of the Willamette River. This region experiences ocean tides that extend from the mouth of the Columbia River up to Bonneville Dam.

Historically, the downstream half of the Columbia River estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. The mouth of the Columbia River was about four miles wide. Winter and spring floods, low flows in late summer, large woody debris floating downstream, and a shallow bar at the mouth of the Columbia River maintained a dynamic environment. Today, navigation channels have been dredged, deepened, and maintained, jetties and pile-dike fields have been constructed to stabilize and concentrate flow in navigation channels, marsh and riparian habitats have been filled and diked, and causeways have been constructed across waterways. These actions have decreased the width of the mouth of the Columbia River to two miles and increased the depth of the Columbia River channel at the bar from less than 20 to more than 55 feet (NMFS 2008a).

Over time, more than 50 percent of the original marshes and spruce swamps in the estuary have been converted to industrial, transportation, recreational, agricultural, or urban uses. More than 3,000 acres of intertidal marsh and spruce swamps have been converted to other uses since 1948. Many wetlands along the shore in the upper reaches of the estuary were converted to industrial and agricultural lands after levees and dikes were constructed. Furthermore, water storage and release patterns from reservoirs upstream of the estuary have changed the seasonal pattern and volume of discharge. The peaks of spring/summer floods have been reduced, and the amount of water discharged during winter has increased (NMFS 2008a).

In addition, model studies indicate that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of suspended particulate matter to the lower river and estuary by about one third(as measured at Vancouver, Washington) and have reduced fine sediment transport by 50 percent or more. The significance of these changes for SR fall Chinook salmon is unclear, although estuarine habitat provides food for the large subyearling and yearling migrants from this ESU that move rapidly downstream to the ocean (Johnson et al. 2018; PNNL and NMFS 2018).

Functioning estuarine areas are essential to conservation because, without them, juvenile SR fall Chinook salmon cannot reach the ocean in a timely manner and use the variety of habitats that allow them to avoid predators, compete successfully, and complete the behavioral and physiological changes needed for life in the ocean. Similarly, these features are essential to the conservation of adult salmonids because these features in the estuary provide a final source of abundant forage that will provide the energy stores needed to make the physiological transition to freshwater, migrate upstream, avoid predators, and develop to maturity upon reaching spawning areas (NMFS 2005b).

2.12.1.3 Climate Change Implications for SR Fall Chinook Salmon and Critical Habitat

One factor affecting the rangewide status of SR fall Chinook salmon and aquatic habitat is climate change. The USGCRP[145] reports average warming of about 1.3ºF from 1895 to 2011, and projects an increase in average annual temperature of 3.3ºF to 9.7ºF by 2070 to 2099 (CCSP 2014). Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004; Scheuerell and Williams 2005; Zabel et al. 2006; ISAB 2007). According to the ISAB,[146] these effects pose the following impacts into the future:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season;
- With a smaller snowpack, watersheds will see their runoff diminished earlier in the season, resulting in lower stream-flows in the June through September period. River flows in general and peak river flows are likely to increase during the winter due to more precipitation falling as rain rather than snow; and
- Water temperatures are expected to rise, especially during the summer months when lower stream-flows co-occur with warmer air temperatures.

These changes will not be spatially homogeneous across the entire Pacific Northwest. Low-lying areas are likely to be more affected. Climate change may have long-term effects that include, but are not limited to, depletion of important cold-water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, premature emergence of fry, and increased competition among species. Overall, climate change effects likely to occur to some degree over the next ten years are expected at a similar rate as the last ten years.

Climate change is predicted to cause a variety of impacts to Pacific salmon and their ecosystems (Mote et al. 2003; Crozier et al. 2008a; Martins et al. 2012; Wainwright and Weitkamp 2013). The complex life cycles of anadromous fishes, including salmon, rely on productive freshwater, estuarine, and marine habitats for growth and survival, making them particularly vulnerable to environmental variation. Ultimately, the effects of climate change on salmon and steelhead across the Pacific Northwest will be determined by the specific nature, level, and rate of change and the synergy between interconnected terrestrial/freshwater, estuarine, nearshore, and ocean environments.

[145] https://www.globalchange.gov
[146] The Independent Scientific Advisory Board (ISAB) serves the National Marine Fisheries Service (NOAA Fisheries), Columbia River Indian Tribes, and Northwest Power and Conservation Council by providing independent scientific advice and recommendations regarding scientific issues that relate to the respective agencies' fish and wildlife programs; see https://www.nwcouncil.org/fw/isab/.

The primary effects of climate change on Pacific Northwest salmon and steelhead include:

- Direct effects of increased water temperatures on fish physiology;
- Temperature-induced changes to stream-flow patterns;
- Alterations to freshwater, estuarine, and marine food webs; and
- Changes in estuarine and ocean productivity.

While all habitats used by Pacific salmon will be affected, the impacts and certainty of the change vary by habitat type. Some effects (e.g., increasing temperature) affect salmon at all life stages in all habitats, while others are habitat-specific, such as stream-flow variation in freshwater, sea-level rise in estuaries, and upwelling in the ocean. How climate change will affect each stock or population of salmon also varies widely depending on the level or extent of change, the rate of change, and the unique life history characteristics of different natural populations (Crozier et al. 2008b). For example, a few weeks' difference in migration timing can have large differences in the thermal regime experienced by migrating fish (Martins et al. 2011).

2.12.1.3.1 Temperature Effects

Like most fishes, salmon are poikilotherms (cold-blooded animals); therefore, increasing temperatures in all habitats can have pronounced effects on their physiology, growth, and development rates (see review by Whitney et al. 2016). Increases in water temperatures beyond their thermal optima will likely be detrimental through a variety of processes, including increased metabolic rates (and therefore food demand), decreased disease resistance, increased physiological stress, and reduced reproductive success. All of these processes are likely to reduce survival (Beechie et al. 2013; Wainwright and Weitkamp 2013; Whitney et al. 2016).

By contrast, increased temperatures at ranges well below thermal optima (i.e., when the water is cold) can increase growth and development rates. Examples of this include accelerated emergence timing during egg incubation stages, or increased growth rates during fry stages (Crozier et al. 2008a; Martins et al. 2011). Temperature is also an important behavioral cue for migration (Sykes et al. 2009), and elevated temperatures may result in earlier-than-normal migration timing. While there are situations or stocks where this acceleration in processes or behaviors is beneficial, there are also others where it is detrimental (Martins et al. 2012; Whitney et al. 2016).

2.12.1.3.2 Freshwater Effects

Climate change is predicted to increase the intensity of storms, reduce winter snow pack at low and middle elevations, and increase snowpack at high elevations in northern areas. Middle and lower-elevation streams will have larger fall/winter flood events and lower late-summer flows, while higher elevations may have higher minimum flows. How these changes will affect freshwater ecosystems largely depends on their specific characteristics and location, which vary at fine spatial scales (Crozier et al. 2008b; Martins et al. 2012). For example, within a relatively small geographic area (the Salmon River basin in Idaho), survival of some Chinook salmon populations was shown to be determined largely by temperature, while in others it was determined by flow (Crozier and Zabel 2006). Certain salmon populations inhabiting regions that are already near or exceeding thermal maxima will be most affected by further increases in temperature and, perhaps, the rate of the increases. The effects of altered flow are less clear and likely to be basin-specific (Crozier et al. 2008b; Beechie et al. 2013). However, river flow is already becoming more variable in many rivers, and is believed to negatively affect anadromous fish survival more than other environmental parameters (Ward et al. 2015). It is likely this increasingly variable flow is detrimental to multiple salmon and steelhead populations, and likely multiple other freshwater fish species in the Columbia River basin as well.

Stream ecosystems will likely change in response to climate change in ways that are difficult to predict (Lynch et al. 2016). Changes in stream temperature and flow regimes will likely lead to shifts in the distributions of native species and provide "invasion opportunities" for exotic species. This will result in novel species interactions, including predator–prey dynamics, where juvenile native species may be either predators or prey (Lynch et al. 2016; Rehage and Blanchard 2016). How juvenile native species will fare as part of "hybrid food webs," which are constructed from natives, native invaders, and exotic species, is difficult to predict (Naiman et al. 2012).

2.12.1.3.3 Estuarine Effects

In estuarine environments, the two big concerns associated with climate change are rates of sea-level rise and temperature warming (Wainwright and Weitkamp 2013; Limburg et al. 2016). Estuaries will be affected directly by sea-level rise: as sea level rises, terrestrial habitats will be flooded and tidal wetlands will be submerged (Kirwan et al. 2010; Wainwright and Weitkamp 2013; Limburg et al. 2016). The net effect on wetland habitats depends on whether rates of sea-level rise are sufficiently slow that the rates of marsh plant growth and sedimentation can compensate (Kirwan et al. 2010).

Due to subsidence, sea-level rise will affect some areas more than others, with the largest effects expected for the lowlands, like southern Vancouver Island and central Washington coastal areas (Verdonck 2006; Lemmen et al. 2016). The widespread presence of dikes in Pacific Northwest estuaries will restrict upward estuary expansion as sea levels rise, likely resulting in a near-term loss of wetland habitats for salmon (Wainwright and Weitkamp 2013). Sea-level rise will also result in greater intrusion of marine water into estuaries, resulting in an overall increase in salinity, which will also contribute to changes in estuarine floral and faunal communities (Kennedy 1990). While not all anadromous fish species are generally highly reliant on estuaries for rearing, extended estuarine use may be important in some populations (Jones et al. 2014), especially if stream habitats are degraded and become less productive.

2.12.1.3.4 Marine Effects

In marine waters, increasing temperatures are associated with observed and predicted poleward range expansions of fish and invertebrates in both the Atlantic and Pacific Oceans (Lucey and Nye 2010; Asch 2015; Cheung et al. 2015). Rapid poleward species shifts in distribution in response to anomalously warm ocean temperatures have been well documented in recent years, confirming this expectation at short time scales. Range extensions were documented in many species from southern California to Alaska during unusually warm water associated with “the blob” in 2014 and 2015 (Bond et al. 2015; Di Lorenzo and Mantua 2016) and past strong El Niño events (Pearcy 2002; Fisher et al. 2015).

Expected changes to marine ecosystems due to increased temperature, altered productivity, or acidification will have large ecological implications through mismatches of co-evolved species and unpredictable trophic effects (Cheung et al. 2015; Rehage and Blanchard 2016). These effects will certainly occur, but predicting the composition or outcomes of future trophic interactions is not possible with current models.

Wind-driven upwelling is responsible for the extremely high productivity in the California Current ecosystem (Bograd et al. 2009; Peterson et al. 2014). Minor changes to the timing, intensity, or duration of upwelling, or the depth of water-column stratification, can have dramatic effects on the productivity of the ecosystem (Black et al. 2014; Peterson et al. 2014). Current projections for changes to upwelling are mixed: some climate models show upwelling unchanged, but others predict that upwelling will be delayed in spring, and more intense during summer (Rykaczewski et al. 2015). Should the timing and intensity of upwelling change in the future, it may result in a mismatch between the onset of spring ecosystem productivity and the timing of salmon entering the ocean, and a shift toward food webs with a strong subtropical component (Bakun et al. 2015).

Columbia River anadromous fish also use coastal areas of British Columbia and Alaska and midocean marine habitats in the Gulf of Alaska, although their fine-scale distribution and marine ecology during this period are poorly understood (Morris et al. 2007; Pearcy and McKinnell 2007). Increases in temperature in Alaskan marine waters have generally been associated with increases in productivity and salmon survival (Mantua et al. 1997; Martins et al. 2012), thought to result from temperatures that have been below thermal optima (Gargett 1997). Warm ocean temperatures in the Gulf of Alaska are also associated with intensified downwelling and increased coastal stratification, which may result in increased food availability to juvenile salmon along the coast (Hollowed et al. 2009; Martins et al. 2012). Predicted increases in freshwater discharge in British Columbia and Alaska may influence coastal current patterns (Foreman et al. 2014), but the effects on coastal ecosystems are poorly understood.

In addition to becoming warmer, the world’s oceans are becoming more acidic as increased atmospheric CO_2 is absorbed by water. The North Pacific is already acidic compared to other oceans, making it particularly susceptible to further increases in acidification (Lemmen et al. 2016). Laboratory and field studies of ocean acidification show it has the greatest effects on invertebrates with calcium-carbonate shells, and relatively little direct influence on finfish; see reviews by Haigh et al. (2015) and Mathis et al. (2015). Consequently, the largest impact of ocean acidification on salmon will likely be its influence on marine food webs, especially its effects on lower trophic levels, which are largely composed of invertebrates (Haigh et al. 2015; Mathis et al. 2015).

2.12.1.3.5 Uncertainty in Climate Predictions

There is considerable uncertainty in the predicted effects of climate change on the globe as a whole, and on the Pacific Northwest in particular, and there is also the question of indirect effects of climate change and whether human "climate refugees" will move into the range of salmon and steelhead, increasing stresses on their respective habitats (Dalton et al. 2013; Poesch et al. 2016). There is also considerable uncertainty in terms of vulnerability and how SR fall Chinook salmon will respond to physical, chemical and biological changes in the ecosystem induced by climate change.

Many of the effects of climate change (e.g., increased temperature, altered flow, coastal productivity, etc.) will have direct impacts on the food webs that species rely on in freshwater, estuarine, and marine habitats to grow and survive. Such ecological effects are extremely difficult to predict even in fairly simple systems, and minor differences in life history characteristics among stocks of salmon may lead to large differences in their response (e.g., Crozier et al. 2008b; Martins et al. 2011, 2012). This means it is likely that there will be "winners and losers," meaning some salmon populations may enjoy different degrees or levels of benefit from climate change while others will suffer varying levels of harm.

Climate change is expected to impact anadromous fish during all stages of their complex life cycle. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream-flow patterns in freshwater and changes to food webs in freshwater, estuarine, and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty.

2.12.2 Environmental Baseline

The "environmental baseline" includes the past and present impacts of all federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

For SR fall Chinook salmon, we focus our description of the environmental baseline on where SR fall Chinook salmon juveniles and adults are exposed to the effects of the proposed action. We also consider the broader action area, including tributary habitat, because these areas are important context for understanding the effects of the proposed action. The upstream extent of SR fall Chinook salmon presence is the head of Lower Granite Reservoir on the Snake River and the Clearwater River upstream to and including the North Fork Clearwater River. SR fall Chinook salmon are exposed to the effects of the CRS (observed changes in flow) downstream through the mainstem Snake and Columbia Rivers, including tributary confluences in this reach to the extent they have been inundated by mainstem reservoirs or are affected by flow management. The area extends down to the Columbia River estuary and plume.

2.12.2.1 Overview of Primary Factors Affecting Status since ESA Listing in 1992

While many factors that have historically affected fall Chinook salmon and their habitat continue to occur, many actions have been taken throughout their range since they were listed under the ESA in 1992 to improve survival throughout their life-cycle and the conservation value of the habitat upon which they depend. In addition, new issues have emerged since the listing which affect the status of the ESU. While still substantial, overall harvest rates have been reduced from around 60 to 80 percent as recently as the 1980s to 40 to 50 percent since the mid-1990s (Figure 2.12-3) as a result of actions taken to reduce ocean harvest and the use of abundance-based "sliding scales" to manage fisheries in the mainstem Columbia River. These actions have improved the productivity and abundance of the single population by increasing the number of adult fall-run Chinook salmon returning to the spawning areas (NMFS 2016e, 2017d).

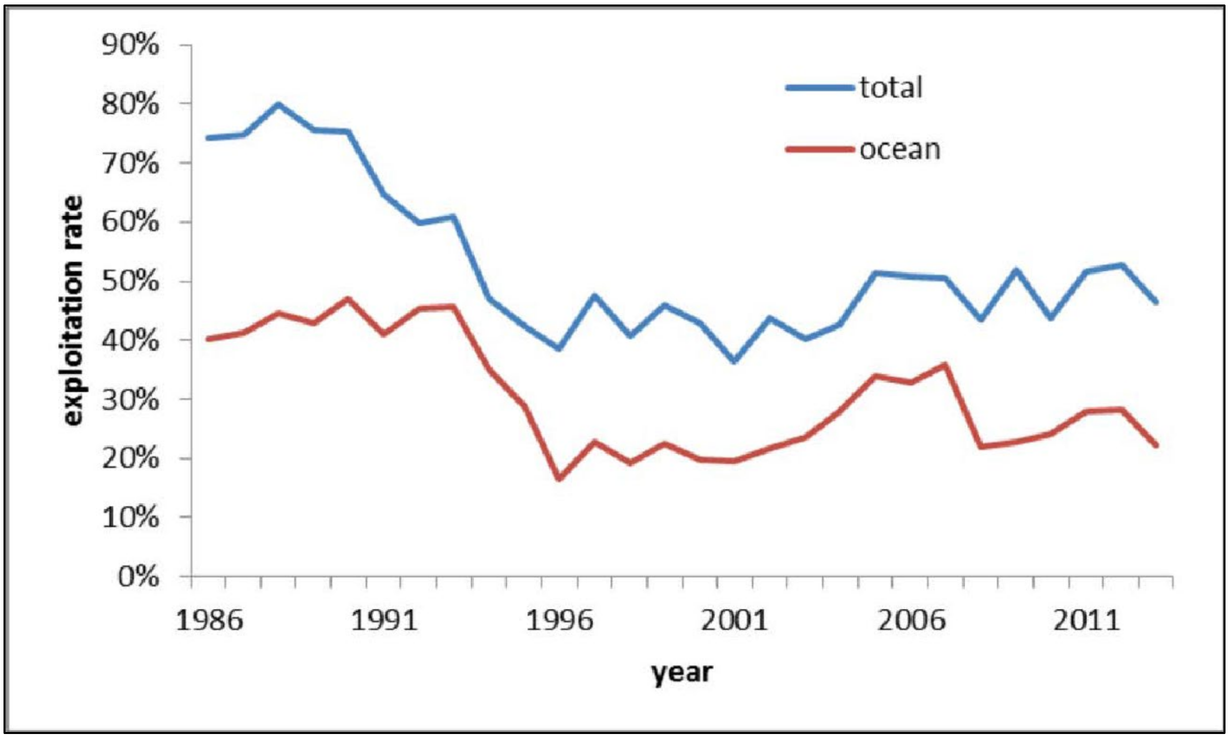


Figure 2.12-3. Total exploitation rates for Snake River fall Chinook salmon over time. Data for ocean exploitation rates from the Chinook Technical Committee model (Calibration 1503) and for in-river harvest rates from the Columbia River Technical Advisory Committee (TAC 2014). Source: NMFS 2017d.

Starting in the late 1990s, large numbers of hatchery-produced fish began to be released from Lyons Ferry Hatchery, at Nez Perce Tribe acclimation facilities in the lower and upper Hells Canyon reaches147 (between the head of Lower Granite Reservoir and Hells Canyon Dam), Clearwater, and Grande Ronde River major spawning areas, and at Hells Canyon Dam. Together, these programs released up to 5.5 million fish annually. These programs have substantially improved the abundance of SR fall Chinook salmon in spawning areas upstream of

[147] The mainstem Snake River is divided into two distinct reaches for management purposes, an upper reach from Hells Canyon Dam downstream to the Salmon River confluence, and a second reach that continues downstream from this point to the head of Lower Granite Reservoir.

Lower Granite Dam. The progeny of hatchery fish spawning in the wild are considered natural-origin when they return to spawn, so these fish contributed to the rapid rebuilding of the ESU. However, NMFS (2016e) stated concerns that continued high levels of hatchery-origin fish on the spawning grounds could pose a risk to long term population diversity and productivity.

Since 1992, Idaho Power Company has operated the Hells Canyon Complex of dams to provide stable spawning and incubation flows in the upper Hells Canyon reach of the Snake River for SR fall Chinook salmon. These flows ensure that redds are not dewatered during winter load-following operations (i.e., daily and hourly flow fluctuations). This voluntary action has likely improved egg-to-fry survival.

The Action Agencies have also taken many structural and operational measures at CRS projects to improve conditions for SR fall Chinook salmon since the ESA listing in 1992. More details affecting the status of the species within the action area are discussed below.

2.12.2.1.1 Mainstem Habitat

Mainstem habitat in the lower Snake and Columbia Rivers has been substantially altered by basinwide water management operations, the construction and operation of mainstem hydroelectric projects, the introduction of nonnative species (e.g., smallmouth bass, walleye, channel catfish, invertebrates, etc.), and other human practices that have increased nutrients, pollutants, and toxic contaminants.

Seasonal Flows

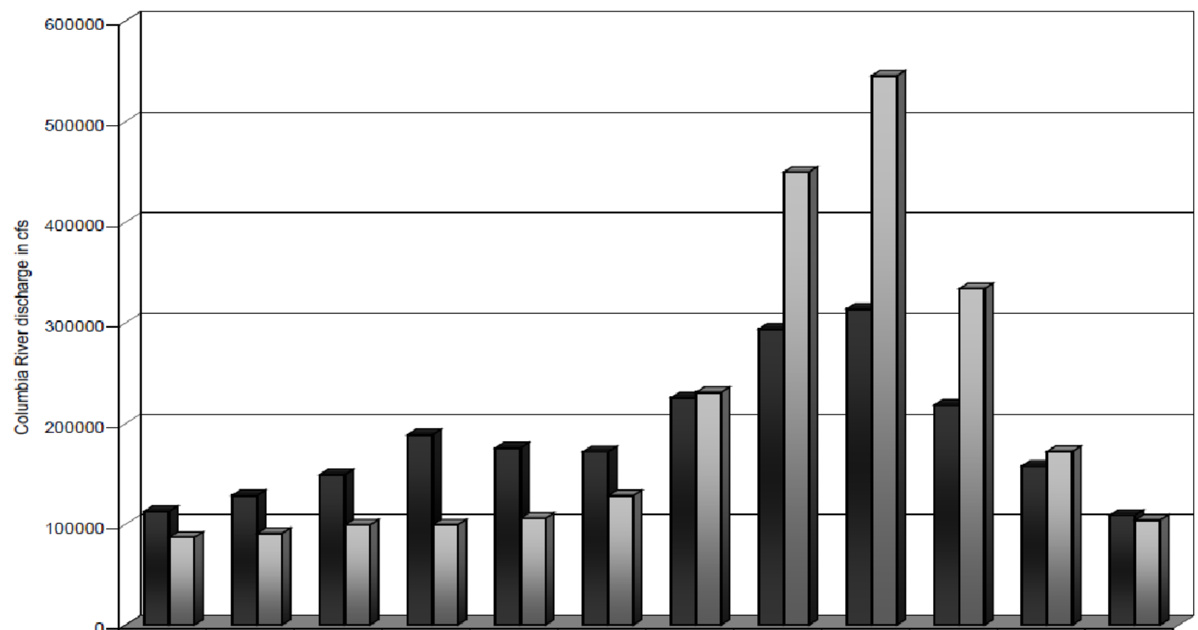
Water diversions for a variety of purposes (agricultural, municipal, etc.) and the management of stored water (including runoff stored in Canadian reservoirs, in the U.S. portion of the Columbia Basin, and in the upper Snake River basin,[148] Yakima River basin, and Deschutes River basin) has altered the quantity and timing of flows entering the lower Snake and Columbia Rivers compared to historical conditions. Altogether, these activities have degraded salmon and steelhead habitats (Bottom et al. 2005; Fresh et al. 2005; NMFS 2013a). The volume of water discharged by the Columbia River varies seasonally according to runoff, snowmelt, and hydropower demands. Mean annual discharge is estimated to be 265 kcfs, but may range from lows of 71–106 kcfs to highs of 530 kcfs (Hamilton 1990; NMFS 1998; Prahl et al. 1998; USACE 1999). Naturally occurring maximum flows on the river occur in May, June, and July as a result of snowmelt in the headwater regions. Minimum flows occur from September to March, with periodic peaks due to heavy winter rains (Holton 1984). Interannual variability in stream flow is strongly correlated with two recurrent climate phenomena, the ENSO and the PDO (Newman et al. 2016).

[148] The effects of the operation and maintenance of ten Bureau of Reclamation projects and two related actions in the upper Snake River above Brownlee Reservoir, including the 2004 Nez Perce Water Rights Settlement and the Snake River Water Rights Act of 2004 (for a 30-year period through 2034; USBR 2007), were consulted upon in 2008. This consultation focused on the effects of these projects on flow in the Snake and Columbia Rivers downstream of Hells Canyon Dam (NMFS 2008a and 2008b).

Water storage projects (dams and reservoirs) and water management activities have reduced spring flows at Bonneville Dam, representing basinwide effects in the lower Columbia River (from McNary Reservoir to the mouth of the Columbia River; NMFS 2008a). On average, this reduction can range from nearly 15 kcfs in August to over 230 kcfs in May (see Figure 2.12-4). Proportional flow reductions of similar magnitude also occur in the lower Snake River (Lower Granite Reservoir to the mouth of the Snake River), and in the lower Clearwater River downstream of Dworshak Dam (North Fork Clearwater River).

Recognizing that the flow versus survival relationships for some interior basin ESUs/DPSs displayed a plateau over a wide range of flows but declined markedly as flows dropped below some threshold (NMFS 1995b, 1998), NMFS and the CRS Action Agencies have attempted to manage Columbia and Snake River water resources to maintain seasonal flows above threshold objectives given the amount of runoff in a given year. This has been accomplished by avoiding excessive reservoir drafts going into spring to minimize the flow reductions needed for refill and by drafting the storage reservoirs during summer to augment flows.[149] These flow objectives have guided preseason reservoir planning and in-season flow management. Nonetheless, since the development of the hydrosystem, average monthly flows at Bonneville Dam have been substantially lower during May–July and higher in October–March compared to an unregulated system. Reduced flows have increased travel times during outmigration for juvenile salmonids and resulted in reduced access to high-quality estuarine habitats from May through July during low tides.

[149] Even though several million acre feet of water are released annually from storage during the summer months to augment flows (and from Dworshak Dam to reduce mainstem temperatures), these volumes do not offset the consumption of water in the basin in July and August.



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Current	113017	128641	149403	189076	175921	172150	225689	293948	313930	218523	157935	109020
Natural	87115	91029	99387	99496	106033	128580	231047	450040	545561	334238	172430	104310

Figure 2.12-4. Comparison of monthly discharge (flow) in the Columbia River between current conditions (black) and normative flows (gray). These data show that predevelopment flows were lower in the winter and higher in the summer months.

Water Quality

Water quality in the action area is impaired as a result of chemical contaminants from municipal, agricultural, industrial, and urban land uses (NMFS 2017d). Common toxic contaminants found in the Columbia River system include PCBs, PAHs, PBDEs, DDT and other legacy pesticides, current use pesticides, pharmaceuticals and personal care products, and trace elements (LCREP 2007). The LCREP (2007) report noted widespread presence of PCBs and PAHs, both geographically and in the food web. Urban and industrial portions of the lower river contribute significantly to contaminant levels in juvenile salmon; juvenile salmon are absorbing toxic contaminants during their time rearing and feeding in the lower Columbia River (LCREP 2007). Likewise, juvenile salmon are accumulating DDT in their tissues and are exposed to estrogen-like compounds in the lower river, likely associated with pharmaceuticals and personal care products. Concentrations of copper are present at levels that could interfere with crucial salmon behaviors. These contaminants are also likely present in the lower Clearwater and lower Snake Rivers, and the inundated portion of the Tucannon River where SR fall Chinook salmon spawn and rear.

Oils, greases, and other lubricants (derived from animal, fish, vegetable, petroleum or marine mammal origin) are used at each of the CRS projects, including, but not limited to, the following: hydropower turbines, hydraulic systems, lubricating systems, gear boxes, machining coolant systems, heat transfer systems, transformers, circuit breakers, and electrical systems. Leakage of oils, greases, or other lubricants into rivers has the potential to affect salmon and steelhead (avoidance, exposure to toxic compounds, or even, in some circumstances death). In response to increased concerns regarding the releases of oils and greases from lower Columbia and lower Snake River Dams (and Dworshak and Chief Joseph Dams) the Corps has taken steps to minimize these risks. For equipment in contact with the water, the Corps has developed best management practices to avoid accidental releases and to minimize the adverse effects in the case of an accidental release. The Corps has also begun using, where feasible, "environmentally acceptable lubricant" greases and in some cases has replaced greased equipment with greaseless equipment. The Corps has also developed and is implementing oil accountability plans with enhanced inspection protocols and is reporting annually.

The extent to which leaked grease or oil, occurring under the environmental baseline in the Clearwater River (Dworshak Dam), Upper Columbia River (Chief Joseph), or lower Snake or lower Columbia Rivers, has affected the behavior, health, or survival of SR fall Chinook salmon in the past is unknown, but likely to be small given that the size of these river systems. For comparison, a large leak of 100 gallons per day is the equivalent of 0.00016 cubic feet per second and the average annual discharge of the Columbia River has ranged from roughly 125,000 to 250,000 cubic feet per second since about 1940 (ISAB 2000). Nevertheless, to the extent past leakages have potentially affected passage or survival, these effects would be encompassed by annual juvenile or adult reach survival estimates. Recent actions (adoption of best management practices, use of environmentally acceptable lubricants, use of greaseless equipment, etc.) would further reduce the potential for negative effects stemming from these materials and slightly improve conditions for juvenile and adult migrants.

Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute municipal and industrial waste discharges to the lower Columbia River. Industrial and municipal wastes from the Portland/Vancouver metro areas, including the superfund-designated reach in the lower Willamette River, also contribute to degraded water quality in the lower river. Legacy and active mining areas scattered around the basin deliver high background concentrations of metals. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river.

Outside of urban areas, the majority of residences and businesses rely on septic systems. Common water-quality issues with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff. Under these environmental conditions, fish in the action area are stressed. Stress may lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival).

Our understanding of the effects on aquatic life impacts of many contaminants, alone or in combination with other chemicals (potential for synergistic effects), is incomplete, especially when considering exposure of rearing juveniles to multiple contaminants, or when considering their interactions with other stressors, food web-mediated effects, and effects in complex mixtures (NMFS 2017d). Together, these contaminants are likely affecting the productivity and abundance of SR fall Chinook salmon, especially during the rearing and juvenile migration phases of their life cycle. The effects can be direct or indirect, and lethal or more likely sublethal; the interaction of co-occurring stressors may have a greater impact on salmon than if they occur in isolation (Dietrich et al. 2014).

Water temperatures in the Columbia River are a concern; the Columbia and Snake Rivers are included on the Clean Water Act §303(d) list of impaired waters established by Oregon, Washington, and Idaho because of temperature-standard exceedances. Temperature conditions in the Columbia River basin area are affected by many factors, including:

- Natural variation in weather and river flow;
- Construction of the dam and reservoir system (the large surface areas of reservoirs and resulting slower river velocities contribute to warmer late summer/fall water temperatures);
- Increased temperatures of tributaries;
- Water managed for irrigated agriculture;
- Point-source discharges such as cities and industries; and
- Climate change (Overman 2017; EPA 2018).

Since the mid-1990s, the Army Corps of Engineers has released up to 1.2 million acre-feet of cool water from Dworshak Dam to reduce temperatures in the lower Snake River from June or July to September. Operators manage the Dworshak project so temperatures do not exceed 68°F at the tailrace of Lower Granite Dam. These releases substantially cool the lower Clearwater River and Lower Granite Reservoir, though the cooler water sinks to the bottom of the reservoir causing vertical stratification in that reach. The warmer surface water is mixed with the cooler, deeper water as it passes through turbines and spillway bays at the dam, and at each subsequent Snake River dam. Thus, cooler temperatures stemming from Dworshak operations result in strong stratification within Lower Granite Reservoir, with the effect diminishing as the water moves downstream through the lower Snake River (NMFS 2008b, 2017d). As an example, Figure 2.12-5 depicts temperature conditions at the Anatone Gage on the Snake River upstream of Lower Granite Reservoir; the Peck Gage on the lower Clearwater River; and the tailrace temperatures at Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams during the especially hot summer of 2015. These ongoing cool-water releases have improved late-summer migration conditions for adult fall Chinook salmon in the Snake River (compared to historical conditions) and allow juvenile fall Chinook salmon (primarily from the lower Clearwater spawning area) to rear within the Snake River reservoirs in the late summer.

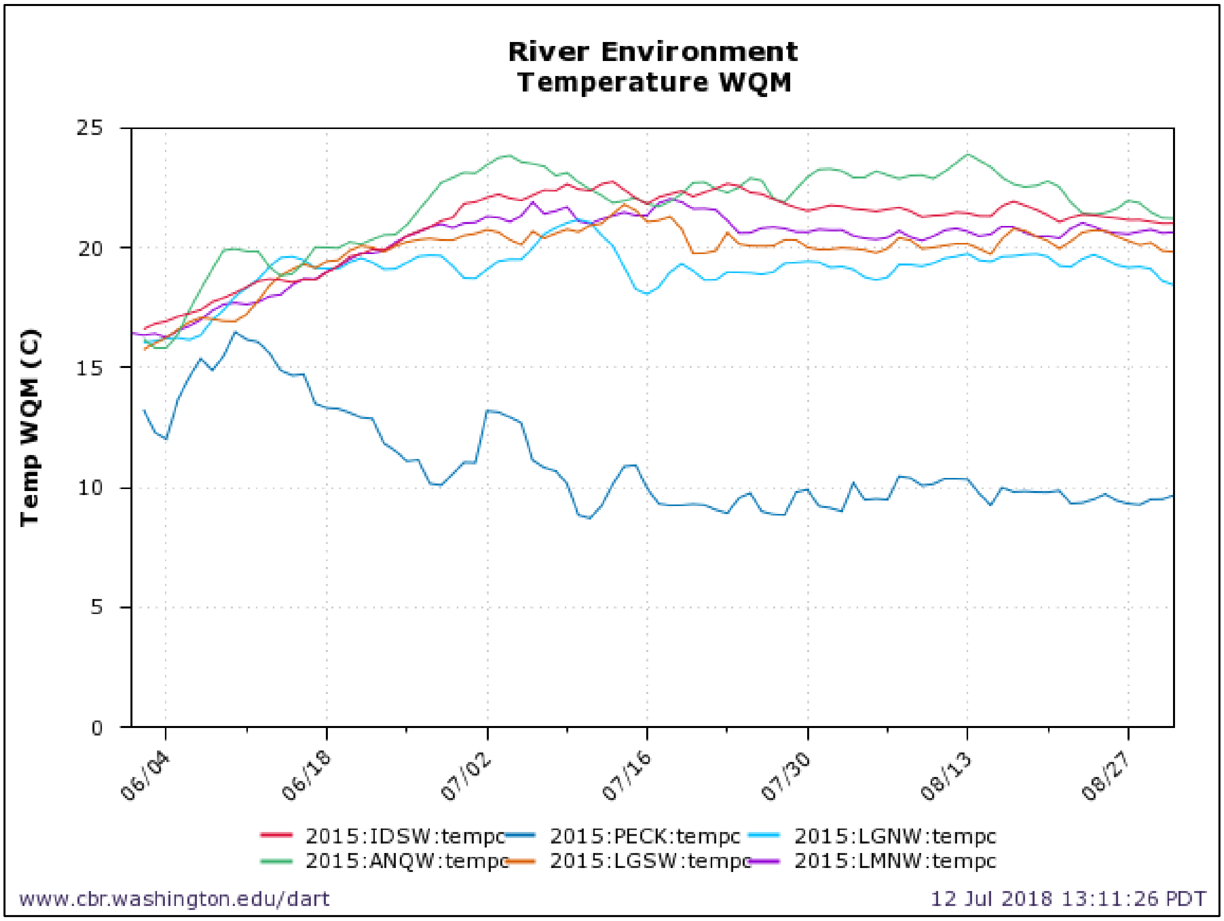


Figure 2.12-5. Temperature conditions at the Anatone Gage on the Snake River upstream of Lower Granite Reservoir (green, top line); the Peck Gage on the lower Clearwater River (dark blue, bottom line); and the tailrace temperatures at Lower Granite (light blue), Little Goose (orange), Lower Monumental (purple), and Ice Harbor (red) Dams during the especially hot summer of 2015. WQM indicates that the data are from Dart's water quality monitor.

The EPA is working with federal and state agencies, tribes, and other stakeholders to develop water-quality improvement plans (total maximum daily loads) for temperature in the Columbia and lower Snake Rivers. As part of the 2015 biological opinion on EPA's approval of water-quality standards, including temperature (NMFS 2015a), EPA committed to work with federal, state, and tribal agencies to identify and protect thermal refugia and thermal diversity in the lower Columbia River and its tributaries. Using historical flows and environmental records for the 35-year period 1960–95, Perkins and Richmond (2001) compared water temperature records in the lower Snake River with and without the lower Snake River dams and found three notable differences between the current versus unimpounded river:

- Maximum summer water temperature has been slightly reduced;
- Water temperature variability has decreased; and
- Post impoundment water temperatures stay cooler longer into the spring and warmer later into the fall, a phenomenon termed thermal inertia.

These hydrosystem effects (influenced by the temperatures of tributary streams entering the Snake and Columbia Rivers both upstream of, within, and downstream of the mainstem dams) continue downstream and influence temperature conditions in the lower Columbia River. At a macro scale, water temperature affects salmonid distribution, behavior, and physiology (Groot and Margolis 1991); at a finer scale, temperature influences migration swim speed of salmonids (Salinger and Anderson 2006), timing of river entry (Peery et al. 2003), susceptibility to disease and predation (Groot and Margolis 1991), and, at temperature extremes, survival.

Exposure to elevated summer temperatures in the Columbia River, from its mouth to its confluence with the Snake River, is greatest for the earliest migrating adult Chinook salmon and the latest migrating subyearling Chinook smolts. In the past decade, the migration timing of juvenile SR fall Chinook salmon has shifted earlier in the year, closer to the historical migration timing, which reduces overall exposure to elevated temperature and warm-water predators and improves overall passage conditions and survival of migrating smolts (see Figure 2.12-5, above).

TDG levels also affect mainstem water quality and habitat. To facilitate the downstream movement of juvenile salmonids, state regulatory agencies issue criteria adjustments for TDG as measured in the forebay and tailrace (NMFS 1995b). Specifically, water that passes over the spillway at a mainstem dam can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). Historically, TDG supersaturation was a major contributor to juvenile salmon mortality; to reduce TDG supersaturation, the Corps installed spillway improvements, typically “flip lips,” at each mainstem dam except The Dalles Dam. Biological monitoring shows that the incidence of observable GBT symptoms in both migrating smolts and adults remains between 1–2 percent when TDG concentrations in the upper water column do not exceed 120 percent of saturation in CRS project tailraces. When those levels are exceeded, there is a corresponding increase in the incidence of signs of GBT symptoms. Fish migrating at depth avoid exposure to the higher TDG levels due to pressure compensation mechanisms (Weitkamp et al. 2003).[150] Under recent operations (2008–18),[151] exposure to excessive high (>120 percent) TDG levels has been restricted to lack of market or lack of turbine capacity spill events. In years when these events have occurred, they have most often taken place between mid-May and mid-June, when outmigrating subyearling fall Chinook salmon smolts are moving through the system, but may occasionally occur in other months when juveniles are overwintering in the lower Snake River reservoirs. Thus, fall Chinook salmon smolts can be exposed to elevated TDG concentrations, and about 1-2 percent may exhibit symptoms of GBT.

[150] Roughly, for each meter below the surface an aquatic organism is located, there is a corresponding reduction in the effective TDG the organism experiences of about 10 percent. Thus, if TDG levels are at 120 percent, an organism two meters below the surface would effectively experience 100 percent TDG saturation.
[151] In 2018, consistent with a court order, the Action Agencies operated the eight mainstem dams to target spill levels to meet, but not exceed, the 120 percent tailrace/115 percent forebay TDG levels, excepting where erosion issues (Bonneville Dam) or adult passage issues (Little Goose Dam) might require limits.

The most extensive urban development in the lower Columbia River subbasin has occurred in the Portland/Vancouver area. Common water-quality issues both in areas with urban development and rural residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff (LCREP 2007). Similar effects are likely to be proportionally associated with smaller urban areas as well (e.g., Lewiston, Idaho; Tri-Cities, Washington; The Dalles and Hood River, Oregon). While it is not clear what the magnitude of effects are to juvenile or adult fall Chinook salmon from exposure to these factors (see previous discussion relating to chemical contaminants), they are likely to have negative effects on fitness and survival.

Sediment Transport

The series of dams and reservoirs have also blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is only one-third of nineteenth-century levels (Simenstad et al. 1982 and 1990; Sherwood et al. 1990; Weitkamp 1994; NRC 1996; NMFS 2008a). Similarly, Bottom et al. (2005) estimated that the delivery of suspended particulate matter to the lower river and estuary has been reduced by about 40 percent (as measured at Vancouver, Washington), and fine sediment transport reduced by 50 percent or more. These estimates reflect the combined total of all activities throughout the Columbia River basin on sediment transport. Similar reductions would be expected throughout the mainstem portion of the action area, though the effect might be less pronounced in the lower Clearwater River,[152] where only Dworshak Dam on the North Fork Clearwater would be expected to substantially interfere with sediment transport rates. The overall reduction in sediment has altered the development of habitat along the margins of the river.

Industrial harbor and port development are also significant influences on the lower Snake and lower Columbia Rivers (Bottom et al. 2005; Fresh et al. 2005; NMFS 2013a). Since 1878, the Army Corps of Engineers has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the Willamette River as a navigation channel. Originally dredged to a 20-foot minimum depth, the federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The navigation channel supports many ports on both sides of the river, resulting in several thousand commercial ships traversing the river every year. The dredging, along with diking, draining, and fill material placed in wetlands and shallow habitat, also disconnects the river from its floodplain, resulting in the loss of shallow-water rearing habitat and the ecosystem functions that floodplains provide (e.g., supply of prey, refuge from high flows, temperature refugia, etc.; Bottom et al. 2005).

Formal consultation for the Channel Maintenance Dredging in the Lower Snake and Clearwater Rivers (WCR-2014-1723) was completed on November 14, 2014. Recent discussions with the Corps indicate that all aspects of the consultation, both in the proposed action and the accompanying terms and conditions within the NMFS biological opinion, were completed by Corps and its permittees (personal communication, B. Tice, Corps).

[152] Most of the Clearwater (excepting the North Fork) is dam-free.

Material was dredged from four sites along the Snake and Clearwater Rivers: (1) Downstream navigation lock of Ice Harbor Dam (Snake RM 9.5); (2) the federal navigation channel in the Snake and Clearwater Rivers confluence area (Snake RM 138 to Clearwater RM 2.0); (3) the berthing area for the Port of Clarkston, Washington (Snake RM 137.9 and 139); and (4) the berthing area for the Port of Lewiston, Idaho (Clearwater River, RM 1–1.5). The Corps also issued regulatory permits for dredging at commercial ports and berths operated by local port districts or private companies in Clarkston, Washington and Lewiston, Idaho. Most of these nonfederal navigation areas consisted of arterial channels leading from the main federal navigation channel to the port or berth, as well as those areas at the port or berth used for loading, unloading, mooring, or turning around. The dredged material was disposed of in-river as fill to construct a shallow-water bench for juvenile fish habitat at Knoxway Bench (RM 116) immediately upstream of Knoxway Canyon.

In 2005–06, the Corps deposited approximately 420,000 cubic yards of sand and silt at the upstream end of the Knoxway Bench site. The Corps then shaped the dredged material to create an estimated 3.7-acre shallow-water habitat bench that could be used by juvenile salmonids, particularly juvenile SR fall Chinook salmon. Post project monitoring for the 2006 effort by the Corps confirmed juvenile salmonids have been and are using the site for resting and rearing. With the dredging conducted under the 2014 biological opinion, the materials were deposited downstream from the bench created in 2006, and extended riverward of the existing shoreline. The new material formed a uniform, gently sloping shallow-water bench along roughly 2,500 linear feet of shoreline. This feature added approximately 11.4 acres of shallow-water habitat with features preferred for foraging by juvenile salmonids, particularly fall Chinook salmon.

Adult Migration/Survival

Adults must migrate from the ocean, upstream through the estuary, and pass eight mainstem dams and reservoirs to reach spawning areas upstream of Lower Granite Dam. Factors that affect the survival rates of migrating adults include harvest, adult and juvenile dam passage, straying, predation, and temperature and flow conditions that increase the energetic demands of migrating fish (NMFS 2008b).

PIT-tag detectors placed near the exits of ladders at the mainstem dams provide a unique ability to monitor the survival of adult migrants that were tagged as juveniles. Starting with the number of adults detected at Bonneville Dam, minimum survival estimates can be derived to detectors at upstream dams. Termed "conversion rates," these survival estimates can be adjusted for reported harvest and the expected rate of straying in an unmanaged system. Figure 2.12-6 depicts estimated conversion rates from Bonneville to Lower Granite Dams (seven reservoirs and seven dams) during 2008–16, years that include recent hydropower operations and harvest rates within the Bonneville to McNary "zone 6 fisheries" and in the lower Snake River. The nine-year average survival is 90.8 percent (range of 80.2–100.9 percent) from Bonneville to Lower

Granite.153 This number includes the losses associated with the hydropower system, as well as any losses in this reach that result from elevated temperatures or from injuries from pinniped attacks downstream of Bonneville Dam. Expressed on a "per project" basis (1/7th root of 90.8 percent), about 98.6 percent (range of 100.0–98.6 percent) of adult SR fall Chinook salmon are surviving passage through each project (dam and its reservoir). These relatively high survival rates indicate that upstream passage conditions are not substantially impaired for adult SR fall Chinook salmon.

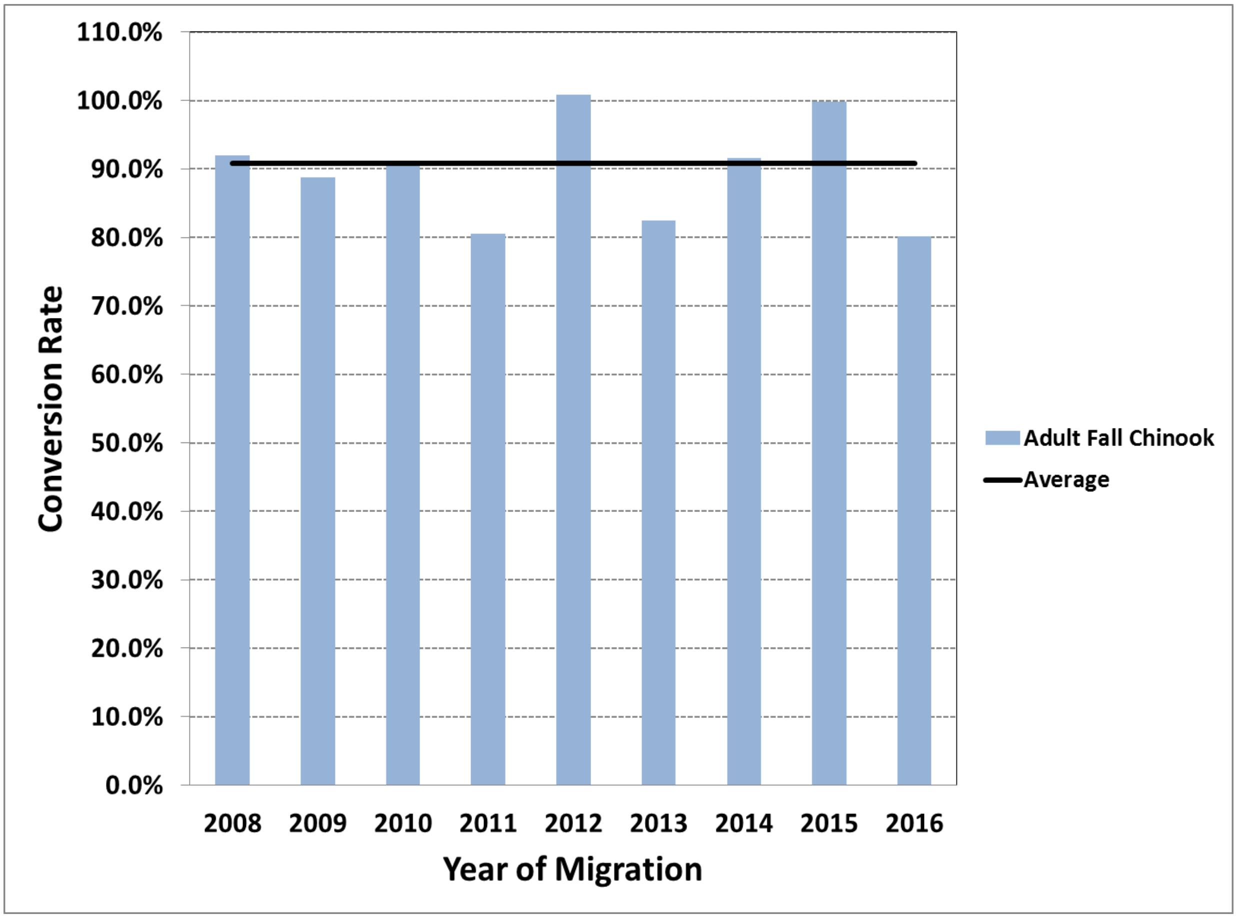


Figure 2.12-6. Conversion rate estimates for known-origin PIT-tagged adult Snake River fall Chinook salmon (natural- and hatchery-origin combined) from Bonneville to Lower Granite Dams, 2008–16. Source: NMFS, using data from PITAGIS, as described in NMFS (2008b).

Juvenile Migration/Survival

The mainstem dams and reservoirs continue to substantially alter the mainstem migration corridor habitat. The reservoirs have increased the cross-sectional area of the river, reducing water velocity, altering the food web, and creating habitat for native and nonnative species which are predators, competitors, or food sources for rearing fall Chinook salmon smolts. The travel

[153] Conversion rates close to, or higher than, 100 percent (2012 and 2015) are possible if estimates of harvest rates (or natural rates of straying) are higher than what actually occurred in a given year (biased high). Conversely, if harvest rates are underestimated, the resulting conversion rate estimates would be biased low.

times of migrating smolts are increased, and some juveniles are injured or killed as they pass through the dams (turbines, bypass systems, spill bays, or surface passage routes; NMFS 2008b, 2017d).

However, overall passage conditions and resulting juvenile survival rates in the migration corridor have improved substantially since 1991, when the species was listed. This is most likely a result of (1) a recent shift of subyearling fall Chinook salmon smolts to an earlier migration pattern which more closely approximates the historical migration timing (Mains and Smith 1964; Connor et al. 2013; NMFS 2017d), (2) improved structures and operations (24-hour spill, surface passage routes, improved juvenile bypass systems, etc.), and (3) continuation of predator management programs at the eight mainstem dams and within the reservoirs. The average survival of hatchery-origin subyearling fall Chinook salmon migrating from Lower Granite to McNary Dams has improved from 53.2 percent during 1992–2005 to 70.2 percent during 2008–17, after the Action Agencies instituted 24-hour spill operations, constructed surface passage routes, and improved juvenile bypass systems at Little Goose, Lower Monumental, and McNary Dams (Figure 2.12-7). Although comparable data are not available, improvements made to John Day, The Dalles, and Bonneville Dams likely improved passage conditions and juvenile survival to a similar extent.

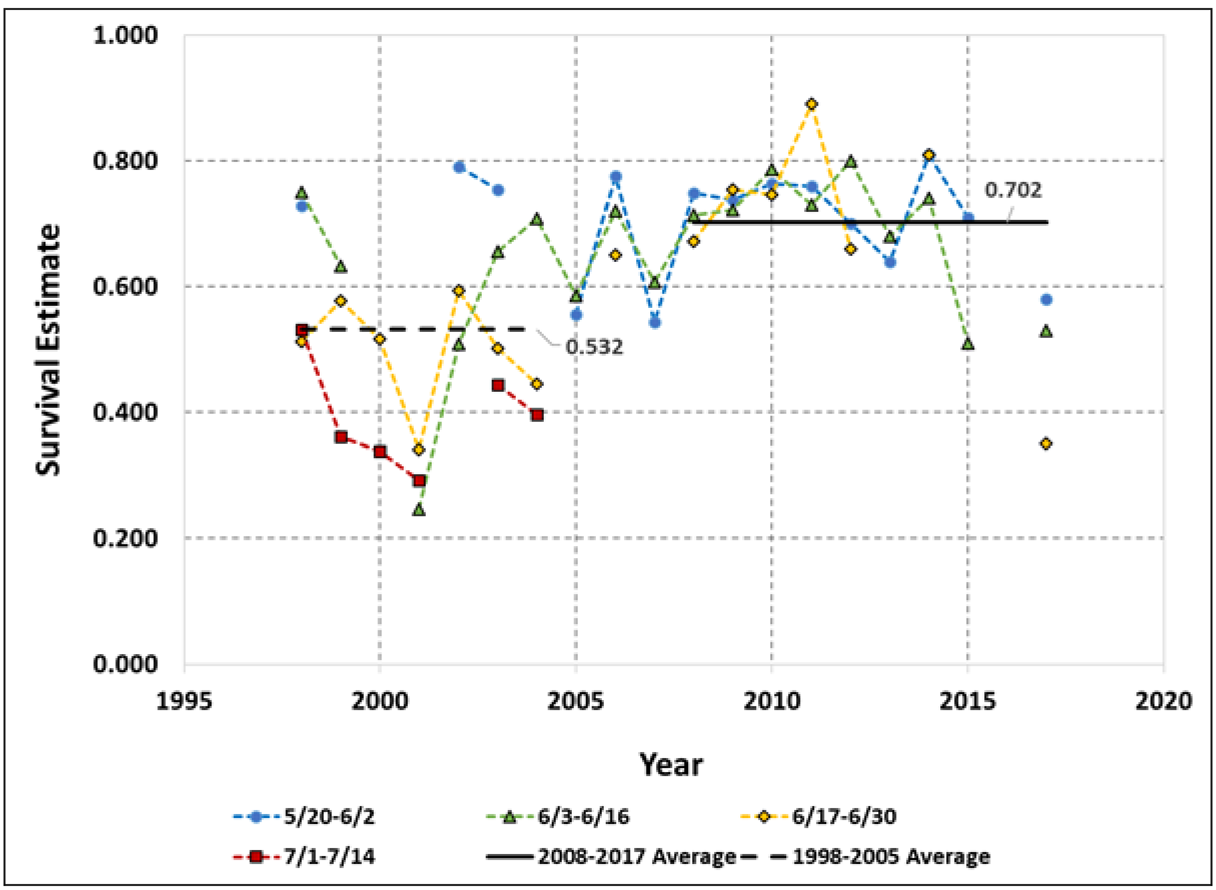


Figure 2.12-7. Survival estimates for hatchery Snake River fall Chinook salmon from Lower Granite to McNary Dams (1998–2017). Source: Fish Passage Center.

In contrast, juveniles from the cooler lower Clearwater River spawning and rearing area often do not migrate as subyearlings, but overwinter in lower Snake River reservoirs before resuming their active migration as yearlings the following spring. While we are unable to estimate the percent of each cohort that uses this life history strategy, the SARs back to Lower Granite Dam of yearling fall Chinook salmon migrants are relatively high, and substantial numbers of returning adults have been linked to this life history strategy (NMFS 2017d). Thus, this life history strategy appears to be relatively stable, productive, and is contributing to the overall abundance and productivity of the lower Clearwater River major spawning area and therefore to the spatial structure and diversity of the population.

Transportation

Turbine intake screens, part of the juvenile bypass systems,[154] divert juvenile fall Chinook salmon away from turbine units and into a system of channels and flumes before delivering them to either the tailrace below the dam (bypassed) or, in the case of Lower Granite, Little Goose, and Lower Monumental Dams (collectively referred to as the collector projects)[155], into raceways where they can be loaded onto barges and taken below Bonneville Dam (transported) where they are released to continue their migration to the ocean.

Although direct survival rates of transported fish are high (at least 98 percent), there are several negative, or potentially negative, effects associated with transporting juveniles from the lower Snake River. Upon their return as adults, fish transported as juveniles have been demonstrated to stray from their natal spawning areas at higher rates than their counterparts that migrated in-river (NMFS 2008a; Bond et al. 2017; Gosselin et al. 2018). This is likely because the speed at which the barges move downstream does not give juveniles sufficient opportunity to imprint on the scent of the rivers they pass, meaning that as adults they must spend more time and energy searching, and finally spawn before reaching their natal streams. In addition, increased travel times are likely to result in increased exposure to the higher (relative to May and June) late-summer temperatures and increased exposure to lower Columbia River fisheries.

For SR fall Chinook salmon, the average conversion rate (reach survival, adjusted for reported harvest and the expected rate of straying in an unmanaged system) of adult fish transported as juveniles is about eight percent lower than for adults that migrated in-river as juveniles. Conversion rates capture all of the direct and indirect effects of transportation on adult passage between Bonneville and Lower Granite Dams. It is not known whether transported fish wander between major spawning areas at higher rates than in-river migrating adults upstream of Lower Granite Dam. This is likely to have a small, or negligible, negative effect on the diversity of SR fall Chinook salmon, given that the strays all make up part of a single, large population and there

[154] Almost all the powerhouses at the eight mainstem dams have juvenile bypass systems that divert downstream migrants away from the turbine units. Exceptions are The Dalles Dam and Powerhouse 1 at Bonneville Dam.
[155] The Corps' ended the transportation of juveniles from McNary Dam during summer in 2014 following NMFS' guidance in the 2014 Supplemental FCRPS biological opinion.

is a relatively high fraction (about 75 percent) of hatchery-produced fish presently spawning in each of the major spawning areas.

Additionally, handling and transport of juveniles at dams results in their being held at much higher densities than observed in the wild, increasing the risk of disease transmission. Also, because it takes in-river migrating fish several weeks (or months, for those adopting the yearling life history strategy) to travel from the lower Snake River to Bonneville Dam, and they are growing during that period, in-river migrants are larger and enter the Columbia River estuary and plume later in time than transported fish. Smaller size at ocean entry is associated with reduced survival (NMFS 2014). Finally, the ability to detect and respond appropriately to pressure waves may be impaired in transported fish due to the relatively loud conditions within the barges. This could also impair their ability to avoid predators, particularly in the days soon after release. These factors, in some combination, likely contribute to the sometimes observed differential (higher) mortality for transported fish after being released from barges compared to in-river migrating smolts as evidenced by adult returns to Bonneville Dam (NMFS 2008a).

Before 2005, summer spill was not provided at the three Snake River collector projects in order to maximize the proportion of subyearling Chinook salmon collected and transported. Since 2005, juvenile fish passage spill has been provided at each of the mainstem dams (including the collector projects) for 24 hours each day during the spring and summer periods. DeHart (2012) estimated that from 2008–11, an average of 52.8 percent of subyearling fall Chinook salmon were collected and transported.

Improved structures and summer spill operations[156] improved in-river passage conditions and juvenile survival, as expected, but it was not clear if these improvements would offset the increased direct survival of transported fish. This created a management dilemma: Would it be better to transport fish or return them back to the river to continue their migration? Which group would return from the ocean at higher rates? How would these impacts compare given conditions experienced across the summer migration period?

Smith et al. (2018) reported on the results of a study designed to specifically assess the response of (hatchery-origin) SR fall Chinook salmon to the two alternate management strategies:

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[156] All eight dams have been fitted with gas-abatement structures to minimize total dissolved gas from spill and are operated to voluntarily spill water for juvenile fish passage beginning April 3 at the lower Snake River dams and April 10 at the lower Columbia River dams through August 31. Surface passage routes are operated at seven of the dams (but were shown to negatively affect survival for summer migrants at McNary Dam). Juvenile bypass systems designed to screen fish away from turbine units and deliver them to the tailrace are operated at seven of the eight dams (The Dalles Dam and Powerhouse 1 at Bonneville Dam do not have screened bypass systems). At Powerhouse 1 at Bonneville Dam and at Ice Harbor Dam, turbine units designed to minimize impacts to fish (direct strike, cavitation, etc.) were installed to improve survival rates. The turbine units at all of the other dams (and at Powerhouse 2 at Bonneville Dam) are operated within 1 percent of maximum efficiency, which is generally considered to be the safest operation for passing fish. These actions, taken together with flow-management operations, have substantially reduced travel times and increased the survival of juvenile subyearling Chinook salmon migrants in the Lower Granite to McNary reach. Source: Fish Passage Center website; data downloaded 10 July 2018. Improvements at John Day, The Dalles, and Bonneville dams have likely had a similar positive effect on in-river survival through the lower Columbia River.

transport with spill versus bypass with spill. Three types of hatchery-reared fall Chinook salmon were used: (1) standard “production” subyearling fish; (2) standard “production” yearling fish, and (3) “surrogate” subyearlings produced to better represent naturally reared subyearling Chinook salmon. Juvenile fish were reared, PIT-tagged, and then released upstream of Lower Granite Dam during six outmigration years (2006, 2008–12). Detections of adults from these release groups back to Lower Granite Dam were used to estimate SARs.

For the surrogate subyearling Chinook salmon group, transported fish had higher return rates than bypassed fish. The average survival advantage was about 8.5 percent for fish released in the Snake River and 14.9 percent for those from the Clearwater River. For production subyearlings, transported fish had lower return rates than bypassed fish. The average survival disadvantage was about 6.3 percent for fish released in the Snake River and 3.5 percent for those released in the Clearwater River. These results are associated with patterns in migration timing: production from the Snake River, then production from the Clearwater River, then surrogates from the Snake River, and finally, surrogates from the Clearwater River. Thus, later-migrating fish tended to derive greater benefit from the transport strategy and earlier-migrating fish tended to derive greater benefit from the bypass/in-river migration strategy.

Looking more closely at seasonal trends, Smith et al. (2018) found that for surrogate fish, the SARs of transported fish tended to exceed those of bypassed fish starting in the first or second week of July and continued to increase through August, peaking around September 1st. For production fish, the SARs of transported fish tended to exceed the SARs of bypassed fish by the third week of June in most years, with late-arriving fish making up only a small proportion of the passage totals. The authors recommended that the management strategy to maximize SARs for SR fall Chinook salmon in isolation (i.e., not considering potential effects on other Snake River DPSs that migrate at the same time) would bypass juveniles early in the season and transport them later in the season; they recommended July 1st as the best day to start transportation, weighting impacts to subyearling surrogate and production fish equally.

Assuming surrogate fish represent naturally produced fish, recent transport operations have likely negatively affected the direct and any delayed survival of juvenile SR fall Chinook salmon migrating during May to mid-June, have had smaller positive or negative effects (depending on the year) between mid-June and mid-to-late July, and have provided a substantial benefit from late July/early August–October as measured by adults returning to Lower Granite Dam.

2.12.2.2 Estuary Habitat

The estuary provides migratory habitat for SR fall Chinook salmon. Since the late 1800s, 68–70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening combined with flow regulation and other modifications (Kukulka and Jay 2003; Bottom et al. 2005; Marcoe and Pilson 2017). Disconnection of tidal wetlands and floodplains has eliminated much of the historical rearing habitat for subyearling Chinook salmon and reduced the production of wetland macrodetritus supporting salmonid food webs (Simenstad et al. 1990; Maier and Simenstad 2009), both in shallow water and for larger juveniles migrating in the mainstem (ERTG 2018).

Restoration actions in the estuary, such as those highlighted in the latest five-year review, have improved access and connectivity to floodplain habitat. From 2004 through 2017, the Action Agencies implemented 58 projects including dike and levee breaching or lowering, tide-gate removal, and tide-gate upgrades that reconnected 5,412 acres of historical tidal floodplain habitat to the mainstem. This represents a 2.5 percent net increase in the connectivity of habitats used extensively by subyearling Chinook salmon (Johnson et al. 2018). In addition, about 2,500 acres of functioning floodplain habitat were acquired for conservation.

Floodplain habitat restoration affects salmon performance directly (for fish that move onto the floodplain) and indirectly (for fish that stay in the mainstem). One direct benefit is that wetland food production supports foraging and growth within the wetland (Johnson et al. 2018). Prey items (primarily chironomid insects and corophiid amphipods; PNNL and NMFS 2018) produced within these wetlands are also exported into the mainstem, where they become available to salmon and steelhead migrating in these locations. Thus, while large subyearling and yearling fall Chinook salmon from the Snake River ESU may not directly enter a tidal wetland channel, they derive indirect benefits from wetland habitats. Improved opportunities for feeding on preferred prey that drift into the mainstem are likely to contribute to survival on ocean entry.

Most unclipped SR fall Chinook salmon (identified through genetic analysis) reach the estuary as subyearlings (Weitkamp 2018). Although these fish have been caught along the shoreline in the lower river (Roegner et al. 2012; Teel et al. 2014), they are rarely observed within the floodplain marshes (Kidd et al. 2018). This new information alters NMFS' understanding of habitats used by this species below Bonneville Dam; in past biological opinions (e.g., NMFS 2008a), subyearling fall Chinook salmon from the Snake River were assumed to use the tidal marsh habitat for extended rearing like other species with "ocean-type" life histories. Nonetheless, like other Chinook salmon sampled in the mainstem in 2016 and 2017, these fish had eaten chironomids (PNNL and NMFS 2018), a wetland-dependent group of insects. Floodplain reconnection projects have created additional opportunities for feeding on commonly consumed prey while moving through the migration corridor, and this is likely to contribute to survival at ocean entry.

Water quality in the estuary has also been degraded by human practices taking place both within the estuary and upstream. Water temperatures above the upper end of the range tolerated by juvenile salmon occur earlier and more often, and these exceedances are likely to increase with climate change (ISAB 2007). Exposure to toxic contaminants could also be affecting species viability; however, our current understanding of the effects on aquatic life impacts of many contaminants, alone or in combination with other chemicals (potential for synergistic or antagonistic effects), is incomplete.

From the estuary, juvenile salmonids enter the Columbia River plume, the zone where recently discharged freshwater interacts with surrounding ocean water (Horner-Devine et al. 2009).[157] The size, shape, volume, and depth of the plume are dynamic and are controlled by the amount of freshwater flowing out of the Columbia River, local winds, tides, and ocean currents (Hickey 1989; Jay and Smith 1990; Horner-Devine et al. 2009). The plume can extend northward to British Columbia or southward to California depending on outflow (e.g., snowpack and rate of melting) and the coastal wind regime (Jacobson et al. 2012). Only a portion of the extent of the plume is attributable to CRS operations, and this will vary with snowpack and the rate of runoff. In general, the survival of SR fall Chinook salmon is a result of bottom-up (food web-related) and top-down (predation) biological processes, which are controlled by different types of physical and chemical processes (climate, winds, stratification, current eddies, and large-scale circulation patterns). Miller et al. (2013) found that returns of unlisted UCR summer/fall Chinook salmon to Priest Rapids Dam were related to plume volume, but a similar relationship has not been reported for SR fall Chinook salmon.

2.12.2.3 Tributary Habitat

Tributary habitat conditions have been significantly degraded by an array of land uses including urbanization, agriculture, forest management, transportation networks, and some gravel mining. These land uses have blocked access to historically productive habitats, simplified stream and side channels, degraded floodplain connectivity and function, increased delivery of fine sediment to streams, and degraded riparian conditions (contributing to stream channel simplification, reduced bank stability, increased sediment load, and elevated water temperatures; NMFS 2013b; NWFSC 2015). In combination, the degraded conditions in these basins contribute, either directly or indirectly, to impaired habitat in the lower reaches of major tributaries (e.g., lower Clearwater River, lower Grande Ronde, Imnaha, Tucannon Rivers, etc.) where fall Chinook salmon spawn and rear.

Numerous tributary habitat protection and restoration efforts have been implemented in recent years through the efforts of local recovery planning groups, federal and state agencies, tribal governments, local governments, conservation groups, private landowners, and other entities. These efforts have led to some local improvements in tributary habitat conditions, focused primarily on upstream segments of basins used by spawning and rearing spring/summer Chinook salmon and steelhead. Some incremental benefit from these projects would be expected to translate to lower river reaches used by fall Chinook salmon (e.g., improved flows, reduced sediment, etc.). However, degraded habitat conditions, particularly with regard to channel complexity, floodplain connectivity, water quality, hydrologic patterns, and toxic contamination continue to impair the ability of habitat to support productive fish populations. Continued land development and habitat degradation, in combination with the potential effects of climate

[157] We know the hydrosystem reduces flows in the spring and increases the flows in the fall and winter. Changes in flows of the Columbia River alter the aerial extent and volume of the plume. We don't have any information on the biological significance of these physical changes.

change, may present a continuing strong negative influence into the foreseeable future (NWFSC 2015).

2.12.2.4 Hatcheries

Hatchery programs can affect naturally produced populations of salmon and steelhead in a variety of ways: competition and predation effects, disease effects, genetic effects, and broodstock collection and facility effects.

NMFS completed a consultation on the Snake River fall Chinook salmon hatchery programs in 2012 (NMFS 2012). At that time, we concluded that the pHOS, coupled with the presumed proportion of natural-origin fish in the broodstocks (pNOB), led to a PNI that was considerably lower than the 67 percent that would be recommended for a population of high conservation concern. Thus, this posed a fitness risk through hatchery-influenced selection. While recognizing these risks, we also considered that although, in theory, the presence of so many hatchery-origin fish on the spawning grounds should cause fitness to decline, natural production in the population was increasing. Given that the hatchery program was also increasing in size, it was possible that the increase in natural production was caused by spawning of an increasing number of hatchery-origin fish, but it could not be ruled out that this was a supplementation response. Based on this hypothesis and the relatively short number of generations the population had been subjected to hatchery influence, NMFS concluded that issuing an ESA Section 10 permit to continue operation of the programs through broodstock collection in 2017 (NMFS 2012), without attempting to reduce hatchery influence, posed low risk to the survival or recovery of the population and thus the SR fall Chinook salmon ESU.

The recent Proposed Action from the *U.S. v. Oregon* biological opinion (NMFS 2018a), as well as the site-specific Snake River fall Chinook salmon hatchery consultation in 2018 (NMFS 2018a), include the movement of the one million fall Chinook salmon that Idaho Power Company releases from the Hells Canyon reach into the Salmon River. Based on our current understanding of homing fidelity of SR fall Chinook salmon, the reprogramming of the Idaho Power Company releases should lessen the effects of the hatchery programs in the upper Snake River area (above the Salmon River) (NMFS 2017d). While this change should result in a substantial reduction in genetic risk relative to current conditions, it involves considerable uncertainty. However, it also potentially offers large benefits in terms of better understanding this salmon population, as well as providing critical information on the consequences of large-scale perturbations in hatchery/natural dynamics. In addition, the population is now being managed at a much higher PNI level than it was previously. Although the hatchery programs continue to pose risk, the level is considerably reduced from previous levels and at this point does not appear to pose a risk to the survival or recovery of SR fall Chinook salmon.

The SR fall Chinook salmon recovery plan (NMFS 2017d) outlines the following three potential recovery scenarios: (1) Achieve highly viable status for the extant Lower Snake River population and viable status for the currently extirpated Middle Snake River population; (2) Achieve highly viable status for Lower Snake River population; and (3) Achieve highly viable status for Lower

Snake River population with the creation of a Natural Production Emphasis Area (NPEA). The creation of an NPEA in (3) dealt with genetic risks to the population in an innovative way. An NPEA is essentially a region of greatly reduced hatchery influence relative to other spawning areas. Updated homing fidelity information from the *Snake River Fall Chinook Symposium* (USFWS 2017) informed the preliminary feasibility of the NPEA, and such a scenario may be possible under the Idaho Power Company's plan to move hatchery releases from Hells Canyon to the Salmon River. Even though these releases were relocated in an attempt to increase survival rates for that component of the program, an ancillary benefit may be an opportunity to evaluate the concept of an NPEA.

Hatchery production levels in the Snake River basin and the interior Columbia River basin are expected to continue at levels similar to those observed in recent years. The effects of these hatchery programs (to the extent they have affected the status of SR fall Chinook salmon through competition, predation, etc.) are expected to continue into the foreseeable future. Moving the release location of one million hatchery fall Chinook salmon from Hells Canyon Dam to the Salmon River basin is expected to improve the productivity (and potentially the diversity) of naturally produced fall Chinook in the upper Hells Canyon reach of the Snake River.

Overall hatchery production levels in the lower Columbia River are expected to decrease following issuance of a biological opinion on Mitchell Act-funded hatchery programs (NMFS 2017d). This should decrease effects of hatcheries (competition and predation effects and, potentially, disease effects) on SR fall Chinook smolts rearing in, or migrating through, the lower Columbia River and estuary.

2.12.2.5 Harvest

In February 2018, NMFS signed the 2018–27 *U.S. v Oregon* Management Agreement, which provides the current framework for managing fisheries and hatchery programs in much of the Columbia River Basin. The Management Agreement accomplishes two primary objectives. First, it implements harvest policies that the parties[158] have agreed should govern the amount of harvest. Second, it incorporates hatchery programs that provide harvest opportunities and that are important to the conservation of salmon and steelhead runs above Bonneville Dam. NMFS' decision to sign the Management Agreement took into account the recently completed Final EIS and the associated biological opinion (NMFS 2018a). As a result, fisheries affecting SR fall Chinook salmon in the 2018–27 *U.S. v. Oregon* Management Agreement are aligned with the recovery plan strategies in the recovery plan (NMFS 2017d).

SR fall-run Chinook salmon are caught in ocean fisheries off the coasts of Oregon, Washington, and British Columbia. In fall fisheries, they are caught in the Columbia River mainstem and tributaries. Since 2012, they have been managed subject to an abundance rate schedule for a total

[158] The Nez Perce, Umatilla, Warm Springs, Yakama, and Shoshone-Bannock Tribes; the states of Washington, Idaho, and Oregon; and NMFS, the U.S. Fish and Wildlife Service (USFWS), and the Bureau of Indian Affairs (BIA) are signatories of the Management Agreement.

exploitation rate that ranges from 30 to 41 percent.[159] Recent exploitation rates have been highly variable, but have averaged 37.2 percent since 2008. Total exploitation rates have ranged between about 40 and 50 percent since the early 1990s (see Section 2.12.1).

2.12.2.6 Predation

A variety of bird and fish predators consume juvenile SR fall Chinook salmon on their migration from tributary rearing areas to the ocean. Pinnipeds eat returning adults in the estuary, including the tailrace of Bonneville Dam. Predation in the estuary and in the migration corridor, and management measures to reduce the effects of predation, are discussed below.

2.12.2.6.1 Predation in the Lower Columbia River Estuary

Avian Predators

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, are having a significant impact on the survival of juvenile salmonids (including SR fall Chinook salmon) in the Columbia River. Caspian terns on Rice Island, an artificial dredged-material disposal island in the estuary, consumed about 5.4-14.2 million juveniles per year in 1997 and 1998, or 5-15 percent of all the smolts reaching the estuary (Roby et al. 2017). Efforts began in 1999 to relocate the tern colony 13 miles closer to the ocean at East Sand Island where the tern diet would diversify to include marine forage fish. During 2001-15, estimated consumption by terns on East Sand Island averaged 5.1 million smolts per year, about a 59 percent reduction compared to when the colony was on Rice Island. Management efforts are ongoing to further reduce salmonid consumption by terns in the lower Columbia River and similar efforts are in progress to reduce the nesting population of double-crested cormorants in the estuary.

Based on PIT-tag recoveries at East Sand Island, average annual tern and cormorant predation rates for this ESU were about 2.5 and 3.0 percent, respectively, before efforts to manage the size of these colonies (Evans et al. 2018a). The Corps has been implementing the Caspian Tern and Double-crested Cormorant Management Plans, but, in terms of effectiveness, has seen mixed results due to the dispersal of both terns and cormorants to other locations within the estuary. Average predation rates on SR fall Chinook salmon have decreased to 0.8 percent for terns nesting on East Sand Island, but in 2017 this improvement was offset to some unknown degree by terns roosting farther upstream on Rice Island (Evans et al. 2018a). Due to failures of the cormorant colony in 2016 and 2017, there are no estimates of predation rates since management of that colony began (Appendix C). substantial numbers of cormorants have relocated to the Astoria-Megler Bridge (preliminary report of 1,737 in 2018) and hundreds more are observed on the Longview Bridge, navigation aids, and transmission towers in the lower river (Anchor QEA et al. 2017). Smolts may constitute a larger proportion of the diet of cormorants nesting at these sites than if the birds were foraging from East Sand Island. Thus, the success of the East Sand

[159] Exploitation rate is the proportion of the total return of adult salmon in a given year that die as a result of fishing activity.

Island tern and cormorant management plans at meeting their underlying goals of reducing salmonid predation is uncertain at this time.

An important question in predator management is whether mortality due to predation is an additive or compensatory source of mortality. Most importantly, do reductions in smolt predation rates by Caspian terns or double-crested cormorants result in higher adult returns because avian predation adds to the other sources of smolt mortality or are the smolts eaten by birds destined to die before returning as adults regardless of the level of predation? The latter case could occur because avian predation could be compensated for by sources of mortality in the ocean phase of the life cycle so that adult returns are unchanged. Haeseker (2015) and Evans et al. (2018b) have begun modeling the degree to which double-crested cormorant and Caspian tern predation, respectively, are additive versus compensatory sources of mortality.

Given the magnitude of bird predation on juvenile salmon observed in the Columbia Basin, and that smolts eaten by birds in the lower river have survived hydrosystem passage, it is likely that some of them could otherwise have survived to adulthood. Therefore, even if avian predation is partially compensatory, we expect that limiting the size of these tern and cormorant colonies will contribute to increased SARs for SR fall Chinook salmon.

Pinniped Predators

Marine mammal predators of salmon have increased considerably along the northwest United States coast since the MMPA was enacted in 1972 (Carretta et al. 2013; Lakke et al. 2018). CSLs, SSLs, and harbor seals consume adult Chinook salmon from the mouth of the Columbia River and tributaries up to Bonneville Dam. A small number of California sea lions have also been observed in Bonneville Reservoir in recent years. The ODFW has been counting the number of individual California sea lion hauling out at the East Mooring Basin in Astoria, Oregon, since 1997. Pinniped counts at the mooring basin during September and October, when Snake River fall Chinook salmon adults are migrating, have increased from an average of 269 from 2008–14 to an average of 914 in 2015 and 2016 (Table 2.12-3). Rub et al. (2018) found strong evidence that the recent increases in Chinook salmon loss estimates were a function of the large increase in pinnipeds in the Columbia River.

Table 2.12-3. Maximum monthly counts of California sea lions at Astoria, Oregon, East Mooring Basin (Brian Wright 2018).

Year	January	February	March	April	May	June	July	August	September	October	November	December
2008	40	56	67	126	162	46	6	191	213	204	273	157
2009	27	42	84	118	173	45	38	346	376	241	89	84
2010	58	93	136	229	216	157	29	316	356	265	98	54
2011	19	42	77	155	242	126	11	302	246	85	159	106
2012	20	27	82	240	201	92	19	212	187	147	91	21
2013	37	149	595	739	722	153	8	368	377	208	182	100
2014	237	586	1420	1295	793	90	32	423	492	369	94	126
2015	260	1564	2340	2056	1234	623	37	394	1318	459	84	208
2016	788	2144	3834	1212	1077	620	3	291	1004	878	235	246
2017	1498	2345	808	1131	1204	573						

Fish Predators

The native northern pikeminnow is a significant predators of juvenile salmonids in the Columbia River (reviewed in ISAB 2015). Before the start of the NPMP this species was estimated to eat about 8 percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River (including the hydrosystem reach) each year. Williams et al. (2017) compared current estimates of northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. The Sport Reward Fishery removed an average of 188,636 piscivorous pikeminnow (>228 mm fork length) per year during 2013-17 (Williams 2013, 2014; Williams et al. 2015, 2016, 2017).

The removal of the larger, piscivorous individuals from northern pikeminnow populations will result in a sustained survival improvement for migrating juvenile Chinook salmon only if it is not offset by a compensatory response by the remaining northern pikeminnow or other piscivorous fishes such as walleye or smallmouth bass. Signs of a compensatory response can include increased numbers of other predators, improved condition factors, or diet shifts. Williams et al. (2017) did not observe increases in numbers of pikeminnow, but did report an increasing trend in condition factor. This could be an intra-specific compensatory mechanism or just a response to beneficial environmental conditions. Similarly, Williams et al. (2017) documented increased numbers of smallmouth bass in parts of the lower Columbia River, which could be related to the NPMP or could be due to factors such as alterations in other parts of the food web or environmental conditions such as warmer temperature that affect this species' consumption rates. Williams et al. (2017) concluded that given these analytical constraints, data collected during 2017 provided ambiguous indicators of a compensatory response from the piscivorous fish community. Given the numbers of fish, bird, and marine mammal predators in the Columbia River and the ocean, we do not expect that all of the Chinook that are "saved" from predation by pikeminnows survive to adulthood. However, a 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity of Chinook salmon populations, including SR fall Chinook salmon.

An average of 27 adult, 15 jack, and 67 juvenile Chinook salmon per year were killed and/or handled in the Sport Reward Fishery, system-wide (i.e., in the lower Columbia River and the hydrosystem reach), during 2013-17 (Williams 2013, 2014; Williams et al. 2015, 2016, 2017). Although it was not practical for the field crews to identify these fish to ESU, we assume that some were SR fall Chinook salmon.

Non-native fishes such as walleye, smallmouth bass, and channel catfish are present in the slower moving off-channel habitats below Bonneville Dam, but yearling and subyearling SR fall Chinook salmon mostly stay in the mainstem migration channel and are less likely to encounter large numbers of these predators than subyearlings from the LCR Chinook salmon ESU, for example. The Oregon and Washington Departments of Fish and Wildlife have removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids.

2.12.2.6.2 Predation in the Hydrosystem Reach

Avian Predators

SR fall Chinook salmon are also vulnerable to predation by terns nesting in the interior Columbia plateau, including colonies on islands in McNary Reservoir, in the Hanford Reach, and in Potholes Reservoir. Smolts come within foraging range of other nesting sites on the plateau (principally the Blalock Islands in John Day Reservoir) as they continue downstream. The objective of the IAPMP (USACE 2014) is to reduce predation rates to less than 2 percent per listed ESU/DPS per tern colony per year. The primary management activities have been to keep terns from nesting on Goose Island in Potholes Reservoir (managed by Reclamation) and on Crescent Island in McNary Reservoir (managed by the Corps). Passive dissuasion, hazing, and revegetation have prevented terns from nesting on Crescent Island since 2015, and similar efforts are in progress at Goose Island. However, the number nesting at the Blalock Islands in John Day Reservoir was ten times higher in 2015 than the year before, and resightings of colored leg-banded terns indicated that large numbers had moved there from Crescent Island. Terns also came to the interior plateau from East Sand Island in the estuary and from alternative Corps-constructed colony sites in southeastern Oregon and northeastern California when those areas experienced severe drought (Roby et al. 2017). Nonetheless, the numbers of pairs of Caspian terns nesting on the Columbia plateau in 2017 represented a 23 percent drop from the pre-management period, and predation rates by terns for SR fall Chinook salmon at sites on the Columbia plateau were below 2 percent in 2015–16 at each of these nesting colonies (Appendix C).

Gull predation was not considered in the IAPMP and there are no regional plans to manage these colonies. Predation rates on smolts from this ESU were less than 2.0 percent per colony during 2015–16 except for the colony on Miller Rock Island in The Dalles Reservoir (up to 2.6 percent; Roby et al. 2016, 2017).

Snake River fall Chinook salmon survival is affected in the mainstem by avian predators that inhabit the dams and reservoirs. The 2008 FCRPS biological opinion required that the Action

Agencies implement avian predation control measures to increase survival of juvenile salmonids in the Lower Snake and Columbia Rivers by implementing and improving avian deterrent programs at all eight CRS dams. The intent of the 2008 FCRPS biological opinion was to have effective monitoring, hazing, and deterrents at each project to reduce predation and improve survival of juvenile salmonids. All CRS projects have been implementing avian control measures at the dams and are currently using several strategies that have proven to be effective at meeting this objective, including: avian arrays in tailrace areas, spike strips, outfall water sprinklers, dam-based hazing with pyrotechnics, propane cannons, and limited lethal take. Because of these efforts, avian predation on juvenile salmon and steelhead at the dams has been reduced since implementation began (Zorich et al. 2012).

An important question in predator management is whether mortality due to predation is an additive or compensatory source of mortality. Most importantly, do reductions in smolt predation rates by Caspian terns or double-crested cormorants result in higher adult returns because avian predation adds to the other sources of smolt mortality or are the smolts eaten by birds destined to die before returning as adults regardless of the level of predation? The latter case could occur because avian predation could be compensated for by sources of mortality in the ocean phase of the life cycle so that adult returns are unchanged. Haeseker (2015) and Evans et al. (2018b) have begun modeling the degree to which double-crested cormorant and Caspian tern predation, respectively, are additive versus compensatory sources of mortality. Given the magnitude of bird predation on smolts observed in the Columbia Basin, it is likely that some of the smolts consumed by birds could otherwise have survived to adulthood. Therefore, even if avian predation is partially compensatory, we expect that limiting the size of these tern and cormorant colonies will contribute to increased SARs for SR fall Chinook salmon.

Pinniped Predators

Within the Columbia River, adult salmonid losses due to pinniped predation are greatest directly downstream of Bonneville Dam (Appendix B). The dam provides a predation advantage, as fish congregate in search of ladder entrances; this can concentrate fish, making them more vulnerable to predation (Stansell 2004). Biologists have been estimating consumption by pinnipeds directly below Bonneville Dam since 2002 (Tidwell et al. 2017), and they began monitoring predation in the fall and winter months in 2017 in response to recent increases in SSL presence (Figure 2.12-8), especially outside of the traditional spring monitoring period. Between 21 July and 31 December 2017, Tidwell et al. (2018) documented an average of 14.5 SSLs per day at Bonneville Dam (Table 2.12-4). Based on predation observation during these periods, they estimate pinnipeds consumed 0.7 percent of the fall Chinook salmon run (Table 2.12-5; Tidwell et al. 2018); this serves as a reasonable estimate for the percentage of SR fall Chinook salmon consumed directly below Bonneville Dam. A small number of California sea lions have also been observed in Bonneville Reservoir in recent years

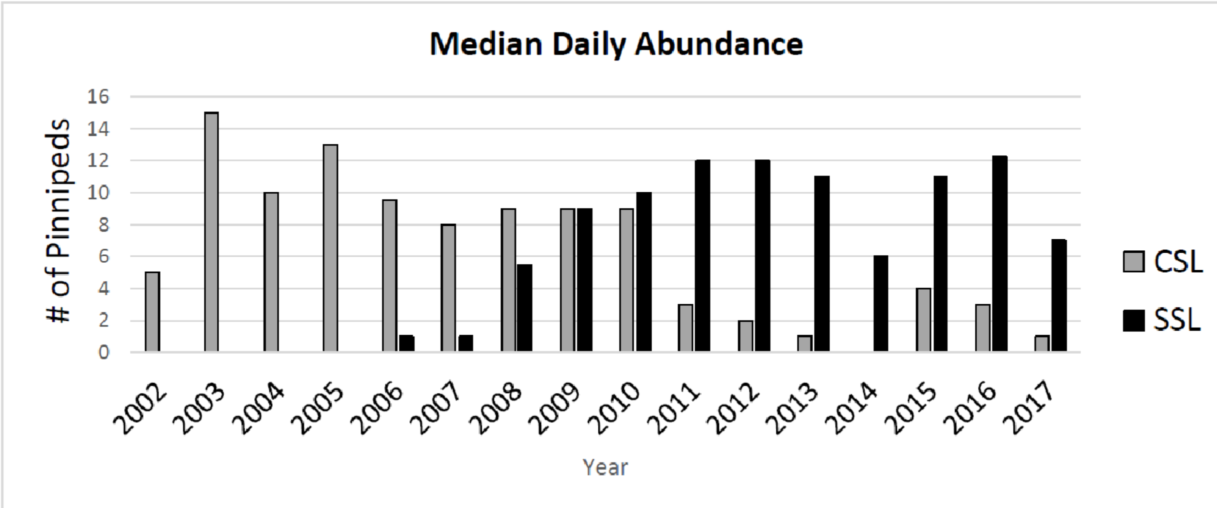

Figure 2.12-8. Annual median daily abundance of Steller sea lions (SSL) and California sea lions (CSL) at Bonneville Dam between 1 January and 2 June from 2002 to 2017.

Table 2.12-4. Average daily combined pinniped presence by month at Bonneville Dam.

	Pinniped Abundance at Bonneville Dam						
Month	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
August	0.0	0.0	0.0	1.0	1.9	5.2	10.8
September	0.0	0.0	1.5	6.8	16.6	30.7	13.2
October	2.4	2.6	13.3	11.7	22.5	26.6	14.8
November	4.9	2.8	15.9	16.8	22.3	18.9	18.5
December	7.0	4.1	10.2	9.2	16.1	16.4	16.4

Table 2.12-5. Adjusted consumption estimates on adult salmonids (including adults and jacks) and white sturgeon by 299 California and Steller sea lions at Bonneville Dam between 30 August and 31 December.

	Adjusted Salmonid Consumption Estimates	Range of Estimate	Total Salmonid Passage at Washington Shore	%Total Passage Consumed	Salmonid Passage at Washington Shore during Observation Period	% Observed Passage Consumed
Chinook	1,433	1,075-1,797	204,707	0.70%	54,371	2.63%
Coho	1,455	1,119-1,787	49,630	2.93%	11,896	12.23%
Steelhead	475	229-695	26,169	1.82%	7,967	5.96%
Sturgeon	999	739-1237	N/A	N/A	N/A	N/A
All salmon	3363	340-3699	280,517	1.19%	74,262	4.53%

Fish Predators

Native northern pikeminnow are significant predators of juvenile salmonids in the hydrosystem reach, followed by non-native smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011, 2015). In addition to the Sport Reward Fishery in the lower Columbia River estuary and throughout the hydrosystem reach, the Action Agencies conduct a Dam Angling Program to remove large pikeminnow from the tailraces of The Dalles and John Day Dams. Angling crews removed an average of 5,913 northern pikeminnow from these two projects per year during 2013-2017 (Williams 2013, 2014; Williams et al. 2015, 2016, 2017). They also reported an average incidental catch of one adult and zero Chinook salmon killed and/or handled per year.

Juvenile salmonids are also consumed by large numbers of non-native fishes including walleye, smallmouth bass, and channel catfish in the reservoirs of the hydrosystem reach. However, yearling and even the relatively large subyearling SR fall Chinook salmon smolts mostly stay in the migration channel and are not likely to encounter large numbers of these species and both the Oregon and Washington Departments of Fish and Wildlife have removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids.

2.12.2.7 Research and Monitoring Activities

The primary effects of the past and ongoing CRS-related RM&E program on SR fall Chinook salmon are associated with the capturing and handling of fish. The RM&E program is a collaborative, regionally coordinated approach to fish and habitat status monitoring, action effectiveness research, critical uncertainty research, and data management. The information derived from the program facilitates effective adaptive management through better understanding the effects of the ongoing CRS action. Capturing, handling, and releasing fish generally leads to stress and other sublethal effects, but fish sometimes die from such treatment. The mechanisms by which these activities affect fish have been well documented and are detailed in Section 8.1.4 of the 2008 biological opinion. Some RME actions also involve sacrificial sampling of fish. We estimated the number of SR fall Chinook salmon that have been handled or died each year during the implementation of RM&E under the 2008 RPA as the average annual take reported for 2013-17:

- Average annual estimates for handling and mortality of SR fall Chinook salmon associated with the Smolt Monitoring Program and the CSS were: (1) zero hatchery and zero wild adults handled; (2) zero hatchery and zero wild adults died; (3) 47,773 hatchery and 15,157 wild juveniles handled; and (4) 673 hatchery juveniles and 240 wild juveniles died.
- The estimated handling and mortality of SR fall Chinook salmon associated with the ISEMP was: (1) 4,132 hatchery and 2,014 wild adults handled; and (2) one hatchery and zero wild adults died; (3) zero hatchery and zero wild juveniles handled; and (4) zero hatchery and zero wild juveniles died.
- Estimates for SR fall Chinook salmon handling and mortality for all other fish RM&E programs are as follows: (1) one hatchery and one wild adult handled; (2) zero hatchery and zero wild adults died; (3) 46,325 hatchery and 14,668 wild juveniles handled; and (4) 84 hatchery and 29 wild juveniles died.

The combined observed mortality associated with these elements of the RM&E program has, on average, affected less than 1 percent of the wild (i.e., natural origin) adult returns or juvenile production for the SR fall Chinook salmon ESU (Bellerud 2018). Although we estimate that more than 16 percent of the wild adults and 6 percent of the wild juveniles were handled each year, on average, we expect that only up to 1 percent of these died after release (in this case, <0.17 percent of adults and <0.06 percent of juveniles. This relatively small effect is deemed worthwhile because it allows the Action Agencies and NMFS to evaluate the effects of CRS operations, including modifications to facilities, operations, and mitigation actions.

In addition, northern pikeminnow are tagged as part of the Sport Reward Fishery and their rate of recapture is used to calculate exploitation rates. Northern pikeminnow are collected for tagging using boat electrofishing in select reaches of the Columbia River. During 2017, boat electrofishing operations in the Columbia River extended upstream from RM 47 (near Clatskanie, Oregon) to RM 394 (Priest Rapids Dam), and in the Snake River from RM 10 (Ice Harbor Dam) to RM 41 (Lower Monumental Dam) and from RM 70 (Little Goose Dam) to RM 156 (upstream of Lower Granite Dam). Researchers conducted four sampling events consisting of 15 minutes of boat electrofishing effort in shallow water within each 0.6-mile reach during April-July.

A side effect of the electrofishing effort is that salmon and steelhead may be exposed to the electrofishing field, with the potential for injury, stress, and fatigue and even cardiac or respiratory failure (Snyder 2003). Some adult and juvenile SR fall Chinook salmon are likely to be present in shallow shoreline areas during the April-July time period. Most sampling occurs in darkness (1800-0500 hours). Operators shut off the electrical field if salmonids are seen and because most stunned fish quickly recover and swim away, they cannot be identified to species (i.e., Chinook, coho, chum, or sockeye salmon or steelhead). Barr (2018) reported encountering an annual average of 1,762 adult and 92,260 juvenile salmonids in the lower and middle Columbia River each year during 2013-17 electrofishing operations based on visual estimation methods. It is likely that some of these were SR fall Chinook salmon.

2.12.2.8 Critical Habitat

The condition of the PBFs of SR fall Chinook salmon critical habitat are discussed above (e.g., mainstem flows/water quantity, temperature, and TDG/water quality, hydrosystem passage/safe passage, etc.) and summarized here in Table 2.12-6. Across the action area, land use activities have disrupted watershed processes (e.g., erosion and sediment transport, storage and routing of water, plant growth and successional processes, input of nutrients and thermal energy, nutrient cycling in the aquatic food web, etc.), reduced water quality, and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and/or current land use or water management activities have adversely affected the quality and quantity of stream and side channel areas (e.g., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for steelhead production have been weakened.

Tributary habitat conditions have been significantly degraded by an array of land uses including urbanization, agriculture, forest management, transportation networks, and some gravel mining. These land uses have blocked access to historically productive habitats, simplified stream and side channels, degraded floodplain connectivity and function, increased delivery of fine sediment to streams, and degraded riparian conditions (contributing to stream channel simplification, reduced bank stability, increased sediment load, and elevated water temperatures; NMFS 2013b; NWFSC 2015). In combination, the degraded conditions in these basins contribute, either directly or indirectly, to impaired habitat in the lower reaches of major tributaries (e.g., lower Clearwater River, lower Grande Ronde, Imnaha, Tucannon Rivers, etc.) where fall Chinook salmon spawn and rear. However, the stabilization of outflow at Idaho Power Company's Hells Canyon Dam has produced high-quality spawning and rearing habitat in the downstream reach, which currently supports the productivity of the ESU.

The effects of mainstem and tributary dams on the functioning of critical habitat include:

- Historically important habitat is blocked by the construction of the Hells Canyon Complex and other mainstem dams built without fish passage (safe passage in juvenile and adult migration corridors);
- Degraded passage conditions at the CRS dams have improved substantially with recent changes in configuration and operations (safe passage in juvenile mainstem rearing areas and the migration corridor);

- Reservoir operations have increased winter and decreased spring and early summer mainstem flows and, with the construction of dikes and levees, disconnected the estuarine floodplain from the mainstem Columbia River (water quantity and velocity, cover/shelter, food/prey, riparian vegetation, and space in the migration corridor and juvenile rearing areas);
- Reservoir operations, combined with changing seasonal temperature patterns, have elevated late-summer temperatures in the lower Columbia River that increase risk to early migrating adults and late migrating juveniles; cold-water releases from Dworshak Dam improve conditions for adult migrants in the lower Snake River (water quality and safe passage in the juvenile and adult migration corridors);
- Reduced sediment transport and turbidity (water quality and safe passage in the juvenile migration corridor);
- Increased risk of total dissolved gas concentrations and gas bubble trauma during spring spill periods (water quality and safe passage in the juvenile migration corridor); and
- Altered food webs in tributary spawning areas, the hydrosystem reach, and the lower Columbia River estuary, including both predators and prey (food/prey and safe passage in juvenile rearing areas and migration corridors).

Habitat quality in the juvenile and adult migration corridors was severely affected by the development and operation of the CRS dams and reservoirs and privately owned dams in the Columbia and Snake River basins. Hydroelectric development has modified natural flow regimes of the rivers, resulting in warmer late summer/fall water temperatures, changes in fish community structure that lead to increased rates of predation on juvenile salmon and steelhead, and delayed migration for both adult and juvenile salmonids. Physical features of dams, such as turbines, also kill outmigrating fish. In-river survival is inversely related to the number of hydropower projects encountered by emigrating juveniles. Additionally, development and operation of extensive irrigation systems and dams for water withdrawal and storage in tributaries have altered hydrological cycles (NMFS 2016e). However, passage conditions and resulting juvenile SR fall Chinook salmon survival rates at the CRS run-of-river dams have improved substantially since 1991, when the species was listed. This is in part due to structural and operational improvements at the dams and predator management programs both at the dams and within the reservoirs.

Many stream reaches designated as critical habitat are listed on Oregon, Washington, and Idaho's Clean Water Act Section 303(d) lists for water temperature. Many areas that were historically suitable rearing and spawning habitat are now unsuitable due to high summer stream temperatures. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water for agricultural or municipal use all contribute to elevated stream temperatures. Furthermore, contaminants, such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste, are common in some areas of critical habitat (NMFS 2016e). They can negatively impact critical habitat and the organisms associated with these areas.

The large numbers of avian predators nesting on man-made or enhanced structures (dredge material deposits that created Rice Island and increased the size of East Sand Island in the lower Columbia River, as well as bridges, aids to navigation, and transmission towers) constitute excessive predation in the lower Snake and Columbia River portions of the juvenile migration corridor. Similarly, sea-lion predation on SR fall Chinook salmon in the tailrace of Bonneville Dam and in the estuary affects safe passage in the adult migration corridor.

In the mainstem of the Columbia and Snake Rivers, the altered habitats in project reservoirs reduce smolt migration rates and create more favorable habitat conditions for fish predators, including native northern pikeminnow and nonnative walleye and smallmouth bass. The effects of the nonnative species and pikeminnows, to the extent the latter's predation rates are enhanced by reservoir and tailrace conditions, are also examples of excessive predation in the juvenile migration corridor.

Restoration activities addressing habitat quality and complexity, migration barriers, and water quality have improved the baseline condition for PBFs. Although there are uncertainties about the productivity of natural-origin fish due to the large proportion of hatchery fish on the spawning grounds, the PBFs of critical habitat appear to be supporting a population that is contributing to the conservation of the ESU.

Table 2.12-6. Physical and biological features (PBFs) of designated critical habitat for SR fall Chinook salmon.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBF in the Action Area
Freshwater spawning and rearing sites	Spawning gravel Water quality Water quantity Food Riparian vegetation Space	LOWER CLEARWATER RIVER ● Urban and rural development, forest and agricultural practices, and channel manipulations have reduced habitat complexity and floodplain connectivity (spawning gravel, food, riparian vegetation, space) ● Forest and agricultural practices, including road building, have led to excessive sediment in spawning gravel (spawning gravel, space) ● Due to its thermal inertia, Dworshak Dam releases warmer water during the winter spawning and incubation periods (water quality) ● Spill events associated with flood-control operations at Dworshak and/or turbine outages periodically elevate total dissolved gas levels over incubating redds (water quality) ● Cool-water releases from Dworshak Dam during the late-June or early-July to mid-September rearing periods slow juvenile development (water quality) ● Water withdrawals, urban and rural development, and forest and agricultural practices cause toxics to accumulate in areas used for spawning and rearing (water quality) HELLS CANYON REACH OF THE LOWER SNAKE RIVER ● Stabilization of outflow at Hells Canyon Dam has produced high-quality spawning and rearing habitat in the downstream reach LOWER SNAKE RIVER RESERVOIRS ● Inundated spawning habitat (space) ● Forest and agricultural practices, including road building, have led to excessive sediment in spawning gravel (spawning gravel, space)

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBF in the Action Area
		● Inundated rearing habitat (food, riparian vegetation, space) ● Water withdrawals, urban and rural development, and forest and agricultural practices cause toxics to accumulate in areas used for spawning and rearing (water quality) ● Due to its thermal inertia, Dworshak Dam releases warmer water during the winter spawning and incubation periods (water quality)
Juvenile migration corridors	Substrate Water quality Water quantity Water temperature Water velocity Cover/shelter Food Riparian vegetation Space Safe passage	● Impaired passage conditions at mainstem CRS dams reduce survival and cause injuries and stress; slower-moving reservoirs increase travel time and exposure to predators; increased risk of predation in forebay and tailrace areas (safe passage) ● Water withdrawals, urban and rural development, and forest and agricultural practices cause toxics to accumulate in juvenile migration corridors (water quality) ● Construction of dredge-material islands in the lower river and other human-built structures used by terns and cormorants for nesting creates increased opportunities for avian predators (safe passage) ● Diking off areas of the estuary floodplain, combined with water diversions and water storage and hydroelectric projects that reduce peak spring and early summer flows, has reduced the productivity of floodplain habitats below Bonneville Dam (food)
Adult migration corridors	Substrate Water quality Water quantity Water temperature Water velocity Cover/shelter Riparian vegetation Space Safe passage	● Impaired passage conditions due to effort expended finding fish ladders, temperature-related delays that sometimes block upstream migration, increased risk of pinniped predation, and increased risk of fallback (safe passage) ● Water withdrawals, reservoir storage and release operations, thermal inertia of reservoirs, and climate change contribute to increased late-summer temperatures (water temperature)

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBF in the Action Area
		● Constricted passage opportunities for adult Chinook salmon in the Bonneville tailrace ● Water withdrawals, urban and rural development, and forest and agricultural practices cause toxics to accumulate in juvenile migration corridors (water quality)
Areas for growth and development to adulthood	Ocean areas – not identified	

2.12.2.9 Future Anticipated Impacts of Completed Federal Formal Consultations

The environmental baseline also includes the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, including the consultation on the operation and maintenance of the Bureau of Reclamation's upper Snake River projects. The 2016 five-year review evaluated new information regarding the status and trends of SR fall Chinook salmon, including recent biological opinions issued for SR fall Chinook salmon and key emergent or ongoing habitat concerns (NMFS 2016e). Since the beginning of 2015 through 2017, we completed 404 formal consultations (107 in 2015, 121 in 2016, and 176 in 2017) that addressed effects to SR fall Chinook salmon (PCTS data query, 31 July 2018). These numbers do not include the many projects implemented under programmatic consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed salmonids. Some of the completed consultations are large (large action area, multiple species), such as the Mitchell Act consultation and the consultation on the 2018-27 *U.S. v. Oregon* Management Agreement. Many of the completed actions are for a single activity within a single subbasin. Some of the projects will improve access to blocked habitat and riparian condition, and increase channel complexity and instream flows. For example, under BPA's Habitat Improvement Programmatic consultation, BPA implemented 29 projects in the Columbia River basin that improved fish passage in 2017, and 99 projects that involved river, stream, floodplain, and wetland restoration. These projects will benefit the viability of the affected populations by improving abundance, productivity, and spatial structure. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more, and typically less, than a few weeks).

Other types of federal projects, including grazing allotments, dock and pier construction, and bank stabilization will be neutral or have short- or even long-term adverse effects. All of these actions have undergone section 7 consultation and the actions[160] were found to meet the ESA standards for avoiding jeopardy.

Similarly, future federal restoration projects that have already undergone consultation will improve the functioning of the PBFs safe passage, spawning gravel, substrate, water quantity, water quality, cover/shelter, food, and riparian vegetation. Projects implemented for other purposes will be neutral or have short- or even long-term adverse effects on some of these same PBFs. However, all of these actions, including any RPAs, have undergone section 7 consultation and were found to meet the ESA standards for avoiding adverse modification of critical habitat.

2.12.3 Effects of the Action

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

The proposed action is an ongoing action that has been modified over time to reflect capital improvements as well as changes in operations. The latter have been based on changing environmental conditions and improved information on how CRS operations affect SR fall Chinook salmon as well as other listed species. The proposed action considered in this opinion includes operational measures (e.g., flood risk management, navigation, fish passage, and hydropower generation) and non-operational measures (e.g., support for conservation hatchery programs, predation management, habitat improvement actions) that will be implemented during the interim period, which begins in 2019. The proposed action, however, is of limited duration. The Action Agencies are developing an EIS in accordance with NEPA that will assess and update the approach for long-term system operations, maintenance, and configuration as well as evaluate measures to avoid, offset, or minimize impacts to resources affected by the management of the hydrosystem, including ESA-listed species and designated critical habitat. A court order currently requires the Action Agencies to issue Records of Decision on or before September 24, 2021.[161] Based on scoping, the range of alternatives being examined is broad and includes potential large-scale changes in the action. Thus, there is substantial uncertainty regarding what system operations, maintenance, and configuration the Action Agencies will propose at the conclusion of the NEPA process. Likewise, it is unknown what measures intended to avoid, offset, or minimize adverse effects will ultimately be included in the final preferred alternative.

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[160] Or the RPA.

[161] *The Presidential Memorandum on Promoting the Reliable Supply and Delivery of Water in the West*, issued on October 19, 2018, required the development of an expedited schedule for completion of the NEPA process. The Council on Environmental Quality has confirmed a revised schedule that calls for completing the Draft EIS in February 2020, the Final EIS in June 2020 and Records of Decision by September 30, 2020. These dates are consistent with, but earlier than, the court-ordered deadlines.

Accordingly, our analysis of effects for SR fall Chinook salmon extends from 2019 into the future, but emphasizes the evaluation of effects that are reasonably certain to occur as a result of implementing the proposed action, pending completion of the EIS and our issuance of a subsequent biological opinion addressing the effects of the final preferred alternative. To the extent our consideration of potential effects beyond that time period assumes the current proposed action remains in place, it is intended, in part, to inform the evaluation of alternatives in the EIS.

The Action Agencies will operate the run-of-river lower Snake and Columbia River projects in accordance with the annual Water Management Plan and Fish Passage Plan (including all appendices). These projects are operated for multiple purposes, including fish and wildlife conservation, irrigation, navigation, power, recreation, and, in the case of John Day Dam, limited flood risk management.

The effects of the proposed action for SR fall Chinook salmon are generally consistent with the effects caused by a continuation of the operations under the environmental baseline, with the exception of the addition of the following:

- Implementation of the flexible spring spill operation. A 0.5-ft increase in operating range at John Day and Lower Snake River reservoirs; and
- The potential for reduction of spill at mainstem projects (August 15 to 31) of 2020 pending consensus among parties;
- Targeting April 24 as the transport start date (collection on April 23) at Snake River collector projects; and
- Potential cessation of transport from June 21 - August 4.

2.12.3.1 Effects to Species

The Action Agencies will continue to operate the run-of-river lower Snake River and Columbia River projects in accordance with the annual Water Management Plan and Fish Passage Plan (including all appendices). These projects are operated for multiple purposes, including fish and wildlife conservation, irrigation, navigation, power, recreation, and, in the case of John Day Dam, limited flood risk management.

The Action Agencies propose to increase spill at the lower Columbia River and lower Snake River dams during the spring spill period which is intended to decrease powerhouse passage for juvenile salmonids and improve adult returns. The Action Agencies propose to implement the flexible spring spill operation which uses a combination of 16 hours of gas cap spill (up to state TDG standards) and 8 hours performance spill. Gas Cap Spill operations are proposed to increase from up to 120 to up to 125 percent TDG Gas Cap levels starting in 2020. Performance spill was developed using a combination of 2008 FCRPS biological opinion prescribed spill and performance standard testing guidelines.

System-wide water management operations involving upstream water storage projects will continue under the proposed action. Thus, the seasonal alterations described in the environmental baseline will continue (decreased spring and early summer flows, increased winter flows) to affect the mainstem migration and rearing corridor, estuary and plume.

Both juvenile and adult SR fall Chinook salmon will be exposed to the effects of the action in the mainstem Snake and Columbia Rivers downstream to the plume. Migrating juveniles and adults from four of the five major spawning areas pass through all eight mainstem dams; those from the Tucannon River pass through six mainstem dams.

Understanding how hydrosystem operations affect juvenile SR fall Chinook salmon is complicated by their diverse life history strategies. Figure 2.12-9 shows PIT-tag detections of juvenile SR fall Chinook salmon at Little Goose Dam (2014–18). Those fish detected from April to mid-May are dominated by yearling migrants which overwintered within the reservoir or in Lower Granite Reservoir or in the lower Clearwater River upstream of the reservoir. Those fish detected migrating past Little Goose Dam from mid-May through the end of the juvenile spill season (31 August) are nearly all subyearlings which emerged from the gravel from March through May earlier in the same year. Thus, the higher spill levels associated with the flexible spring spill operation would mostly affect only yearling SR fall Chinook salmon in the early spring and subyearling Chinook salmon in the later portion of the spring spill period. Reducing August spill in 2020 would affect only subyearling migrants (though some of these individuals may overwinter in a reservoir downstream and migrate the following spring as yearling smolts). Similar patterns in the timing of juvenile PIT-tag detections are observed at the lower Columbia River dams as well.

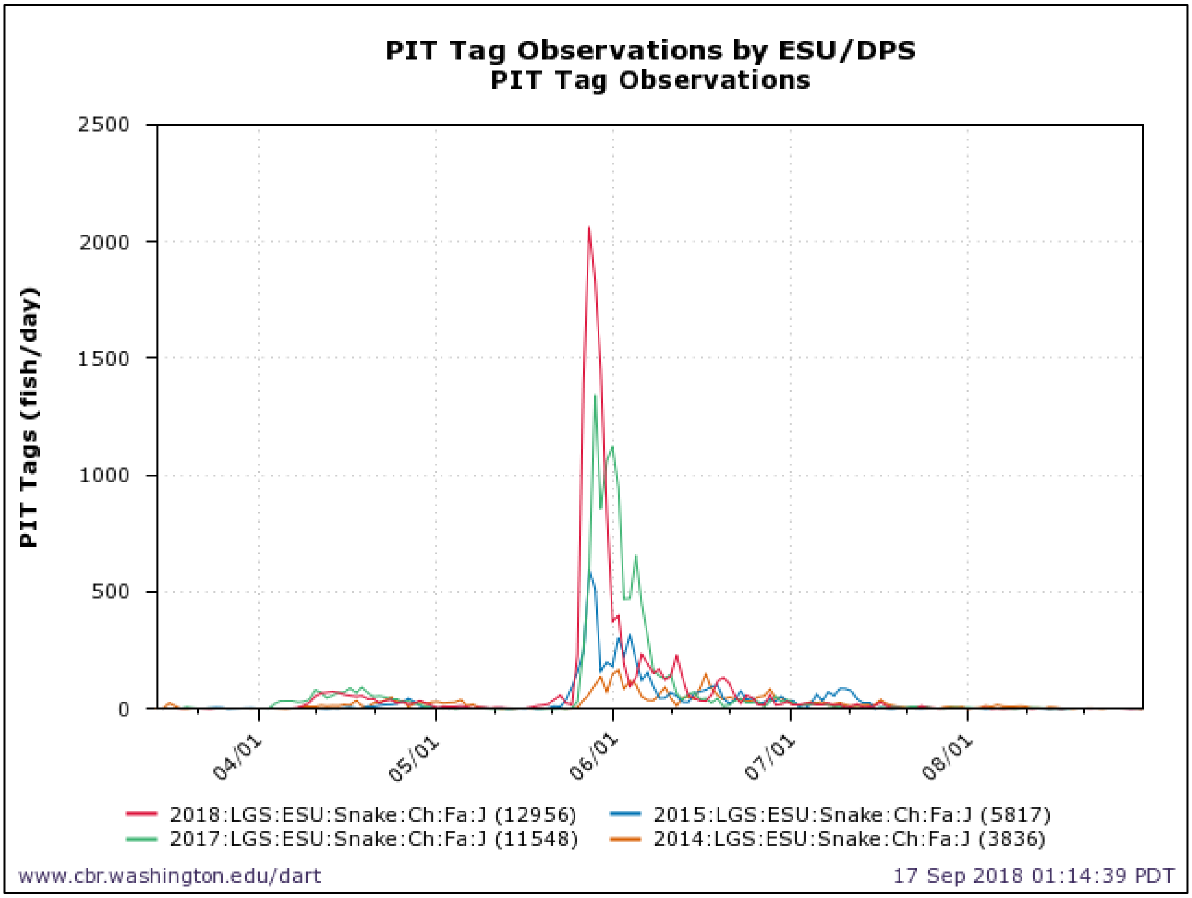


Figure 2.12-9. Detections of juvenile Snake River fall Chinook salmon at Little Goose Dam from 15 March to 31 August (2014–18). Source: Columbia River DART, downloaded 17 September 2018.

2.12.3.2 Hydrosystem Operations

For SR fall Chinook salmon, the effects of operating the hydrosystem as proposed will generally be a continuation of the effects described in the environmental baseline (resulting from implementation of the 2008 biological opinion's reasonable and prudent alternative hydro actions), with the addition of the flexible spring spill operation to reduce powerhouse passage, reduce travel time, and potentially reduce post-Bonneville (delayed) mortality for juveniles migrating in the spring. The Action Agencies also propose to reduce voluntary summer spill at the lower Snake River and lower Columbia River dams in August pending agreement among parties *(Natl Wildlife Fed'n et al. v. NMFS et al.*, ECF 2298).

In our 2008 biological opinion, based on 2002–07 conversion rate estimates, we estimated that the adult survival rates for SR fall Chinook salmon migrating from Bonneville to Lower Granite dams would average about 81 percent (ranging from about 59 to 99 percent). Recent (2008–17) survival rates have averaged about 90 percent (i.e., substantially higher than anticipated). Adult SR fall Chinook salmon will not be affected by the proposed flexible spring spill operation because they migrate after June 20th, when voluntary spring spill will end. A small increase in adult mortalities could occur as a result of adults ascending the ladders, but then falling back through the turbines at Snake River dams[162] in August if spill is reduced in 2020. However, these losses would not be expected to substantively affect survival rates. Therefore, the recent survival rates (about 90 percent) from Bonneville to Lower Granite Dam would be expected to continue under the proposed action.

Similarly, based on the available information at that time, we estimated that juvenile survival rates (following implementation of the 2008 biological opinion's reasonable and prudent alternative) would average between 19 to 55 percent (ranging from 12 to 72 percent; NMFS 2008a). Using subyearling hatchery releases as surrogates for the survival of naturally produced subyearling smolts (see Figure 2.12-3), juvenile survival rates from mid-May through June 2008–17 averaged about 70 percent (ranging from about 49 percent in 2017 to 79 percent in 2011) between Lower Granite and McNary Dams. Assuming that mortalities from Lower Granite to Bonneville Dams accrue on a per-mile basis (CSS 2017), the average 2008–17 Lower Granite to Bonneville juvenile survival rates would be about 54 percent (ranging from about 38 to 61 percent), which includes effects of both the CRS and the survival rates expected in an unmanaged reach of equal length. Another way to calculate survival would be to assume that mortalities accrue on a per dam and reservoir basis; using this approach, the average 2008–17 Lower Granite to Bonneville Dam juvenile survival rate would be about 40 percent (ranging from 28 percent to 45 percent).[163] Either of these average Lower Granite to Bonneville survival estimates are on the higher end of those made in the 2008 biological opinion. These increased survival estimates would generally be expected to continue for the four major spawning aggregates upstream of Lower Granite Dam (eight dams) and for the Tucannon River spawning aggregate which enters the Snake River upstream of Lower Monumental Dam (six dams).

The Action Agencies have proposed to operate in accordance with the flexible spring spill operation. To the extent that yearling SR fall Chinook migrants are positively affected by increased spill from 3 April-June 20 at Snake River dams and April 10-June 15 at lower Columbia River dams, yearling survival rates could be somewhat higher than in past years. The CSS study suggests that increased spill could substantially reduce latent mortality of juvenile yearling Chinook salmon moving downstream through the mainstem dams. If this were to occur for SR fall Chinook salmon, SARs would also be improved.

The available information indicates that supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). The proposed flexible spill operation (up to 120 or 125 percent TDG) would increase the exposure of spring migrating juveniles to elevated TDG levels from the tailrace of Lower Granite Dam to at least 35 miles downstream of Bonneville Dam. This would affect all subyearling and yearling smolts migrating in the river between April 3 and June 20 in the Snake River and April 10 to June 20 in

[162] Many adults falling back at Lower Granite or Little Goose Dams are fish that overshoot Lyons Ferry Hatchery and then voluntarily fall back to return to the hatchery.
[163] Lower Granite to McNary survival rates must be expanded to estimate Lower Granite to Bonneville survival rates. The Comparative Survival Study multiplies the LGR to MCN survival estimate by 0.77 (77 percent) to estimate LGR to BON survival rates. Assuming fish have passed 4 of 7 dams and reservoirs (already passing LGR), the LGR to MCN survival estimate is multiplied by 4/7 (about 51 percent) to estimate LGR to BON survival rates.

the lower Columbia River. Smolts migrating outside these time period would not be affected by the flexible spill operation. Smolts typically migrate at depths which effectively reduce TDG exposure due to pressure compensation mechanisms (Weitkamp et al. 2003). However, the proposed flexible spill operation would likely result in a slight increase in the incidence and severity of GBT symptoms and a very small (not measurable through reach survival studies) increase in mortality for those juveniles that are exposed.

Adult SR fall Chinook salmon migrate in the last summer and fall between Bonneville and Lower Granite Dam and will not be affected by the flexible spill operation.

The Action Agencies also propose to increase operational flexibility by increasing pool elevation limits by 6 inches (an average of 3 inches) at the Snake River dams (MOP 1.5-foot range) and at John Day Dam (MIP 2-foot range). This change will allow full use of the 1.0-foot operating range at the Snake River dams and 1.5-foot operating range at John Day Dam (BPA et al. 2018a). McNary, The Dalles, and Bonneville Dams will be operated within the normal forebay operating range for each project.

Operating reservoirs at the lowest possible level is intended to help reduce the reservoir's volume and thus reduce travel time for downstream migrating juvenile Chinook salmon. Continuous spring spill operations and the use of surface passage structures in recent years have greatly reduced juvenile travel times so that the effectiveness of limiting the operating range of pool elevations as a means of improving fish travel time has likely diminished. Increasing the Snake River and John Day pool operating range by 6 inches (an average of 3 inches) is likely to result in a slight increase in travel time for SR fall Chinook salmon smolts that are migrating during higher pool levels. s. However, the spring spill program will likely reduce delay through many of the mainstem dams (again using estimates calculated for SR spring/summer Chinook salmon as a surrogate, the reduction is about 10 hours), compensating for higher pool levels to some degree.

Because of these factors, an increase in travel time associated with the proposed increase in operating range at the Snake River dams and John Day Dam will have a minimal effect on the survival and condition of juvenile SR fall Chinook salmon smolts. There should be no substantial effect on adult migrants, as their migration timing (late summer and fall) does not appear to be affected by the dams and reservoirs (Ferguson et al. 2005) and they are not exposed to predators (other than fisheries) upstream of Bonneville Dam.

2.12.3.2.1 August Spill Reduction and Summer Transport Cessation

The Action Agencies propose to reduce spill in August if the State of Oregon, Nez Perce Tribe, and other parties agree to the operation as described in the Flexible Spill Operations Agreement (*Natl Wildlife Fed'n et al. v. NMFS et al.,* ECF 2298). Concern was expressed that this action could negatively affect later migrating juvenile subyearling Chinook salmon and that this group is made up of a larger proportion of wild fish and is important to the spatial and genetic diversity of the population. NMFS' acknowledges that the small portion of the ESU passing the Snake River projects during August if spill is reduced will likely experience slightly lower in-river survival rates. However, NMFS' does not conclude that these effects, stemming from the Action Agencies' proposal, will significantly affect this single population ESU for the following reasons:

- SR fall Chinook salmon are at low risk of extinction due to improved abundance and relatively high productivity, although natural productivity is difficult to measure due to high proportion of hatchery-origin fish spawning naturally. The spill operation will not change the risk category, and the effects of the flexible spill operation is not expected to substantially or negatively affect the abundance or productivity of this ESU.
- The overall abundance of SR fall Chinook salmon continues to increase substantially: 55,000 adults passed Lower Granite Dam in 2013 (though the most recent returns with poor ocean conditions have been about one-fourth this number).
- Because August spill reduction starting in 2020 would occur during very low juvenile fish passage numbers, it is not reasonable to expect a substantial decline in the overall abundance or productivity of the ESU (other factors - hatcheries, harvest, and limited habitat - have far greater influence on these metrics (NMFS 2008a; Ford 2011).
- Because of the small difference in survival afforded by the various passage routes: i.e. spillways, transport, or return to the river by way of the juvenile bypass system, reduction of spill will not have a significant effect on the number of returning adults. Available information generally indicates that most juvenile fall Chinook salmon smolts are not actively migrating past multiple Snake River projects in August (Connor et al. 2002).
- The genetic diversity of the ESU will not be significantly affected. Late migrating smolts are predominantly from the cooler Clearwater River, which, while an important spawning area, is not a separate population within the ESU (Connor et al. 2003, 2005).
- The potential for genetic differentiation of this spawning aggregate is further diminished by currently high (about 75 percent) proportions of Lyons Ferry hatchery derived adults on the spawning grounds (Ford 2011).

We also assessed likely impacts to adult SR fall Chinook salmon that would fall back at the Snake River dams during August if spill reduction were to be based on a juvenile abundance trigger. While survival rates for adults falling back at the Snake River projects without spill will be somewhat reduced, this impact is likely to be offset by substantial reductions in overall fallback rates resulting from reduced spill (compared to current levels of spill; Conder 2014).

Potentially ending transport from June 21 to August 4 starting in 2020, would likely have no substantial effect on the SR fall Chinook ESU. Transport studies (see Environmental Baseline discussion) generally indicate that not, or neutrally, beneficial (compared to fish left to migrate inriver) at this time. Thus, on average, not transporting juvenile fall Chinook in this period of time would most likely result in either no difference, or a slightly positive increase in adult returns compared to continuing transport in this period.

2.12.3.2.2 Predation Management

Predation Management in the Lower Columbia River Estuary

Avian Predators

The Action Agencies propose continued implementation of the Caspian Tern Nesting Habitat Management Plan (USACE 2015a) and the Double-crested Cormorant Management Plan (USACE 2015b). Tern habitat on East Sand Island will continue to be maintained at no less than one acre for the period covered by this interim consultation. Management actions for double-crested cormorants on East Sand Island will be limited to passive dissuasion and hazing, except that limited egg take (up to 500 eggs) may be requested from USFWS each year to preclude cormorants from nesting in new or different areas on East Sand Island. Although these ongoing actions have the potential to improve the survival of juvenile SR fall Chinook salmon as they move through the estuary, their success is uncertain at this time, as discussed below. The Action Agencies will also continue to implement, and will improve as needed, avian predation deterrence measures in the tailraces of the mainstem dams. However, any reduced predation rates achieved under the 2008 biological opinion and associated RPA will continue during the interim period.

In addition, the Action Agencies propose to synthesize colony size and predation rate data collected under the tern and cormorant colony management plans. The intent of the synthesis report is to summarize data on predation by piscivorous waterbirds on ESA-listed salmonids in the Columbia River basin before, during, and after the management actions, in order to assess their effectiveness on a basinwide scale. For example, the dispersal of double-crested cormorants from East Sand Island to nest sites on the Astoria-Megler Bridge in recent years, and observations of thousands of Caspian terns roosting on Rice Island in 2017, indicate that the numbers of avian predators in the estuary and their effects on the viability of salmonids such as SR spring/summer Chinook salmon are still in flux. The synthesis report will help managers assess whether to recommend that the Action Agencies or other regional parties consider additional measures for implementation after the interim period.

Ongoing annual monitoring will include estimates of double-crested cormorant abundance, nesting density, and PIT-tag detection on East Sand Island. The average estimated three-year peak colony size will be used to evaluate management activities relative to plan objectives (2019–21); the management plan will be considered successful when the average three-year peak colony size estimate does not exceed 5,939 nesting pairs while no management actions are conducted. Annual PIT detection will continue for 5–10 years to assess overall trends in predation rates (through the 2023 breeding season, at minimum), accounting for annual variability in predation impacts. These measures are likely to effectively constrain and evaluate double-crested cormorant predation on listed salmonids such as SR fall Chinook salmon at Corps-managed sites in the estuary.

Fish Predators

The Action Agencies will continue to implement the NPMP, including the Sport Reward Fishery in the lower Columbia River estuary as described under the environmental baseline. We expect that this ongoing measure will continue the 30 percent reduction in predation rates achieved under the 2008 RPA. We estimate that numbers of Chinook salmon, including some from the SR fall Chinook salmon ESU, handled and/or killed in the Sport Reward Fishery, system-wide, will be no more than 100 adults (including jacks) and 200 juveniles per year, system-wide, during the interim period.

Predation Management in the Hydrosystem Reach

Avian Predators

Snake River fall Chinook salmon survival is affected in the mainstem by avian predators that inhabit the dams and reservoirs. All CRS projects have been implementing avian control measures at the dams and are currently using several strategies that have proven to be effective at meeting this objective, including: avian arrays in tailrace areas, spike strips, outfall water sprinklers, dam-based hazing with pyrotechnics, propane cannons, and limited lethal take. Because of these efforts, avian predation on juvenile salmon and steelhead at the dams has been reduced since implementation began (Zorich et al. 2012). The current efforts are expected to continue at the current level of effectiveness into the future (BPA et al. 2018a).

The Action Agencies propose to continue to address tern predation at lands that they manage on the Columbia plateau: Crescent Island (Corps) and Goose Island (Reclamation). The Corps has excluded tern use on Crescent Island via revegetation since 2015, but will continue to monitor that site to ensure that conditions remain unfavorable for nesting. If tern use does resume during the interim period, the Corps will work with NMFS and USFWS to address concerns, perform any necessary environmental compliance, and seek permits and funding for active hazing, if warranted. If no nesting of concern to the Corps and NMFS is identified, the Corps will discontinue monitoring after three years. These measures are likely to preclude use of Crescent Island by Caspian terns during the interim period.

Reclamation has excluded terns from Goose Island using ropes and flagging, and is currently experimenting with revegetation. They propose to maintain the ropes and flagging and to monitor for tern presence on a regular basis between late February and early July. If terns resume nesting despite these activities and efforts to establish vegetative cover, and if the number of terns exceeds metrics identified in the IAPMP (more than 40 nesting pairs on Goose Island or more than 200 pairs at sites across the interior Columbia Basin; USACE 2014), Reclamation will work with NMFS to identify management actions and tools that can be put in place to dissuade tern use of the island before the next nesting season (e.g., permits from USFWS for hazing and egg take). These measures are likely to preclude use of Goose Island by Caspian terns during the interim period.

Pinniped Predators

Research indicates SSLs aggregate at Bonneville Dam in the summer and fall to eat adult salmonids (Stansell et al. 2013); the abundance of SSL during this period (summer and fall) has increased significantly (Tidwell et al. 2018). SSLs are using a USACE-constructed island (Tower Island) to haul out on and are using the dam structure and ladder entrances to increase their predation advantage on adult salmonids. While pinniped predation impacts to spring Chinook salmon are far more severe, pinnipeds at Bonneville Dam still consume an estimated 0.7 percent of the Snake River fall Chinook salmon ESU. The USACE will continue to maintain and install SLEDs during the Snake River fall Chinook salmon migration. There are currently no expectations to implement hazing or dissuasion efforts in the fall at Bonneville Dam. If pinnipeds are observed at The Dalles Dam, the Corp may respond with hazing at adult fish ladder entrances.

Fish Predators

The Action Agencies will continue to implement the Northern Pikeminnow Sport Reward Fishery in the hydrosystem reach and the Dam Angling Program at The Dalles and John Day Dams, as described under the environmental baseline. These ongoing measures will continue the reduction in predation rates achieved under the 2008 RPA. We estimate that the 2013-2017 annual average numbers of Chinook salmon, including SR fall Chinook salmon, which will be handled and/or killed in the in the Sport Reward Fishery will continue as described above (Predation Management in the Lower Columbia River Estuary). In addition, we estimate that no more than ten adult and 20 juvenile Chinook salmon, including some from the SR fall Chinook salmon ESU, will be killed and/or handled in the Dam Angling Program per year during the interim period.

2.12.3.2.3 Tributary Habitat

There are no habitat actions specifically targeted to improve spawning and rearing habitat conditions for SR fall Chinook salmon in the proposed action. While there is some potential that habitat restoration actions targeted at spring/summer Chinook salmon and steelhead spawning and rearing habitat could benefit habitat used by SR fall Chinook salmon inhabiting the lower reaches of these river systems (e.g., reduced sediment, improved flows, etc.), those effects are speculative and not taken into account.

2.12.3.2.4 Estuary Habitat

The Action Agencies will continue to implement the CEERP (Ebberts et al. 2018; BPA and USACE 2018). Program goals are to increase the capacity and quality of estuarine ecosystems and to improve access to these resources for juvenile salmonids. Floodplain reconnections are expected to continue to increase the production and availability of commonly consumed prey (chironomid insects and corophiid amphipods) to SR fall Chinook salmon as they migrate through the estuary.

NMFS agrees with ISAB's assessment findings (ISAB 2014) that it has been difficult to quantify the survival benefits of estuary habitat restoration, but the Action Agencies' assessment method, including review by the ERTG,[164] is useful to prioritize projects. For the interim period, the

[164] As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss with ERTG and regional partners relevant climate change science in an effort to understand whether their planned estuary projects are resilient to climate change (i.e., sea level rise, temperatures, and mainstem flow levels). In addition, the Action Agencies' annual update of their restoration and monitoring plans for the estuary will document

Action Agencies' proposed commitment is to reconnect an average of 300 acres of floodplain per year, a goal that they have a record of meeting in 2008-17 (BPA et al. 2018b), rather than to achieve a specific survival improvement. NMFS also agrees with the ISAB that the Action Agencies' assessment method, including review by the ERTG (Krueger et al. 2017), remains useful for prioritizing projects and for optimizing project design (number of breaches and channels, etc.) to site conditions. Thus, NMFS expects that the proposed implementation of the estuary program during the interim period will continue to partially mitigate for effects flow management that, combined with dikes and levees, have cut much of the floodplain off from the mainstem river. The trend in increased connected area (Johnson et al. 2018) is expected to continue during the interim period. It is likely that these benefits will increase as habitat quality matures.

The Action Agencies also propose continued implementation of their monitoring program, the CEERP component that provides a basis for adaptive management. This includes action effectiveness monitoring at each restoration site. A set of "standard" indicators (photo points, water surface elevation, and salinity) are measured at all sites (Level 3); core indicators (plant species composition, percent cover, and biomass) are measured at a subset of the sites (Level 2); and intensive indicators (juvenile salmon species composition, density, diet, and growth, along with structures and controlling factors) are measured at an even smaller number of sites (Level 1; Johnson et al. 2018). Monitoring will continue at recently built sites and will be initiated for sites constructed during the interim period. Johnson et al. (2018) evaluated the action effectiveness monitoring data collected since 2012 and found that they generally indicated that the restoration of physical and biological processes was underway at these sites. Continued implementation and evaluation of this monitoring program will show that these floodplain reconnections are enhancing conditions for salmonids such as SR fall Chinook salmon, or will provide sufficient information to the Action Agencies that site selection or project design will improve through adaptive management.

2.12.3.2.5 Research and Monitoring Activities

The Action Agencies' RM&E program will be similar to the current program, or will be implemented at a reduced scale. Thus, the level of injury and mortality discussed in the Environmental Baseline, primarily from the capture and handling of fish, is likely to continue at a similar or reduced level. We estimate that, on average, the following number of SR fall Chinook salmon will be affected each year during the interim period:

- Projected estimates of SR fall Chinook salmon handling and mortality during activities associated with the Smolt Monitoring Program and CSS: (1) five hatchery and zero wild adults handled; (2) zero hatchery or wild adults killed; (3) 356,087 hatchery and 125,167 wild juveniles handled; and (4) 6,051 hatchery and 4,147 wild juveniles killed.

any needed adjustments in design, location, or other elements of a given project to address climate change impacts, both during and beyond the interim period.

- Projected estimates of SR fall Chinook salmon handling and mortality during activities associated with Fish Status Monitoring[165]: (1) 4,588 hatchery and 1,297 wild adults handled; (2) 46 hatchery and 13 wild adults killed; (3) zero hatchery or wild juveniles handled; and (4) zero hatchery or wild juveniles killed.
- Projected estimates of SR fall Chinook salmon handling and mortality for all other RM&E programs: (1) 143 hatchery and 307 wild adults handled; (2) one hatchery and three wild adults killed; (3) 1,412,6390 hatchery and 389,947 wild juveniles handled; (4) 14,126 hatchery and 3,899 wild juveniles killed.

The combined observed mortality associated with these elements of the RM&E program will, on average, affect less than 1 percent of the wild (i.e., natural origin) adult returns and just over one percent of the juvenile production for the SR fall Chinook salmon ESU (Bellerud 2018). Although we estimate that 11.75 percent of the wild adults and 75.5 percent of the wild juvenile production will be handled each year, on average, we expect that only up to 1 percent of these will die after release (in this case, 0.12 percent of adults and 0.75 percent of juveniles handled). This relatively small effect is deemed worthwhile because it will allow the Action Agencies and NMFS to continue to evaluate the effects of CRS operations including modifications to facilities, operations, and mitigation actions.

Electrofishing operations for the NPMP during the interim period are expected to continue at the same level of effort as in recent years (four 15-minute sampling events per 0.6-mile reach between RM 47 near Clatskanie, Oregon, and RM 394 on the Columbia River and to RM 156 on the lower Snake River during April-July; a total of 550 hours system-wide). Some adult and juvenile SR fall Chinook salmon are likely to be present in shallow shoreline areas during electrofishing activities and may be stunned and even killed. However, because the operator releases the electrical field as soon as salmonids are observed and most of these fish quickly recover and swim away, we are unable to use observations from past operations to estimate the number of fish from this ESU that will be affected. Information obtained through electrofishing supports management of the NPMP, which is reported to have reduced salmonid predation by about 30 percent (Williams et al. 2017). This level of take is anticipated to occur for the duration of this proposed action, pending completion of the NEPA process.

2.12.3.3 Effects to Critical Habitat

Implementation of the proposed action is likely to affect passage conditions at CRS dams in the lower Snake and Columbia Rivers (safe passage in the juvenile migration corridor). Subyearling and yearling juveniles that migrate prior to June 21 will experience increased spill levels associated with the flexible spill operation (up to the120 or 125 percent TDG levels) and could have slightly improved survival rates, compared to recent operations. In low-flow years, spring

[165] Fish Status Monitoring is intended to include individuals handled/killed during status and trend, “fish-in/fish out,” and habitat effectiveness monitoring projects.

spill could cause eddies that degrade tailrace egress conditions and increase exposure to predators at the three lower Snake collector projects.

During periods of increased spill, exposure to TDG levels under the flexible spill operation will be increased from the tailrace of Lower Granite Dam to more than 35 miles downstream of Bonneville Dam. This exposure could result in increased incidence of GBT symptoms which can be roughly assessed at smolt monitoring facilities or, potentially, mortalities (more susceptible to avian predators, etc.). However, only TDG up to state water quality standards in project tailraces would be an effect of the proposed action; any higher TDG levels would be caused by high runoff that leads to lack of market or lack of turbine capacity spill. This might result in small negative effects to water quality, but salmonids swim lower in the water column where TDG concentrations are reduced by depth compensation.

If implemented in 2020, spill reductions at the lower Snake River and lower Columbia River dams in late August may negatively affect passage conditions for the small number of late-migrating juveniles passing between the day spill is reduced and 31 August, when summer spill normally would otherwise end at these projects. This could also impair downstream passage survival of adult fall Chinook salmon falling back during this time at the lower Snake River dams, but could also reduce adult fallback rates.

The PBFs that could be affected by the proposed action are described in Table 2.12-6.

Table 2.12-6. Effects of the proposed action on the physical and biological features (PBFs) of designated critical habitat within the action area for SR fall Chinook salmon.

Physical and Biological Feature (PBF)	Effects of the Proposed Action
Freshwater spawning and rearing areas	Lower Snake River reservoirs will continue to inundate mainstem spawning and rearing habitat (food, riparian vegetation, space in spawning and rearing areas) Spill caused by flood-control operations, any turbine unit outages, and lack of load spill at Dworshak Dam will continue to expose redds and incubating juveniles rearing in the lower Clearwater River to increased levels of TDG (water quality in spawning and rearing areas) Reservoir operations at Dworshak Dam will continue to elevate water temperatures in the lower Clearwater River during winter (water quality in spawning areas) Reservoir operations at Dworshak will continue to cool temperatures in the lower Clearwater River and lower Snake River reservoirs during summer (water quality in rearing areas) The existence and operation of mainstem reservoirs will continue to alter food webs and predator/prey interactions (food, safe passage in juvenile rearing areas)
Juvenile migration corridors	Increased spill levels associated with the flexible spring spill operation (up to the 120 and 125 percent TDG level) will improve migration conditions from 3 April - 20 June (lower Snake River) or 10 April - 15 June (lower Columbia River); but could also degrade juvenile passage conditions at some projects (e.g. John Day, Little Goose, Lower Granite) especially in low-flow years, if eddies

Physical and Biological Feature (PBF)	Effects of the Proposed Action
	develop/intensify and tailrace egress conditions degrade (safe passage in juvenile migration corridors) Increasing pool elevation limits by 6 inches at the four lower Snake River dams and John Day Dam will slightly increase reservoir travel times and thus, exposure to predators (safe passage in juvenile migration corridors). However, this will be balanced by a slight mean reduction in passage time past the dams during periods of increased spill. Increase in TDG levels up to the state-approved limits (up to 120 or 125 percent TDG) at the CRS run-of-river projects) will result in only a slight increase in the incidence and severity of GBT symptoms (water quality in the juvenile migration corridor) Reservoir operations at Dworshak will continue to cool temperatures in the lower Snake River reservoirs during summer (water quality in juvenile migration corridors) The existence and operation of mainstem reservoirs will continue to alter food webs and predator/prey interactions (food, safe passage in juvenile migration corridors) Sediment will continue to accumulate behind CRS dams, reducing turbidity in the migration corridor during the spring outmigration, which could increase the vulnerability of smolts to visual fish and avian predators (safe passage in juvenile migration corridors) Ongoing implementation of the predator management programs will continue to reduce the risk of avian and fish predation (safe passage in juvenile migration corridors) Increased access to forage with the proposed reconnection of an average of 300 acres of floodplain habitat per year in the lower Columbia River estuary during the interim period (food)
Adult migration corridors	Reduced risk of involuntary fallback at lower Snake River dams with August spill reductiont, but adults that do fall back will be at higher risk of mortality through the turbine or juvenile bypass routes (safe passage in adult migration corridors). Ongoing implementation of the Action Agencies' predator management programs will continue to reduce the risk of pinniped predation in the Bonneville tailrace (safe passage in adult migration corridors)
Areas for growth and development to adulthood	Ocean areas – not identified

2.12.4 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation (50 CFR 402.02). Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Nonfederal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. These projects also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth-management programs (planning and regulation); a variety of stream and riparian habitat projects; watershed planning and implementation; acquisition of water rights for instream purposes and sensitive areas; instream flow rules; stormwater and discharge regulation; TMDL implementation to achieve water-quality standards; hydraulic project permitting; and increased spill and bypass operations at hydropower facilities. NMFS determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. These activities are likely to have beneficial cumulative effects that will significantly improve conditions for salmon and steelhead, including SR fall Chinook salmon.

NMFS also noted that some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects are activities that occurred in the recent past and were included in the environmental baseline. Some of these activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the action area, nonfederal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations.

Some continuing nonfederal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult, if not impossible, to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline.

Overall, we anticipate that projects to restore and protect habitat, restore access and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area.

2.12.5 Integration and Synthesis

In this section, we add the effects of the action (Section 2.12.3) to the environmental baseline (Section 2.12.2) and the cumulative effects (Section 2.12.4), taking into account the status of the species and critical habitat (Sections 2.12.1.1 and 2.12.1.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat for the conservation of the species.

2.12.5.1 Species

For SR fall Chinook salmon, the most recent status review (NMFS 2016e) recognized that the single, extant population has recently experienced substantial improvements in productivity and abundance, and recommended that the overall risk rating for SR fall Chinook salmon be reduced from moderate risk (i.e., maintained) to low risk (i.e., viable). The remaining risk factors of most import include: (1) blocked access to historic spawning areas resulting in a single, remaining population; (2) relatively high harvest rates (40 to 50 percent), (3) long-term risk relating to high levels of hatchery-origin fish spawning in each of the major spawning areas; (4) continuing mortalities due to dams and reservoirs in the mainstem migration and rearing corridor; (5) continued degraded conditions in tributary spawning and rearing areas; and (6) degraded, but somewhat improving conditions in the Columbia River estuary.

The environmental baseline conditions in the action area (mainstem spawning, rearing, and migration corridors) remain degraded, but have generally improved over the past two to three decades. The most notable improvements include: (1) changes to the configuration and operation of dams in the mainstem migration corridor (24-hour spill, surface passage routes, improved juvenile bypass systems, etc.), which improve passage conditions for migrating smolts; (2) summer flow augmentation and releases of cool water from Dworshak Dam to reduce summer temperatures and improve flows in the lower Snake River, improving conditions for migrating smolts, juveniles rearing in the reservoirs, and adult migrants; and (3) improved conditions in the estuary, particularly improvements in floodplain connectivity resulting from recent Action Agency-funded restoration efforts, which should improve conditions for subyearling Chinook salmon smolts that use these areas and enhance the amount of prey available for the those smolts migrating more quickly through the estuary to the plume.

Other environmental baseline conditions have shown little change or have declined. The most notable of these include: (1) winter and spring spill events, resulting from flood-control operations and/or turbine unit outages at Dworshak Dam, occasionally increase TDG levels to beyond 110 percent in the lower Clearwater River major spawning area, which is likely to negatively affect redds or fry inhabiting shallow-water areas; (2) pinniped predation downstream of Bonneville Dam has increased slightly, but is not thought to be a substantial factor affecting SR fall Chinook salmon productivity and abundance; (3) it is still unknown whether management efforts to reduce numbers of nesting terns and cormorants on East Sand Island have reduced predation rates on SR fall Chinook salmon; (4) continued exposure to chemicals and toxic substances throughout the mainstem migration corridor, lower Columbia River, and estuary remains a concern; and (5) though there is considerable uncertainty related to the scale of the changes over the coming decades and the response of fall Chinook salmon, climate change is a concern because it will affect temperature and seasonal precipitation patterns—however, ocean-type fall Chinook salmon are generally more tolerant of warmer conditions, are less affected by flow alterations because they occupy habitat in the lower segments of larger rivers, and their life history allows most juveniles and adults to avoid the peak summer temperatures.

Improvements including tributary hydrosystem modification and habitat restoration (e.g., in the estuary), coupled with significant harvest reductions from historic levels, have allowed for progress in improving SR fall Chinook salmon abundance, productivity, spatial structure, and diversity. However, these improvements also occur in the context of natural fluctuations in environmental conditions, such as cyclical changes in ocean circulation and the unusually warm ocean conditions seen predominating during 2015, which can temporarily adversely affect survival and adult returns of all salmonid species, even if freshwater habitat conditions are improving.

The status of SR fall Chinook salmon is also likely to be affected by climate change. Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycle. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater and changes to food webs in freshwater, estuarine, and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management actions may help alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations, increased riparian vegetation to control water temperatures, etc.).

Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life history types that will be successful in the future are neither static nor predictable. Therefore, maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the SR fall Chinook salmon ESU. Because of its location in the Columbia River basin, the ESU is likely to be more affected by climate-related effects in the estuary, and in tributary streams (altered seasonal flows and temperatures) that support spawning and early rearing. Emerging research using complex life cycle modeling indicates a potentially strong link between SST and survival of Snake River spring/summer Chinook salmon populations. However, the apparent link between SST and survival is presumably caused by foodweb interactions, relationships which could be disrupted by major transformations of community dynamics as well as ocean acidification and other factors under a changing climate. The degree to which SST is linked to survival of SR fall Chinook salmon and how that relationship interacts with other variables throughout the SR fall Chinook salmon life cycle will likely be an important area of future research.

The future operation of the CRS will continue to affect SR fall Chinook salmon within the action area as described in the Status and Environmental Baseline sections (altered flows, highly modified/inundated spawning, rearing, and migration habitat, increased exposure to avian, fish, and pinniped predators, degraded water quality, take under RME programs, etc.). However, there are aspects of the proposed action that will affect SR fall Chinook salmon differently than recent operations. The most important of these are: (1) the proposed flexible spring spill operation (up to 120 or 125 percent TDG levels-) will increase juvenile fish passage spill levels up to the state water quality limits, which could improve juvenile survival (and potentially SARs if latent mortality is reduced as hypothesized by the CSS for yearling Chinook salmon); (2) an overall reduction in travel time during spring spill operations despite the increase in reservoir operating ranges by 6 inches at the Snake River projects (to MOP[166]1.5-foot range) and John Day Dam (MIP 2foot range), reducing exposure to predators; (3) the potential to reduce spill at the Snake River dams in August of 2020 would result in slight decreases in survival for those few fish passing the dams after spill is ended, but would also increase transport rates slightly during this time, possibly increasing overall smolt-to-adult returns; (4) stopping transport from June 21 to August 4 would likely result in either a slight increase, or no change, in adult returns; and (5) continue estuary habitat restoration activities which should continue to benefit SR fall Chinook salmon smolts migrating through the estuary.

The proposed action, and other actions described in the environmental baseline and cumulative effects, address several management strategies identified in the SR fall Chinook salmon recovery plan (NMFS 2017d):

- Maintain and improve spawning, incubation, rearing, and migration conditions by continuing ongoing actions and implementing additional actions as appropriate in the lower mainstem Snake and Columbia Rivers and lower Snake River tributaries (Proposed Action).
- Address loss of off-channel habitat in the estuarine floodplain and altered food web by continuing ongoing actions and implementing additional actions identified in the Estuary Module (Appendix F) of the FCRPS biological opinion (NMFS 2008a, 2010, 2014) and the recovery plan, as appropriate (Proposed Action).
- Continue ongoing actions and implement additional actions, as appropriate, to gain a better understanding of potential impacts from climate change during freshwater, estuarine, and ocean life stages, and to support Snake River fall Chinook salmon adaptation and resilience in response to climate change (Proposed Action and Environmental Baseline).

[166] Minimum operating pool.

- Implement harvest-management programs in a manner that protects and restores Snake River fall Chinook salmon (Environmental Baseline).
- Continue ongoing actions and implement additional actions, as appropriate, to reduce predation and competition and address other ecological interactions that affect Snake River fall Chinook salmon (Proposed Action).
- Continue ongoing actions and implement additional actions that will improve ESU viability by reducing the impacts of hatchery-origin fish on natural-origin Snake River fall Chinook salmon (Environmental Baseline and Proposed Action).

After reviewing and analyzing the current status of SR fall Chinook salmon and designated critical habitat, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, and considering the interim nature of this proposed action pending the decision to implement a new action as a result of the NEPA process, it is NMFS' biological opinion that the proposed action is not likely to reduce appreciably the likelihood of both survival and recovery of SR fall Chinook salmon.

2.12.5.2 Critical Habitat

The rangewide status of critical habitat designated for SR fall Chinook salmon is discussed in Section 2.12.1.2 of this opinion. Across much of the designated area, land use activities have disrupted watershed processes, reduced water quality, and diminished habitat quantity, quality, and complexity. Past and/or current land use or water management activities have adversely affected the quality and quantity of riparian conditions and side channels, floodplain function, sediment conditions, and other water quality and quantity parameters. As a result, the important watershed processes and functions that once created healthy ecosystems for fall Chinook salmon production have been weakened. An important exception is that the stabilization of outflow at Idaho Power Company's Hells Canyon Dam has resulted in high-quality spawning and rearing habitat in the downstream reach of the lower Snake River, which supports the conservation of the remaining population. These outflows provide resiliency to climate-induced changes in temperature and flow.

The environmental baseline conditions in the action area (mainstem spawning, rearing, and migration corridors) remain degraded, but have generally improved over the past two to three decades. The most notable improvements to the condition of PBFs in the juvenile and adult migration corridors are: (1) improvements to the configuration and operation of the CRS dams, including 24-hour spill, surface passage routes, and improved juvenile bypass systems and summer flow augmentation (safe passage), and (2) releases of cool water from Dworshak Dam to reduce summer temperatures and improve flows in the lower Snake River (improved water quantity and water quality). For in-river migrants, the Gas Cap spill portions of the proposed flexible spring spill operation will further improve passage conditions in the migration corridor, except during low-flow years if tailrace egress conditions degrade. Reducing summer spill at the lower Snake River and lower Columbia River dams in late August will increase the risk of turbine passage at the projects (safe passage), but is designed to affect only a small portion of the juvenile production from this ESU. Seasonal flows and temperatures in the lower Columbia River will continue to be altered compared to an undeveloped system, with negative effects on water quantity, water velocity, water quality, and water temperature. Increased numbers of predators compared to an undeveloped system, including birds and native and nonnative fishes that prey on juvenile fall Chinook salmon, will continue to be present in the hydrosystem reach (safe passage). The reduced levels of predation by Caspian terns nesting on Goose and Crescent Islands on the interior Columbia plateau and northern pikeminnows in project tailraces and reservoirs that were achieved under the 2008 RPA will be maintained by the continued implementation of their respective predator management plans (safe passage).

In the lower Columbia River estuary, the proposed habitat restoration program will continue to reconnect the historical floodplain, increasing the availability of wetland-derived prey to yearling and subyearling SR fall Chinook salmon migrating to the ocean (prey). Toxic contaminants, an effect of land use practices, will continue to be present, especially near urban and industrial areas (water quality). Ongoing management of the tern and cormorant colonies at East Sand Island is expected to reduce smolt predation rates, colony size and predation rate data from 2018 and during the interim period will be needed to evaluate whether this program is meeting its management goals.

Cumulative effects include projects to restore and protect habitat that will improve the functioning of PBFs compared to the current conditions. We also expect that future development activities will continue to have adverse effects on the conservation value of critical habitat in the action area.

Considering the ongoing and future effects of the environmental baseline and cumulative effects and in light of the status of critical habitat, the proposed action will not appreciably reduce the value of designated critical habitat for the conservation of SR fall Chinook salmon.

2.12.6 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, and considering the interim nature of this proposed action pending the decision to implement a new action as a result of the NEPA process, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of SR fall Chinook salmon or destroy or adversely modify its designated critical habitat.

2.13 Snake River (SR) Sockeye Salmon

This section applies the analytical framework described in section 2.1 to the SR sockeye salmon ESU and provides NMFS' finding regarding whether the proposed action is likely to jeopardize the continued existence of SR sockeye salmon or destroy or adversely modify its critical habitat.

2.13.1 Rangewide Status of the Species and Critical Habitat

The status of Snake River (SR) sockeye salmon is determined by the level of extinction risk that the listed species faces, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status also helps to inform the description of the species' current reproduction, numbers, or distribution as described in 50 CFR 402.02. The condition of critical habitat throughout the designated area is determined by the current function of the PBFs that help to form that conservation value.

2.13.1.1 Status of Species

NMFS' reviewed listing and recovery plan information, status reviews (NMFS 2016), and limiting factors for SR sockeye salmon for this analysis. These documents are available on the NMFS' West Coast Region website (http://www.westcoast.fisheries.noaa.gov/). The SR sockeye salmon ESU includes all anadromous and residual sockeye salmon from the Snake River basin, Idaho, as well as artificially propagated sockeye salmon from the Redfish Lake captive broodstock program. The SR sockeye salmon were ESA-listed in November 1991 (56 FR 58619) as endangered. We reaffirmed the listing in 2005 (70 FR 2853). NMFS adopted an ESA recovery plan for SR sockeye salmon in June 2015 (80 FR 32365) (NMFS 2015b).

SR sockeye salmon populations declined through the early- and mid-1900s, leading to an ESA-listing of the species as endangered in 1991. By the time of listing, all populations but one, the Redfish Lake population in the Sawtooth Valley, were gone, and that population had dwindled to fewer than 10 fish per year. In some years before 1998, no anadromous sockeye salmon returned to the Snake River basin. Many human activities contributed to the near extinction of SR sockeye salmon. The NMFS status review that led to the original listing decision attributed the decline to overfishing; irrigation diversions; obstacles to migrating fish, including dams; and eradication through poisoning. NMFS' 1991 listing decision for SR sockeye salmon noted that such factors as hydropower development, water withdrawal and irrigation diversions, water storage, commercial harvest, and inadequate regulatory mechanisms represented a continued threat to the species' existence. Since that time, our understanding of key threats has expanded to include factors affecting survival at different points in the SR sockeye salmon life cycle. Sources of mortality for adults include predation, exposure to elevated water temperatures and elevated TDG, fallback over dams, straying to non-natal streams, harvest, and disease. Sources of mortality for juveniles include hatchery effects (e.g., disease, water quality, and mechanical failure), stress of release from the hatchery, food supply (productivity) and water quality in lakes, losses during downstream passage to and through the CRS or during transport, predation, and ocean conditions.

Before the turn of the twentieth century, large runs of sockeye salmon returned annually to the Snake River basin (Evermann 1895; Selbie et al. 2007). Sockeye salmon ascended the Snake River to the Wallowa River basin in northeastern Oregon and the Payette and Salmon River basins in Idaho to spawn in natural lakes.[167] Today, the last remaining SR sockeye salmon are in the Sawtooth Valley of Idaho and, of the five lakes that formerly supported sockeye populations, only the Redfish Lake population remains (Figure 2.13.1). This population is supported by a captive broodstock program and conventional hatchery programs; reintroduction of captive broodstock progeny has included incorporating multiple releases into Redfish, Pettit, and Alturas Lakes. The Redfish Lake population migrates 900 miles downstream from the Sawtooth Valley through the Salmon, Snake, and Columbia Rivers and passes through eight major federal dams to reach the ocean. After one to three years in the ocean, the fish return to the Sawtooth Valley as adults, passing once again through the eight dams. Anadromous sockeye salmon returning to Redfish Lake travel a greater distance from the sea (900 miles) and to a higher elevation (6,500 feet) than any other sockeye salmon population.

[167] The historical relationships between the different SR Sockeye Salmon populations are not known. Because of the large geographic separation between the Wallowa, Payette, and Salmon River lakes, it is possible that each drainage supported a separate evolutionarily significant unit (ESU) (ICTRT 2005).

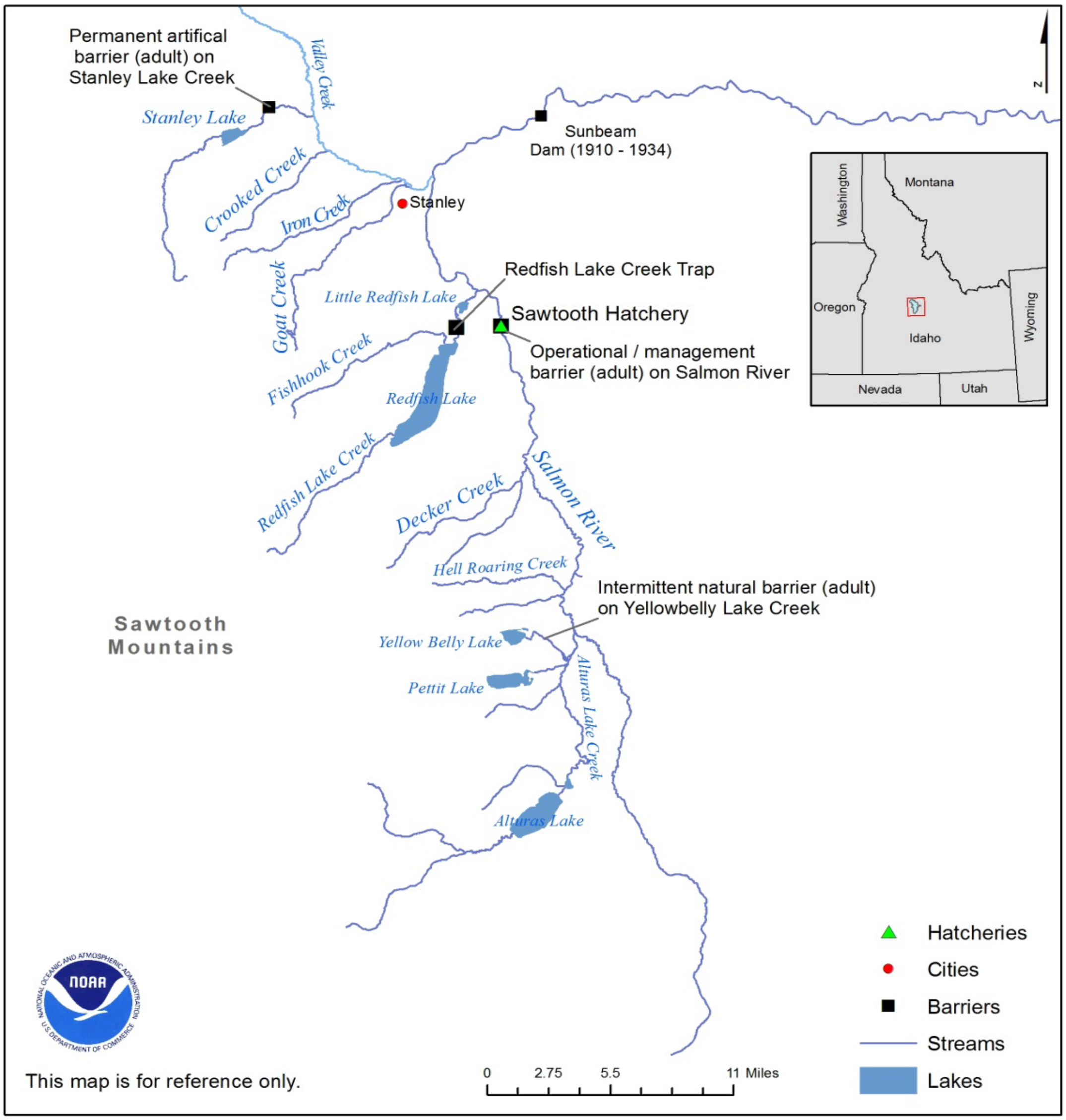


Figure 2.13-1. Map of the Sawtooth Valley, Idaho.

The Snake River sockeye salmon ESU is at a high risk of extinction. The recovery strategy aims to reintroduce and support adaptation of naturally self-sustaining sockeye salmon populations in the Sawtooth Valley lakes. The recovery strategy has three phases: (1) preservation with the captive broodstock program; (2) reintroduction; and (3) a program emphasizing natural adaptation and viability. At this time, we are still working on the first two phases; reintroduction efforts using Redfish Lake stock have been ongoing in Redfish Lake since 1993, Pettit Lake since 1995, and Alturas Lake since 1997 (Figures 2.13-1 and 2.13-2).

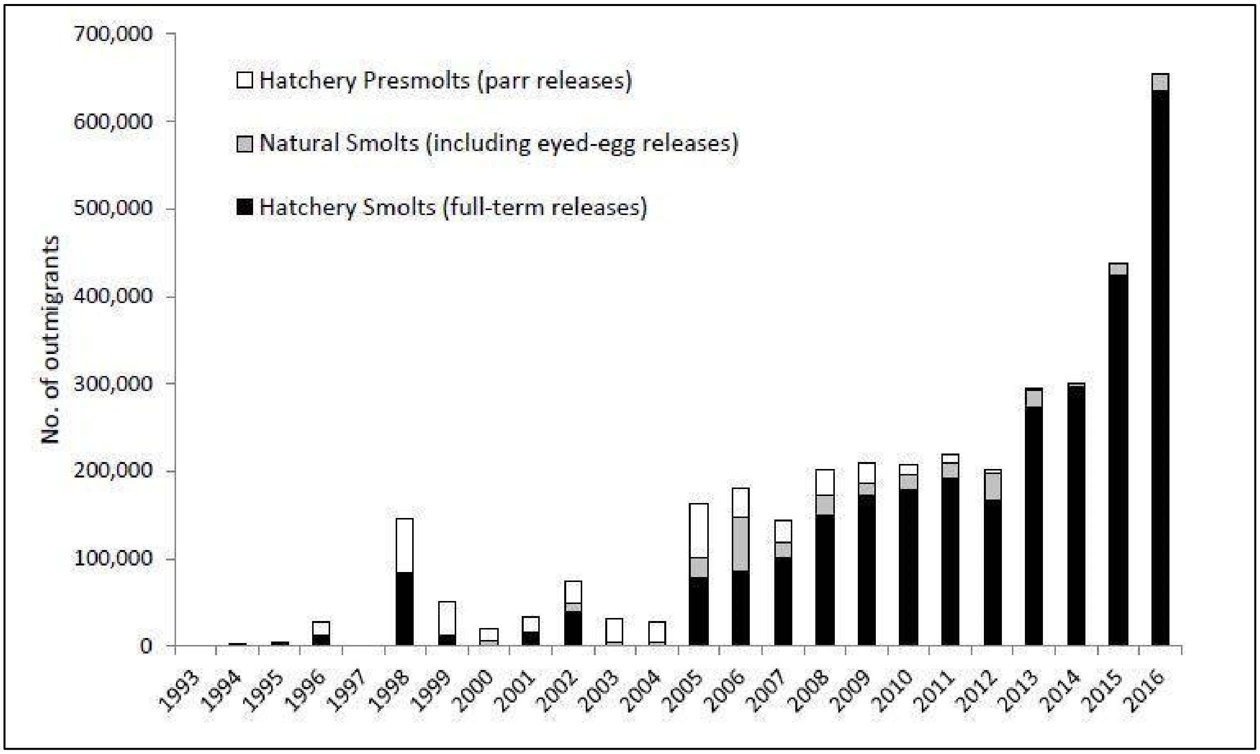


Figure 2.13-2. Estimated annual numbers of sockeye salmon smolt outmigrants from the Sawtooth Valley basin. This includes all hatchery smolt releases, known outmigrants originating from hatchery presmolts, and estimates of unmarked juveniles from Redfish, Alturas, and Pettit Lakes (Johnson et al. 2017).

Approximately two-thirds of the adults captured each year are taken at the Redfish Lake Creek weir; the remaining adults are captured at the Sawtooth Hatchery weir on the mainstem Salmon River upstream of the Redfish Lake Creek confluence. Although total SR sockeye salmon returns to the Sawtooth Basin in recent years have been high enough to allow for some level of spawning in Redfish Lake, the hatchery program's priority is on genetic conservation and building sufficient returns to support sustained outplanting (NMFS 2015b). The number of SR sockeye salmon outmigrants has continued to increase through 2017.

Adult returns of sockeye salmon to the Sawtooth Basin showed a general pattern of increase through 2014. Adult returns in the seven years before 2015 varied from year-to-year, from a low of 257 adults in 2012 (including 52 natural-origin fish) to a high of 1,579 adults in 2014 (including 453 natural-origin fish (NWFSC 2015). The large increases in returning adults in those years reflected improved survival during downstream migration through the mainstem Salmon, lower Snake, and Columbia Rivers and in the ocean, as well as increases in juvenile production since the early 1990s (NMFS 2016e).

In 2015, the trend of adult returns was interrupted. Although the largest number of SR sockeye salmon adults in recent history (4,093) arrived at Bonneville Dam that year, elevated water temperatures resulted in only 1 percent survival from Bonneville to Lower Granite Dam. Agencies and stakeholders quickly implemented a transportation program where sockeye salmon were captured at Lower Granite Dam and trucked to the Sawtooth Valley to avoid the high temperatures. Fortunately, the "safety net" captive broodstock program was able to provide adults to maintain the SR sockeye salmon hatchery program. In addition to the high temperature issue, the hatcheries had operational issues during 2015-17 that resulted in high mortalities; it appears that the operational issues are resolved or close to resolution, however. Given the low return of adults to the Sawtooth Valley in 2015, and the hatchery juvenile production issues in 2015–17, SR sockeye salmon returns for 2016-18 show a decline from previous years.

2.13.1.1.1 Spatial Structure and Diversity

This species includes all anadromous and residual sockeye salmon from the Snake River basin, Idaho, and artificially propagated sockeye salmon from the Redfish Lake Captive Broodstock Program. The ICTRT defined Sawtooth Valley sockeye salmon as the single MPG within the SR sockeye salmon ESU. The MPG contains one extant population (Redfish Lake) and two to four historical populations (Alturas, Petit, Stanley, and Yellowbelly Lakes) (NMFS 2015b). At the time of listing in 1991, the only confirmed extant population included in the ESU was the beach-spawning population of sockeye salmon from Redfish Lake, with about 10 fish returning per year (NMFS 2015b).

2.13.1.1.2 Abundance and Productivity

Adult returns in the last six years have ranged from a high of 1,579 fish in 2014 (including 453 natural-origin fish) to a low of 257 adults in 2012 (including 52 natural-origin fish) (Table 2.13-1). Sockeye salmon returns to Alturas Lake ranged from one fish in 2002 to 14 fish in 2010. No fish returned to Alturas Lake in 2012, 2013, or 2014 (NMFS 2015b). Although total sockeye salmon returns to the Sawtooth Valley in recent years have been high enough to allow for some level of natural spawning in Redfish Lake, the hatchery program remains at its initial phase with a priority on genetic conservation and building sufficient returns to support sustained outplanting and recolonization of the species historic range (NMFS 2015b; NWFSC 2015).

Table 2.13-1. Hatchery- and natural-origin sockeye salmon returns to Sawtooth Valley, 1999-2014 (IDFG, in prep.; NMFS 2015c; Dan Baker (IDFG) personal communication September 21, 2017).

Return Year	Total Return	Natural Return	Hatchery Return	Alturas Returns[1]	Observed Not Trapped
1999	7	0	7	0	0
2000	257	10	233	0	14
2001	26	4	19	0	3
2002	22	6	9	1	7
2003	3	0	2	0	1
2004	27	4	20	0	3
2005	6	2	4	0	0
2006	3	1	2	0	0
2007	4	3	1	0	0
2008	646	140	456	1	50
2009	832	86	730	2	16
2010	1,355	178	1,144	14	33
2011	1,117	145	954	2	18
2012	257	52	190	0	15
2013	272	79	191	0	2
2014	1,579	453	1,062	0	63
2015[2]	91	n/a	n/a	n/a	n/a
2016	574	n/a	n/a	n/a	n/a
2017	157	11	146	n/a	n/a

[1] These fish were assigned as sockeye salmon returns to Alturas Lake and are included in the natural-return numbers.
[2]In 2015, 56 sockeye returned to the Sawtooth Valley and 35 Snake Basin-origin sockeye were transported from Lower Granite Dam.

2.13.1.1.3 Limiting Factors

Understanding the limiting factors and threats that affect SR sockeye salmon provides important information and perspective regarding the status of the species. One of the necessary steps in achieving species' recovery and delisting is to ensure that the underlying limiting factors and threats have been addressed.

NMFS (2015b) identified the following factors as limiting the viability of the ESU:

- In the Sawtooth Valley (and Stanley Basin) – blocked access to the natal lakes; effects on food webs (predators and prey) in the natal lakes from the introduction and continued stocking of non-native fishes such as brook trout, rainbow trout, lake trout, and kokanee; increased sediment inputs from historical land use, mining practices, sheep and cattle grazing, timber harvest, and road building in the watersheds surrounding the natal lakes; and reduced flow and blocked migration due to water withdrawals and irrigation diversions.

- On the mainstem Salmon River – reduced baseflows; altered hydrologic regimes; elevated water temperatures; reduced availability of thermal refugia at tributary confluences due to water withdrawals; presence of toxic compounds with the potential to impair fitness; degraded riparian and instream habitat due to historical and current land use, roads and erosion control, floodplain development, and mining activities; and predation on emigrating juveniles by smallmouth bass, hatchery steelhead, rainbow trout, and brook trout.
- In the lower Snake River upstream of Lower Granite Reservoir – altered flows, riparian function, and food webs due to dam operations in the Hells Canyon Complex; degraded water quality; and an altered thermal regime due to land use adjacent to the Snake River and its tributaries.
- In the mainstem CRS migration corridor – passage barriers, conversion of riverine habitat to reservoirs, and water withdrawals that have degraded habitat conditions.
- In the lower Columbia River estuary – an altered food web due to dikes and levees, and hydrosystem operations that disconnect the river from much of its historical floodplain.

Long-term recovery objectives for this ESU are framed in terms of natural production. Substantial progress has been made with the SR sockeye salmon captive broodstock hatchery program, but natural production levels of anadromous returns remain extremely low for this ESU. In recent years, sufficient numbers of eggs, juveniles, and returning hatchery adults have been available from the captive broodstock program to allow for initiation of efforts to evaluate alternative supplementation strategies in support of reestablishing natural production of anadromous sockeye salmon (NWFSC 2015).

The ICTRT developed viability curves that used quantitative metrics to evaluate the abundance and productivity of the populations. The ICTRT set the minimum spawning abundance threshold at 1,000 natural-origin spawners, measured as a ten-year geometric mean, for the Redfish and Alturas Lake populations, and 500 natural-origin spawners for the smaller Pettit, Yellowbelly, and Stanley Lake populations. For SR sockeye salmon, the ICTRT determined that risks to ESU life history diversity and spatial structure could be diminished by reestablishing or reintroducing independent sockeye salmon populations to Alturas and Pettit Lakes, and possibly eventually into Stanley or Yellowbelly Lakes. Risks to ESU life history patterns could also be reduced by reestablishing historical life history patterns that may have been present in the natal lakes (NMFS 2015b). The SR sockeye salmon recovery plan (NMFS 2015b) describes a long-term recovery scenario which includes restoring at least two of the three historical lake populations in the ESU to highly viable, and one to viable status, using the Redfish Lake, Alturas Lake, and Pettit Lake populations.

2.13.1.2 Status of Critical Habitat

This section examines the rangewide status of designated critical habitat for SR sockeye salmon. Critical habitat includes the stream channels within designated streams reaches and a lateral extent defined by the ordinary high-water line (33 CFR 319.11).

NMFS determines the rangewide status of critical habitat by examining the condition of the PBFs that were identified when critical habitat was designated (Table 2.13-2). These features are essential to the conservation of the listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration, and foraging; NMFS 1993). Designated areas support one or more life stages (spawning, rearing, and/or migration) and contain the PBFs essential to the conservation of the species. For example, overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, undercut banks, and migration corridors free of artificial obstruction with sufficient water quantity and quality.

Table 2.13-2. Physical and biological features (PBFs) of critical habitats designated for SR sockeye salmon, and corresponding species life history events.

Physical and Biological Features	Components of the PBFs
Spawning and juvenile rearing areas	Spawning gravel Water quality Water quantity Water temperature Food Riparian vegetation Access
Adult and juvenile migration corridors	Substrate Water quality Water quantity Water temperature Water velocity Cover/shelter Food (juveniles) Riparian vegetation Space Safe passage
Areas for growth and development to adulthood	Ocean areas – not identified

Critical habitat for SR sockeye salmon includes the juvenile and adult migration corridors to the Pacific Ocean: the lower Columbia River and its estuary, the Snake River, and the mainstem Salmon River up to the Sawtooth Valley, Idaho. Historical nursery areas that are essential to the conservation of the species and identified as critical habitat include Redfish, Alturas, Pettit, Stanley, and Yellowbelly Lakes and their inlet and outlet creeks; Alturas Lake Creek; and that portion of Valley Creek that lies between Stanley Lake Creek and the Salmon River. Designated areas consist of the water, waterway bottom, and the adjacent riparian zone (defined as an area 300 feet from the normal high-water line on each side of the river channel) (NMFS 1993).

The lower Columbia River estuary is among the areas of high conservation value to all Columbia and Snake River basin species because it connects every population with the ocean and is used by rearing/migrating juveniles and migrating adults. The estuary is a unique and essential area for juveniles and adults making the physiological transition between life in freshwater and marine habitats.

Historically, adult SR sockeye salmon entered the Columbia River in June and July, migrated upstream through the Snake and Salmon Rivers, and arrived at their natal lakes in the Sawtooth Valley in August and September (Bjornn et al. 1968). Migration timing has not been altered substantially by the adults migrating upstream past the eight mainstem Columbia and Snake River dams. Spawning in lakeshore gravels peaks in October with fry emerging in late April-May the following year. Fry move to the open waters of the lake where they feed on plankton for one to three years before migrating to the ocean. Juvenile sockeye salmon generally leave the Sawtooth Valley lakes during late April-May and migrate nearly 900 miles to the Pacific Ocean. While pre-hydrosystem reports indicate that sockeye salmon smolts migrated through the lower Snake River in May and June, PIT-tagged smolts from Redfish Lake now pass Lower Granite Dam during mid-May to mid-July (SCA, NMFS 2008b). SR sockeye salmon spend two to three years in the ocean before returning to their natal lakes to spawn.

This complex life cycle gives rise to complex habitat needs, particularly in freshwater. The gravel used for spawning must be a certain size and largely free of fine sediments to allow successful incubation of the eggs and support later emergence or escape from the gravel of alevins. Eggs also require cool, clean, and well-oxygenated waters for proper development. Juveniles need abundant food sources, including plankton and insects. During their downstream migration, they need instream places to hide from predators (mostly birds and larger fish) such as under logs, root wads, and boulders, as well as beneath overhanging vegetation. They also need refuge from periodic high flows in side channels and off-channel areas, and from warm summer water temperatures in cold-water springs and deep pools. Returning adults generally do not feed in freshwater, but instead, rely on limited stored energy to migrate, mature, and spawn. Like juveniles, the returning adults also require cool water that is free of contaminants and migratory corridors with adequate passage conditions (timing, water quality/quantity) to allow access to the various habitats required to complete their life cycle.

In the following paragraphs, we discuss the current status of the functioning of the PBFs of critical habitat in the Interior Columbia and Lower Columbia River Estuary recovery domains.[168]

2.13.1.2.1 Interior Columbia Recovery Domain

Critical habitat for SR sockeye salmon has been designated in the Interior Columbia recovery domain, which encompasses all of the Columbia River basin accessible to SR sockeye salmon above Bonneville Dam. Habitat quality within this domain varies from excellent in wilderness

[168] A recovery domain is an administrative unit for recovery planning defined by NMFS based on species boundaries, ecosystem boundaries, and existing local planning processes. Recovery domains may contain one or more listed species.

and roadless areas to poor in areas subject to heavy agricultural and urban development. Critical habitat throughout much of the domain has been degraded by intense agriculture, alteration of stream morphology (i.e., channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining, and urbanization. Reduced summer stream flows, impaired water quality, and reduced habitat complexity are common problems for critical habitat in developed areas.

NMFS (2015b) described the following measures as needed to ensure that critical habitat supports the conservation of the species:

- Remove or modify passage obstructions (dams, artificial fish barriers, weirs, and culverts) to improve survival and restore access to historically accessible habitat;
- Achieve flow conditions that support adequate rearing, spawning, and migration;
- Implement forest management practices that protect watershed and stream functions;
- Manage agricultural practices, including grazing, in a manner that protects and restores riparian areas, floodplains, and stream channels, and protects water quality from sediment, pesticide, herbicide, and fertilizer runoff;
- Ensure that urban, rural, and recreational development does not reduce water quality or quantity, or impair natural stream or lake conditions;
- Protect and restore limnetic processes so that ecological inputs (of sediment, instream and groundwater flows, insects, leaves and wood) and ecological habitat processes support properly functioning lake and shoreline habitat conditions;
- Understand and limit the effects of toxic contaminants on salmonid fitness and survival so as not to affect recovery;
- Restore channel function, including vegetated riparian areas, canopy cover, stream-bank stability, off-channel and side-channel habitats, natural substrate and sediment processes, and channel complexity; and
- Restore floodplain function and the availability of floodplain habitats including connectedness between river and floodplain and the restoration of impaired sediment delivery processes.

2.13.1.2.2 Lower Columbia River Estuary Recovery Domain

Critical habitat has also been designated for SR sockeye salmon in the lower Columbia River estuary. The estuary is broadly defined to include the entire reach where tidal forces and river flows interact, regardless of the extent of saltwater intrusion. This encompasses areas from Bonneville Dam (RM 146) to the mouth of the Columbia River. It also includes the tidally influenced portions of tributaries below Bonneville Dam including the lower 26 miles of the Willamette River. This region experiences ocean tides that extend from the mouth of the Columbia River up to Bonneville Dam.

Historically, the downstream half of the Columbia River estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. The mouth of the Columbia River was about four miles wide. Winter and spring floods, low flows in late summer, large woody debris floating downstream, and a shallow bar at the mouth of the Columbia River maintained a dynamic environment. Today, navigation channels have been dredged, deepened, and maintained, jetties and pile-dike fields have been constructed to stabilize and concentrate flow in navigation channels, marsh and riparian habitats have been filled and diked, and causeways have been constructed across waterways. These actions have decreased the width of the mouth of the Columbia River to two miles and increased the depth of the Columbia River channel at the bar from less than 20 to more than 55 feet (NMFS 2008a).

Over time, more than 50 percent of the original marshes and spruce swamps in the estuary have been converted to industrial, transportation, recreational, agricultural, or urban uses, including more than 3,000 acres of this habitat being converted to other uses since 1948. Many wetlands along the shore in the upper reaches of the estuary were converted to industrial and agricultural lands after levees and dikes were constructed. Furthermore, water storage and release patterns from reservoirs upstream of the estuary have changed the seasonal pattern and volume of discharge. The peaks of spring/summer floods have been reduced, and the amount of water discharged during winter has increased (NMFS 2008a).

In addition, Bottom et al. (2005) estimate that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of suspended sediment to the lower river and estuary by about 60 percent (as measured at Vancouver, Washington). The significance of these changes for SR sockeye salmon is unclear, although estuarine habitat provides food for other yearling salmon and steelhead migrants that move rapidly downstream to the ocean (Johnson et al. 2018; PNNL and NMFS 2018).

Functioning estuarine areas are essential to conservation because, without them, juvenile SR sockeye salmon cannot reach the ocean in a timely manner and use the variety of habitats that allow them to avoid predators, compete successfully, and complete the behavioral and physiological changes needed for life in the ocean. Similarly, these features are essential to the conservation of adult salmonids because these features in the estuary provide a final source of abundant forage that will provide the energy stores needed to make the physiological transition to freshwater, migrate upstream, avoid predators, and develop to maturity upon reaching spawning areas (NMFS 2005a).

2.13.1.3 Climate Change Implications for Snake River Sockeye Salmon and Critical Habitat

Climate change is affecting the rangewide status of SR sockeye salmon and aquatic habitat. The USGCRP[169] reports average warming of about 1.3ºF from 1895 to 2011, and projects an increase in average annual temperature of 3.3ºF to 9.7ºF by 2070 to 2099 (CCSP 2014). Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate

[169] http://www.globalchange.gov

Impacts Group 2004; Scheuerell and Williams 2005; Zabel et al. 2006; ISAB 2007). According to the ISAB,[170] these effects pose the following impacts into the future:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season;
- With a smaller snowpack, watersheds will see their runoff diminished earlier in the season, resulting in lower stream flows in the June through September period. River flows in general and peak river flows are likely to increase during the winter due to more precipitation falling as rain rather than snow; and
- Water temperatures are expected to rise, especially during the summer months when lower stream flows co-occur with warmer air temperatures.

These changes will not be spatially homogeneous across the entire Pacific Northwest. Low-lying areas are likely to be more affected. Climate change may have long-term effects that include, but are not limited to, depletion of important cold-water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, premature emergence of fry, and increased competition among species. Overall, climate change effects likely to occur to some degree over the next ten years are expected at a similar rate as the last ten years.

Climate change is predicted to cause a variety of impacts to Pacific salmon and their ecosystems (Mote et al. 2003; Crozier et al. 2008a; Martins et al. 2012; Wainwright and Weitkamp 2013). The complex life cycles of anadromous fishes, including salmon, rely on productive freshwater, estuarine, and marine habitats for growth and survival, making them particularly vulnerable to environmental variation. Ultimately, the effects of climate change on salmon and steelhead across the Pacific Northwest will be determined by the specific nature, level, and rate of change and the synergy between interconnected terrestrial/freshwater, estuarine, nearshore, and ocean environments.

The primary effects of climate change on Pacific Northwest salmon and steelhead include:

- Direct effects of increased water temperatures on fish physiology;
- Temperature-induced changes to stream-flow patterns;
- Alterations to freshwater, estuarine, and marine food webs; and
- Changes in estuarine and ocean productivity.

[170] The Independent Scientific Advisory Board (ISAB) serves the National Marine Fisheries Service, Columbia River Indian Tribes, and Northwest Power and Conservation Council by providing independent scientific advice and recommendations regarding scientific issues that relate to the respective agencies' fish and wildlife programs; see https://www.nwcouncil.org/fw/isab/

While all habitats used by Pacific salmon will be affected, the impacts and certainty of the change vary by habitat type. Some effects (e.g., increasing temperature) affect salmon at all life stages in all habitats, while others are habitat-specific, such as stream-flow variation in freshwater, sea-level rise in estuaries, and upwelling in the ocean. How climate change will affect each stock or population of salmon also varies widely depending on the level or extent of change, the rate of change, and the unique life history characteristics of different natural populations (Crozier et al. 2008b). For example, a few weeks difference in migration timing can have large differences in the thermal regime experienced by migrating fish (Martins et al. 2011). This occurred in 2015 on adult sockeye salmon in the Columbia River when over 475,000 sockeye salmon passed Bonneville Dam, but only 2 to 10-15 percent of these adult sockeye, depending upon the population, survived to their spawning grounds. Most died in the lower Columbia River beginning in June when the water warmed to above 68°F, the temperature at which sockeye salmon begin to die. Water temperatures rose to 73°F in July when the area experienced a combination of continued high summer temperatures and lower than average flows (due to the lower snowpack from the previous winter and drought conditions exacerbate due to increased occurrences of warm weather patterns) (NMFS 2016e).

2.13.1.3.1 Temperature Effects

Like most fishes, salmon are poikilotherms (cold-blooded animals); therefore, increasing temperatures in all habitats can have pronounced effects on their physiology, growth, and development rates (see review by Whitney et al. 2016). Increases in water temperatures beyond their thermal optima will likely be detrimental through a variety of processes, including increased metabolic rates (and therefore food demand), decreased disease resistance, increased physiological stress, and reduced reproductive success. All of these processes are likely to reduce survival (Beechie et al. 2013; Wainwright and Weitkamp 2013; Whitney et al. 2016).

By contrast, increased temperatures at ranges well below thermal optima (i.e., when the water is cold) can increase growth and development rates. Examples of this include accelerated emergence timing during egg incubation stages, or increased growth rates during fry stages (Crozier et al. 2008a; Martins et al. 2011). Temperature is also an important behavioral cue for migration (Sykes et al. 2009), and elevated temperatures may result in earlier-than-normal migration timing. While there are situations or stocks where this acceleration in processes or behaviors is beneficial, there are also others where it is detrimental (Martins et al. 2012; Whitney et al. 2016).

2.13.1.3.2 Freshwater Effects

Climate change is predicted to increase the intensity of storms, reduce winter snow pack at low and middle elevations, and increase snowpack at high elevations in northern areas. Middle and lower-elevation streams will have larger fall/winter flood events and lower late-summer flows, while higher elevations may have higher minimum flows. How these changes will affect freshwater ecosystems largely depends on their specific characteristics and location, which vary at fine spatial scales (Crozier et al. 2008b; Martins et al. 2012). For example, within a relatively small geographic area (the Salmon River basin in Idaho), survival of some Chinook salmon populations was shown to be determined largely by temperature, while in others it was determined by flow (Crozier and Zabel 2006). Certain salmon populations inhabiting regions that are already near or exceeding thermal maxima will be most affected by further increases in temperature and, perhaps, the rate of the increases. The effects of altered flow are less clear and likely to be basin-specific (Crozier et al. 2008b; Beechie et al. 2013). However, river flow is already becoming more variable in many rivers, and is believed to negatively affect anadromous fish survival more than other environmental parameters (Ward et al. 2015). It is likely this increasingly variable flow is detrimental to multiple salmon and steelhead populations, and likely multiple other freshwater fish species in the Columbia River basin as well.

Stream ecosystems will likely change in response to climate change in ways that are difficult to predict (Lynch et al. 2016). Changes in stream temperature and flow regimes will likely lead to shifts in the distributions of native species and provide “invasion opportunities” for exotic species. This will result in novel species interactions including predator–prey dynamics, where juvenile native species may be either predators or prey (Lynch et al. 2016; Rehage and Blanchard 2016). How juvenile native species will fare as part of “hybrid food webs,” which are constructed from natives, native invaders, and exotic species, is difficult to predict (Naiman et al. 2012).

2.13.1.3.3 Estuarine Effects

In estuarine environments, the two big concerns associated with climate change are rates of sea-level rise and temperature warming (Wainwright and Weitkamp 2013; Limburg et al. 2016). Estuaries will be affected directly by sea-level rise: as sea level rises, terrestrial habitats will be flooded and tidal wetlands will be submerged (Kirwan et al. 2010; Wainwright and Weitkamp 2013; Limburg et al. 2016). The net effect on wetland habitats depends on whether rates of sea-level rise are sufficiently slow that the rates of marsh plant growth and sedimentation can compensate (Kirwan et al. 2010).

Due to subsidence, sea-level rise will affect some areas more than others, with the largest effects expected for the lowlands, like southern Vancouver Island and central Washington coastal areas (Verdonck 2006; Lemmen et al. 2016). The widespread presence of dikes in Pacific Northwest estuaries will restrict upward estuary expansion as sea levels rise, likely resulting in a near-term loss of wetland habitats for salmon (Wainwright and Weitkamp 2013). Sea-level rise will also result in greater intrusion of marine water into estuaries, resulting in an overall increase in salinity, which will also contribute to changes in estuarine floral and faunal communities (Kennedy 1990). While not all anadromous fish species are generally highly reliant on estuaries for rearing, extended estuarine use may be important in some populations (Jones et al. 2014), especially if stream habitats are degraded and become less productive.

Juvenile sockeye salmon could be affected by climate change in the estuary and plume environments through reduced spring freshet flows and turbidity, altered food webs, and predator/prey interactions, which could result in reduced survival rates. However, the use of both estuary and plume habitat by sockeye salmon is poorly understood.

2.13.1.3.4 Marine Effects

In marine waters, increasing temperatures are associated with observed and predicted poleward range expansions of fish and invertebrates in both the Atlantic and Pacific Oceans (Lucey and Nye 2010; Asch 2015; Cheung et al. 2015). Rapid poleward species shifts in distribution in response to anomalously warm ocean temperatures have been well documented in recent years, confirming this expectation at short time scales. Range extensions were documented in many species from southern California to Alaska during unusually warm water associated with “the blob” in 2014 and 2015 (Bond et al. 2015; Di Lorenzo and Mantua 2016) and past strong El Niño events (Pearcy 2002; Fisher et al. 2015).

Wind-driven upwelling is responsible for the extremely high productivity in the California Current ecosystem (Bograd et al. 2009; Peterson et al. 2014). Minor changes to the timing, intensity, or duration of upwelling, or the depth of water-column stratification, can have dramatic effects on the productivity of the ecosystem (Black et al. 2014; Peterson et al. 2014). Current projections for changes to upwelling are mixed: some climate models show upwelling unchanged, but others predict that upwelling will be delayed in spring, and more intense during summer (Rykaczewski et al. 2015). Should the timing and intensity of upwelling change in the future, it may result in a mismatch between the onset of spring ecosystem productivity and the timing of salmon entering the ocean, and a shift toward food webs with a strong sub-tropical component (Bakun et al. 2015).

Columbia River anadromous fish also use coastal areas of British Columbia and Alaska, and mid-ocean marine habitats in the Gulf of Alaska, although their fine-scale distribution and marine ecology during this period are poorly understood (Morris et al. 2007; Pearcy and McKinnell 2007). Increases in temperature in Alaskan marine waters have generally been associated with increases in productivity and salmon survival (Mantua et al. 1997; Martins et al. 2012), thought to result from temperatures that have been below thermal optima (Gargett 1997). Warm ocean temperatures in the Gulf of Alaska are also associated with intensified down welling and increased coastal stratification, which may result in increased food availability to juvenile salmon along the coast (Hollowed et al. 2009; Martins et al. 2012). Predicted increases in freshwater discharge in British Columbia and Alaska may influence coastal current patterns (Foreman et al. 2014), but the effects on coastal ecosystems are poorly understood.

In addition to becoming warmer, the world’s oceans are becoming more acidic as increased atmospheric CO_2 is absorbed by water. The North Pacific is already acidic compared to other oceans, making it particularly susceptible to further increases in acidification (Lemmen et al. 2016). Laboratory and field studies of ocean acidification show it has the greatest effects on invertebrates with calcium-carbonate shells and relatively little direct influence on finfish; see reviews by Haigh et al. (2015) and Mathis et al. (2015). Consequently, the largest impact of ocean acidification on salmon will likely be its influence on marine food webs, especially its effects on lower trophic levels, which are largely composed of invertebrates (Haigh et al. 2015; Mathis et al. 2015).

For sockeye salmon, a mismatch between earlier smolt migrations (because of earlier peak spring freshwater flows and decreased incubation period) and altered upwelling may also reduce marine survival rates (NMFS 2015). Further, ocean warming also may change migration patterns, increasing distances to feeding areas. Rising atmospheric carbon dioxide concentrations drive changes in seawater chemistry, increasing the acidification of seawater and thus reducing the availability of carbonate for shell-forming invertebrates, including some that are prey items for juvenile salmonids. These changes could also reduce marine survival rates (NMFS 2015b).

2.13.1.3.5 Uncertainty in Climate Predictions

There is considerable uncertainty in the predicted effects of climate change on the globe as a whole, and on the Pacific Northwest in particular, and there is also the question of indirect effects of climate change and whether human "climate refugees" will move into the range of salmon and steelhead, increasing stresses on their respective habitats (Dalton et al. 2013; Poesch et al. 2016).

Many of the effects of climate change (e.g., increased temperature, altered flow, coastal productivity, etc.) will have direct impacts on the food webs that species examined in this analysis rely on in freshwater, estuarine, and marine habitats to grow and survive. Such ecological effects are extremely difficult to predict even in fairly simple systems, and minor differences in life history characteristics among stocks of salmon may lead to large differences in their response (Crozier et al. 2008b; Martins et al. 2011, 2012). This means it is likely that there will be "winners and losers," meaning some salmon populations (even within the same species) may enjoy different degrees or levels of benefit from climate change while others will suffer varying levels of harm. Observations from 2015 (discussed later in this opinion) demonstrate that SR sockeye salmon is vulnerable to warmer stream temperatures, suggesting that this species will be harmed by climate change effects in the future.

Emerging research using complex life-cycle modeling indicates a potentially strong link between sea-surface temperature and survival of SR spring/summer Chinook salmon populations. However, the apparent link between SST and survival is presumably caused by food web interactions, relationships which could be disrupted by major transformations of community dynamics, as well as ocean acidification and other factors under a changing climate. The degree to which SST is linked to survival of SR sockeye salmon, and how that relationship interacts with other variables throughout the SR sockeye salmon life cycle, will likely be an important area of future research.

Climate change is expected to impact anadromous fish during all stages of their complex life cycle. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream-flow patterns in freshwater and changes to food webs in freshwater, estuarine and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty.

2.13.2 Environmental Baseline

The "environmental baseline" includes the past and present impacts of all federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

For SR sockeye salmon, we focus our description of the environmental baseline on areas where juveniles and adults from this ESU are exposed to the effects of the proposed action, especially where they are affected by hydropower projects and their operations, which starts at the head of Lower Granite Pool (at the confluence of Snake and Clearwater Rivers) and extends downstream through eight mainstem projects to the Columbia River estuary. We also consider the broader action area, including spawning, rearing, and migration habitat in the Salmon River basin, because these areas are important context for understanding the effects of the proposed action.

2.13.2.1 Mainstem Habitat

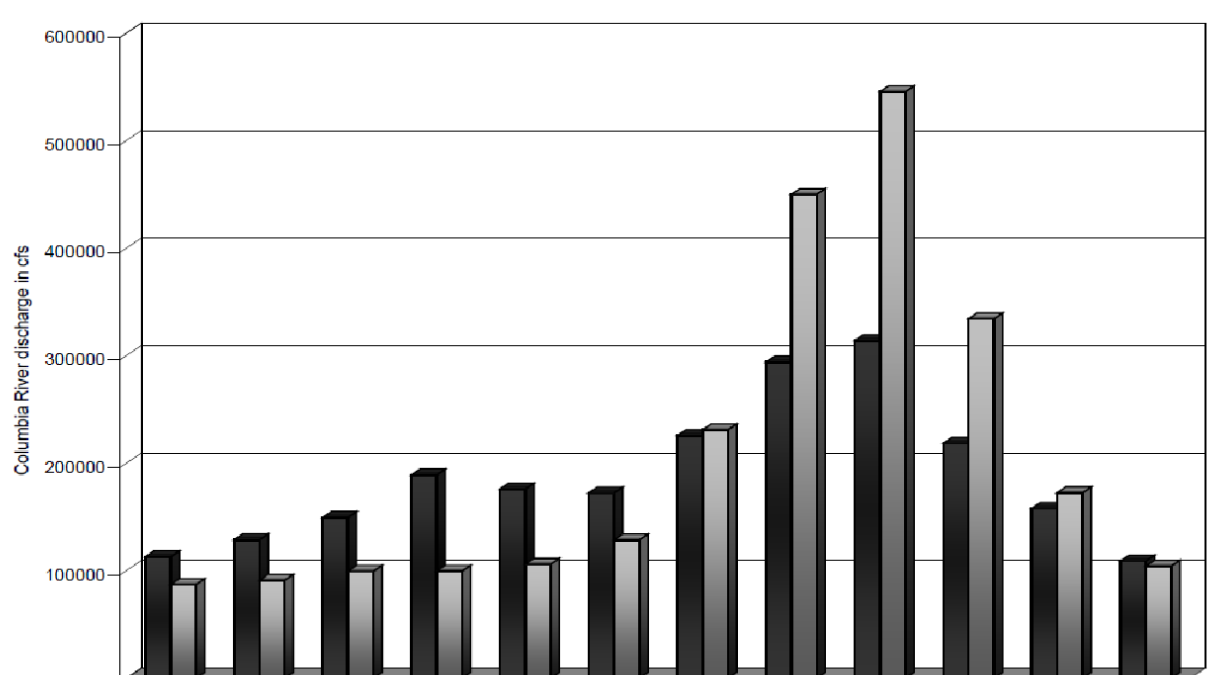
Mainstem habitat in the lower Snake and Columbia Rivers has been substantially altered by basinwide water management operations, the construction and operation of mainstem hydroelectric projects, the introduction of non-native species (e.g., smallmouth bass, walleye, channel catfish, invertebrates, etc.), and other human practices that have increased nutrients, pollutants, and toxic contaminants.

2.13.2.1.1 Seasonal Flows

On the mainstem of the Columbia River, hydropower projects (including the CRS), water storage projects (including reservoirs in Canada operated under the Columbia River Treaty), and the withdrawal of water for irrigation and urban uses have significantly degraded salmon and steelhead habitats (Bottom et al. 2005; Fresh et al. 2005; NMFS 2013a). The volume of water discharged by the Columbia River varies seasonally according to runoff, snowmelt, and hydropower demands. Mean annual discharge is estimated to be 265 kcfs, but may range from lows of 71–106 kcfs to highs of 530 kcfs (Hamilton 1990; NMFS 1998; Prahl et al. 1998; USACE 1999). Maximum flows on the river occur in May, June, and July as a result of snowmelt in the headwater regions. Minimum flows occur from September to March, with periodic peaks due to heavy winter rains (Holton 1984). Interannual variability in stream flow is strongly correlated with two recurrent climate phenomena, the ENSO and the PDO (Newman et al. 2016).

Water storage projects (dams and reservoirs) and water management activities have reduced flows at Bonneville Dam in the spring, representing basinwide effects in the lower Columbia River (NMFS 2008b). On average, this reduction can range from nearly 15 kcfs in August to over 230 kcfs in May (see Figure 2.13-3). Proportional flow reductions of similar magnitude also occur in the lower Snake River. Arthaud et al. (2010) estimated that spring flows of the Snake and Columbia Rivers were depleted about 30–50 percent, although peak runoff exceeded historical averages in some years.

Recognizing that the flow versus survival relationships for some interior basin ESUs/DPSs displayed a plateau over a wide range of flows but declined markedly as flows dropped below some threshold (NMFS 1995b, 1998), NMFS and the CRS Action Agencies have attempted to manage Columbia and Snake River water resources to maintain seasonal flows above threshold objectives given the amount of runoff in a given year. This has been accomplished by avoiding excessive drafts going into spring to minimize the flow reductions needed to refill the reservoirs and by drafting the storage reservoirs during summer to augment flows.[171] These flow objectives have guided preseason reservoir planning and in-season flow management. Nonetheless, since the development of the hydrosystem, average monthly flows at Bonneville Dam have been substantially lower during May–July and higher in October–March compared to an unregulated system. Reduced flows have increased travel times during outmigration for juvenile salmonids and reduced access to high-quality estuarine habitats during spring and early summer.



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Current	113017	128641	149403	189076	175921	172150	225689	293948	313930	218523	157935	109020
Natural	87115	91029	99387	99496	106033	128580	231047	450040	545561	334238	172430	104310

Figure 2.13-3. Comparison of monthly discharge (flow) in the Columbia River between current conditions (black) and normative flows (gray). These data show that pre-development flows were lower in the winter and higher in the summer months.

[171] Even though several million acre feet of water are released annually from storage during the summer months to augment flows (and from Dworshak Dam, to reduce temperatures in the lower Snake River), these volumes do not offset the consumption of water in the basin in July and August.

2.13.2.1.2 Water Quality

Water quality in the action area is impaired as a result of chemical contaminants from municipal, agricultural, industrial, and urban land uses (NMFS 2017e). Common toxic contaminants found in the Columbia River system include PCBs, PAHs, PBDEs, DDT and other legacy pesticides, current-use pesticides, pharmaceuticals and personal care products, and trace elements (LCREP 2007). The LCREP (2007) report noted widespread presence of PCBs and PAHs, both geographically and in the food web. Urban and industrial portions of the lower river contribute significantly to contaminant levels in juvenile salmon; juvenile salmon are absorbing toxic contaminants during their time rearing and feeding in the lower Columbia River (LCREP 2007). Likewise, juvenile salmon are accumulating DDT in their tissues and are exposed to estrogen-like compounds in the lower river, likely associated with pharmaceuticals and personal care products. Concentrations of copper are present at levels that could interfere with crucial salmon behaviors.

Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute municipal and industrial waste discharges to the lower Columbia River. Industrial and municipal wastes from the Portland/Vancouver metro areas, including the superfund-designated reach in the lower Willamette River, also contribute to degraded water quality in the lower river. Legacy and active mining areas scattered around the basin deliver high background concentrations of metals. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river.

The most extensive urban development in the lower Columbia River basin has occurred in the Portland/Vancouver area. Common water-quality issues with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff (LCREP 2007). Similar effects are likely to be proportionally associated with smaller urban areas as well (e.g., Lewiston, Idaho; Tri-Cities, Washington; The Dalles and Hood River, Oregon). While it is not clear what the magnitude of effects are to juvenile or adult SR sockeye salmon, stress is likely to lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g. growth, osmoregulation, and survival).

Oils, greases, and other lubricants (derived from animal, fish, vegetable, petroleum or marine mammal origin) are used at each of the CRS projects (and all other dams in the Columbia River Basin), including, but not limited to, the following: hydropower turbines, hydraulic systems, lubricating systems, gear boxes, machining coolant systems, heat transfer systems, transformers, circuit breakers, and electrical systems. Leakage of oils, greases, or other lubricants into rivers has the potential to affect salmon and steelhead (avoidance, exposure to toxic compounds, or even, in some circumstances death). In response to increased concerns regarding the releases of oils and greases from lower Columbia and lower Snake River dams (and Dworshak and Chief Joseph Dams) the Corps has taken steps to minimize these risks. For equipment in contact with the water, the Corps has developed best management practices to avoid accidental releases and to minimize the adverse effects in the case of an accidental release. The Corps has also begun using, where feasible, "environmentally acceptable lubricant" greases and in some cases has replaced greased equipment with greaseless equipment. The Corps has also developed and are implementing oil accountability plans with enhanced inspection protocols and are reporting annually.

The extent to which leaked grease or oil, occurring under the environmental baseline in the Clearwater River (Dworshak Dam), Upper Columbia River (Chief Joseph), or lower Snake or lower Columbia Rivers, has affected the behavior, health, or survival of SR sockeye salmon in the past is unknown, but likely to be small given that the size of these river systems. For comparison, a large leak of 100 gallons per day is the equivalent of 0.00016 cubic feet per second and the average annual discharge of the Columbia River has ranged from roughly 125,000 to 250,000 cubic feet per second since about 1940 (ISAB 2000). Nevertheless, to the extent past leakages have potentially affected passage or survival, these effects would be encompassed by annual juvenile or adult reach survival estimates. Recent actions (adoption of best management practices, use of environmentally acceptable lubricants, use of greaseless equipment, etc.) would further reduce the potential for negative effects stemming from these materials and slightly improve conditions for juvenile and adult migrants.

Our understanding of the effects on aquatic life impacts of many contaminants, alone or in combination with other chemicals (potential for synergistic effects), is incomplete especially when considering the exposure of juveniles to multiple contaminants, or when considering their interactions with other stressors, food web-mediated effects, and effects in complex mixtures (NMFS 2017e). Together, these contaminants are likely affecting the productivity and abundance of sockeye salmon, especially during the rearing and juvenile migration phases of their life cycle. The effects can be direct or indirect, and lethal or more likely sublethal; the interaction of co-occurring stressors may have a greater impact on salmon than if they occur in isolation (Dietrich et al. 2014).

Warmer summer water temperatures in the lower Snake and Columbia Rivers, especially in June and July, are a concern; the Columbia River is included on the Clean Water Act §303(d) list of impaired waters established by Oregon, Washington and Idaho because of temperature-standard exceedances. Temperature conditions in the Columbia River basin area are affected by many factors, including:

- Natural variation in weather (air temperature) and river flow;
- Construction of the dam and reservoir system (thermal inertia resulting from the relatively large reservoirs (volume) and reduced water velocity, and increased surface areas of reservoirs);
- Increased temperatures of tributaries;
- Water managed for irrigated agriculture;
- Point-source discharges such as cities and industries; and

- Climate change (Overman 2017; EPA 2018).

Since the mid-1990s, the Corps has released up to 1.2 million acre-feet of cool water from Dworshak Dam to reduce temperatures in the lower Snake River from June or July to September. Operators manage water releases from Dworshak so temperature does not exceed 68°F at the tailrace of Lower Granite Dam. These releases substantially cool the lower Clearwater River and Lower Granite Reservoir, though the cooler water sinks to the bottom causing vertical stratification of the reservoir. The warmer surface water is mixed with the cooler, deeper water as it passes through turbines and spillway bays at the dam, and at each subsequent Snake River dam. Thus, cooler temperatures stemming from Dworshak operations result in strong stratification within the forebay of Lower Granite Dam, with the effect diminishing as the water moves downstream through Little Goose Dam and subsequent Snake River dams (i.e., the effect is increasingly attenuated by mixing with distance downstream; NMFS 2008a, 2017e). As an example, Figure 2.13-4 depicts temperature conditions at the Anatone Gage on the Snake River upstream of Lower Granite Reservoir; the Peck Gage on the lower Clearwater River; and tailrace temperatures at Lower Granite, Little Goose, Lower Monumental and Ice Harbor Dams during the unusually hot, low-flow summer of 2015. Cool-water releases from Dworshak Dam have improved late-summer migration conditions for adult sockeye salmon in the lower Snake River compared to those at the Anatone Gage.

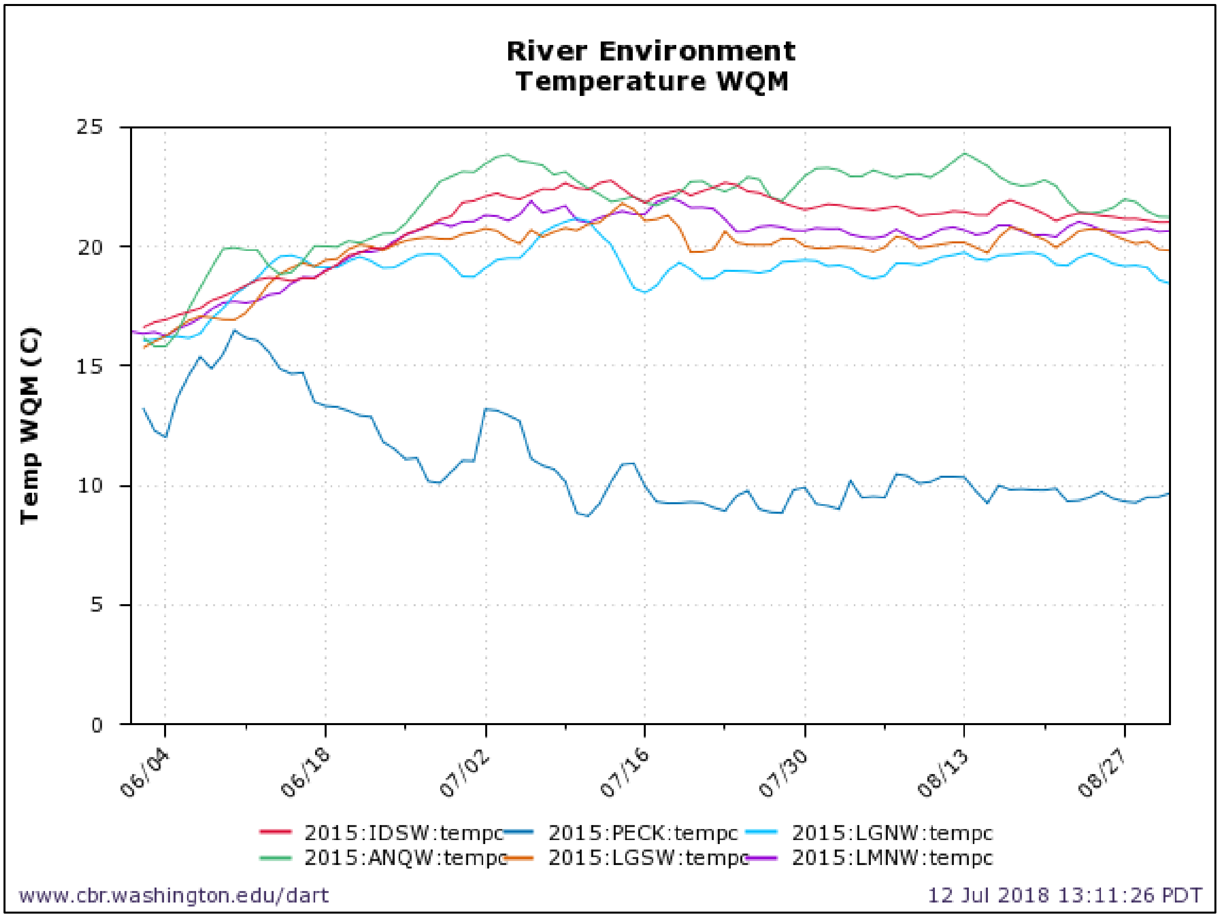


Figure 2.13-4. Temperature conditions at the Anatone Gage on the Snake River upstream of Lower Granite Reservoir (green, top line); the Peck Gage on the lower Clearwater River (blue, bottom line); and the tailrace temperatures at Lower Granite (light blue), Little Goose (orange), Lower Monumental (purple), and Ice Harbor (red) Dams during the especially hot summer of 2015.

Cool-water releases from Dworshak Dam have substantially improved summer migrations conditions for adult sockeye salmon in the Snake River compared to operations before the mid-1990s.

The EPA is working with federal and state agencies, tribes, and other stakeholders to develop water-quality improvement plans (total maximum daily loads) for temperature in the Columbia River and lower Snake River. As part of the 2015 biological opinion on EPA's approval of water-quality standards, including temperature (NMFS 2015a), EPA committed to work with federal, state, and tribal agencies to identify and protect thermal refugia and thermal diversity in the lower Columbia River and its tributaries.

Comparisons of long-term temperature monitoring in the migration corridor before and after impoundment reveal a change in the thermal regime of the Snake and Columbia Rivers. Using historical flows and environmental records for the 35-year period 1960–1995, Perkins and Richmond (2001) compared water-temperature records in the lower Snake River with and without the lower Snake River dams and found three notable differences between the current versus unimpounded river:

- Maximum summer water temperature has been slightly reduced;
- Water temperature variability has decreased; and
- Post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall, a phenomenon termed thermal inertia.

These hydrosystem effects continue downstream and influence temperature conditions in the lower Columbia River. At a macro scale, water temperature affects salmonid distribution, behavior, and physiology (Groot and Margolis 1991); at a finer scale, temperature influences migration swim speed of salmonids (Salinger and Anderson 2006), timing of river entry (Peery et al. 2003), susceptibility to disease and predation (Groot and Margolis 1991), and, at temperature extremes, survival. Exposure to elevated summer temperatures in the lower Columbia River is greatest for the latest migrating juvenile smolts (late May and June) and adult sockeye salmon (late July and August).

TDG levels also affect mainstem water quality and habitat. To facilitate the downstream movement of juvenile salmonids, state regulatory agencies issue criteria adjustments for TDG as measured in the forebay and tailrace (NMFS 1995b). Specifically, water that passes over the spillway at a mainstem dam can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids resulting in injury and death (Weitkamp and Katz 1980). Historically, TDG supersaturation was a major contributor to juvenile salmon mortality; to reduce TDG supersaturation, the Corps installed spillway improvements, typically "flip lips," at each mainstem dam except The Dalles Dam. Biological monitoring shows that the incidence of observable GBT symptoms in both migrating smolts and adults remains between 1–2 percent when TDG concentrations in the upper water column do not exceed 120 percent of saturation in CRS project tailraces. When those levels are exceeded, there is a corresponding increase in the incidence of signs of GBT symptoms. Fish migrating at depth avoid exposure to the higher TDG levels due to pressure compensation mechanisms (Weitkamp et al. 2003).[172] Under recent operations (2008–2017), exposure to excessive high TDG levels exceeding state water quality standards has been restricted to lack of market or lack of turbine capacity spill. These spill events have most often occurred between mid-May and mid-June. Crozier et al. (2014) found that high levels of TDG were associated with reduced survival of SR sockeye salmon in the Ice Harbor to Lower Granite Dam reach, with the biggest effect at Lower Granite Dam.

[172] Roughly, for each meter below the surface an aquatic organism is located, there is a corresponding reduction in the effective TDG the organism experiences of about 10 percent. Thus, if TDG levels are at 120 percent, and organism two meters below the surface would effectively experience 100 percent TDG saturation.

2.13.2.1.3 Sediment Transport

The series of dams and reservoirs have also blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is about one third of nineteenth-century levels (Simenstad et al. 1982 and 1990; Sherwood et al. 1990; Weitkamp 1994; NRC 1996; NMFS 2008a). Similarly, Bottom et al. (2005) estimated that the delivery of suspended particulate matter to the lower river and estuary has been reduced by about 40 percent (as measured at Vancouver, Washington), and fine-sediment transport reduced by 50 percent or more. These estimates reflect the combined total of all activities throughout the Columbia River basin on sediment transport. Similar reductions would be expected throughout the mainstem portion of the action area. The overall reduction in sediment has altered the development of habitat along the margins of the river.

Industrial harbor and port development are also significant influences on the lower Snake and lower Columbia Rivers (Bottom et al. 2005; Fresh et al. 2005; NMFS 2013a). Since 1878, the Corps has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the Willamette River as a navigation channel. Originally dredged to a 20-foot minimum depth, the federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The navigation channel supports many ports on both sides of the river, resulting in several thousand commercial ships traversing the river every year. The dredging, along with diking, draining, and fill material placed in wetlands and shallow habitat, also disconnects the river from its floodplain, resulting in the loss of shallow-water rearing habitat and the ecosystem functions that floodplains provide (e.g., supply of prey, refuge from high flows, temperature refugia, etc.; Bottom et al. 2005).

Formal consultation for the Channel Maintenance Dredging in the lower Snake and Clearwater Rivers (WCR-2014-1723) was completed on November 14, 2014. Recent discussions with the Corps indicate that all aspects of the consultation, both in the proposed action and the accompanying terms and conditions within the NMFS Biological Opinion, were completed by the Corps and its permittees (personal communication, B. Tice, Corps).

Material was dredged from four sites along the Snake and Clearwater Rivers: (1) downstream navigation lock of Ice Harbor Dam (Snake RM 9.5); (2) the federal navigation channel in the Snake and Clearwater Rivers confluence area (Snake RM 138 to Clearwater RM 2.0); (3) the berthing area for the Port of Clarkston, Washington (Snake RM 137.9 and 139); and (4) the berthing area for the Port of Lewiston, Idaho (Clearwater River, RM 1 to 1.5). The Corps also issued regulatory permits for dredging at commercial ports and berths operated by local port districts or private companies in Clarkston, Washington and Lewiston, Idaho. Most of these non-federal navigation areas consisted of arterial channels leading from the main federal navigation channel to the port or berth, as well as those areas at the port or berth used for loading, unloading, mooring, or turning around. The dredged material was disposed of in-river as fill to construct a shallow-water bench for juvenile fish habitat at Knoxway Bench (RM 116) immediately upstream of Knoxway Canyon.

2.13.2.1.4 Adult Migration and Survival

Sockeye salmon adults typically begin arriving at Bonneville Dam in mid-June and migrate upstream during summer in depleted flows and warmer temperatures than in an undeveloped system (Figure 2.13-6). While the upstream migration of adults can be slowed as fish search for fishway entrances and navigate through the fishways themselves, reduced June and July flows would likely benefit migrating adults by reducing the energetic costs of upstream migration (Rand et al. 2006).

Large upstream water storage and flood-control projects, mainstem run-of-river hydropower projects, land use practices throughout the basin, and warmer temperatures resulting from climate change have affected the thermal regime of the mainstem Snake and Columbia Rivers. Together, these factors have increased minimum winter temperatures, delayed spring warming, reduced maximum summer temperatures, and delayed fall cooling. Delayed spring warming would be expected to benefit sockeye salmon adults that migrate during June-early July (by providing relatively cooler temperatures), but warmer temperatures later in the summer are negatively affecting those that migrate through the lower Snake and Columbia Rivers in late July–September. To mitigate for (or, where cooler, enhance) these thermal effects, Dworshak Dam, on the North Fork Clearwater River, releases cool water during July–September to reduce temperatures on the lower Snake River, at least as far downstream as Little Goose Dam.

Recent (2013–17) adult survival rates have averaged about 60 percent from Bonneville to McNary Dam and about 50 percent from Bonneville to Lower Granite Dam (NMFS estimates using PIT tags). This includes the extremely poor survival year of 2015, when only 15 percent of adult SR sockeye salmon survived from Bonneville to McNary Dam, and only 4 percent survived from Bonneville to Lower Granite Dam (NMFS 2016e).[173] In 2015, low snowpack, coupled with extremely high air temperatures throughout the interior Columbia Basin, resulted in warm water in the major tributaries to the lower Snake and Columbia Rivers. Temperatures in the mainstem Columbia River were the highest recorded from roughly mid-June to mid-July. Adult sockeye salmon, which normally migrate during this period, sustained heavy losses in the Columbia River and tributaries (NMFS 2016e).

Estimated survival rates for PIT-tagged sockeye salmon show that 73 percent of the adults that passed Lower Granite Dam (2008–12) were recovered at Redfish Lake, the Sawtooth Hatchery weir, or other locations. The rates also indicate that very few fish that pass Lower Granite Dam after the first week in July will survive to reach the Sawtooth Valley (Crozier et al. 2014).

The greatest challenge for migrating SR sockeye salmon adults is the increasing water temperatures as they move upstream through the hydrosystem. At water temperatures above 64.4°F, sockeye salmon display increases in fallback and straying, and decreases in survival. This is especially true for fish transported as juveniles. From 1999 to 2012, survival of PIT-

[173] The average 2008-2016 estimates of adult survival, excluding 2015, are about 77 percent from Bonneville to McNary Dam and 69 percent from Bonneville to Lower Granite Dam (about 7 percent higher).

tagged adult sockeye salmon from Lower Granite Dam to the Sawtooth Valley was negatively correlated ($r^2 = 0.53$) to water temperature in the Snake River (Arthaud and Morrow 2013). When Snake River (at Anatone, Washington gage, upstream of Lower Granite Reservoir) average July water temperatures exceeded 71.6°F, the percent conversion was less than 20 percent, yet reached 90 percent as temperatures declined to 64°F. Current efforts to control summer water temperatures in the lower Snake River include regulating outflow temperatures at Dworshak Dam (NMFS 2015b). Extremely high rates of fallback have been observed at Lower Granite Dam in some years, possibly associated with high forebay temperatures. A device that introduces cold water pumped from deeper in the reservoir at the entrance to the fishway likely contributed to lower fallback rates in 2016-2017. A similar, permanent structure was constructed near the Little Goose Dam fishway exit and began operating in 2018. Mechanical issues related to the pump resulted in some short-term outages in 2018, but these issues are being addressed (repairs or replacements will be installed next season) and this structure should continue to improve passage conditions for adult sockeye salmon at Little Goose Dam.

SR sockeye salmon experience relatively high rates of fallback at Bonneville, The Dalles and Lower Granite Dams. Detailed examination of PIT-tag records revealed the existence of fish that may fall back and reascend the same dam many times in a short period, or fall back at multiple dams and then reascend. An increased incidence of fallback events at these dams tend to be associated with water temperatures in excess of 71.6°F, and may be related to temperature stress and the failure of homing behavior. Some of the unaccounted for losses of SR sockeye salmon adults could be related to fish that fallback but fail to reascend the dams (with the current PIT-tag detection systems, only those fish which reascend the fish ladder after falling back over the dam can be detected). Fish transported as juveniles were more likely to fall back than in-river migrants at Bonneville, The Dalles, and McNary Dams, but not at the lower Snake River dams. Fish also had a higher fallback rate if they had fallen back at previous dams (Crozier et al. 2018).

SR sockeye salmon have relatively low survival though the Bonneville to McNary Dam reach (Figure 2.13-5), with their survival rate slightly lower than the rate for Upper Columbia sockeye salmon which migrate through the reach at the same time. However, when the data for fish that were transported are separated from the data for fish that migrated in-river as juveniles, the in-river migrants show survival rates similar to the Upper Columbia River sockeye salmon, while transported SR sockeye salmon have lower survival rates. Survival for both transported fish and in-river migrants improves after they enter the Snake River (NMFS 2016e).

Crozier et al. (2014) reviewed PIT-tag data from 2008–2013 and developed statistical models to identify factors associated with upstream migration survival and the strength of their effects. They found that the most important predictors of survival across reaches and years were thermal exposure and fish travel time, which are both influenced by fallback rates. Fallback for migrating adults is also a concern for SR sockeye salmon because this ESU appears to fallback more than other species; as discussed above, fallback rates are significantly higher for adults that were transported as juveniles, although this effect is variable from year-to-year (Crozier et al. 2014). Fallback is also influenced by temperature, flow, TDG, and fish history. There is also the potential for unreported harvest or estimation methods for harvest to contribute to the lower adult sockeye salmon survival rate estimates through the lower Columbia River (compared to the Snake River) (NMFS 2014). It is also possible that interaction effects between the temperature, hydrosystem operations, harvest, and potentially other factors are affecting adult survival rates in this reach.

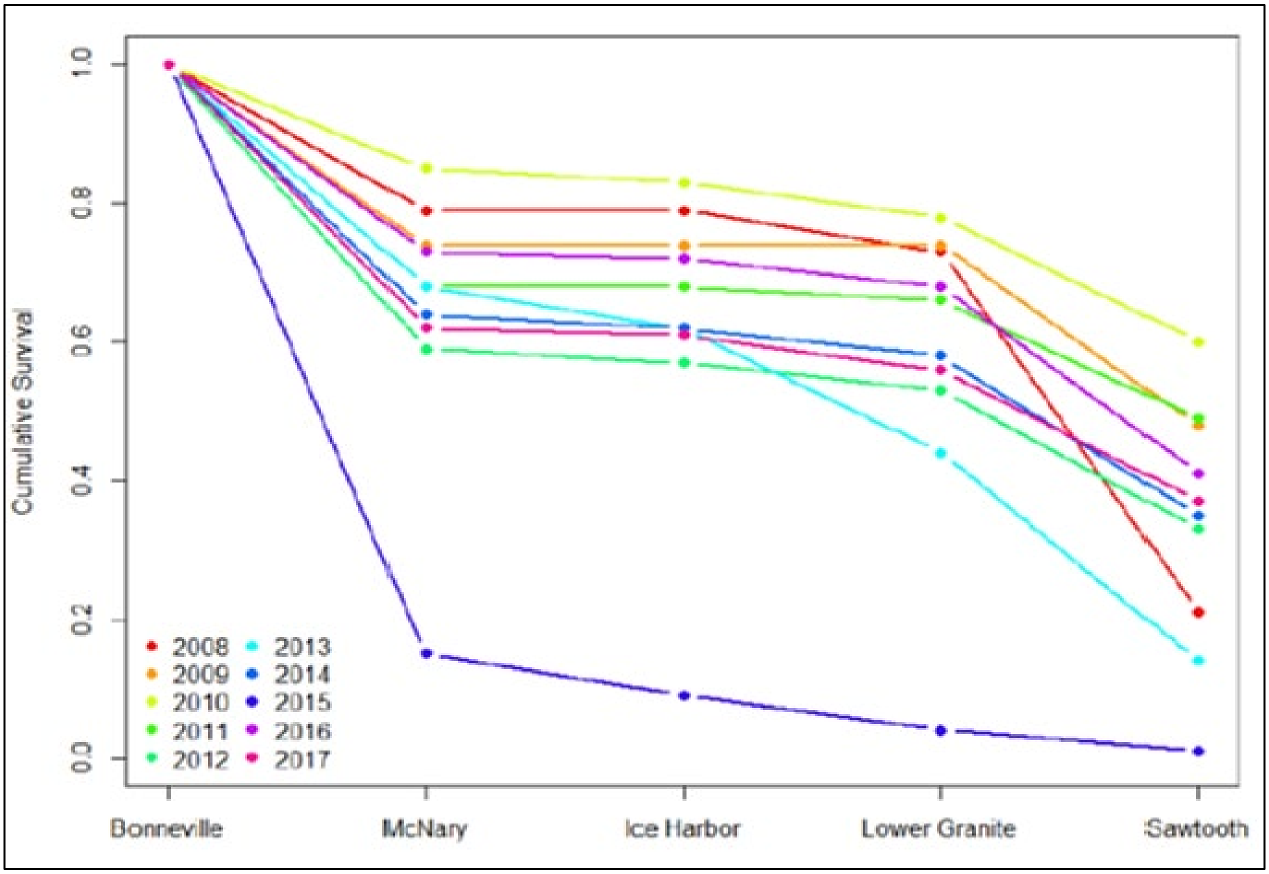


Figure 2.13-5. Observed cumulative survival for Snake River sockeye salmon from Bonneville Dam to the Sawtooth Valley.

2.13.2.1.5 Juvenile Migration and Survival

The Salmon River joins the lower Snake River at RM 188. The Grande Ronde River also contributes flow to this reach, along with the Imnaha River, Asotin Creek, and other small tributaries. The channel of the Snake River widens near RM 180, with gently sloping shorelines. Downstream of the Salmon and Grande Ronde Rivers there are long, deep pools, runs, and low-gradient rapids (Groves and Chandler 1999). The free-flowing reach of the lower Snake River ends at RM 147, where it enters the Lower Granite Reservoir near Lewiston, Idaho (NMFS 2015b).

Although unimpounded, flows in this reach of the lower Snake River have been altered since the 1960s by power-peaking operations at the Hells Canyon Complex of dams (Snake RM 247). Flow fluctuations in the reach can strand or entrap juveniles in shallow-water areas; however, there is no indication that this is a significant issue for SR sockeye salmon, which migrate quickly through the mainstem and spend limited time in nearshore areas. PIT-tag and radiotelemetry studies during the 2012–13 outmigration season showed that median travel time for Sawtooth and Oxbow Hatchery sockeye salmon was approximately 7 days from the Sawtooth Valley to Lower Granite Dam (Axel et al. 2013, 2014).

Increasing water temperatures may be a limiting factor for SR sockeye salmon in the Salmon River and lower Snake River reaches, potentially affecting juvenile migration timing and survival rates.

A substantial proportion of outmigrating juvenile SR sockeye salmon are killed during dam passage. Mortality can be direct (collisions with structures and abrupt pressure changes during passage through turbines and spillways) or indirect/delayed (non-fatal injury and disorientation), which leave fish more susceptible to predation and disease.

Several actions implemented by the Action Agencies in recent years have improved conditions in the migration corridor for all listed Columbia Basin salmon and steelhead species including SR sockeye salmon. By 2009, each of the eight mainstem lower Snake and lower Columbia River dams was equipped with a surface passage structure (spillbay weirs, powerhouse corner collectors, or modified ice and trash sluiceways). Smolts primarily migrate in the upper 20 feet of the water column in the lower Snake and Columbia Rivers. Water is drawn through these surface passage routes from the same depths as juveniles migrate, whereas conventional spillbays or turbine unit intakes draw water from depths greater than 50 feet. The surface passage routes provide a safe and effective passage route for migrating smolts by reducing migration delay (time spent in the forebay of the dams) and increasing the proportion of smolts passing the dams via the spillway rather than via the turbines or juvenile bypass systems (spill passage efficiency). Changes have included the relocation of juvenile bypass system outfalls to avoid areas where predators collect; as well as other operational and structural changes. Other changes include changes to spill operations, the installation of avian wires to reduce juvenile losses to avian predators, as well as changes to reduce dissolved gas concentrations that might otherwise limit spill operations. Together, these factors have improved the in-river survival of SR sockeye salmon (NMFS 2014).

Juvenile survival estimates from Lower Granite to Bonneville Dam from 2015 to 2017 were substantially impacted by issues relating to the rearing and transport of Springfield Hatchery smolts (which made up the great majority of PIT-tagged fish used to make survival estimates). Survival rates in these years ranged from about 12–37 percent, but the rates are not considered estimates of juvenile survival because they do not reflect passage conditions through the lower Snake and Columbia dams and reservoirs, but rather the compromised condition of the test fish. In 2018, 64 percent of juvenile SR sockeye salmon were estimated to survive from Lower Granite to Bonneville Dam (Zabel 2018). This recent survival estimate includes hatchery fish that were raised at Springfield Hatchery after water quality improvements were made. The 2018 survival estimate is above average and indicates the recent improvements to hatchery rearing and transport practices have likely addressed the problem related to the relatively low survival rates observed from 2015-2017.

Survival estimates for juvenile migrants are summarized below:

- Lower Granite Dam to Bonneville Dam: Juvenile survival from Lower Granite to Bonneville Dam (2008–14) averaged 54 percent, ranging from about 40–71 percent (Widener et al. 2018; Figure 2.13-6). This represents a substantial improvement in survival, due to improved structures and operations, compared to 1998–2003 estimates, which ranged from 2 percent in 2001 to 55 percent in 1999).
- Preliminary survival estimates from Lower Granite to Bonneville Dam in 2018 was 64.3 percent (Zabel 2018), the second highest estimate since 2008; 2014 being the highest estimate.

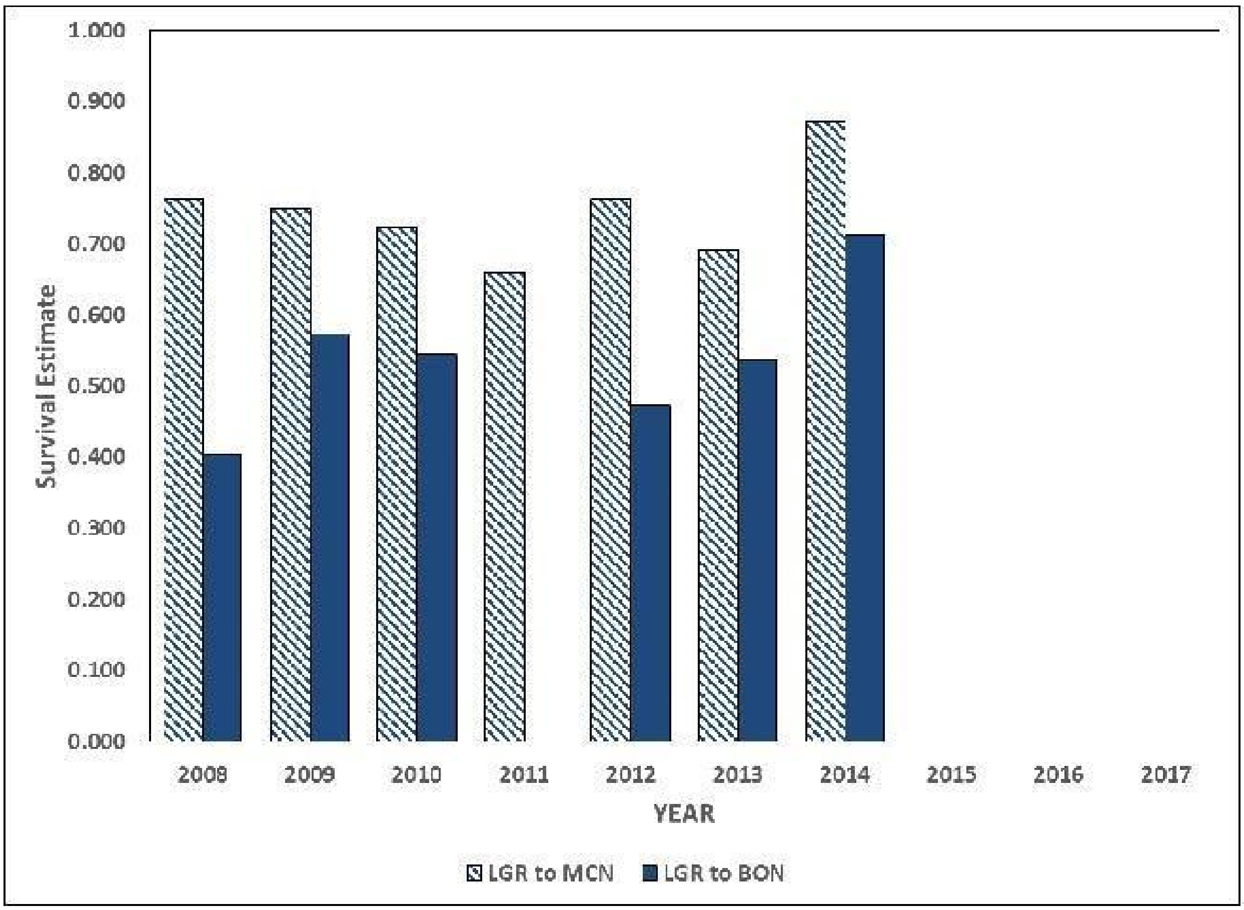


Figure 2.13-6. Juvenile Snake River sockeye salmon survival rates from Lower Granite to McNary and Bonneville Dams (2008-2014). Source: Widener et al. 2018.

2.13.2.1.6 Transportation

The goal of transporting juvenile SR sockeye salmon downstream is to improve the survival of juveniles and increase adult returns. The juveniles are collected from three facilities on the Lower Snake River (Lower Granite, Little Goose, and Lower Monumental Dams) through screened juvenile bypass systems and loaded on barges; they are collected by the same transportation program that transports Chinook salmon and steelhead smolts from those locations. The sockeye salmon smolts are then transported downstream by barge and released one or two days later below Bonneville Dam. Given their relatively low downstream survival through the CRS (40–71 percent in 2008–14) the transportation provides a large advantage in the survival of adults back to Bonneville Dam (average transport-to-inriver survival ratio of 2.47). However, upon returning as adults, sockeye salmon that were transported as juveniles tend to spend more time migrating and have a lower upstream survival rate (likely due to increased wandering and resultant interactions with fisheries, and increased fallback rates) than fish that migrate inriver as juveniles in the Bonneville to McNary Dam reach. Both the NWFSC and the Fish Passage Center have estimated the percentage of SR sockeye salmon transported during the years 2013 to 2017. The NWFSC mean estimate for these years is 34 percent (range 26-51 percent) (Smith 2018) while the Fish Passage Center estimate is 39 percent (range 8-58 percent) (DeHart 2018). The two estimates are based on different estimation methods.

Because of concerns about cumulative thermal effects (which contributed substantially to high adult mortalities observed in 2013 and 2015), and to avoid high temperatures in the Salmon River in 2015, NMFS authorized the IDFG to trap some adult SR sockeye salmon at Lower Granite Dam and transport them directly to their hatchery facility in Eagle, Idaho. The effort was limited to those fish that could be captured at Lower Granite Dam, but nearly all of the adults handled in this way survived and contributed to the 2015 brood-year production. Ultimately, 35 of the 91 fish (38 percent) that were spawned in 2015, were captured and transported from Lower Granite Dam (NMFS 2016e). In 2015, SR sockeye salmon adults, especially those fish that were previously transported as juveniles, were more impacted by temperature conditions (impaired or died) in the lower Columbia River (Bonneville to McNary Dam) than were unlisted sockeye salmon from the upstream Columbia River tributaries (NMFS 2016e).

2.13.2.2 Estuary Habitat

The estuary provides important migratory habitat for SR sockeye salmon. Since the late 1800s, 68–70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening combined with flow regulation and other modifications (Kukulka and Jay 2003; Bottom et al. 2005; Marcoe and Pilson 2017). Disconnection of tidal wetlands and floodplains has reduced the production of wetland macrodetritus supporting salmonid food webs (Simenstad et al. 1990; Maier and Simenstad 2009), both in shallow water and for larger juveniles migrating in the mainstem (ERTG 2018).

Restoration actions in the estuary, such as those highlighted in the latest five-year review, have improved access and connectivity to floodplain habitat. From 2004 through 2017, the Action Agencies implemented 58 projects including dike and levee breaching or lowering, tide, gate removal, and tide, gate upgrades that reconnected 5,412 acres of historical tidal floodplain habitat to the mainstem. This represents a 2.5 percent net increase in the connectivity of habitats that produce prey used by juvenile sockeye salmon (Johnson et al. 2018). In addition, about 2,500 acres of functioning floodplain habitat were acquired for conservation.

Floodplain habitat restoration can affect juvenile salmonid performance directly (for fish that move onto the floodplain) and indirectly (for fish that stay in the mainstem). Wetland food production supports foraging and growth within the wetland (Johnson et al. 2018), but potential prey items are also exported to the mainstem (PNNL and NMFS et al. 2018) and off-channel habitats behind islands and other landforms where they become available to juveniles migrating in these locations. There is very little information available about the prey of sockeye salmon in Pacific coast estuaries; adult dipterans and chironomid larvae were the primary food items in juvenile sockeye salmon in the Kamchatka River estuary (Bugaev and Karpenko 1984, as cited in Higgs et al. 1995). Insects were the primary prey of subyearling sockeye salmon in the estuary of the Fraser River (Birtwell et al. 1987), although these were not identified as terrestrial or wetland dependent. Based on these observations, juvenile sockeye salmon are likely to feed on chironomid insects, like other Columbia River salmonids. Thus, while most juvenile sockeye salmon may not directly enter a tidal wetland channel, they are likely to derive indirect benefits from wetland habitats. Improved opportunities for feeding on prey that drift into the mainstem are likely to contribute to survival at ocean entry.

Habitat quality and the food web in the estuary are also degraded because of past and continuing releases of toxic contaminants (Fresh et al. 2005; LCREP 2007) from both estuarine and upstream sources. Historically, levels of contaminants in the Columbia River were low, except for some metals and naturally occurring substances (Fresh et al. 2005). Today, the levels in the estuary are much higher, with the estuary receiving contaminants from more than 1,000 sources that discharge into a river and numerous sources of runoff (Fuhrer et al. 1996). With Portland and other cities on its banks, the Columbia River below Bonneville Dam is the most urbanized section of the river. Sediments in the river at Portland are contaminated with various toxic compounds, including metals, PAHs, PCBs, chlorinated pesticides, and dioxin (ODEQ 2008). Contaminants have been detected in aquatic insects, resident fish species, salmonids, river mammals, and osprey, and they are widespread throughout the estuarine food web (Furher et al. 1996; Tetra Tech 1996; LCREP 2007).

Exposure to toxic contaminants can either kill aquatic organisms outright or have sublethal effects that compromise their health and behavior. Sublethal concentrations increase stress and decrease fitness, predisposing organisms to disease, slowing development, and disrupting physiological processes, such as reproduction and smoltification. Acute lethal effects of toxic contaminants, such as fish kills from accidental discharges or spills, are generally rare, but some researchers have described direct mortality of salmonids including high levels of pre-spawning mortality in Puget Sound coho salmon due to road runoff (McCarthy et al. 2008), synergistic toxicity of agricultural pesticide mixtures causing death in juvenile salmon (Laetz et al. 2009), and increased egg mortality due to PAH exposure (Heintz et al. 1999; Carls et al. 2015).

Sublethal effects are more likely a significant threat to juvenile salmon in the Columbia River estuary. Exposure can reduce immune function and fitness, impair growth and development, and disrupt olfaction; salmonids depend on olfaction for migration, imprinting, homing, and detecting predators, prey, potential mates, and spawning cues. These sublethal effects can interact with other factors like infectious disease, parasites, predation, exhaustion, and starvation by suppressing salmonid immune systems and impairing necessary behaviors such as swimming, feeding, responding to stimuli, and avoiding predators (LCREP 2007).

Toxic contaminants can also affect salmon via the food web, especially through prey such as aquatic and terrestrial insects. Insect bodies accumulate contaminants, which salmon in turn ingest when they consume insects. Additionally, many toxic contaminants are specifically designed to kill insects and plants, reducing the availability of insect prey or modifying the surrounding vegetation and habitats. Changes in vegetative habitat can shift the composition of biological communities; create favorable conditions for invasive, pollution-tolerant plants and animals; and further shift the food web from macrodetrital to microdetrital sources. Overall, more work is needed on contaminant uptake and impacts on salmon of different populations and life history types.

2.13.2.3 Tributary Habitat

2.13.2.3.1 Conditions at the Natal Lakes in the Sawtooth Valley

At the time of the initial listing (NMFS 1991), the greatest habitat problem faced by the SR sockeye salmon ESU was the lack of physical access to any of the historical spawning areas but Redfish Lake. NMFS (2015b) noted that improving spatial structure with access to multiple spawning areas would reduce the risk of extinction due to catastrophic environmental events. Local recovery actions to remove barriers are therefore being implemented. The barriers on Alturas and Pettit Lake Creeks (an irrigation intake and a concrete non-game fish barrier, respectively) were modified to facilitate passage in the early-to-late 1990s (Teuscher and Taki 1996, cited in Flagg et al. 2004). The fish barrier at Yellowbelly Lake was removed by the U.S. Forest Service in 2000. Currently, however, anadromous returns are entirely precluded from Alturas, Pettit and Yellowbelly Lakes by the Sawtooth weir, and from Stanley Lake by the fish barrier at the lake outlet. Plans are underway to begin allowing adult sockeye salmon to return to their lake of origin, including trapping adults at the Sawtooth weir and transporting them to Alturas or Pettit Lakes, or to allow for volitional migration.[174]

Most of the Redfish Lake watershed remains in near natural condition although decades of fire suppression has allowed most of the surrounding forest to reach late seral stage. Many of the mature lodgepole pines are now standing dead because of a natural infestation of mountain pine beetle (USFS 2011, as cited in NMFS 2015b). The U.S. Forest Service is reducing the accumulated risk of catastrophic fires by thinning trees, conducting prescribed burns, and

[174] Since 2014, IDFG has released a small number of captive-reared adults (n = 100) into Pettit Lake for reintroduction efforts (Kozfkay 2018, email from Furfey to Krasnow dated 9/4/18). IDFG also screens any natural-origin fish trapped at the Sawtooth weir to determine if they originate from Pettit or Alturas Lake and releases them into the appropriate lake upon genetic confirmation. The agency plans to evaluate whether smolt production has increased as a result of those releases. This will inform future actions for Pettit Lake and help determine whether the program can continue to release captive adults at current levels (or increase release numbers) or should focus on Redfish Lake.

removing surface fuels (fallen branches, low flammable brush, and other flammable understory vegetation).

Some recreational facilities (a private restaurant, cabin, and boat rentals and the U.S. Forest Service's campgrounds, boat launch, day-use areas, and visitor center) sit at the north end of Redfish Lake. Tours on the lake are common, as are motorized and non-motorized pleasure and fishing boats. In 2007, nearly 75 percent of the lakeshore remained in near pristine condition. Along the 25 percent developed portion of the shoreline, banks were altered and riparian vegetation had been removed (NMFS 2015b). The U.S. Forest Service therefore has implemented several projects to remove lakeshore trails and install fences to encourage recovery of shoreline vegetation. The agency is also improving lake and shoreline habitat conditions by moving campsites away from spawning areas.

Conditions around the other historical spawning lakes are considered relatively pristine or improving. Local issues, as described in USFWS (2011, as cited in NMFS 2015b) include:

- Stanley Lake – The U.S. Forest Service describes the watershed as having high-quality habitat conditions and integrity, with some areas of low integrity along the lakeshore. Past intensive uses include mining, even within some sensitive streamside and lakeside areas. The main access road was upgraded in the 1930s with long segments located next to Stanley Lake Creek. Intensive sheep and cattle grazing occurred within the watershed until 1993. Timber harvest, including road building, occurred on Elk Mountain in the 1960s. Campground and boat launch developments also affect some habitat areas.
- Yellowbelly Lake – Habitat conditions are considered near pristine. Recreation use on public land and minor development on private land near the mouth of the lake have had only a small influence within the watershed. IDFG management of the lake through a former fish barrier and chemical treatments has had the greatest influence on fish.
- Pettit Lake – Other than lakeshore developments (recreation and cabin lots) that occupy nearly 50 percent of the shoreline, there is little land use disturbance in the watershed. However, it is possible that historical sockeye salmon spawning habitats are adjacent to these lakeside developments. Condition assessments by the U.S. Forest Service in 2006 showed that the shoreline in these areas had more trampled banks and less vegetation or woody debris.
- Alturas Lake – In the past, irrigation diversions, including one on Alturas Lake Creek, significantly affected stream flow and fish passage into the lake. During the core of the summer irrigation season, natural flows were less than the appropriated flows such that, prior to 1992, Alturas Lake Creek was routinely dewatered. Even when not fully dewatered, the diversion structure itself precluded or impaired upstream migration. In 1992 the U.S. Forest Service purchased much of the former Busterback Ranch and the associated water rights from both Alturas Lake Creek and the Salmon River. The rights from Alturas Lake Creek were immediately returned to the creek to improve habitat and passage conditions. In 1997, when the last private irrigator discontinued use, the U.S.

Forest Service removed the former diversion structure and restored natural channel conditions. Historical legacy effects of grazing and mining in the headwaters have exacerbated sediment loading impacts in Alturas Lake. More recently, about 60 percent of the historical spawning habitat is adjacent to recreation sites that occupy about 1 mile of shoreline. However, the U.S. Forest Service has closed and rehabilitated more than 5 miles of roads and the remaining roads within the Alturas Lake recreation complex are now paved. The visitor facilities have been altered to reduce streamside pressure and habitat conditions of these areas are improving.

2.13.2.3.2 Salmon River Migration Corridor

The Salmon River flows 410 miles through central Idaho to join the Snake River in lower Hells Canyon and represents almost half of the SR sockeye salmon migration route. Juvenile migrants move quickly through this reach after leaving the natal lakes in late spring and early summer, arriving at Lower Granite Dam in about seven days. Adults migrate upstream in late summer, returning to the Sawtooth Valley lakes in August and September, a journey of more than 30 days.

For juvenile sockeye salmon migrating from the Sawtooth Valley to Lower Granite Dam, the great majority of juvenile mortality is incurred upstream of Lower Granite Reservoir (Axel et al 2013, 2014). Estimated survival of hatchery juveniles in the reach has been highly variable. The survival of Sawtooth Hatchery-reared fish released at Redfish Lake Creek Trap between 2010–15 averaged nearly 51 percent, ranging from 15 percent in 2010 to 72 percent in 2011 (Faulkner et al. 2011, 2012, 2013a, 2013b, 2015, 2016).

Adult migrants are also lost in the Salmon River corridor (Keefer et al. 2008). Adult sockeye salmon return to the Salmon River in late summer, when flows often reach low levels and water temperatures peak. Summer flow reductions in the Salmon River basin could impair upstream migration and survival to the extent they contribute to increased water temperatures (Crozier et al. 2014; Keefer et al. 2008).

Much of the upper Salmon basin is managed for public use, with some areas in wilderness or roadless areas. High watershed and aquatic integrity is found in the Upper Middle Fork, Lower Middle Fork, and Middle Salmon–Chamberlain watersheds (NPCC 2004a). Habitats tend to be more modified or degraded in broad valleys with easier access for humans and development such as the Little Salmon, lower Salmon, Pahsimeroi, and Lemhi River watersheds. Much of the subbasin is managed by the U.S. Forest Service or Bureau of Land Management for multiple uses.

Private lands tend to be concentrated along the valley bottoms near the Salmon River. Small towns in the subbasin (Stanley, Challis, Salmon, Riggins, New Meadows, and White Bird) also are located along the river, with rural populations in the surrounding areas. The town of Salmon is the largest, with slightly more than 3,000 people; most towns have under 500 residents (NPCC 2004a). Cattle ranching and agriculture are the main economic activities. Irrigation diversions are common and contributed to low summer flows in the past; however, restoration efforts are now reducing impacts on sockeye salmon from irrigation water withdrawals and diversion structures in some areas. Logging and mining were important activities historically, but have declined since the 1990s. Water quality is affected by land uses that include livestock grazing, road construction, irrigation withdrawals, logging, and mining. New road construction and other development is occurring in some areas, causing stream erosion and sediment input to streams.

Predation could be responsible for much of the juvenile mortality in the upper Salmon River. In 2013, researchers watched common mergansers (*Mergus merganser*), osprey (*Pandion haliaetus*), double-crested cormorants (*Phalacrocorax auritus*), and western grebe (*Aechmophorus occidentalis*) feeding in Little Redfish Lake below their release site as study fish moved through the area. Bull trout (*Salvelinus confluentus*) also chased schools of juvenile sockeye salmon as they moved through Little Redfish Lake (Axel et al. 2014). The factors responsible for the losses of adult sockeye salmon migrants are not fully established, but are thought to be related to stream flow and temperature (Arthaud and Morrow 2013). Adult sockeye salmon return to the Salmon River in late summer, when flows often reach low levels and water temperatures peak.

2.13.2.4 Hatcheries

Since the ESA listing in 1991, a partnership of state, tribal and federal fish managers have initiated a captive broodstock hatchery program to save the Redfish Lake sockeye salmon population. Between 1991 and 1998, all 16 of the natural-origin adult sockeye salmon that returned to the weir at Redfish Lake were incorporated into the captive broodstock program, as well as out-migrating smolts captured between 1991 and 1993, and residual sockeye salmon captured between 1992 and 1995. The program has used multiple rearing sites to minimize chances of catastrophic loss of broodstock and has produced several million eggs and juveniles, as well as several thousand adults, for release into the wild. Fish rearing at each facility is conducted at low density in tanks in bio-secure buildings.

The Sawtooth Valley is seeing results from the captive broodstock program. Sockeye salmon returns to the valley have increased, especially in recent years, to 650 in 2008 (including 142 natural-origin fish), 833 in 2009 (including 85 natural-origin fish), 1,355 in 2010 (including 179 natural-origin fish), 1,117 in 2011 (including 142 natural-origin fish), 257 in 2012 (including 52 natural-origin fish), and 272 in 2013 (including 78 natural-origin fish). A weir at Sawtooth Hatchery on the Salmon River restricts sockeye salmon passage to natal lakes.

Approximately two-thirds of the adults captured in recent years for the captive broodstock program were taken at the Redfish Lake Creek weir; the remaining adults were captured at the Sawtooth Hatchery weir on the mainstem Salmon River upstream of the Redfish Lake Creek confluence. Although total sockeye salmon returns to the Sawtooth Basin in recent years have been high enough to allow for some level of spawning in Redfish Lake, the hatchery program's priority is on genetic conservation and building sufficient returns to support sustained outplanting (NMFS 2015b). The number of SR sockeye salmon outmigrants has continued to increase through 2017 (Johnson et al. 2017).

Hatchery production of SR sockeye salmon was switched from Oxbow and Sawtooth Hatcheries to Springfield Hatchery in 2014. As previously mentioned, survival of the 2015–17 hatchery releases during migrating from Lower Granite to Bonneville Dam ranged from 12–37 percent, compared with the 2009-2014 average of 54 percent (Widener et al. 2018). Survival from release to Lower Granite Dam was also affected, ranging from 20–30 percent when releases from Oxbow and Sawtooth Hatcheries typically exceeded 50 percent. After investigating the potential causes for the reduced survival, IDFG determined that the new hatchery site had much harder water (234 mg/l) than the original Sawtooth Hatchery site and the release locations (11-68 mg/l). This caused stress in the juveniles when directly released into Redfish Lake Creek. In 2018 a series of strategies were put in place including acclimation before release, and the use of commercial water softeners to reduce the hardness of rearing water. Initial indications are that these strategies have yielded increased survival rates to Lower Granite Dam. Survivals of acclimation and water treatment groups ranged from 53–69 percent, while fish released directly into Redfish Lake Creek only survived at 18 percent (Trushenski et al., in review).

2.13.2.5 Harvest

NMFS recently completed a biological opinion on the 2018–27 *U.S. v. Oregon* Management Agreement, which provides a framework for managing salmon and steelhead fisheries and hatchery programs in much of the Columbia River basin. Few SR sockeye salmon are caught in ocean fisheries, and ocean-fishing mortality on SR sockeye salmon is assumed to be zero (NMFS 2018a). Non-Indian fisheries in the Columbia River mainstem below the Highway 395 Bridge, where it crosses the Columbia River between Kennewick and Pasco, Washington, are limited to a harvest rate of 1 percent and Treaty Indian fisheries to 5 to 7 percent, depending on the run size of upriver sockeye salmon stocks. The biological opinion concluded that the effects of harvest on SR sockeye salmon, when considering the current reliance on hatchery programs, will allow continued gains in viability scores.

Although reported harvest estimates are consistently below the 8 percent limit on SR sockeye salmon, there are indications that actual harvest impacts may be greater. Mortality rates (corrected for reported harvest) through the Bonneville to McNary Dam reach, where zone 6 non-treaty recreational and treaty net fisheries occur, range from about 9–37 percent while rates in the McNary to Lower Granite Dam reach, range from 3.7–9.1 percent (2013 and 2015 excluded due to elevated water temperatures). Sampling of SR sockeye salmon at Lower Granite Dam shows a rate of injuries associated with gill nets at a 2009–16 (2013 and 2015 excluded) average rate of 11 percent with a range of 3.1–26.3 percent, indicating that SR sockeye salmon encounter fisheries at a low rate. Baker and Schindler (2009) found that 11–29 percent of sockeye salmon captured in the Bristol Bay, Alaska fishery showed signs of net marks and that more than half of fish reaching natal spawning grounds with fishery-related injuries failed to reproduce. Estimates of injuries in this fishery are may not be applicable to the Columbia River fishery as the gear type used in the Alaska fishery is actually targeting sockeye salmon.

The migration behavior of SR sockeye salmon makes them less vulnerable to harvest impacts than other Columbia Basin sockeye salmon stocks. Their migration period is slightly later, though it overlaps the migration of the Upper Columbia sockeye salmon run and also coincides with the more heavily exploited summer Chinook salmon harvest season. SR sockeye salmon also migrate through the system in a relatively short period, with 80 percent of the sockeye salmon run passing Bonneville in 17–28 days. The timing of 3–4 day gillnet openings has a potentially limited impact on SR sockeye salmon returns as the mesh size the use are large enough to generally pass smaller bodysized sockeye salmon through them while targeting larger-bodied Chinook salmon. However, the slightly later run timing of SR sockeye salmon makes them vulnerable to late season openings, a management strategy frequently employed when initial run size estimates were too low, or harvest rates were lower than expected so there is a large remaining catch quota at the end of the season.

Other potential causes of mortality, fallback and straying (Crozier et al. 2014), have been examined and do not appear to occur at a high enough rate to account for this extra mortality in this reach. In years when Lower Columbia water temperatures have exceeded 64.4°F, primarily 2013 and 2015, there have been indications of mortality due to disease and stress caused by high temperatures, but there is little or no indication of this source of mortality other years.

Harvest managers continue to evaluate this issue (lower observed PIT-tag survival rates in the lower Columbia River for SR sockeye salmon) within the *U.S. v. Oregon* Technical Advisory Committee.

2.13.2.6 Predation

A variety of avian and fish predators consume juvenile SR sockeye salmon on their migration from tributary rearing areas to the ocean. Predation in the estuary and in the migration corridor, and management measures to reduce the effects of predation are discussed below.

2.13.2.6.1 Predation in the Lower Columbia River Estuary

Avian Predators

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, are having a significant impact on the survival of juvenile salmonids (including SR sockeye salmon) in the Columbia River. Caspian terns on Rice Island, an artificial dredged-material disposal island in the estuary, consumed about 5.4–14.2 million juveniles per year in 1997 and 1998, or 5–15 percent of all the smolts reaching the estuary (Roby et al. 2017). Efforts began in 1999 to relocate the tern colony 13 miles closer to the ocean at East Sand Island where the tern diet would diversify to include marine forage fish. During 2001-15, estimated consumption by terns on East Sand Island averaged 5.1 million smolts per year, about a 59 percent reduction compared to when the colony was on East Sand Island. Management efforts are ongoing to further reduce salmonid consumption by terns in the lower Columbia River and similar efforts are in progress to reduce the nesting population of double-crested cormorants in the estuary.

Based on PIT-tag recoveries at East Sand Island, average annual tern and cormorant predation rates for this ESU were about 1.5 and 3.6 percent, respectively, before efforts to manage the size of these colonies (Evans et al. 2018a). The Corps has been implementing the Caspian Tern and Double-crested Cormorant Management Plans, but, in terms of effectiveness, has seen mixed results due to the dispersal of both terns and cormorants to other locations within the estuary. Average predation rates on SR sockeye salmon have decreased to 1.4 percent for terns nesting on East Sand Island, but in 2017 this small improvement was offset to some unknown degree by terns roosting on Rice Island (Evans et al. 2018a). Due to failures of the cormorant colony in 2016 and 2017, there are no estimates of predation rates since management of that colony began (Appendix C). substantial numbers of cormorants have relocated to the Astoria-Megler Bridge (preliminary report of 1,737 in 2018) and hundreds more are observed on the Longview Bridge, navigation aids, and transmission towers in the lower river (Anchor QEA et al. 2017). Smolts may constitute a larger proportion of the diet of cormorants nesting at these sites than if the birds were foraging from East Sand Island. Thus, the success of the East Sand Island tern and cormorant management plans at meeting their underlying goals of reducing salmonid predation is uncertain at this time.

An important question in predator management is whether mortality due to predation is an additive or compensatory source of mortality. Most importantly, do reductions in smolt predation rates by Caspian terns or double-crested cormorants result in higher adult returns because avian predation adds to the other sources of smolt mortality or are the smolts eaten by birds destined to die before returning as adults regardless of the level of predation? The latter case could occur because avian predation could be compensated for by sources of mortality in the ocean phase of the life cycle so that adult returns are unchanged. Haeseker (2015) and Evans et al. (2018b) have begun modeling the degree to which double-crested cormorant and Caspian tern predation, respectively, are additive versus compensatory sources of mortality.

Given the magnitude of bird predation on juvenile salmon observed in the Columbia Basin, and that smolts eaten by birds in the lower river have survived hydrosystem passage, it is likely that some of them could otherwise have survived to adulthood. Therefore, even if avian predation is partially compensatory, we expect that limiting the size of these tern and cormorant colonies will contribute to increased SARs for SR sockeye salmon.

Pinniped Predators

Marine mammal predators of salmon have increased considerably along the northwest United States coast since the MMPA was enacted in 1972 (Carretta et al. 2013). CSLs, SSLs, and harbor seals consume both adult and juvenile sockeye salmon from the mouth of the Columbia River and tributaries up to Bonneville Dam. A small number of California sea lions have also been observed in Bonneville Reservoir in recent years. The ODFW has been counting the number of individual CSLs hauling out at the East Mooring Basin in Astoria, Oregon since 1997. The data from this study serves as our best evidence that CSL abundance within the Columbia River has increased substantially since 2015 during the peak of the adult SR sockeye salmon run in June (Table 2.13-3). Upstream migrating sockeye salmon are likely encountering outmigrating CSLs and SSLs as they move towards breeding grounds outside of the Columbia Basin. There are no estimates on the proportion of sockeye salmon which are consumed by pinnipeds in the

Columbia River, however, the overall impact of pinniped predation on salmon is likely related to overall pinniped abundance Rub et al. (2018) found evidence that recent increases in pinniped abundance in the Columbia River have likely resulted in increased predation of sockeye salmon in recent years. Numbers during June when sockeye salmon are migrating have increased substantially in recent years, from about 45 pinnipeds in 2008–2009 to over 500 in 2014–2017 (Wright 2018).

Table 2.13-3. Maximum monthly counts of California Sea Lions at Astoria Oregon East Mooring Basin (Appendix B). Counts during the peak of the sockeye salmon run in June are shown in bold.

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
2008	40	56	67	126	162	46	6	191	213	204	273	157
2009	27	42	84	118	173	45	38	346	376	241	89	84
2010	58	93	136	229	216	157	29	316	356	265	98	54
2011	19	42	77	155	242	126	11	302	246	85	159	106
2012	20	27	82	240	201	92	19	212	187	147	91	21
2013	37	149	595	739	722	153	8	368	377	208	182	100
2014	237	586	1420	1295	793	90	32	423	492	369	94	126
2015	260	1564	2340	2056	1234	623	37	394	1318	459	84	208
2016	788	2144	3834	1212	1077	620	3	291	1004	878	235	246
2017	1498	2345	808	1131	1204	573						

Fish Predators

The native northern pikeminnow is a significant predator of juvenile salmonids in the Columbia River basin (reviewed in ISAB 2015). Before the start of the NPMP, in 1990, this species was estimated to eat about eight percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River (including the hydrosystem reach) each year. Williams et al. (2017) compared current estimates of northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. The Sport Reward Fishery removed an average of 188,636 piscivorous pikeminnow (> 228 mm fork length) per year during 2013-17 (Williams 2013, 2014; Williams et al. 2015, 2016, 2017).

The removal of the larger, piscivorous individuals from northern pikeminnow populations will result in a sustained survival improvement for migrating juvenile sockeye salmon only if it is not offset by a compensatory response by the remaining northern pikeminnow or other piscivorous fishes such as walleye or smallmouth bass. Signs of a compensatory response can include increased numbers of other predators, improved condition factors, or diet shifts. Williams et al. (2017) did not observe increases in numbers of pikeminnow, but did report an increasing trend in condition factor. This could be an intra-specific compensatory mechanism or just a response to beneficial environmental conditions. Similarly, Williams et al. (2017) documented increased numbers of smallmouth bass in parts of the lower Columbia River, which could be related to the NPMP or could be due to factors such as alterations in other parts of the food web or environmental conditions such as warmer temperature that affect this species' consumption rates. Williams et al. (2017) concluded that given these analytical constraints, data collected during 2017 provided ambiguous indicators of a compensatory response from the piscivorous fish community. Given the numbers of fish, bird, and marine mammal predators in the Columbia River and the ocean, we do not expect that all of the sockeye that are "saved" from predation by pikeminnows will survive to adulthood. However, a 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity of sockeye salmon populations, including SR sockeye salmon.

An average of five adults and zero juvenile sockeye salmon per year were killed and/or handled in the Sport Reward Fishery, system-wide (i.e., in the lower Columbia River and the hydrosystem reach), during 2013–17 (Williams. 2013, 2014; Williams et al. 2015, 2016, 2017). Although it was not practical for the field crews to identify these fish to ESU, we assume that some were SR sockeye salmon.

Non-native fishes such as walleye, smallmouth bass, and channel catfish are present in the slower moving off-channel habitats below Bonneville Dam, but yearling SR sockeye salmon, which mostly stay in the mainstem migration channel, are not likely to encounter large numbers of these species. The Oregon and Washington Departments of Fish and Wildlife have removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids.

2.13.2.6.2 Predation in the Hydrosystem Reach

Avian Predators

SR sockeye salmon survival is affected in the mainstem by avian predators that inhabit the dams and reservoirs. The 2008 FCRPS Biological Opinion required that the Action Agencies implement avian predation control measures to increase survival of juvenile salmonids in the lower Snake and Columbia Rivers through effective monitoring, hazing, and deterrents at each project. All CRS projects have been using several effective strategies, including wire arrays that crisscross the tailrace areas, spike strips along the concrete, water sprinklers at juvenile bypass outfalls, pyrotechnics, propane cannons, and limited amounts of lethal take. These efforts have reduced avian predation on juvenile salmon at the dams. Zorich et al. (2012) estimated that, compared to the numbers of smolts consumed at John Day Dam in 2009 and 2010, 84–94 percent fewer smolts were consumed by gulls in 2011. At The Dalles Dam, 81 percent fewer smolts were consumed in 2011 than in 2010. Zorich et al. (2012) describe these estimates as accounting for additive and compensatory sources of mortality.

SR sockeye salmon are also vulnerable to predation by terns nesting in the interior Columbia plateau, including colonies on islands in McNary Reservoir, in the Hanford Reach, and in Potholes Reservoir. Smolts come within foraging range of other nesting sites on the plateau (principally Blalock Islands in John Day Reservoir) as they continue to migrate downstream. The objective of the IAPMP (USACE 2014) is to reduce predation rates to less than 2 percent per listed ESU/DPS per tern colony per year. The primary management activities have been to keep terns from nesting on Goose Island in Potholes Reservoir (managed by the Bureau of Reclamation) and on Crescent Island in McNary Reservoir (managed by the Corps). Passive dissuasion, hazing, and revegetation have prevented terns from nesting on Crescent Island since 2015, and similar efforts are in progress at Goose Island. However, the number of terns nesting at the Blalock Islands in John Day Reservoir was ten times higher in 2015 than the year before, and resightings of colored leg-banded terns indicate that many of the terns moved there from Crescent Island. Terns also came to the interior plateau from East Sand Island in the estuary and from alternative Corps-constructed colony sites in southeastern Oregon and northeastern California in 2015 when those areas experienced severe drought (Collis et al. 2016).

In 2017, the goal of the IAPMP to reduce ESU/DPS-specific predation rates to less than 2 percent was achieved at Goose Island for the second consecutive year and at Crescent Island for the third year (Collis et al. 2018). As a result, predation rates on SR sockeye salmon by Caspian terns have declined from up to 1.1 percent at these sites during the pre-management period to <0.1 percent (Collis et al. 2018; Appendix C).

Gull predation was not considered in the IAPMP and there are no regional plans to manage these colonies. Predation rates on smolts from this ESU were as high as 7.4 percent (Miller Rock Island in The Dalles Reservoir) in 2015–2016 (Roby et al. 2016, 2017).

Pinniped Predators

Although pinniped presence in the Bonneville tailrace has increased in the last six years (Tidwell et al. 2017), most pinnipeds leave the area before the June peak of the sockeye salmon migration in June and July (Figure 2.13-7). Thus, while consumption of SR sockeye salmon may have increased somewhat, adult mortalities are still extremely low. A small number of California sea lions have also been observed in Bonneville Reservoir in recent years.

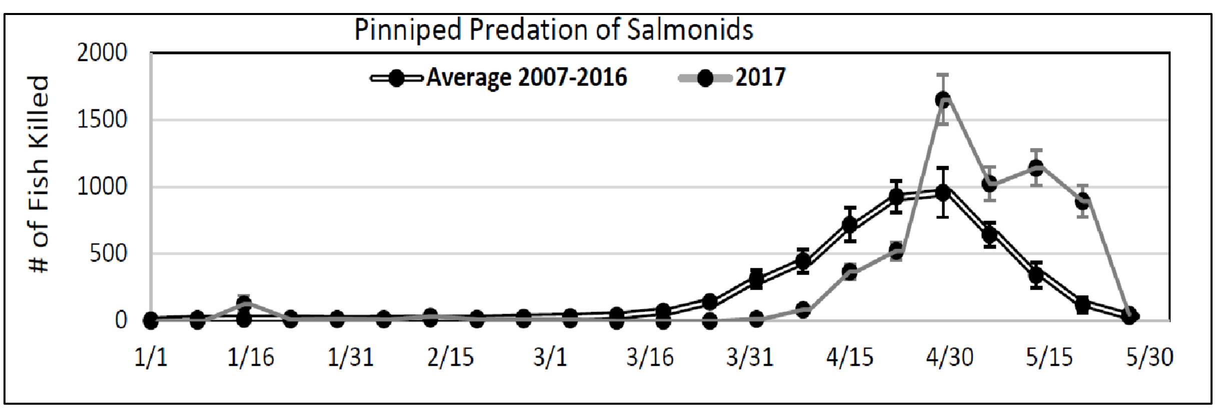


Figure 2.13-7. Temporal distribution of all salmonids that crossed Bonneville Dam and weekly adjusted predation estimates (i.e. # of fish killed) of these salmonids by Steller sea lions (SSL) and California sea lions (CSL) between January 1 and June 2, 2017 at Bonneville Dam. The predation data labeled "Average 2007 – 2016" is the combined

weekly average predation by both pinniped species over the last ten years. All error bars represent the Standard Error of the estimates (Tidwell et al. 2017).

Concerns about predation rates on spring Chinook salmon and winter steelhead led the Corps to begin constructing physical exclusion devices at the adult ladder entrances in 2006. These devices are designed to block pinnipeds from entering the ladders while allowing fish passage. The SLEDs are installed at all eight ladder entrances at Bonneville when SR sockeye salmon are present (Tidwell et al. 2017). In addition, the Corps has installed smaller physical exclusion gratings on the 16 FOGs along the face of Powerhouse 2 that allow fish to enter the collection channel and pass via the Washington shore ladder. The SLEDs and FOGs successfully prevent pinnipeds from entering the adult fish ladders.

Fish Predators

Native pikeminnow are significant predators of juvenile salmonids in the hydrosystem reach, followed by non-native smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011, 2015). In addition to the Sport Reward Fishery in the lower Columbia River estuary and throughout the hydrosystem reach, the Action Agencies conduct a Dam Angling Program to remove large pikeminnow from the tailraces of The Dalles and John Day Dams. Angling crews removed an average of 5,913 northern pikeminnow from these two projects per year during 2013-17 (Williams 2013, 2014; Williams et al. 2015, 2016, 2017). They reported zero incidental catch of adult or juvenile sockeye salmon during the five-year period.

Juvenile salmonids are also consumed by large numbers of non-native fishes including walleye, smallmouth bass, and channel catfish in the reservoirs of hydrosystem reach. As described for the lower Columbia River estuary: (1) yearling SR sockeye salmon mostly stay in the mainstem migration channel and are not likely to encounter large numbers of these species and (2) both the Oregon and Washington Departments of Fish and Wildlife have removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids.

2.13.2.7 Research and Monitoring Activities

The primary effects of the past and ongoing CRS-related RM&E program on SR sockeye salmon are associated with the capturing and handling of fish. The RM&E program is a collaborative, regionally coordinated approach to fish and habitat status monitoring, action effectiveness research, critical uncertainty research, and data management. The information derived from the program facilitates effective adaptive management through better understanding the effects of the ongoing CRS action. Capturing, handling, and releasing fish generally leads to stress and other sublethal effects, but fish sometimes die from such treatment. The mechanisms by which these activities affect fish have been well documented and are detailed in Section 8.1.4 of the 2008 biological opinion. Some RM&E actions also involve sacrificial sampling of fish. We estimated the number of SR sockeye salmon that have been handled or killed each year during the implementation of RM&E under the 2008 RPA as the average annual take reported for 2013-17:

- Average annual estimates for handling and mortality of SR sockeye salmon associated with the Smolt Monitoring Program and CSS were: (1) one hatchery and one wild adult handled; (2) zero hatchery and zero wild adult died; (3) 435 hatchery and 164 wild juveniles handled; and (4) ten hatchery and 16 wild juveniles died.
- The estimated handling and mortality of SR sockeye salmon associated with the ISEMP was limited to 16 hatchery and 11 wild adults handled (no hatchery or wild adults died and no hatchery or wild juveniles died).
- Estimates for SR sockeye salmon handling and mortality for all other RM&E programs are as follows: (1) one hatchery and one wild adult handled; (2) zero hatchery and zero wild adults died; (3) 607 hatchery and 133 wild juveniles handled; and (4) four hatchery and one wild juvenile died.

The combined observed mortality associated with these elements of the RM&E program has, on average, affected less than 1 percent of the wild (i.e., natural origin) adult returns or juvenile production for the SR sockeye salmon ESU (Bellerud 2018). Although we estimate that over 1 percent of the wild adults and juveniles were handled, we expect that only 1 percent of these died after release (in this case, <0.02 percent of the adults and <0.02 percent of juveniles). This relatively small, negative effect is deemed worthwhile because it allowed the Action Agencies and NMFS to evaluate the effects of CRS operations, including modifications to facilities, operations, and mitigation actions.

In addition, northern pikeminnow are tagged as part of the Sport Reward Fishery and their rate of recapture is used to calculate exploitation rates. Northern pikeminnow are collected for tagging using boat electrofishing in select reaches of the Columbia River. During 2017, boat electrofishing operations in the Columbia River extended upstream from RM 47 (near Clatskanie, Oregon) to RM 394 (Priest Rapids Dam), and in the Snake River from RM 10 (Ice Harbor Dam) to RM 41 (Lower Monumental Dam) and from RM 70 (Little Goose Dam) to RM 156 (upstream of Lower Granite Dam). Researchers conducted four sampling events consisting of 15 minutes of boat electrofishing effort in shallow water within each 0.6-mile reach during April-July.

A side effect of the electrofishing effort is that salmon and steelhead may be exposed to the electrofishing field, with the potential for injury, stress, and fatigue and even cardiac or respiratory failure (Snyder 2003). Some adult and juvenile SR sockeye salmon are likely to be present in shallow shoreline areas during the April-July time period. Most sampling occurs in darkness (1800-0500 hours). Operators shut off the electrical field if salmonids are seen and because most stunned fish quickly recover and swim away, they cannot be identified to species (i.e., Chinook, coho, chum, or sockeye salmon or steelhead). Barr (2018) reported encountering an annual average of 1,762 adult and 92,260 juvenile salmonids in the lower and middle Columbia River each year during 2013-17 electrofishing operations based on visual estimation methods. It is likely that some of these were SR sockeye salmon.

2.13.2.8 Critical Habitat

The environmental baseline for the PBFs of SR sockeye salmon critical habitat are discussed above (e.g., mainstem flows, passage, water quality, predation, etc.) and summarized here in Table 2.13-4. Across much of the action area, resource extraction, agriculture, development, and other land use activities have disrupted watershed processes (e.g., storing and routing of water, plant growth and successional processes, inputs of nutrients and thermal energy, nutrient cycling in the aquatic food web, etc.), reduced water quality, and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and/or current land use or water management activities have adversely affected the quality and quantity of stream and side channel areas (e.g., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for sockeye salmon production have been weakened.

Although NMFS (1993) recognized that the Columbia River estuary was an essential rearing area and migration corridor for SR sockeye salmon and designated the estuary as critical habitat, it did not define essential PBFs unique to this portion of the designated area. Instead, we consider the estuary part of the juvenile and adult migration corridors. As such, PBFs include substrate; water quality, quantity, and temperature; water velocity; cover/shelter; food (juveniles); riparian vegetation; space; and safe passage.

Habitat quality in tributary streams in the Interior Columbia recovery domain varies from excellent in wilderness and roadless areas (much of the watershed areas surrounding the natal lakes in the Sawtooth Valley) to poor in areas subject to heavy agricultural development (valley bottoms along the mainstem Salmon River). Activities that have reduced the function of PBFs include intensive livestock grazing, channel modifications and diking, loss of riparian vegetation, wetland draining and conversion, dredging, road construction and maintenance, logging, and mining. Reduced summer stream flows, impaired water quality, and reduction of habitat complexity are common problems within the Interior Columbia recovery domain (NMFS 2016e).

Many stream reaches designated as critical habitat are listed on Oregon, Washington, and Idaho's Clean Water Act Section 303(d) list for water temperature. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water for agricultural or municipal use all contribute to elevated stream temperatures. Furthermore, contaminants, such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste, are common in some areas of critical habitat (NMFS 2016e). They can negatively impact critical habitat and the organisms associated with these areas.

The large numbers of avian predators nesting on man-made or enhanced structures (dredge material deposits that created Rice Island and increased the size of East Sand Island in the lower Columbia River, as well as bridges, aids to navigation, and transmission towers) result in excessive predation in the lower Snake and Columbia River portions of the juvenile migration corridor. Similarly, sea-lion predation on adult sockeye salmon in the tailrace of Bonneville Dam is excessive predation associated with a man-made structure. Predation associated with sea lions in the estuary is a natural phenomenon, and waxes and wanes with the abundance of sea lions.

Habitat quality of the mainstem migration corridors in the lower Snake and Columbia Rivers has been severely altered by the development and operation of the CRS dams and reservoirs in the mainstem Columbia River, and by Bureau of Reclamation tributary projects and privately owned dams in the Snake and upper Columbia River basins. Hydroelectric development has modified natural flow regimes of these rivers, resulting in warmer late summer/fall water temperatures, changes in fish community structure that lead to increased rates of predation on juvenile salmon, and delayed migration for both adults and juveniles. Physical features of dams, such as turbines and juvenile bypass systems, also kill some out-migrating fish (NMFS 2016e).

The altered habitats in CRS project reservoirs and tailraces create more favorable habitat conditions for fish predators, including native northern pikeminnow and non-native walleye and smallmouth bass. The effects of the non-native species and those of pikeminnows, to the extent the latter's predation rates are enhanced by reservoir and tailrace conditions, are also examples of excessive predation in the juvenile migration corridor.

Restoration activities addressing habitat quality and complexity, migration barriers, and water quality have improved the baseline condition for PBFs; however, the conservation role of critical habitat is to provide PBFs that support populations that can contribute to conservation of the ESU. More restoration is needed before the PBFs can fully support the conservation of SR sockeye salmon.

Table 2.13-4. Physical and biological features (PBFs) of designated critical habitat for Snake River sockeye salmon.

Physical and Biological Feature (PBF)	**Components (essential features) of the PBF**	**Principal Factors affecting Environmental Baseline Condition of the PBF**
Spawning and juvenile rearing areas	Spawning gravel, water quality, water quantity, water temperature, food, riparian vegetation, access	● Much of the area surrounding the natal lakes and headwaters remains in functional condition due to recreational, wilderness, and similar land use designations, but increased sediment load to streams in some portions due to historical grazing, mining, and timber harvest (spawning gravel, water quality, water quantity, water temperature) ● Conditions at the spawning/rearing lakes are under pressure from recreation and commercial activities, but are improving with efforts to move camp sites away from spawning areas (water quality, water temperature, riparian vegetation) ● Passage barrier at the outlet of Stanley Lake and weirs at the Sawtooth Fish Hatchery and Redfish Lake Creek (access)
Juvenile migration corridors	Substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food,	● Reduced flows during the spring outmigration due to water-storage operations and water withdrawals (water quantity, water velocity)

Physical and Biological Feature (PBF)	Components (essential features) of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBF
	riparian vegetation, space, and safe passage conditions.	● Elevated levels of chemical contaminants (legacy and current use) and coliform bacteria; reduced dissolved-oxygen concentrations due to discharge from urban and rural land use to rivers and streams and stormwater runoff (water quality) ● Delayed spring warming, delayed fall cooling, and reduced daily temperature variability during the spring outmigration due to the thermal inertia of the CRS reservoirs (water quality, water temperature) ● Increased temperatures in the lower Snake and Columbia Rivers due to water storage and withdrawals, degraded riparian function, and climate change (water quality) ● TDG levels exceeding state water quality standards during periods of lack of market or lack of turbine capacity spill (water quality) ● Reduced sediment transport due to settling in mainstem reservoirs (water quality, substrate) ● Passage delay and direct and indirect/delayed mortality at the eight CRS run-of-river hydrosystem dams; improved in the last decade with the addition of surface passage routes and higher spill levels (safe passage) ● Elevated temperatures and degraded riparian conditions in the lower Snake River above Lower Granite Dam and in the mainstem Salmon River due to water withdrawals and flow regulation (water quality, water quantity, water temperature, water velocity, cover/shelter, food, space, safe passage conditions) ● Concerns about increased opportunities for predators, fish and birds (construction of dredge material islands in the lower river and other human-built structures used by terns and cormorants for nesting, expanded predator fish habitat and lack of cover in reservoirs, introduction of exotic piscivorous fish species) ● Disconnection of much of the historical tidally influenced wetlands and riverine floodplain below Bonneville Dam due to reduced flows and the presence of dikes and levees (water quantity, cover/shelter, riparian vegetation, food)
Adult migration corridors	Substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, riparian vegetation, space and safe passage conditions.	● Cooler mainstem temperatures for early (May to early-July) upstream migrants; warmer conditions for later (late-July to August) migrants (water quality, water temperature)

Physical and Biological Feature (PBF)	Components (essential features) of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBF
		● Passage delay and direct and indirect/delayed mortality at the eight CRS run-of-river hydrosystem dams (safe passage) ● Increased numbers of pinnipeds in the lower Columbia River, and constricted passage opportunities for adult sockeye salmon in the Bonneville tailrace (safe passage)

2.13.2.9 Future Anticipated Impacts of Completed Federal Formal Consultations

The environmental baseline also includes the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, including the consultation on the operation and maintenance of the Bureau of Reclamation's upper Snake River projects. The 2016 five-year review evaluated new information regarding the status and trends of SR sockeye salmon, including recent biological opinions issued for SR sockeye salmon and key emergent or ongoing habitat concerns (NMFS 2016e). Since the beginning of 2015 through 2017, we completed 356 formal consultations (98 in 2015, 108 in 2016, and 150 in 2017) that addressed effects to SR sockeye salmon (PCTS data query, July 31, 2018). These numbers do not include the many projects implemented under programmatic consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed salmonids. Some of the completed consultations are large (large action area, multiple species), such as the Mitchell Act consultation and the consultation on the 2018–2027 *U.S. v. Oregon* Management Agreement. Many of the completed actions are for a single activity within a single subbasin.

Some of the projects will improve access to blocked habitat, improve riparian condition, increase channel complexity, and increase instream flows. For example, under BPA's Habitat Improvement Programmatic consultation, BPA implemented 29 projects in the Columbia Basin that improved fish passage in 2017, and 99 projects that involved river, stream, floodplain, and wetland restoration. These projects will benefit the viability of the affected populations by improving abundance, productivity, and spatial structure. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more, and typically less, than a few weeks).

Other types of federal projects, including grazing allotments, dock and pier construction, and bank stabilization will be neutral or have short- or even long-term adverse effects on viability. All of these actions have undergone section 7 consultation and the actions or the RPA were found to meet the ESA standards for avoiding jeopardy.

Similarly, future federal restoration projects will improve the functioning of the PBFs safe passage, spawning gravel, substrate, water quantity, water quality, cover/shelter, food, and riparian vegetation. Projects implemented for other purposes will be neutral or have short- or even long-term adverse effects on some of these same PBFs. However, all of these actions, including any RPAs, have undergone section 7 consultation and were found to meet the ESA standards for avoiding adverse modification of critical habitat.

2.13.3 Effects of the Action

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

The proposed action is an ongoing action that has been modified over time to reflect capital improvements, as well as changes in operation based on existing conditions and improved information on how CRS operations affect SR sockeye salmon and other listed species and their critical habitat. The current proposed action includes operational measures (e.g., flood risk management, navigation, fish passage, and hydropower generation) and non-operational measures (e.g., support for conservation hatchery programs, predation management, habitat improvement actions) that will be implemented beginning in 2019.

As described in Section 2.1 above, our analysis of effects for SR sockeye salmon extends from 2019 into the future, but emphasizes the evaluation of effects that are reasonably certain to occur as a result of implementing the proposed action pending completion of the EIS and our issuance of a subsequent biological opinion addressing the effects of the final preferred alternative. To the extent our consideration of potential effects beyond that time period assumes the current proposed action remains in place, it is intended, in part, to inform the evaluation of alternatives in the EIS.

The effects of the proposed action for SR sockeye salmon are generally consistent with the effects caused by a continuation of the CRS operations as described in the environmental baseline section, with the exception of the addition of the following:

- Implementation of the flexible spring spill operation;
- A 0.5-ft increase in operating range at John Day and Lower Snake River reservoirs; and
- Reduction of spill at Snake River projects in August of 2020 if consensus among parties is achieved
- Targeting April 24 as the transport start date (collection on April 23) at Snake River collector projects.
- The potential for reduction of spill at mainstem projects (August 15 to 31) of 2020 pending consensus among parties

2.13.3.1 Effects to Species

Juvenile and adult SR sockeye salmon will primarily be exposed to the effects of the proposed action from the upper end of Lower Granite Reservoir on the Snake River,[175] through all eight of the mainstem dams and reservoirs, to the mouth of the Columbia River.

The Action Agencies will continue to operate the run-of-river lower Snake River and Columbia River projects in accordance with the annual Water Management Plan and Fish Passage Plan (including all appendices). These projects are operated for multiple purposes, including fish and wildlife conservation, irrigation, navigation, power, recreation, and, in the case of John Day Dam, limited flood risk management.

The Action Agencies propose to increase spill at the lower Columbia River and lower Snake River dams during the spring spill period in an effort to improve juvenile survival through the dams and thereby improve adult returns. The Action Agencies propose to operate each dam for 16 hours per day at gas cap spill, and 8 hours per day at performance spill. Gas Cap Spill operations are proposed to increase from up to 120 to up to 125 percent TDG Gas Cap levels starting in 2020. Performance spill was developed using a combination of 2008 FCRPS biological opinion prescribed spill and performance standard testing guidelines. Gas cap spill is spill up to state water quality limits with some limitations based on agreed upon concerns about erosion and powerhouse minimum requirements.

System-wide water management operations involving upstream water storage projects will continue under the proposed action. Thus, the seasonal alterations described in the environmental baseline will continue (decreased spring and early summer flows, increased winter flows) to affect the mainstem migration and rearing corridor, estuary, and plume. The effects of these flows on the physical environment and to SR sockeye salmon juveniles and adults are discussed below.

2.13.3.1.1 Hydrosystem Operations

For SR sockeye salmon, the effect of the continued operation of the CRS is generally a continuation of the effects of recent hydrosystem operation as described in the environmental baseline (resulting from implementation of the 2008 biological opinion's reasonable and prudent alternative hydro actions) with the addition of the proposed flexible spring spill operation and increase in forebay operation range at some projects.

The available information indicates that supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). The proposed flexible spill operation (up to 120 or 125 percent TDG) would increase the exposure of spring migrating juveniles to elevated TDG levels from the tailrace of Lower Granite Dam to at least 35 miles downstream of Bonneville Dam. Smolts typically migrate at depths which effectively

[175] U.S. Bureau of Reclamation operations in the upper Snake River are part of a different action and consultation (F/NWR/2006/07518, signed May 5, 2008).

reduce TDG exposure due to pressure compensation mechanisms (Weitkamp et al. 2003). However, the proposed flexible spill operation would likely result in a slight increase in the incidence and severity of GBT symptoms and a very small (not measurable through reach survival studies) increase in mortality.

Adult SR sockeye salmon typically migrate between Bonneville and Lower Granite Dam starting in June, so only the earliest migrants would be affected by the proposed flexible spill operation. Adults also migrate at depths which reduce the effective exposure to TDG through depth compensation mechanisms. The proposed flexible spill operation would likely result in a slight increase in the incidence and severity of GBT symptoms and a very small (not measurable) increase in mortality for those adults that are exposed.

The Action Agencies propose to reduce juvenile fish passage spill in late August in 2020 if they can reach agreement on a trigger with the regional parties, and to increase the reservoir operating range at the four lower Snake River dams to MOP[176] 1.5-foot range and at John Day Dam to MIP[177] 2.0-foot range (an average increase in reservoir elevation of about 3 inches).

The effects of continuing the CRS operations will include the continued reduced flows in the lower Snake and Columbia River portions of the action area during the months of May through July. Juveniles migrate primarily in May and adult sockeye salmon migrate through this area primarily in June and July.

Adult Passage and Survival

Recent (2013–17) adult survival rates have averaged about 60 percent from Bonneville to McNary Dam and about 50 percent from Bonneville to Lower Granite Dam (NMFS estimates using PIT tags). This includes the extremely poor survival year of 2015, when only 15 percent of adult SR sockeye salmon survived from Bonneville to McNary Dam and only 4 percent survived from Bonneville to Lower Granite Dam (NMFS 2016e).[178] Lower Granite and Little Goose Dams have been equipped with cool-water "showers" to reduce temperature differentials within the adult fish ladders and in the forebay at the ladder exits to reduce delays and potentially improve adult survival rates. Opportunities for this type of improvement are being evaluated at the remaining six mainstem dams, but temperatures experienced in June and July of 2015, were they to reoccur, would likely result in similarly low survival rates, especially in the Bonneville to McNary Dam reach where the great majority of sockeye salmon perished.

A review and analysis by Crozier et al (2014) found the most significant factors associated with adult SR sockeye salmon fallback and upstream survival included a history of juvenile transport, warmer temperatures, and lower flows during upstream migration. Spill volume was not significantly associated with fallback for this species. This is important because increased

[176] MOP is the minimum operating pool height.
[177] MIP is the minimum irrigation pool height.
[178] The average 2008–16 estimates of adult survival, excluding 2015, are about 77 percent from Bonneville to McNary Dam and 69 percent from Bonneville to Lower Granite Dam (about 7 percent higher).

fallback is related to lower conversion rates to natal tributaries for adult salmonids (Keefer et al. 2005; Crozier et al. 2014). Thus, the flexible spill operation would not be expected to substantially alter fallback rates or the survival of adult SR sockeye salmon migrating in the lower Snake or Columbia Rivers prior to June 21 or June 15, respectively.

Few adult SR sockeye salmon migrate in August; the 2008-2017 average date by which 95 percent of the run has passed Lower Granite Dam is August 6 (DART 2019c). Thus, if agreement is reached among the regional parties to reduce summer spill at the eight mainstem dams in late August, we expect that this change in operation will not affect large numbers of SR sockeye salmon. However, the installation of devices to provide cool water in the fish ladders and forebay exit areas (Ladder Cooling Structures) at Little Goose and Lower Granite Dams will continue to reduce fallback by preventing rejection of the ladders and forebay exit areas.

Based on the average date by which 25 percent of SR sockeye salmon passed Bonneville Dam in 2008-17 (July 6), up to 25 percent of the returning adults would be exposed to effects of the flexible spring spill operation. However, as described above, Crozier et al. (2014) found only a weak association between increasing spill rates and fallback for this species.

While the information in Crozier et al. (2014) indicates that the additional spring spill is not likely to increase the overall proportion of adult sockeye salmon that fallback, the reduction in flow through the powerhouse will likely reduce the proportion that fallback through turbine units, the route which typically has the lowest estimates survival rates(Normandeau et. al 2014).

Altogether, recent (2008–16) adult survival rates would be expected to continue at similar levels under the proposed action. However, these survival rates will be much lower if the mainstem environmental conditions (low flows and high temperatures) of 2015 reoccur during the interim period. The installation of ladder cooling structures at Lower Granite and Little Goose Dams has reduced temperature differentials in the adult ladders and forebay exit areas at these projects (improving passage and potentially reach survival), but the great majority of impacts in 2015 occurred downstream of McNary Dam. It is not clear to what extent cooling systems, had they been installed at the lower Columbia River dams, could have improved migration conditions and adult survival. Conditions at the other six mainstem Columbia and lower Snake River dams are being evaluated to determine if ladder cooling structures would be effective at these projects as well, but the results of these studies are not yet available.

Juvenile Passage and Survival

Recent (2008–2014) juvenile SR sockeye salmon survival rates from Lower Granite to McNary Dam averaged 76 percent (ranging from about 69 percent in 2013 to 87 percent in 2014). Juvenile survival rates from Lower Granite to Bonneville Dam averaged 54 percent (ranging from about 40 percent in 2008 to 71 percent in 2014).[179] The Action Agencies propose to operate

[179] We excluded data for 2011 because there were too few PIT-tag detections to make a reasonable estimate of survival to Bonneville Dam. In addition, the low 2015–17 survival estimates were strongly affected by the issues at the new Springfield Hatchery that negatively affected smolt condition in those years (see environmental baseline

spring spill in accordance with the flexible spring spill operation agreement during 2019-20 *(Natl Wildlife Fed'n et al. v. NMFS et al.*, ECF 2298). Assuming COMPASS model predictions for SR yearling Chinook salmon and steelhead are applicable to juvenile sockeye salmon,[180] travel times from Lower Granite to Bonneville Dam (flexible spill up to 120 percent TDG) will be up to one day faster and direct survival rates will be slightly (i.e., less than 1 percent) higher than during 2008-14. That is, more juvenile sockeye will pass through spillways and other surface passage routes. However, impaired tailrace egress conditions during higher spill levels could cause juvenile in-river survival rates to be somewhat lower than predicted by COMPASS.

Nearly all SR sockeye salmon smolts migrate in May. The 2017 CSS report hypothesizes that increased spill could substantially reduce latent mortality for juvenile yearling Chinook salmon and steelhead moving downstream through the mainstem dams. If this is correct and latent mortality is similarly reduced for SR sockeye salmon, SARs would also improve, otherwise, survival improvement would be limited to small increases in direct survival.

Based on COMPASS modeling of SR spring/summer Chinook salmon and steelhead, juvenile sockeye salmon would likely be exposed to a slightly higher TDG levels (about 1.8 percent higher on average from Lower Granite tailrace to Bonneville Dam) under the flexible spill operation (up to 120 percent TDG) compared to recent operations.

The Action Agencies propose additional operation flexibility at the lower Snake River reservoirs (MOP 1.5-foot range) and John Day reservoir (MIP 2.0-foot range), with elevations about 3 inches higher (on average) than in past years. We assume that the change in travel time experienced by juvenile SR sockeye salmon will be similar to that expected for yearling SR spring/summer Chinook salmon and steelhead (the other species with juveniles migrating during the spring spill period). While increasing reservoir operating ranges may slightly increase travel times for SR sockeye salmon, we expect that the overall effect of increased reservoir operating ranges and the flexible spring spill operation (either up to the 120 or 125 percent) or will reduce travel time through the CRS by up to one day.[181] We expect recent (2008–14) juvenile survival rates to continue at similar levels under the proposed action. To the extent that higher spill levels reduce latent mortality (as hypothesized by the CSS), SARs could increase substantially.

The proposed cessation of transport operations in 2020 would have no effect on juvenile SR sockeye which migrate earlier during the spring spill period.

Estuary Habitat

The Action Agencies will continue to implement the CEERP (Ebberts et al. 2018; BPA and USACE 2018). Program goals are to increase the capacity and quality of estuarine ecosystems

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discussion). We determined that these low survival rates do not represent typical data quality or passage conditions through the lower Snake and Columbia Rivers and are not expected to reoccur.

[180] Due to data limitations, COMPASS cannot be used to model juvenile SR sockeye salmon survival.

[181] COMPASS estimated an average decrease of 0.4 days for steelhead and 0.9 days in travel time for yearling Chinook salmon from Lower Granite to Bonneville Dam. We expect sockeye salmon travel times to be similarly affected.

and to improve access to these resources for juvenile salmonids. Floodplain reconnections are expected to continue to increase the production and availability of commonly consumed prey (chironomid insects and corophiid amphipods; PNNL and NMFS 2018) to SR sockeye salmon as they migrate through the estuary.

NMFS agrees with ISAB's assessment findings (ISAB 2014) that it has been difficult to quantify the survival benefits of estuary habitat restoration, but the Action Agencies' assessment method, including review by the ERTG,[182] is useful to prioritize projects. For the interim period, the Action Agencies' proposed commitment is to reconnect an average of 300 acres of floodplain per year, a goal that they have a record of meeting in 2008–17 (BPA et al. 2018b), rather than to achieve a specific survival improvement. NMFS also agrees with the ISAB that the Action Agencies' assessment method, including review by the ERTG (Krueger et al. 2017), remains useful for prioritizing projects and for optimizing project design (number of breaches and channels, etc.) to site conditions. Thus, NMFS expects that the proposed implementation of the estuary program during the interim period will continue to mitigate for effects from flow management that, combined with dikes and levees, have cut much of the floodplain off from the mainstem river. The trend of increasing connected area (Johnson et al. 2018) is expected to continue during the interim period, providing benefits (flux of insect prey to the mainstem migration corridor) to juvenile SR sockeye salmon. It is also likely that these benefits will increase as habitat quality matures.

The Action Agencies also propose continued implementation of their monitoring program, the component of CEERP that provides the basis for adaptive management of the restoration program. This includes action effectiveness monitoring at each restoration site. A set of "standard" indicators (photo points, water surface elevation, and salinity) are measured at all sites (Level 3); core indicators (plant species composition, percent cover, and biomass) are measured at a subset of the sites (Level 2); and intensive indicators (juvenile salmonid species composition, density, diet, and growth, along with structures and controlling factors) are measured at a smaller number of sites (Level 1) (Johnson et al. 2018). Monitoring will continue at sites built as recently as 2016–2017 and will be initiated for sites constructed during the interim period. Johnson et al. (2018) evaluated the action effectiveness monitoring data collected since 2012 and found they generally indicated that the restoration of physical and biological processes was underway. Continued implementation and evaluation of this monitoring program will elucidate how these floodplain reconnections are enhancing conditions for yearling salmonids such as SR sockeye salmon as they migrate through the mainstem, and provide sufficient information to the Action Agencies to help refine site selection and project design through adaptive management.

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[182] As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss with ERTG and regional partners relevant climate change science in an effort to understand whether their planned estuary projects are resilient to climate change (i.e., sea level rise, temperatures, and mainstem flow levels). In addition, the Action Agencies' annual update of their restoration and monitoring plans for the estuary will document any needed adjustments in design, location, or other elements of a given project to address climate change impacts, both during and beyond the interim period.

Tributary Habitat

While the Action Agencies have not proposed to implement tributary habitat projects that will specifically target SR sockeye salmon as part of the proposed action, projects in the Sawtooth Valley that increase flows, or improve riparian area or floodplain functions, could improve juvenile migration or adult-holding conditions for SR sockeye salmon in the Salmon River or its tributaries. However, the effect of these potential improvements for SR sockeye salmon, though likely positive, are too speculative to assess.

Conservation and Safety Net Hatchery Actions

The safety net hatchery program for SR sockeye salmon has prevented extinction in the near term and preserved the genetic lineage of Redfish Lake sockeye salmon. The Action Agencies propose to continue to fund this program, which will allow for increased abundance and support the establishment of naturally spawning populations in Sawtooth Valley lakes.

Predation Management in the Lower Columbia River Estuary

Avian Predators

The Action Agencies propose continued implementation of the Caspian Tern Nesting Habitat Management Plan (USACE 2015a) and the Double-crested Cormorant Management Plan (USACE 2015b). Tern habitat on East Sand Island will continue to be maintained at no less than one acre for the interim period covered by this consultation. Management actions for double-crested cormorants on East Sand Island will be limited to passive dissuasion and hazing, except that limited egg take (up to 500 eggs) may be requested from the USFWS each year to preclude cormorants from nesting in new or different areas on East Sand Island. These ongoing actions are likely to continue current levels of predation by birds nesting on East Sand Island, which in the case of Caspian terns has been shown to be an improvement compared to the pre-colony management period. Due to the dispersal of the colony in 2016 and 2017, predation rates for East Sand Island cormorants are not available for the management period. Colony size and predation rate data from 2018 and during the interim period will be needed to evaluate whether this program is meeting its management goals.

In addition to the monitoring results mentioned above, the Action Agencies propose to synthesize colony-size and predation-rate data collected under the tern and cormorant colony management plans. The intent of the synthesis report is to summarize data on predation by piscivorous waterbirds on ESA-listed salmonids in the Columbia River basin before, during, and after the management actions, in order to assess their effectiveness on a basinwide scale. For example, the dispersal of double-crested cormorants from East Sand Island to nest sites on the Astoria-Megler Bridge in recent years, and observations of thousands of Caspian terns roosting on Rice Island in 2017, indicate that the numbers of avian predators in the estuary are still in flux and their effects on the viability of salmonids, such as SR sockeye salmon, is variable. The synthesis report will help managers assess whether to recommend that the Action Agencies or other regional parties consider additional measures for implementation over the long term.

Ongoing annual monitoring will include estimates of double-crested cormorant abundance, nesting density, and PIT-tag detection on East Sand Island. The average estimated three-year peak colony size will be used to evaluate management activities relative to plan objectives (2019–21); the management plan will be considered successful when the average three-year peak colony size estimate does not exceed 5,939 nesting pairs while no management actions are conducted. Annual PIT detection will continue for 5–10 years to assess overall trends in predation rates (through the 2023 breeding season, at minimum), accounting for annual variability in predation impacts. These measures are likely to effectively constrain and evaluate double-crested cormorant predation on listed salmonids such as SR sockeye salmon at Corps-managed sites in the estuary.

Fish Predators

The Action Agencies will continue to implement the NPMP, including the Sport Reward Fishery, in the lower Columbia River estuary as described under the environmental baseline. We expect that this ongoing measure will continue the 30 percent reduction in predation rates achieved under the 2008 RPA. We estimate that numbers of sockeye salmon, including some from the SR sockeye salmon ESU, killed and/or handled in the Sport Reward Fishery, system-wide, will be no more than ten adults and 100 juveniles per year during the interim period.

Predation Management in the Hydrosystem Reach

Avian Predators

The Corps will continue to implement and improve, as needed, avian predator deterrent programs at lower Columbia River and Snake River dams. At each dam, bird numbers will be monitored, feeding birds will be hazed, and passive predation deterrents, such as irrigation sprinklers and bird wires will be deployed. Hazing, including launching long-range pyrotechnics at concentrations of feeding birds near the spillway and powerhouse discharge areas, and juvenile bypass outfall areas, will also continue. These measures will continue to reduce levels of predation on juvenile SR sockeye salmon.

The Action Agencies propose to continue to address Caspian tern predation at lands that they manage on the interior Columbia plateau: Crescent Island (Corps) and Goose Island (Bureau of Reclamation). The Corps has excluded tern use on Crescent Island via revegetation since 2015, but will continue to monitor that site to ensure that conditions remain unfavorable for nesting. If tern use does resume during the interim period, the Corps will work with NMFS and USFWS to address concerns, perform any necessary environmental compliance, and seek permits and funding for active hazing, if warranted. If no nesting of concern to the Corps and NMFS is identified, the Corps will discontinue monitoring after three years. These measures are likely to preclude use of Crescent Island by Caspian terns during the interim period of this consultation.

The Bureau of Reclamation has excluded Caspian terns from Goose Island using ropes and flagging and is currently experimenting with revegetation. They propose to maintain the ropes and flagging and to monitor for tern presence on a regular basis between late February and early July each year. If terns resume nesting, and if the number of terns exceeds metrics identified in the IAPMP (more than 40 nesting pairs on Goose Island or more than 200 pairs at sites across the interior Columbia Basin; USACE 2014), the Bureau of Reclamation will work with NMFS to identify management actions and tools that can be put in place to dissuade tern use of the island before the next nesting season (e.g., permits from USFWS for hazing and egg take). These measures are likely to successfully preclude use of Goose Island by Caspian terns during the interim period of this consultation.

Pinniped Predators

The Corps will continue to install, and improve as needed, sea lion excluder gates at all adult fish ladder entrances at Bonneville Dam each year. In addition, the Corps and BPA will continue to support land- and water-based harassment efforts by ODFW, WDFW, and CRITFC to keep sea lions away from the area downstream of Bonneville Dam. The Corps will continue estimating sea lion abundance, spatial distribution, temporal distribution, predation attempts, and predation rates in the Bonneville Dam tailrace annually from early August through May 31. Collection of predation data will occur when sea lion abundance is greater than or equal to 20 animals. The Corps will continue to use adaptive management, including recommendations from the Fish Passage Operations and Management Coordination Team and the Sea Lion Task Force, to address changing circumstances as they relate to sea lion harassment efforts and predation monitoring at Bonneville Dam. These ongoing measures are expected to maintain the current very low levels of sea lion predation on SR sockeye salmon in the Bonneville Dam tailrace. If pinnipeds are observed at The Dalles Dam, the Corp may respond with hazing at adult fish ladder entrances.

Fish Predators

The Action Agencies will continue to implement the Northern Pikeminnow Sport Reward Fishery in the hydrosystem reach and the Dam Angling Program at The Dalles and John Day Dams, as described under the environmental baseline. These ongoing measures will continue the reduction in predation rates achieved under the 2008 RPA. We estimate that the 2013-2017 annual average numbers of sockeye salmon, including SR sockeye salmon, which will be handled and/or killed in the Sport Reward Fishery will continue as described above (Predation Management in the Lower Columbia River Estuary). In addition, we estimate that no more than five adult and 20 juvenile sockeye salmon, including some from the SR sockeye salmon ESU, will be killed and/or handled in the Dam Angling Program per year during the interim period.

Research and Monitoring Activities

The Action Agencies' RM&E program will be similar to the current program, or will be implemented at a reduced scale. Thus, the level of injury and mortality discussed in the Environmental Baseline, primarily from the capture and handling of fish, is likely to continue at a similar or reduced level. We estimate that, on average, the following number of SR sockeye salmon will be affected each year during the interim period:

- Projected estimates of SR sockeye salmon handling and mortality during activities associated with the Smolt Monitoring Program and CSS: (1) five hatchery and zerowild adults handled; (2) zero hatchery or wild adults killed; (3) 8,381 hatchery and 3,768 wild juveniles handled; and (4) 293 hatchery and 133 wild juveniles killed.

- Projected estimates of SR sockeye salmon handling and mortality during activities associated with the Fish Status Monitoring:[183] (1) 210 hatchery and zero wild adults handled; (2) two hatchery and zero wild adults killed; (3) zero hatchery or wild juveniles handled; and (4) zero hatchery or wild juveniles killed.
- Projected estimates of SR sockeye salmon handling and mortality for all other RM&E programs: (1) 337 hatchery and zero wild adults handled; (2) three hatchery and one wild adults killed; (3) 55,294 hatchery and 5,698 wild juveniles handled; (4) 553 hatchery and 57 wild juveniles killed.

The combined observed mortality associated with these elements of the RM&E program will, on average, affect less than one percent of the wild (i.e., natural origin) adult returns or juvenile production for the SR sockeye salmon ESU (Bellerud 2018). We estimate that none of the wild adults and 47.97 percent of the wild juvenile production will be handled each year, on average, we expect that only up to one percent of these will die after release (in this case, no adults and 0.48 percent of juveniles handled). This relatively small effect is deemed worthwhile because it will allow the Action Agencies and NMFS to continue to evaluate the effects of CRS operations including modifications to facilities, operations, and mitigation actions.

Electrofishing operations for the NPMP during the interim period are expected to continue at the same level of effort as in recent years (four 15-minute sampling events per 0.6-mile reach between RM 47 near Clatskanie, Oregon, and RM 394 on the Columbia River and to RM 156 on the lower Snake River during April-July; a total of 550 hours system-wide). Some adult and juvenile SR sockeye salmon are likely to be present in shallow shoreline areas during electrofishing activities and may be stunned and even killed. However, because the operator releases the electrical field as soon as salmonids are observed and most of these fish quickly recover and swim away, we are unable to use observations from past operations to estimate the number of fish from this ESU that will be affected. Information obtained through electrofishing supports management of the NPMP, which is reported to have reduced salmonid predation by about 30 percent (Williams et al. 2017). This level of take is anticipated to occur for the duration of this proposed action, pending completion of the NEPA process.

2.13.3.2 Effects to Critical Habitat

Implementation of the flexible spring spill operation is likely to improve the direct survival of in-river juvenile migrants at the eight mainstem dams by a small amount (safe passage). Adults migrating during periods of Gas Cap spill are likely to experience a small increase in the rate of involuntary fallback, although survival will be higher than for fish that fallback through turbines

[183] Fish Status Monitoring is intended to include individuals handled/killed during status and trend, "fish-in/fish out," and habitat effectiveness monitoring projects.

or the juvenile bypass system (see Section 2.13.3.1). Effects of the proposed action on PBFs are listed in Table 2.13-5.

Table 2.13-5. Effects of the proposed action on the physical and biological features (PBFs) of designated critical habitat within the action area for SR sockeye salmon.

Physical and Biological Feature (PBF)	Effects of the Proposed Action
Spawning and juvenile rearing areas	The proposed action will not alter the PBFs in the natal lakes.
Juvenile migration corridors	Continuation of reduced flows during the spring outmigration (water quantity, water velocity) Continuation of delayed spring warming and reduced daily temperature variability during the spring outmigration due to thermal inertia in the CRS reservoirs (water quality, water temperature) Small increase in the survival of juvenile in-river migrants during the flexible spring spill operation; could be offset by increased exposure to predators if tailrace egress conditions degrade in low flow conditions (safe passage) Overall reduction in juvenile travel time and exposure to predators during flexible spring spill operation, offsetting a small increase in travel time from increasing reservoir operating ranges at the lower Snake River and John Day projects (safe passage) Continued accumulation of sediment behind CRS dams, reducing turbidity in the migration corridor during the spring outmigration (safe passage) Continuation of current levels of predation with ongoing implementation of the avian and pikeminnow management programs (safe passage) Increase in TDG levels up to the state-approved limits (up to 120 or 125 percent TDG) at the CRS run-of-river projects) will result in only a slight increase in the incidence and severity of GBT symptoms (water quality in the juvenile and adult migration corridor) (water quality) Increased access to forage with the proposed reconnection of an average of 300 acres of floodplain habitat per year in the lower Columbia River estuary during the interim period (food)
Adult migration corridors	Continuation of reduced flows during the adult migration in the mainstem lower Columbia and Snake Rivers (water quantity, water velocity) Continuation of delayed spring warming and reduced daily temperature variability during the adult migration due to thermal inertia in the CRS reservoirs (water quality, water temperature) Continuation of increased summer temperatures in the lower Snake and Columbia Rivers due to several factors including CRS water storage operations (water quality) Continuation of improved temperature conditions in fish ladders at forebay exit areas due to recent structural improvements at Lower Granite and Little Goose Dams (water quality) Continuation of cooler water releases from Dworshak Dam into the lower Snake River during the adult migration (water quality, water temperature, safe passage) Continuation of current low levels of pinniped predation (safe passage) Increase in TDG levels up to the state-approved limits (up to 120 or 125 percent TDG) at the CRS run-of-river projects) will result in only a slight increase in the incidence and severity of GBT symptoms (water quality in the juvenile and adult migration corridor) (water quality)

Physical and Biological Feature (PBF)	Effects of the Proposed Action
	Increase in survival of adults that fallback over the spillway during the flexible spring spill operation;compared to fallback through the turbines or juvenile bypass system (safe passage)

2.13.4 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation (50 CFR 402.02). Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Non-federal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. These projects also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth-management programs (planning and regulation), a variety of stream and riparian habitat projects, watershed planning and implementation, acquisition of water rights for instream purposes and sensitive areas, instream flow rules, stormwater and discharge regulation, TMDL implementation to achieve water-quality standards, hydraulic project permitting, and increased spill and bypass operations at hydropower facilities. NMFS determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. These activities are likely to have beneficial cumulative effects that will significantly improve conditions for the salmon and steelhead, including SR sockeye salmon.

NMFS also noted that some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects are activities that occurred in the recent past and were included in the environmental baseline. Some of these activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the action area, non-federal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations.

Some continuing non-federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult, if not impossible, to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline.

Overall, we anticipate that projects to restore and protect habitat, restore access and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area.

2.13.5 Integration and Synthesis

In this section, we add the effects of the action (Section 2.13.3) to the environmental baseline (Section 2.13.2) and the cumulative effects (Section 2.13.4), taking into account the status of the species and critical habitat (Sections 2.13.1.1 and 2.13.1.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat for the conservation of the species.

2.13.5.1 Species

The future operation of the CRS will continue to affect SR sockeye salmon within the action area, as described in the Status and Environmental Baseline (flows, highly modified/inundated habitat, exposure to predators, predator hazing and reduction programs, habitat improvements, water quality, survival, research and monitoring, etc.). However, there are aspects of the proposed action that will affect SR sockeye salmon differently than recent operations. The proposed flexible spring spill operation will increase juvenile fish passage spill levels up to the state water quality gas cap limits. Based on COMPASS modeling results for yearling SR spring/summer Chinook salmon and SR steelhead (flexible spill up to 120 percent TDG), we expect this operation to reduce travel time from Lower Granite to Bonneville Dam by up to one day and to slightly improve juvenile survival. In addition, SARs will improve if some aspect of latent mortality is reduced as hypothesized by CSS for yearling Chinook salmon and steelhead. Increasing the reservoir operating ranges by 6 inches (an average of 3 inches) at the lower Snake River projects (to MOP 1.5-ft range) and John Day Dam (MIP 2-ft range) will slightly increase juvenile travel times and exposure to predators. However, travel time will be reduced by increased spill. Pending agreement with the regional parties, reducing spill at the lower Snake River and lower Columbia River dams before 31 August in 2020 will have some small effect (potentially either positive or negative) on adult SR sockeye salmon survival rates.

The environmental baseline conditions in the mainstem rearing and migration corridor–beginning at the head of Lower Granite Reservoir and extending through the eight mainstem projects, lower Columbia River, and estuary–remain degraded, but have generally improved over the past two to three decades. The most notable improvements include: (1) changes to the configuration and operation of dams in the mainstem migration corridor (24-hour spill, surface passage routes, improved juvenile bypass systems, etc.) which improves passage conditions for migrating smolts; (2) summer flow augmentation and releases of cool water from Dworshak Dam to reduce summer temperatures and improve flows in the lower Snake River, which improves conditions for migrating smolts, juveniles rearing in the reservoirs, and adult migrants; and (3) improved conditions in the estuary, particularly improvements in floodplain connectivity resulting from recent Action Agency-funded restoration efforts, which should improve conditions for sockeye salmon smolts that use these areas, and enhance the amount of prey available for those smolts migrating more quickly through the estuary to the plume.

Other environmental baseline conditions have shown little change or have declined. The most notable of these include: (1) pinniped predation downstream of Bonneville Dam has increased slightly, but is not thought to be a substantial factor affecting productivity and abundance for sockeye salmon given their migration timing; (2) avian predation, especially in the estuary increased (baseline) and it is still unknown whether management efforts to reduce cormorant numbers and further reduce Caspian tern numbers in the estuary will stop or reverse this trend; (3) continued exposure to chemicals and toxic substances throughout the mainstem migration corridor, lower Columbia River, and estuary remains a concern; and (4) though there is considerable uncertainty related to the scale of the changes over the coming decades, and the response of salmon and steelhead, climate change remains a concern because it will affect temperature and seasonal precipitation patterns. The latter is especially of concern for adult SR sockeye salmon, which suffered extremely high mortalities in 2015 related to June and early–July temperatures. The emergency transportation of adults at Lower Granite Dam that year increased the survival of adults to the spawning grounds in these circumstances, and would be expected to be similarly deployed if these circumstances were to arise again. The Action Agencies have already implemented several recommendations stemming from NMFS' (2016e) 2015 Adult Sockeye Salmon report to improve ladder conditions and be better prepared to facilitate emergency transportation of adult SR sockeye salmon at the Lower Granite adult trap facility should temperature conditions similar to those in 2015 reoccur.

For SR sockeye salmon, the most recent status review (NMFS 2016e) recognized that the ESU has experienced improvements in productivity and abundance in spite of recent low survival rates for juveniles released from the Springfield Hatchery. Total adult returns (to the Sawtooth Valley) from 2008–17 ranged from 91 (2015) to 1,579 (2014), compared to 3 (2006) to 257 (2000) adults during 1999–2007. The Springfield Hatchery issues appear to have been resolved (2018 survival rates to Lower Granite Dam and from Lower Granite to Bonneville Dam returned to ranges observed for other release groups in previous years) and we expect the improved productivity and abundance to continue. The ESU's range has also been expanded through reintroduction into two of the historical lakes. Still, the risk rating for SR sockeye salmon remains high and the overall status of the species remains endangered. Key threats for adults include: predation, exposure to elevated water temperatures, exposure to elevated TDG, fallback over dams, straying to non-natal streams, harvest, and disease. Key threats to juveniles include: hatchery effects (e.g., disease, water quality, and mechanical failure), stress of release from the hatchery, food supply (productivity) and water quality in lakes, downstream passage through the CRS or during transport, predation, and ocean conditions.

NMFS estimates that recovery of the SR sockeye salmon ESU could take 50 to 100 years (NMFS 2015b). The recovery plan for the species has three phases: (1) preservation with the captive broodstock program (preserve the remaining genetic diversity); (2) reintroduction (increase spatial structure); and (3) an emphasis on natural adaptation and viability. At this time, efforts have been focused on the first two phases, while taking actions to improve survival rates throughout the life-cycle (increase abundance and productivity) and resolve uncertainties relating to key threats for adults and juveniles. The targeted minimum spawning abundance threshold (as a ten-year geometric mean) for natural-origin spawners in the recovery plan is 1,000 adults for the intermediate Redfish Lake and Alturas Lake populations, and 500 for the small populations in Pettit, Stanley, or Yellowbelly Lakes. The recovery plan recommended that two of the three historical lake populations (Redfish Lake, Alturas Lake, or Pettit Lake) in the ESU should be restored to highly viable status, and the remaining population to viable status. It also recommended that managers consider expanding reintroductions into Yellowbelly Lake and Stanley Lake.

The proposed action is consistent with the recovery plan. It is employing a method (increased spill) that has the potential to increase juvenile survival and SARs (the latter as hypothesized by the CSS). The proposed action also continues to fund the conservation hatchery program, PIT tagging, and PIT-tag detection systems, which allow the Action Agencies to monitor both juvenile and adult survival rates. Lastly, though not targeting sockeye salmon, the proposed tributary habitat improvement program could also improve conditions for juvenile migrants and adults holding in the Salmon River and reconnecting the floodplain in the estuary will continue to provide prey for juvenile migrants. Ongoing implementation of the NPMP will continue to reduce predation rates on juvenile and adult sockeye salmon although the success of avian predation management in reducing juvenile mortality is less certain at this time. In short, the proposed action will contribute to the recovery of SR sockeye salmon and is not expected to impede other called-for recovery actions over the time frame considered in the recovery plan.

The status of SR sockeye salmon is also likely to be affected by climate change. Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycle. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater and changes to food webs in freshwater, estuarine, and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management actions may help alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations, increased riparian vegetation to control water temperatures, etc.).

Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life history types that will be successful in the future are neither static nor predictable. Therefore, maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the SR sockeye salmon ESU. Because of its location in the Columbia River basin, the ESU is likely to be more affected by climate-related effects in the estuary, and in tributary streams (altered seasonal flows and temperatures) that support spawning and early rearing. Emerging research using complex life cycle modeling indicates a potentially strong link between SST and survival of Snake River spring/summer Chinook salmon populations. However, the apparent link between SST and survival is presumably caused by foodweb interactions, relationships which could be disrupted by major transformations of community dynamics as well as ocean acidification and other factors under a changing climate. The degree to which SST is linked to survival of SR sockeye salmon and how that relationship interacts with other variables throughout the SR sockeye salmon life cycle will likely be an important area of future research.

Overall, we anticipate that projects to restore and protect habitat, restore access, recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area.

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, and considering the interim nature of this proposed action pending the decision to implement a new action as a result of the NEPA process, it is NMFS' biological opinion that the proposed action is not likely to reduce appreciably the likelihood of both survival and recovery of SR sockeye salmon.

2.13.5.2 Critical Habitat

The rangewide status of critical habitat designated for SR sockeye salmon is discussed in Section 2.13.1 of this opinion. Across much of the designated area, land use activities have disrupted watershed processes, reduced water quality, and diminished habitat quantity, quality, and complexity. Past and/or current land use or water management activities have adversely affected the quality and quantity of riparian conditions and side channels, floodplain function, sediment conditions, and other water quality and quantity parameters. As a result, the important watershed processes and functions that once created healthy ecosystems for sockeye salmon production have been weakened. An important exception is that the natal lakes in the Sawtooth Valley are in relatively good condition due to functioning PBFs in large portions of their contributing watersheds. This is associated with recreational, wilderness (i.e., roadless), and similar land use designations. In addition, local recovery actions have restored access to multiple historical spawning areas as well as improved conditions along the shorelines of these lakes.

Effects of the CRS (historical and proposed) on the functioning of critical habitat in the migration corridor include increased passage times and reduced juvenile and adult survival at the run-of-river mainstem dams. For in-river migrants, the flexible spring spill operation will reduce those obstructions in the migration corridor (except during low flow years if tailrace egress conditions degrade). Seasonal flows and temperatures will continue to be altered compared to an undeveloped system with negative effects on water quantity, water velocity, water quality, and water temperature. Increased numbers of predators, including birds and native and non-native fishes that prey on yearling sockeye salmon will continue to be present in the hydrosystem reach (safe passage). The reduced levels of predation by Caspian terns on the interior Columbia plateau and northern pikeminnows in project tailraces and reservoirs that were achieved under the 2008 biological opinion and associated RPA will be maintained by the continued implementation of the respective predator management plans (safe passage).

In the lower Columbia River estuary, the proposed habitat restoration program will continue to reconnect the historical floodplain, increasing the availability of wetland-derived prey to yearling sockeye salmon migrating to the ocean (prey). Toxic contaminants, an effect of land use practices, will continue to be present, especially near urban and industrial areas (water quality). Ongoing management of the tern and cormorant colonies at East Sand Island is expected to reduce smolt predation rates, but monitoring results from 2018 and the interim period and the data compilation expected in the avian predation synthesis report will be needed for confirmation.

Considering the ongoing and future effects of the environmental baseline and cumulative effects, and in light of the status of critical habitat, the proposed action will not appreciably reduce the value of designated critical habitat for the conservation of SR sockeye salmon.

2.13.6 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, and considering the interim nature of this proposed action pending the decision to implement a new action as a result of the NEPA process, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of SR sockeye salmon or destroy or adversely modify its designated critical habitat.

2.14 Snake River Basin (SRB) Steelhead

This section applies the analytical framework described in section 2.1 to the SRB steelhead DPS and provides NMFS' finding regarding whether the proposed action is likely to jeopardize the continued existence of SRB steelhead or destroy or adversely modify its critical habitat.

2.14.1 Rangewide Status of the Species and Critical Habitat

The status of the SRB steelhead DPS is determined by the level of extinction risk that SRB steelhead face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The condition of critical habitat throughout the designated area is determined by the current function of the PBFs that help to form that conservation value.

2.14.1.1 Status of the Species

On August 18, 1997, NMFS listed the SRB steelhead DPS as a threatened species (62 FR 43937). The threatened status was reaffirmed in 2006 and most recently on April 14, 2014 (79 FR 20802). Critical habitat for the DPS was designated on September 2, 2005 (70 FR 52769). Table 2.14-1 provides a summary of the status of the DPS and limiting factors. The summary that follows describes the status of SRB steelhead. More detailed information can be found in the recovery plan (NMFS 2017e) and status review for this species (NMFS 2016e). These documents are available on the NMFS West Coast Region website (http://www.westcoast.fisheries.noaa.gov/).

The SRB steelhead DPS includes all naturally spawned anadromous *O. mykiss* originating below natural and manmade impassable barriers in streams in the Snake River basin of southeast Washington, northeast Oregon, and Idaho (Figure 2.14-1) (NWFSC 2015). Twenty four historical populations (an additional three are extirpated) within six MPGs comprise the SRB steelhead DPS. Inside the geographic range of the DPS, 12 hatchery steelhead programs are currently operational. Five of these artificial programs are included in the DPS (Table 2.14-2) (Jones 2015).

Table 2.14-1. Summary of the most recent status and limiting factors information for SR steelhead considered in this opinion.

Status Summary	**Limiting Factors**
This DPS comprises six separate MPGs with 24 extant populations. The recovery plan is based upon three management unit plans – Idaho, Northeast Oregon and Southeast Washington. Four out of the five MPGs are not meeting the specific objectives in the recovery plan based on the updated status information, and the status of many individual populations remains uncertain. The new information has resulted in an updated view of the relative abundance of natural-origin spawners and life-history diversity across the populations in the DPS. The more specific information on the distribution of natural returns among stock groups and populations indicates that differences in abundance/productivity status among populations may be more related to geography or elevation rather than A run versus B run. A great deal of uncertainty still remains regarding the relative proportion of hatchery fish in natural spawning areas near major hatchery release sites within individual populations.	● Mainstem Columbia River hydropower-related adverse effects; ● Impaired tributary fish passage; ● Degraded freshwater habitat, including degradation in floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream flow, and water quality as a result of cumulative impacts of agriculture, forestry, and development; ● Impaired water quality and increased water temperature; ● Related harvest effects, particularly for B-Index steelhead; ● Predation; and ● Genetic diversity effects from out-of-population hatchery releases.

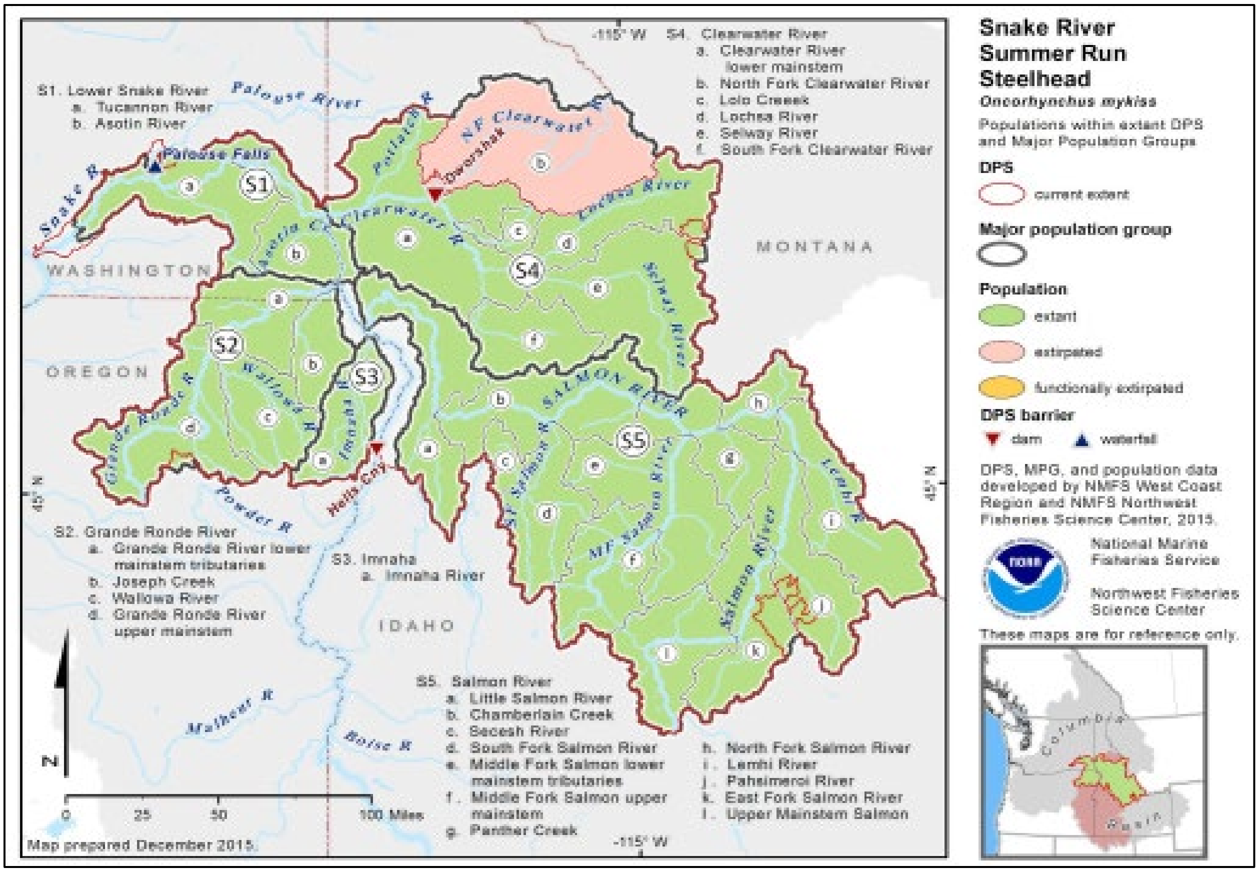

Figure 2.14-1. Map of the SRB steelhead DPS' spawning and rearing areas, illustrating natural populations and major population groups (MPGs) (NWFSC 2015).

Table 2.14-2. Snake River Basin steelhead DPS description and six major population groups (NMFS 2012, NWFSC 2015).

Major Population Group	***Populations***
Grande Ronde	Joseph Creek, Upper Mainstem, Lower Mainstem, Wallowa River
Imnaha River	Imnaha River
Clearwater	Lower Mainstem River, North Fork Clearwater River, Lolo Creek, Lochsa River, Selway River, South Fork Clearwater River
Salmon River	Little Salmon/Rapid Rivers, Chamberlain Creek, Secesh River, South Fork Salmon, Panther Creek, Lower MF, Upper MF, North Fork, Lemhi River, Pahsimeroi River, East Fork Salmon, Upper Mainstem
Lower Snake	Tucannon River, Asotin Creek
Hells Canyon Tributaries	n/a
Artificial Production	
Hatchery programs included in DPS (5)	Tucannon River summer, Little Sheep Creek summer, EF Salmon River Natural A, Dworshak NFH B, SF Clearwater (Clearwater Hatchery) B, Salmon River B
Hatchery programs not included in DPS (7)	Lyons Ferry NFH summer, Wallowa Hatchery summer, Hells Canyon A, Pahsimeroi Hatchery A, Upper Salmon River A, Streamside Incubator Project A and B, Little Salmon River A

Adult SRB steelhead are generally classified as summer-run, returning to the Snake River basin from late summer through fall, where they hold in larger rivers for several months before moving upstream into smaller tributaries. Most SRB steelhead arrive above Lower Granite Dam by fall, but approximately 2.1 percent of the adults remain below Lower Granite Dam over the winter and move upstream in the spring (April through June 20).[184] SRB steelhead spawn and rear across a wide range of freshwater temperature/precipitation regimes; however, much of the freshwater habitat used by SRB steelhead for spawning and rearing is warmer and drier than that associated with other steelhead DPSs. Fisheries managers classify SRB summer-run steelhead

184 Approximately 2.1 percent of all adults (hatchery plus unclipped "wild" SRB steelhead) and 4.0 percent of the unclipped "wild" steelhead move upstream from April 3 through June 20, based on a query of data from 2008 through 2017. Source: Columbia River DART 8-21-2018.

into two aggregate or morphological groups, A-Index and B-Index,[185] based on ocean age at return, adult size at return, and migration timing. A-Index steelhead predominately spend one year at sea, returning to spawning areas beginning in the summer and are assumed to be associated with low-to-mid-elevation streams throughout the interior Columbia Basin. B-Index steelhead begin migration in the fall and are generally larger than A-Index steelhead, with most individuals returning after two years in the ocean. The differences in the two fish stocks represent an important component of phenotypic and genetic diversity of the SRB steelhead DPS through the asynchronous timing of ocean residence, segregation of spawning in larger and smaller streams, and possible differences in the habitats of the fish in the ocean (NMFS 2012). A-Index steelhead occur throughout the steelhead-bearing streams in the Snake River basin and inland Columbia River, while research indicates that B-Index steelhead only reproduce in the Clearwater River basin and the lower and middle Salmon River basin (NWFSC 2015).

Like all salmonid species, steelhead are cold-water fish (Magnuson et al. 1979) that survive in a relatively narrow range of temperatures, which limits the species distribution in freshwater to northern latitudes and higher elevations. SRB steelhead migrate a substantial distance from the ocean (up to 930 miles) and occupy habitat that is considerably warmer and drier (on an annual basis) than steelhead of other DPSs. Adult SRB steelhead return to the Snake River basin from late summer through fall, where they hold in larger rivers for several months before moving upstream into smaller tributaries (NMFS 2012, 2013b).

Steelhead live primarily off stored energy during the holding period, with little or no active feeding (Shapovalov and Taft 1954; Laufle et al. 1986). Adult dispersal toward spawning areas varies with elevation, with the majority of adults dispersing into tributaries from March through May, with earlier dispersal at lower elevations, and later dispersal at higher elevations. Spawning begins shortly after fish reach spawning areas, which is typically during a rising hydrograph and before peak flows (Thurow 1987; NMFS 2012).

Steelhead typically select spawning areas in gravels at the downstream end of pools (Laufle et al. 1986). Juveniles emerge from redds in four to eight weeks, depending on temperature. Juveniles in the Snake River basin typically reside in freshwater for no more than two years, but may stay longer, depending on temperature and growth rate (Mullan et al. 1992; Chandler and Richardson 2006; Kucera and Johnson 1986; Fuller et al. 1984). Smolts migrate downstream during spring runoff, which occurs from March to mid-June in the Snake River basin, depending on elevation (NMFS 2012).

2.14.1.1.1 Abundance, Productivity, Spatial Structure, and Diversity

Population-specific adult population abundance is generally not available for SRB steelhead due to difficulties conducting surveys in much of their range. Evaluations in the 2015 status review were done using a set of metrics corresponding to those used in prior BRT reviews, as well as a

[185] In all previous CRS consultations, we used the terms A-run and B-run. We are using this new terminology to be consistent with terminology used by fisheries managers and to reflect a better understanding of the phenotypic and genotypic diversity within SRB steelhead.

set corresponding to the specific viability criteria based on ICTRT recommendations for this DPS (Table 2.14-3). The BRT-level metrics were consistently done across all ESUs and DPSs to facilitate comparisons across domains. The most recent five-year geometric mean abundance estimates for the two long-term data series of direct population estimates (Joseph Creek and Upper Grande Ronde Mainstem populations) increased compared to the prior review estimates; each of the populations increased an average of two percent per year over the past 15 years. Hatchery-origin spawner estimates for both populations continued to be low, and both populations are currently approaching the peak abundance estimates observed since the mid-1980s (NWFSC 2015).

The ICTRT viability criteria adopted in the Snake River management unit recovery plans include spatially explicit criteria and metrics for both spatial structure and diversity. With one exception, spatial structure ratings for all of the SRB steelhead populations were low or very low risk, given the evidence for distribution of natural production with populations. The exception was the Panther Creek population, which was given a high-risk rating for spatial structure based on the lack of spawning in the upper sections. No new information was provided for the 2015 status update that would change those ratings (NWFSC 2015).

Updated information is available for two important factors that contribute to rating diversity risk under the ICTRT approach: hatchery-spawner fractions and life-history diversity. Hatchery straying appears to be relatively low. At present, direct estimates of hatchery returns are available for the run assessed at Lower Granite Dam (Vu et al. 2015). Furthermore, information from Genetic Stock Identification assessment sampling provides an opportunity to evaluate the relative contribution of B-Index returns within each stock group. No population fell exclusively into the B-Index size category, although there were clear differences among population groups in the relative contributions of the larger B-Index life-history type (NWFSC 2015).

Table 2.14-3. Major population groups, populations, and scores for the key elements (A&P, diversity, and SS/D) used to determine current overall viability risk for SRB steelhead (NWFSC 2015). Risk ratings included very low (VL), low (L), moderate (M), high (H), and very high (VH). Maintained (MT) population status indicates that the population does not meet the criteria for a viable population but does support ecological functions and preserve options for recovery of the DPS. The '?' reflects uncertainty in the data.

Major Population Group	Spawning Populations (Watershed)	ICTRT min threshold	A&P	Diversity	Integrated SS/D	Overall Viability Risk*
Lower Snake River	Tucannon River	1,000	H?	M	M	H?
	Asotin Creek	500	M?	M	M	MT
Grande Ronde River	Lower Grande Ronde	1,000	**	M	M	MT?
	Joseph Creek	500	VL	L	L	Highly viable
	Upper Grande Ronde	1,500	V	M	M	Viable

Major Population Group	Spawning Populations (Watershed)	ICTRT min threshold	A&P	Diversity	Integrated SS/D	Overall Viability Risk*
	Wallowa River	1,000	H?	L	L	M?
Clearwater River	Lower Clearwater	1,500	M?	L	L	MT?
	South Fork Clearwater	1,000	H	M	M	H?/MT
	Lolo Creek	500	H	M	M	H?/MT
	Selway River	1,000	M?	L	L	MT?
	Lochsa River	1,000	M?H	L	L	MT?
Salmon River	Little Salmon River	500	M?	M	M	MT?
	South Fork Salmon	1,000	M?	L	L	MT?
	Secesh River	500	M?	L	L	MT?
	Chamberlain Creek	500	M?	L	L	MT?
	Lower MF Salmon	1,000	M?	L	L	MT?
	Upper MF Salmon	1,000	M?	L	L	MT?
	Panther Creek	500	M?	M	H	H?
	North Fork Salmon	500	M	M	M	MT?
	Lemhi River		**	M	M	MT
	Pahsimeroi River	1,000	M	M	M	MT?
	East Fork Salmon	1,000	M	M	M	MT?
	Upper Main Salmon	1,000	M	M	M	MT?
Imnaha	Imnaha River	1,000	M	M	M	M

** Insufficient data.

The level of natural production in the two populations with full data series and the Asotin Creek index reaches are encouraging, but the status of most populations in the DPS remain highly uncertain. Population-level natural-origin abundance and productivity inferred from aggregate data and juvenile indices indicate that many populations are likely below the minimum combination defined by the ICTRT viability criteria (NWFSC 2015).

Population-level abundance data sets are limited for multiple populations in this DPS. For the two populations in the Lower Snake River MPG (i.e., Tucannon River and Asotin Creek populations) we have one total Lower Snake River data set, and one Asotin Creek data set, but none for the Tucannon River population alone.

Lower Snake River MPG

The Lower Snake MPG contains two populations. The ICTRT recommends that both populations (Tucannon River and Asotin Creek) be restored to viable status, with at least one meeting the criteria for highly viable. The overall population viability ratings for both populations reflect a combination of known conditions and uncertainties about key factors, primarily average natural-origin abundance and productivity and hatchery influences. Both populations are currently rated as maintained and at moderate risk overall, with the possibility that the Tucannon River could be at high risk for abundance and productivity. More direct estimates of natural-origin abundance and hatchery contribution rates for a series of years would be required to change ratings in future assessments (NWFSC 2015).

Even though population-level spawner escapement estimates are not available for the Tucannon River population, indications are that the numbers of spawning steelhead in the system are low. One contributing factor to these low spawning numbers is an apparent high overshoot rate of returning adults passing by and continuing upstream from their natal stream. A portion of the outmigrating natural smolt production from the Tucannon River population has been PIT-tagged in recent years (Bumgarner and Dedloff 2015). Analysis of returning PIT-tagged adults (2005–12 return years) indicates overshoot rates past the Tucannon River and over Lower Granite Dam often exceed 60 percent (Bumgarner and Dedloff 2015; NWFSC 2015; Keefer et al. 2016).

Grande Ronde River MPG

Two of the four populations should achieve viable status to meet the ICTRT criteria for this MPG. In addition, at least one of these populations should be rated as highly viable.

Given their current status, it is expected that Joseph Creek and the Upper Grande Ronde River populations are the most likely to satisfy the MPG-level requirement for one highly viable and one viable population. Although the average abundance levels have dropped from the prior review period, the paired geometric mean natural-origin spawner abundance and productivity estimates for both populations exceed the 1 percent viability curves for their respective size categories (basic and large respectively) (NWFSC 2015). The Grande Ronde MPG is tentatively rated as achieving viable status. One population (Joseph Creek) is highly viable, the Upper Grande Ronde population meets the criteria for viable, and the remaining two populations are provisionally rated as maintained. Efforts are underway that might lead to population specific abundance and productivity series for those two populations and to a more explicit understanding of the relative distribution of hatchery spawners (NWFSC 2015).

Imnaha River MPG

This MPG contains one population. The Imnaha River population should meet highly viable status for this MPG to be rated as viable under the basic ICTRT criteria. Based on the information currently available, the Imnaha River steelhead population is not meeting the highly viable rating for a single population MPG called for in the recovery plan. Achieving a highly viable rating would require achieving a very low risk rating for abundance and productivity, and a low overall risk rating for spatial structure and diversity. There is some evidence indicating that hatchery returns to the Imnaha River population may be concentrated in particular spawning reaches (e.g., Big Sheep Creek and adjacent mainstem reaches). If this is the case and substantial production areas in the population have relatively low hatchery-origin inputs, it is possible that additional years of information from the PIT-tag array project and/or refinements to the genetic stock identification program will result in improved estimates in future status reviews.

Clearwater River MPG

Based on the updated risk assessments, the Clearwater River MPG does not meet the ICTRT criteria for a viable MPG. Although the more explicit information on natural-origin spawner abundance indicates that the Lower Clearwater, Lochsa River, and Selway River populations are improved in overall status relative to prior reviews, the South Fork Clearwater and Lolo Creek populations do not achieve maintained status due in part to uncertainties regarding productivity and hatchery spawner composition (NWFSC 2015). The recovery scenario for this MPG calls for recovery of the Lower Clearwater River (large size), along with the Lochsa River and the Selway River. Three populations must meet viability criteria, one of which must meet the criteria for high viability.

Salmon River MPG

This relatively large MPG includes 12 extant populations and one extirpated population (Panther Creek). The Idaho Management Unit of the recovery plan identifies six populations to prioritize for viable status across this MPG. The recovery scenario is consistent with the ICTRT recommendations and includes the two Middle Fork Salmon River populations (highest B-Index proportions within the MPG), the South Fork Salmon River, Chamberlain Creek, Panther Creek and the North Fork Salmon River populations. The proposed scenario for this MPG includes consideration for historical population size as well as inclusion of populations exhibiting a range of A-Index and B-Index timing proportions, resulting in a distribution of viable populations across the geographical extent of the MPG.

Hells Canyon Tributaries MPG

This MPG historically contained three independent populations. However, all three of these populations were above Hells Canyon Dam (Powder River, Burnt River and Weiser River) and are now extirpated. A small number of steelhead occupy some tributaries below Hells Canyon Dam; however, none of these tributaries (nor all combined) appear to be large enough to support an independent population. Based on the extirpated status of populations in the MPG, it is not expected to contribute to recovery of the DPS.

Recovery Plan

Four out of the five SRB steelhead MPGs are not meeting the specific objectives in the recovery plan (NMFS 2017e), and the status of many individual populations remain uncertain (NWFSC 2015). The Grande Ronde River MPG is tentatively rated as viable, but more specific data on spawning abundance and the relative contribution of hatchery spawners for the Lower Grande Ronde and Wallowa populations would improve future assessments. The additional monitoring programs instituted in the early 2000s to gain better information on natural-origin abundance and related factors have significantly improved the ability to assess status at a more detailed level. The more specific information on the distribution of natural returns among stock groups and populations indicates that differences in abundance/productivity status among populations may be more related to geography or elevation rather than the morphological forms (i.e., A-Index versus B-Index). A great deal of uncertainty still remains regarding the relative proportion of hatchery-origin fish in natural spawning areas near major hatchery release sites within individual populations. Overall, the information analyzed for the 2015 status review does not indicate a change in biological risk status (NWFSC 2015).

2.14.1.1.2 Limiting Factors

Understanding the limiting factors and threats that affect SRB steelhead provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting the species is to ensure that the underlying limiting factors and threats have been addressed. Steelhead were historically harvested in tribal and non-tribal gillnet fisheries, and in recreational fisheries in the mainstem Columbia River and in tributaries. Steelhead are still harvested in tribal fisheries and there is incidental mortality associated with mark-selective recreational and commercial fisheries. The majority of impacts on the summer run occur in tribal gillnet and dip net fishing targeting Chinook salmon. Because of their larger size, the B-Index fish are more vulnerable to gillnet gear. In recent years, total exploitation rates (exploitation rates are the sum of all harvest) on the A-Index have been stable around five percent, while exploitation rates on the B-Index have generally been in the range of 15-20 percent (NWFSC 2015).

Factors that limit the DPS (in no particular order) have been, and continue to be, hydropower projects, predation, harvest, hatchery effects, tributary habitat, and ocean conditions; together these factors have affected the natural populations of this DPS (NMFS 2017e). Specifically, limiting factors also include:

- Mainstem Columbia River hydropower-related adverse effects;
- Impaired tributary fish passage;
- Degraded freshwater habitat, including degradation in floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream flow, and water quality as a result of cumulative impacts of agriculture, forestry, and development;

- Impaired water quality and increased water temperature;
- Related harvest effects, particularly for B-Index steelhead;
- Predation; and
- Genetic diversity effects from out-of-population hatchery releases.

2.14.1.2 Status of Critical Habitat

This section examines the rangewide status of designated critical habitat for SRB steelhead. Critical habitat includes the stream channels within designated stream reaches and a lateral extent defined by the ordinary high-water line (33 CFR 319.11).

NMFS determines the rangewide status of critical habitat by examining the condition of the PBFs that were identified when critical habitat was designated (Table 2.14-4). These features are essential to the conservation of the listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration, and foraging). For example, these features include overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks and migration corridors free of artificial obstruction, with sufficient water quantity and quality.

The SRB steelhead DPS is distributed throughout the Snake River drainage system, including tributaries in southeast Washington, eastern Oregon and north/central Idaho. SRB steelhead migrate a substantial distance from the ocean (up to 930 miles) and use high elevation tributaries (typically 3,300–6,600 feet above sea level) for spawning and juvenile rearing. Critical habitat for this DPS encompasses 25 subbasins, as well as 58 miles of the lower Snake River, 320 miles of the Columbia River, and the Columbia River estuary.

Table 2.14-4. Physical and biological features (PBFs) of critical habitat designated for SRB steelhead, and corresponding species life-history events.

Physical and Biological Features (PBFs)	Components of the PBF
Freshwater spawning sites	• Water quantity and quality conditions and substrate supporting spawning, incubation, and larval development
Freshwater rearing sites	• Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility • Water quality and forage supporting juvenile development • Natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks
Freshwater migration corridors	• Free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival

Physical and Biological Features (PBFs)	Components of the PBF
Estuarine areas	● Free of obstruction and excessive predation with: - Water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater - Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels - Juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation
Nearshore marine areas[1]	● Free of obstruction and excessive predation with: - Water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation
Offshore marine areas	● Not designated

[1] Designated area includes only the mouth of the Columbia River to an imaginary line connecting the outer extent of the north and south jetties.

The complex life cycle of SRB steelhead gives rise to complex habitat needs, particularly in freshwater. The gravel used for spawning must be a certain size and largely free of fine sediments to allow successful incubation of the eggs and later emergence or escape from the gravel as alevins. Eggs also require cool, clean, and well-oxygenated waters for proper development. Juveniles need abundant food sources, including insects, crustaceans, and other small fish. They need instream places to hide from predators (mostly birds and larger fish), such as under logs, root wads, and boulders, as well as beneath overhanging vegetation. They also need refuge from periodic high flows in side channels and off-channel areas, and from warm summer water temperatures in cold-water springs and deep pools. Returning adults generally do not feed in freshwater, but instead, rely on limited energy stored to migrate, mature, and spawn. Like juveniles, the returning adults also require cool water that is free of contaminants and migratory corridors with adequate passage conditions (timing, water quality/quantity) to allow access to the various habitats required to complete their life cycle (NMFS 2005b).

In the following paragraphs, we discuss the current status of the functioning of PBFs for critical habitat in the Interior Columbia and Lower Columbia River Estuary recovery domains.

2.14.1.2.1 Interior Columbia Recovery Domain

Critical habitat for SRB steelhead has been designated in the Interior Columbia recovery domain, which encompasses all of the Columbia River basin accessible to SRB steelhead above Bonneville Dam. Habitat quality in tributary streams within this domain varies from excellent in wilderness and roadless areas, to poor in areas subject to heavy agricultural and urban development. Critical habitat throughout much of the Interior Columbia recovery domain has been degraded by intense agricultural practices, stream morphology alteration (i.e., channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining, and urbanization. Reduced summer stream flows, impaired water quality, and reduced habitat complexity are common problems for critical habitat in developed areas.

Migratory habitat quality in this area has been severely affected by the development and operation of the CRS dams and reservoirs in the mainstem Columbia River, Bureau of Reclamation tributary projects, and privately owned dams in the Snake River basin. For example, construction of the Hells Canyon Complex of dams eliminated access to several likely production areas in Oregon and Idaho, including the Burnt, Powder, Weiser, Payette, Malheur, Owyhee, and Boise River basins (Good et al. 2005).

Hydroelectric development has modified natural flow regimes, resulting in warmer late summer/fall water temperatures, changes in fish community structure leading to increased rates of piscivorous and avian predation on juvenile salmon and steelhead, and delayed migration for both adult and juvenile salmonids. Physical features of dams, such as turbines,[186] also kill migrating fish. In-river survival is inversely related to the number of hydropower projects encountered by emigrating juveniles. Similarly, development and operation of extensive irrigation systems and dams for water withdrawal and storage in tributaries have altered hydrological cycles.

Many stream reaches designated as critical habitat are over-allocated, with more allocated water rights than existing stream flow. Withdrawal of water, particularly during low-flow periods that commonly overlap with agricultural withdrawals, often increases summer stream temperatures, blocks fish migration, strands fish, and alters sediment transport (Spence et al. 1996). Reduced tributary stream flow has been identified as a major limiting factor for SRB steelhead.

Many stream reaches designated as critical habitat are listed on Oregon, Washington, and Idaho Clean Water Act section 303(d) lists for water temperature. Many areas that were historically suitable rearing and spawning habitat are now unsuitable due to high summer stream temperatures. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water all contribute to elevated stream temperatures. Contaminants, such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste, are common in some areas of critical habitat.

2.14.1.2.2 Lower Columbia River Estuary Recovery Domain

Critical habitat has also been designated for SRB steelhead in the lower Columbia River estuary. The estuary is broadly defined to include the entire reach where tidal forces and river flows interact, regardless of the extent of saltwater intrusion. This encompasses areas from Bonneville Dam (RM 146) to the mouth of the Columbia River. It also includes the tidally influenced portions of tributaries below Bonneville Dam, including the lower 26 miles of the Willamette

[186] Turbine units include many structures: water intake, scroll case, stay vanes and wicket gates, blades, hub, draft tube, and cooling water intakes.

River. This region experiences ocean tides that extend from the mouth of the Columbia River up to Bonneville Dam.

Historically, the downstream half of the Columbia River estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. The mouth of the Columbia River was about four miles wide. Winter and spring floods, low flows in late summer, large woody debris floating downstream, and a shallow bar at the mouth of the Columbia River maintained a dynamic environment. Today, navigation channels have been dredged, deepened, and maintained, jetties and pile-dike fields have been constructed to stabilize and concentrate flow in navigation channels, marsh and riparian habitats have been filled and diked, and causeways have been constructed across waterways. These actions have decreased the width of the mouth of the Columbia River to two miles, and increased the depth of the Columbia River channel at the bar from less than 20 to more than 55 feet (NMFS 2008a).

Over time, more than 50 percent of the original marshes and spruce swamps in the estuary have been converted to industrial, transportation, recreational, agricultural, or urban uses. More than 3,000 acres of intertidal marsh and spruce swamps have been converted to other uses since 1948. Many wetlands along the shore in the upper reaches of the estuary were converted to industrial and agricultural lands after levees and dikes were constructed. Furthermore, water storage and release patterns from reservoirs upstream of the estuary have changed the seasonal pattern and volume of discharge. The peaks of spring/summer floods have been reduced, and the amount of water discharged during winter has increased (NMFS 2008a).

In addition, model studies indicate that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of suspended particulate matter to the lower river and estuary by about one third (as measured at Vancouver, Washington) and have reduced fine sediment transport by 50 percent or more. The significance of these changes for SRB steelhead is unclear, although estuarine habitat provides food for yearling migrants that move rapidly downstream to the ocean (Johnson et al. 2018; PNNL and NMFS 2018).

Functioning estuarine areas are essential to conservation because, without them, juvenile SRB steelhead cannot reach the ocean in a timely manner and use the variety of habitats that allow them to avoid predators, compete successfully, and complete the behavioral and physiological changes needed for life in the ocean. Similarly, these features are essential to the conservation of adult salmonids because they provide a final source of abundant forage that will furnish the energy stores the fish need to make the physiological transition to freshwater, migrate upstream, avoid predators, and develop to maturity upon reaching spawning areas (NMFS 2005b).

2.14.1.3 Climate Change Implications for SRB Steelhead and Critical Habitat

One factor affecting the rangewide status of SRB steelhead and aquatic habitat is climate change. The USGCRP[187] reports average warming of about 1.3ºF from 1895 to 2011, and projects an

[187] http://www.globalchange.gov

increase in average annual temperature of 3.3ºF to 9.7ºF by 2070 to 2099 (CCSP 2014). Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004; Scheuerell and Williams 2005; Zabel et al. 2006; ISAB 2007). According to the ISAB,[188] these effects pose the following impacts into the future:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season;
- With a smaller snowpack, watersheds will see their runoff diminished earlier in the season, resulting in lower stream flows in the June through September period. River flows in general and peak river flows are likely to increase during the winter due to more precipitation falling as rain rather than snow; and
- Water temperatures are expected to rise, especially during the summer months when lower stream flows co-occur with warmer air temperatures.

These changes will not be spatially homogeneous across the entire Pacific Northwest. Low-lying areas are likely to be more affected. Climate change may have long-term effects that include, but are not limited to, depletion of important cold-water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, premature emergence of fry, and increased competition among species.

Climate change is predicted to cause a variety of impacts to Pacific salmon and their ecosystems (Mote et al. 2003; Crozier et al. 2008a; Martins et al. 2012; Wainwright and Weitkamp 2013). The complex life cycles of anadromous fishes, including salmon, rely on productive freshwater, estuarine, and marine habitats for growth and survival, making them particularly vulnerable to environmental variation. Ultimately, the effects of climate change on salmon and steelhead across the Pacific Northwest will be determined by the specific nature, level, and rate of change and the synergy between interconnected terrestrial/freshwater, estuarine, nearshore, and ocean environments.

The primary effects of climate change on Pacific Northwest salmon and steelhead include:

- Direct effects of increased water temperatures on fish physiology;
- Temperature-induced changes to stream flow patterns;
- Alterations to freshwater, estuarine, and marine food webs; and
- Changes in estuarine and ocean productivity.

[188] The Independent Scientific Advisory Board (ISAB) serves the National Marine Fisheries Service (NMFS), Columbia River Indian Tribes, and Northwest Power and Conservation Council by providing independent scientific advice and recommendations regarding scientific issues that relate to the respective agencies' fish and wildlife programs. https://www.nwcouncil.org/fw/isab/

While all habitats used by Pacific salmon will be affected, the impacts and certainty of the change vary by habitat type. Some effects (e.g., increasing temperature) affect salmon at all life stages in all habitats, while others are habitat-specific, such as stream-flow variation in freshwater, sea-level rise in estuaries, and upwelling in the ocean. How climate change will affect each stock or population of salmon also varies widely depending on the level or extent of change, the rate of change, and the unique life-history characteristics of different natural populations (Crozier et al. 2008b). For example, a few weeks' difference in migration timing can have large differences in the thermal regime experienced by migrating fish (Martins et al. 2011).

2.14.1.3.1 Temperature Effects

Like most fishes, salmon are poikilotherms (cold-blooded animals); therefore, increasing temperatures in all habitats can have pronounced effects on their physiology, growth, and development rates (see review by Whitney et al. 2016). Increases in water temperatures beyond their thermal optima will likely be detrimental through a variety of processes, including increased metabolic rates (and therefore food demand), decreased disease resistance, increased physiological stress, and reduced reproductive success. All of these processes are likely to reduce survival (Beechie et al. 2013; Wainwright and Weitkamp 2013; Whitney et al. 2016).

By contrast, increased temperatures at ranges well below thermal optima (i.e., when the water is cold) can increase growth and development rates. Examples of this include accelerated emergence timing during egg incubation stages, or increased growth rates during fry stages (Crozier et al. 2008a; Martins et al. 2011). Temperature is also an important behavioral cue for migration (Sykes et al. 2009), and elevated temperatures may result in earlier-than-normal migration timing. While there are situations or stocks where this acceleration in processes or behaviors is beneficial, there are also others where it is detrimental (Martins et al. 2012; Whitney et al. 2016).

2.14.1.3.2 Freshwater Effects

Climate change is predicted to increase the intensity of storms, reduce winter snow pack at low and middle elevations, and increase snowpack at high elevations in northern areas. Middle and lower-elevation streams will have larger fall/winter flood events and lower late-summer flows, while higher elevations may have higher minimum flows. How these changes will affect freshwater ecosystems largely depends on their specific characteristics and location, which vary at fine spatial scales (Crozier et al. 2008b; Martins et al. 2012). For example, within a relatively small geographic area (the Salmon River basin in Idaho), survival of some Chinook salmon populations was shown to be determined largely by temperature, while in others it was determined by flow (Crozier and Zabel 2006). Certain salmon populations inhabiting regions that are already near or exceeding thermal maxima will be most affected by further increases in temperature and, perhaps, the rate of the increases. The effects of altered flow are less clear and likely to be basin-specific (Crozier et al. 2008b; Beechie et al. 2013). However, river flow is already becoming more variable in many rivers, and is believed to negatively affect anadromous fish survival more than other environmental parameters (Ward et al. 2015). It is likely this increasingly variable flow is detrimental to multiple salmon and steelhead populations, and likely multiple other freshwater fish species in the Columbia River basin as well.

Stream ecosystems will likely change in response to climate change in ways that are difficult to predict (Lynch et al. 2016). Changes in stream temperature and flow regimes will likely lead to shifts in the distributions of native species and provide "invasion opportunities" for exotic species. This will result in novel species interactions, including predator-prey dynamics, where juvenile native species may be either predators or prey (Lynch et al. 2016; Rehage and Blanchard 2016). How juvenile native species will fare as part of "hybrid food webs," which are constructed from natives, native invaders, and exotic species, is difficult to predict (Naiman et al. 2012).

2.14.1.3.3 Estuarine Effects

In estuarine environments, the two big concerns associated with climate change are rates of sea-level rise and water temperature warming (Wainwright and Weitkamp 2013; Limburg et al. 2016). Estuaries will be affected directly by sea-level rise: as sea level rises, terrestrial habitats will be flooded and tidal wetlands will be submerged (Kirwan et al. 2010; Wainwright and Weitkamp 2013; Limburg et al. 2016). The net effect on wetland habitats depends on whether rates of sea-level rise are sufficiently slow that the rates of marsh plant growth and sedimentation can compensate (Kirwan et al. 2010).

Due to subsidence, sea-level rise will affect some areas more than others, with the largest effects expected for the lowlands, like southern Vancouver Island and central Washington coastal areas (Verdonck 2006; Lemmen et al. 2016). The widespread presence of dikes in Pacific Northwest estuaries will restrict upward estuary expansion as sea levels rise, likely resulting in a near-term loss of wetland habitats for salmon (Wainwright and Weitkamp 2013). Sea-level rise will also result in greater intrusion of marine water into estuaries, resulting in an overall increase in salinity, which will also contribute to changes in estuarine floral and faunal communities (Kennedy 1990). While not all anadromous fish species are highly reliant on estuaries for rearing, extended estuarine use may be important in some populations (Jones et al. 2014), especially if stream habitats are degraded and become less productive. Preliminary data indicate that some SRB steelhead smolts are feeding and actively growing as they migrate between Bonneville Dam and the ocean (Beckman et al. 2018).

2.14.1.3.4 Marine Effects

In marine waters, increasing temperatures are associated with observed and predicted poleward range expansions of fish and invertebrates in both the Atlantic and Pacific Oceans (Lucey and Nye 2010; Asch 2015; Cheung et al. 2015). Rapid poleward species shifts in distribution in response to anomalously warm ocean temperatures have been well documented in recent years, confirming this expectation at short time scales. Range extensions were documented in many species from southern California to Alaska during unusually warm water associated with "the blob" in 2014 and 2015 (Bond et al. 2015; Di Lorenzo and Mantua 2016) and past strong El Niño events (Pearcy 2002; Fisher et al. 2015).

Non-native species benefit from these extreme conditions to increase their distributions. Green crab recruitment increased in Washington and Oregon waters during winters with warm surface waters, including 2014 (Yamada et al. 2015). Similarly, Humboldt squid dramatically expanded their range during warm years of 2004–09 (Litz et al. 2011). The frequency of extreme conditions, such as those associated with El Niño events or "blobs" is predicted to increase in the future (Di Lorenzo and Mantua 2016).

Expected changes to marine ecosystems due to increased temperature, altered productivity, or acidification will have large ecological implications through mismatches of co-evolved species and unpredictable trophic effects (Cheung et al. 2015; Rehage and Blanchard 2016). These effects will certainly occur, but predicting the composition or outcomes of future trophic interactions is not possible with current models.

Wind-driven upwelling is responsible for the extremely high productivity in the California Current ecosystem (Bograd et al. 2009; Peterson et al. 2014). Minor changes to the timing, intensity, or duration of upwelling, or the depth of water-column stratification, can have dramatic effects on the productivity of the ecosystem (Black et al. 2015; Peterson et al. 2014). Current projections for changes to upwelling are mixed: some climate models show upwelling unchanged, but others predict that upwelling will be delayed in spring, and more intense during summer (Rykaczewski et al. 2015). Should the timing and intensity of upwelling change in the future, it may result in a mismatch between the onset of spring ecosystem productivity and the timing of salmon entering the ocean, and a shift toward food webs with a strong sub-tropical component (Bakun et al. 2015).

Columbia River anadromous fish also use coastal areas of British Columbia and Alaska and mid-ocean marine habitats in the Gulf of Alaska, although their fine-scale distribution and marine ecology during this period are poorly understood (Morris et al. 2007; Pearcy and McKinnell 2007). Increases in temperature in Alaskan marine waters have generally been associated with increases in productivity and salmon survival (Mantua et al. 1997; Martins et al. 2012), thought to result from temperatures that have been below thermal optima (Gargett 1997). Warm ocean temperatures in the Gulf of Alaska are also associated with intensified downwelling and increased coastal stratification, which may result in increased food availability to juvenile salmon along the coast (Hollowed et al. 2009; Martins et al. 2012). Predicted increases in freshwater discharge in British Columbia and Alaska may influence coastal current patterns (Foreman et al. 2014), but the effects on coastal ecosystems are poorly understood.

In addition to becoming warmer, the world's oceans are becoming more acidic as increased atmospheric CO_2 is absorbed by water. The North Pacific is already acidic compared to other oceans, making it particularly susceptible to further increases in acidification (Lemmen et al. 2016). Laboratory and field studies of ocean acidification show it has the greatest effects on invertebrates with calcium-carbonate shells, and relatively little direct influence on finfish; see reviews by Haigh et al. (2015) and Mathis et al. (2015). Consequently, the largest impact of ocean acidification on salmon will likely be its influence on marine food webs, especially its effects on lower trophic levels, which are largely composed of invertebrates (Haigh et al. 2015; Mathis et al. 2015). Marine invertebrates fill a critical gap between freshwater prey and larval and juvenile marine fishes, supporting juvenile salmon growth during the important early-ocean residence period (Daly et al. 2009, 2014).

2.14.1.3.5 Uncertainty in Climate Predictions

There is considerable uncertainty in the predicted effects of climate change on the globe as a whole, and on the Pacific Northwest in particular, and there is also the question of indirect effects of climate change and whether human “climate refugees” will move into the range of salmon and steelhead, increasing stresses on their respective habitats (Dalton et al. 2013; Poesch et al. 2016).

Many of the effects of climate change (e.g., increased temperature, altered flow, coastal productivity, etc.) will have direct impacts on the food webs that species rely on in freshwater, estuarine, and marine habitats to grow and survive. Such ecological effects are extremely difficult to predict even in fairly simple systems, and minor differences in life-history characteristics among stocks of salmon may lead to large differences in their response (e.g., Crozier et al. 2008b; Martins et al. 2011, 2012). This means it is likely that there will be “winners and losers,” meaning some salmon populations may enjoy different degrees or levels of benefit from climate change while others will suffer varying levels of harm.

Climate change is expected to impact anadromous fish during all stages of their complex life cycle. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream-flow patterns in freshwater and changes to food webs in freshwater, estuarine, and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty.

2.14.2 Environmental Baseline

The “environmental baseline” includes the past and present impacts of all federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

For SRB steelhead, we focus our description of the environmental baseline on where SRB steelhead juveniles and adults are exposed to the effects of the proposed action. We also consider the broader action area, including tributary habitat in the Salmon and Clearwater subbasin, because the Action Agencies propose to conduct habitat restoration actions in these subbasins, and because these areas provide important context for understanding the effects of the proposed action. The area in which SRB steelhead are exposed to the effects of the proposed action includes all water within the Columbia River from the mouth and plume upstream to the Salmon and Clearwater subbasins where SRB steelhead are present. This includes all waters impounded by Bonneville, The Dalles, John Day, McNary, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite Dams.

2.14.2.1 Mainstem Habitat

Mainstem habitat in the lower Snake and Columbia Rivers has been substantially altered by basinwide water management operations, the construction and operation of mainstem hydroelectric projects, the growth of native avian and pinniped predator populations, the introduction of non-native species (e.g., fishes and invertebrates), and other human practices that have degraded water quality.

2.14.2.1.1 Seasonal Flows

Water diversions for a variety of purposes (agricultural, municipal, etc.) and the management of stored water (including runoff stored in Canadian reservoirs, in the U.S. portion of the Columbia Basin, and in the upper Snake River basin, Yakima River basin, and Deschutes River basin) has altered the quantity and timing of flows entering the lower Snake and Columbia Rivers compared to historical conditions.

On the mainstem Snake and Columbia Rivers, hydropower projects (including the CRS), water-storage projects (including reservoirs in Canada operated under the Columbia River Treaty), and the withdrawal of water for irrigation and urban uses have significantly degraded salmon and steelhead habitats (Bottom et al. 2005; Fresh et al. 2005; NMFS 2013a). The volume of water discharged by the Columbia River varies seasonally according to runoff, snowmelt, and hydropower demands. Mean annual discharge is estimated to be 265 kcfs, but may range from lows of 71–106 kcfs to highs of 530 kcfs (Hamilton 1990; Prahl et al. 1998; NMFS 1998; USACE 1999). Naturally occurring maximum flows on the river occur in May, June, and July as a result of snowmelt in the headwater regions. Minimum flows occur from September to March, with periodic peaks due to heavy winter rains (Holton 1984). Interannual variability in stream flow is strongly correlated with two recurrent climate phenomena: the ENSO and the PDO (Newman et al. 2016).

Water storage projects (dams and reservoirs) and water management activities have generally reduced flows at Bonneville Dam (especially during the spring months), consistent with basinwide effects on flows in the lower Columbia River (from McNary Reservoir to the mouth of the Columbia River; see Figure 2.14-2; NMFS 2008b). On average, this reduction can range from nearly 15 kcfs in August to over 230 kcfs in May. Proportional flow reductions of similar magnitude also occur in the middle Columbia River (Chief Joseph tailrace to the Columbia River's confluence with the Snake River within McNary Reservoir).

Recognizing that the flow versus survival relationships for some interior basin ESUs/DPSs displayed a plateau over a wide range of flows but declined markedly as flows dropped below some threshold (NMFS 1995b, 1998), NMFS and the CRS Action Agencies have attempted to manage Columbia and Snake River water resources to maintain seasonal flows above threshold objectives given the amount of runoff in a given year. This has been accomplished by avoiding excessive drafts going into spring to minimize the flow reductions needed to refill the reservoirs, and by drafting the storage reservoirs during summer to augment flows.[189] These flow objectives have guided preseason reservoir planning and in-season flow management. Nonetheless, since the development of the hydrosystem, average monthly flows at Bonneville Dam have been substantially lower during May–July and higher in October–March compared to an unregulated system. Reduced flows have increased travel times during outmigration for juvenile salmonids and resulted in reduced access to high-quality estuarine habitats from May through July during low tides.

Table 2.14-5 depicts the FOP for spring spill during 2017 and 2018. There was a substantial increase in spill over the dam spillways in the spring during 2018 (as a result of a court order) in an effort to improve survival of juvenile salmon and steelhead. A discussion of the effects of elevated TDG is provided below in Section 3.14.2.1.2 Water Quality.

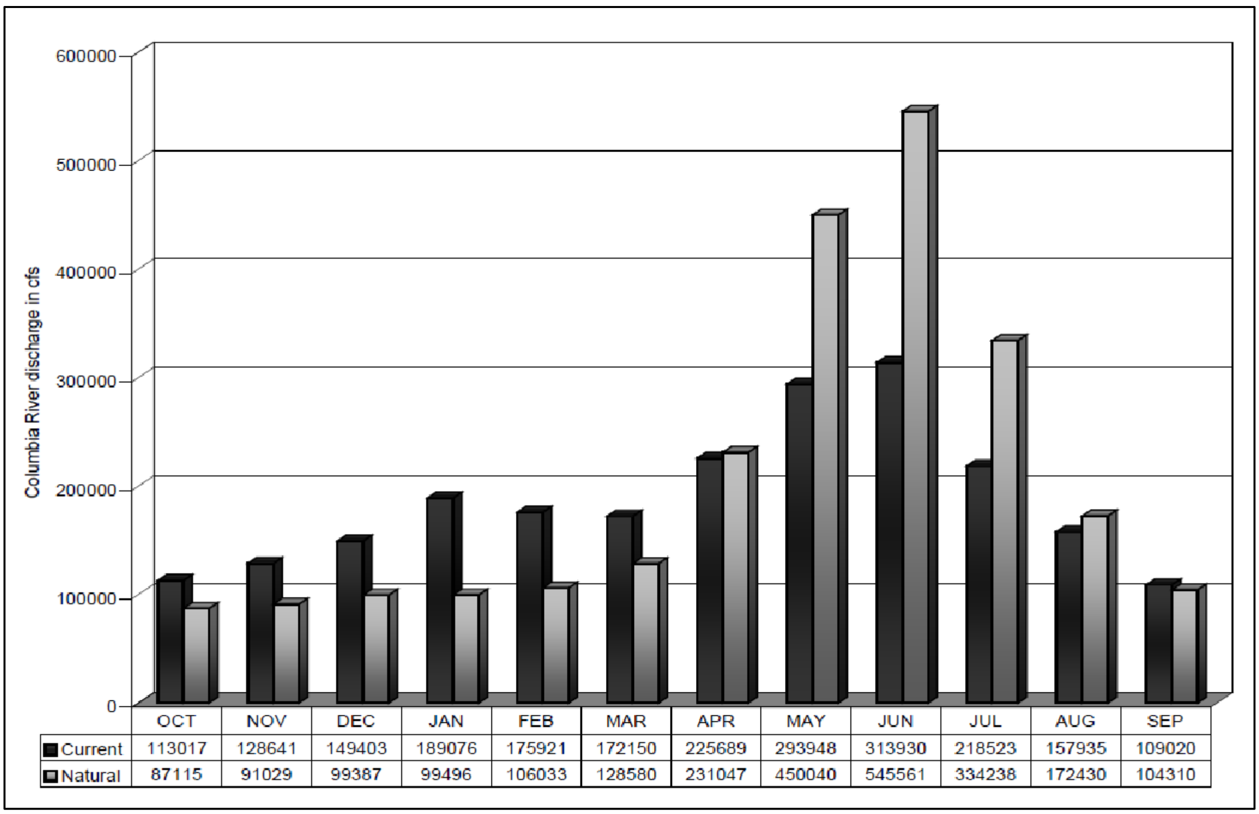

Figure 2.14-2. Comparison of monthly discharge (flow) in the Columbia River between current conditions (black) and normative flows (gray). These data show that pre-development flows were lower in the winter and higher in the summer months.

[189] Even though several million acre feet of water are released annually from storage during the summer months to augment flows (and from Dworshak Dam, to reduce mainstem temperatures), these volumes do not offset the consumption of water in the basin in July and August.

Table 2.14-5. Summary of 2017 and 2018 Fish Operations Plan (FOP) spring spill levels at lower Snake River and Columbia River projects.

Project	2017 Spring Spill Operations (Day/Night)	2018 Operations
Lower Granite	20 kcfs/20 kcfs	120% TDG tailrace (gas cap)/115% to the next forebay
Little Goose	30%/30%	120% TDG tailrace (gas cap)/115% to the next forebay
Lower Monumental	Gas Cap/Gas Cap (approximate Gas Cap range: 20-29 kcfs)	120% TDG tailrace (gas cap)/115% to the next forebay
Ice Harbor	April 3-April 28: 45 kcfs/Gas Cap April 28-June 20: 30%/30% vs. 45 kcfs/Gas Cap (approximate Gas Cap range: 75-95 kcfs)	120% TDG tailrace (gas cap)/115% to the next forebay
McNary	40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay
John Day	April 10-April 28: 30%/30% April 28-June 15: 30%/30% and 40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay
The Dalles	40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay
Bonneville	100 kcfs/100 kcfs	120% TDG tailrace (gas cap) to a cap of 150 kcfs because of erosion concerns (no next forebay)

2.14.2.1.2 Water quality

Water quality in the action area is impaired as a result of chemical contaminants from municipal, agricultural, industrial, and urban land uses (NMFS 2017e). Common toxic contaminants found in the Columbia River system include PCBs, PAHs, PBDEs, DDT and other legacy pesticides, currently used pesticides, pharmaceuticals and personal care products, and trace elements (LCREP 2007). The LCREP (2007) report noted widespread presence of PCBs and PAHs, both geographically and in the food web. Urban and industrial portions of the lower river contribute significantly to contaminant levels in juvenile salmon; juvenile salmon are absorbing toxic contaminants during their time rearing and feeding in the lower Columbia River. (LCREP 2007). Likewise, juvenile salmon are accumulating DDT in their tissues and are exposed to estrogen-like compounds in the lower river, likely associated with pharmaceuticals and personal care products. Concentrations of copper are present at levels that could interfere with crucial salmon behaviors.

Growing population centers throughout the Columbia River and Snake River basins and numerous smaller communities contribute municipal and industrial waste discharges to the lower Columbia River. Industrial and municipal wastes from the Portland–Vancouver metro areas, including the superfund-designated reach in the lower Willamette River, also contribute to degraded water quality in the lower river. Legacy and active mining areas scattered around the basin deliver high background concentrations of metals. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river.

Outside of urban areas, the majority of residences and businesses rely on septic systems. Common water quality issues with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff. Under these environmental conditions, fish in the action area are stressed. Stress may lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival).

Oils, greases, and other lubricants (derived from animal, fish, vegetable, petroleum or marine mammal origin) are used at each of the CRS projects (and all other dams in the Columbia River Basin), including, but not limited to, the following: hydropower turbines, hydraulic systems, lubricating systems, gear boxes, machining coolant systems, heat transfer systems, transformers, circuit breakers, and electrical systems. Leakage of oils, greases, or other lubricants into rivers has the potential to affect salmon and steelhead (avoidance, exposure to toxic compounds, or even, in some circumstances death). In response to increased concerns regarding the releases of oils and greases from lower Columbia and lower Snake River dams (and Dworshak and Chief Joseph Dams) the Corps has taken steps to minimize these risks. For equipment in contact with the water, the Corps has developed best management practices to avoid accidental releases and to minimize the adverse effects in the case of an accidental release. The Corps has also begun using, where feasible, “environmentally acceptable lubricant” greases and in some cases has replaced greased equipment with greaseless equipment. The Corps has also developed and is implementing oil accountability plans with enhanced inspection protocols and is reporting annually.

The extent to which leaked grease or oil, occurring under the environmental baseline in the Clearwater River (Dworshak Dam), Upper Columbia River (Chief Joseph), or lower Snake or lower Columbia Rivers, has affected the behavior, health, or survival of SRB steelhead in the past is unknown, but likely to be small given that the size of these river systems. For comparison, a large leak of 100 gallons per day is the equivalent of 0.00016 cubic feet per second and the average annual discharge of the Columbia River has ranged from roughly 125,000 to 250,000 cubic feet per second since about 1940 (ISAB 2000). Nevertheless, to the extent past leakages have potentially affected passage or survival, these effects would be encompassed by annual juvenile or adult reach survival estimates. Recent actions (adoption of best management practices, use of environmentally acceptable lubricants, use of greaseless equipment, etc.) would further reduce the potential for negative effects stemming from these materials and slightly improve conditions for juvenile and adult migrants.

Our understanding of the effects on aquatic life impacts of many contaminants, alone or in combination with other chemicals (potential for synergistic effects), is incomplete, especially when considering exposure of rearing juveniles to multiple contaminants, or when considering their interactions with other stressors, food web-mediated effects, and effects in complex mixtures (NMFS 2017e). Together, these contaminants are likely affecting the productivity and abundance of SRB steelhead, especially during the rearing and juvenile migration phases of their life cycle. The effects can be direct or indirect, and lethal or more likely sublethal; the interaction of co-occurring stressors may have a greater impact on salmon than if they occur in isolation (Dietrich et al. 2014).

Water temperatures in the Snake and Columbia Rivers are a concern; both rivers are included on the Clean Water Act §303(d) list of impaired waters established by the relevant states because of temperature-standard exceedances. Temperature conditions in the Columbia River basin area are affected by many factors, including:

- Natural variation in weather and river flow;
- Construction of the dam and reservoir system (the large surface areas of reservoirs and resulting slower river velocities contribute to warmer late summer/fall water temperatures);
- Increased temperatures of tributaries;
- Water managed for irrigated agriculture;
- Point-source discharges such as cities and industries; and
- Climate change (Overman 2017; EPA 2018).

Since the mid-1990s, the Corps has released up to 1.2 million acre-feet of cool water from Dworshak Dam on the North Fork Clearwater River to reduce temperatures in the lower Snake River from June or July to September. Operators manage water releases from Dworshak so water temperature does not exceed 68°F at the tailrace of Lower Granite Dam. This operation reduces temperatures in the lower Clearwater River, and the Snake River from the confluence with the Clearwater River to at least Lower Monumental Dam. This action has little to no discernible effect on temperature in the Columbia River downstream of the Snake River confluence.

Temperatures in the middle Columbia River are affected by Grand Coulee Dam, which was completed in 1942. Thermal inertia from the large mass of water in the reservoir (total storage capacity of 9.6 million acre-feet, active capacity of about 5.2 million acre-feet) results in delayed warming in the spring (cooler temperatures) and delayed cooling in the late summer and fall (warmer temperatures). However, even in the extremely warm year of 2015, the average temperature of the Columbia River below McNary Dam was less than 68°F during this species' juvenile migration period, but warmer than 68°F during the adult migration period (Figure 2.14-3; NMFS 2016e). Cooler spring (April and May) temperatures in the middle Columbia River would reduce exposure to high temperatures and would be expected to enhance the survival of spring migrating smolts.

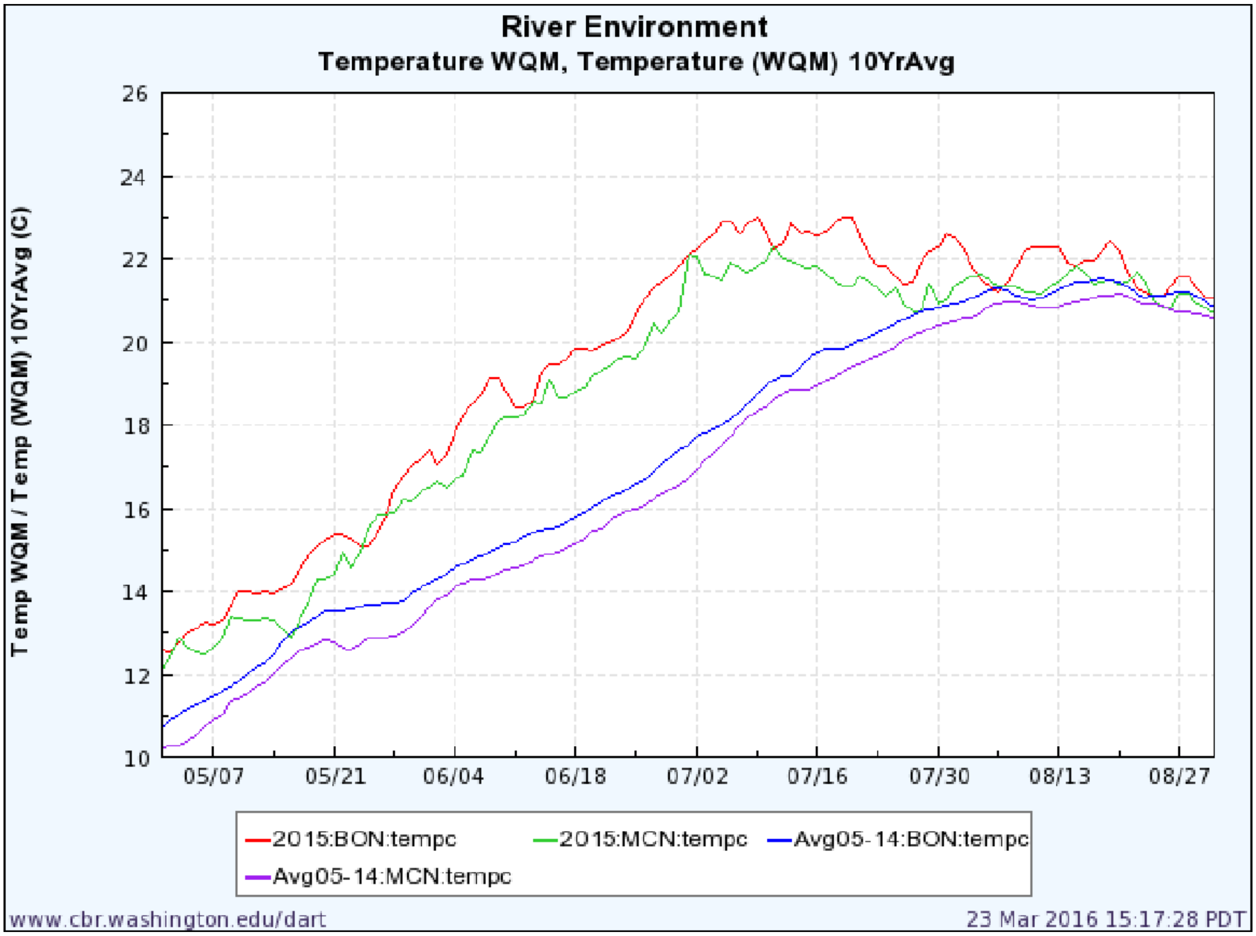

Figure 2.14-3. Columbia River temperature at McNary and Bonneville Dams (2015 compared to the 2005-2014 10-year average).

The EPA is working with federal and state agencies, tribes, and other stakeholders to develop water-quality improvement plans (total maximum daily loads) for temperature in the Columbia River and lower Snake River. As part of the 2015 biological opinion on EPA's approval of water-quality standards, including temperature (NMFS 2015a), EPA committed to work with federal, state, and tribal agencies to identify and protect thermal refugia and thermal diversity in the lower Columbia River and its tributaries.

Comparisons of long-term temperature data in the migration corridor before and after impoundment reveal a change in the thermal regime of the Snake and Columbia Rivers. Using historical flows and environmental records for the 35–year period 1960–95, Perkins and Richmond (2001) compared water temperature records in the lower Snake River with and without the lower Snake River dams and found three notable differences between the current versus unimpounded river:

- Maximum summer water temperature has been slightly reduced;

- Water temperature variability has decreased; and
- Post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall, a phenomenon termed thermal inertia.

Dams in the middle and lower reaches of the Columbia River likely have similar effects.

These hydrosystem effects (influenced by the temperatures of tributary streams entering the Snake and Columbia Rivers both upstream of, within, and downstream of the mainstem dams) continue downstream and influence temperature conditions in the lower Columbia River. At a macro scale, water temperature affects salmonid distribution, behavior, and physiology (Groot and Margolis 1991); at a finer scale, temperature influences migration swim speed of salmonids (Salinger and Anderson 2006), timing of river entry (Peery et al. 2003), susceptibility to disease and predation (Groot and Margolis 1991), and, at temperature extremes, survival.

Exposure to elevated temperatures in the Columbia River from its mouth to its confluence with the Snake River, is greatest for adult SRB steelhead migrating in late summer when water temperatures are highest (Keefer et al. 2016; Keefer and Caudill 2017).

TDG levels also affect mainstem water quality and habitat. To facilitate the downstream movement of juvenile salmonids, state regulatory agencies issue criteria adjustments for TDG as measured in the forebay and tailrace (NMFS 1995b). Specifically, water that passes over the spillway at a mainstem dam can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). Historically, TDG supersaturation was a major contributor to juvenile salmon mortality. To reduce TDG supersaturation, the Corps installed spillway improvements, typically “flip lips,” at each mainstem dam except The Dalles Dam. Biological monitoring shows that the incidence of observable GBT symptoms in both migrating smolts and adults remains between 1–2 percent when TDG concentrations in the upper water column do not exceed 120 percent of saturation in CRS project tailraces.[190] When those levels are exceeded, there is a corresponding increase in the incidence of signs of GBT symptoms. Fish migrating at depth avoid exposure to the higher TDG levels due to pressure compensation mechanisms (Weitkamp et al. 2003).[191] Under recent operations (2008–18), exposure to excessive high TDG levels (exceeding state water quality standards) has been restricted to forced spill events associated with high flow conditions and/or lack of load—which have most often occurred between mid-May and mid-June, affecting most SRB steelhead juveniles.

[190] Monitoring at the Lower Granite Dam trap showed that GBT and headburn symptoms on adult steelhead and Chinook in 2018 (experiencing higher court-ordered spill operations in 2018) were similar in prevalence to past years (Odgen 2018).

[191] Roughly, for each meter below the surface an aquatic organism is located, there is a corresponding reduction in the effective TDG the organism experiences of about 10 percent. Thus, if TDG levels are at 120 percent, organism two meters below the surface would effectively experience 100 percent TDG saturation.

The most extensive urban development in the lower Columbia River basin has occurred in the Portland/Vancouver area. Common water-quality issues both in areas with urban development and rural residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff (LCREP 2007). Similar effects are likely to be proportionally associated with smaller urban areas as well (e.g., Lewiston, Idaho; Tri-Cities, Washington; The Dalles and Hood River, Oregon). While it is not clear what the magnitude of effects are to juvenile or adult SRB steelhead from exposure to these factors (see previous discussion relating to chemical contaminants), they are likely to negatively affect fitness and survival to some extent.

2.14.2.1.3 Sediment Transport

The series of dams and reservoirs have also blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is about one-third of nineteenth-century levels (Simenstad et al. 1982, 1990; Sherwood et al. 1990; Weitkamp 1994; NRC 1996; NMFS 2008a). Similarly, Bottom et al. (2005) estimated that the delivery of suspended particulate matter to the lower river and estuary has been reduced by about 40 percent (as measured at Vancouver, Washington), and fine sediment transport reduced by 50 percent or more. These estimates reflect the combined total of all activities throughout the Columbia River basin on sediment transport. Similar reductions would be expected throughout the mainstem. The overall reduction in sediment has altered the development of habitat along the margins of the river and likely increased the risk of migrating juveniles to visual predators like birds and fish.

Industrial harbor and port development are also significant influences on the lower Snake and lower Columbia Rivers (Bottom et al. 2005; Fresh et al. 2005; NMFS 2013a). Since 1878, the Corps has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the Willamette River as a navigation channel. Originally dredged to a 20-foot minimum depth, the federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The navigation channel supports many ports on both sides of the river, resulting in several thousand commercial ships traversing the river every year. The dredging, along with diking, draining, and placing of fill material in wetlands and shallow habitat, also disconnects the river from its floodplain, resulting in the loss of shallow-water rearing habitat and the ecosystem functions that floodplains provide (e.g., supply of prey, refuge from high flows, temperature refugia, etc.; Bottom et al. 2005).

2.14.2.2 Adult Migration/Survival

Adults must migrate from the ocean, upstream through the estuary, and pass up to eight mainstem dams and reservoirs to reach their spawning areas, except for the Tucannon River steelhead population in the Lower Snake River MPG which passes seven mainstem dams. Factors that affect the survival rates of migrating adults include harvest (either reported or unreported), dam passage (adults must find and ascend ladders and reascend the ladders if they fall back through spillways or other routes), straying (either naturally or as a result of impaired homing stemming from transport or other factors), pinniped predation, and temperature and flow conditions that can increase energetic demands of migrating fish (NMFS 2008a; Keefer et al. 2016; Keefer and Caudill 2017).

PIT-tag detectors placed near the exits of adult ladders at the mainstem dams provide a unique ability to monitor the upstream survival of adults that were tagged as juveniles.[192] Starting with the number of adults detected at Bonneville Dam, minimum survival estimates can be derived to detectors at upstream dams. Termed "conversion rates," these survival estimates are adjusted for reported harvest and the expected rate of straying of natural-origin adults. Figure 2.14-4 depicts minimum estimated survival rates for SRB steelhead from Bonneville Dam to McNary Dam (three reservoirs and dams) and to Lower Granite Dam (seven reservoirs and dams) during 2008–17, years that include recent hydropower operations and harvest rates within the "zone 6" fishery (as designated in the *U.S. v. Oregon* Management Agreement).

As shown in Figure 2.14-4, the ten-year average (2008–17) minimum survival estimate for SRB steelhead adults from Bonneville to McNary Dam is 94.3 percent (range of 90.1 to 100.0 percent).[193] The ten-year average minimum survival estimate from Bonneville to Lower Granite Dam is 86.6 percent (range of 81.2 to 94.1 percent).

These survival estimates account for total losses from the dams and reservoirs as well as any losses in these reaches resulting from elevated temperatures, disease, injury, or other natural causes. Expressed on a "per project" basis (1/3rd root of 94.3 percent), about 98.1 percent of adult SRB steelhead are surviving passage through each project (dam and reservoir) in the lower Columbia River after accounting for reported harvest and natural stray rates. From Bonneville to Lower Granite Dam, per-project survival rates are averaging around 97.9 percent (1/7th root of 86.6). These relatively high survival rates indicate that upstream passage conditions are not substantially impaired for adult SRB steelhead migrating through impounded reaches of the lower Columbia and lower Snake Rivers.

[192] Using only known origin fish that were not transported as juveniles. The numbers are adjusted for reported harvest and natural stray rates.
[193] Conversion rates close to, or higher than, 100 percent are possible if estimates of harvest rates (or natural rates of straying) are higher than what actually occurred in a given year (biased high). Conversely, if harvest rates are underestimated, the resulting conversion rate estimates would be biased low. For this analysis, 100 percent was used as a maximum value for calculating the ten-year average survival estimate.

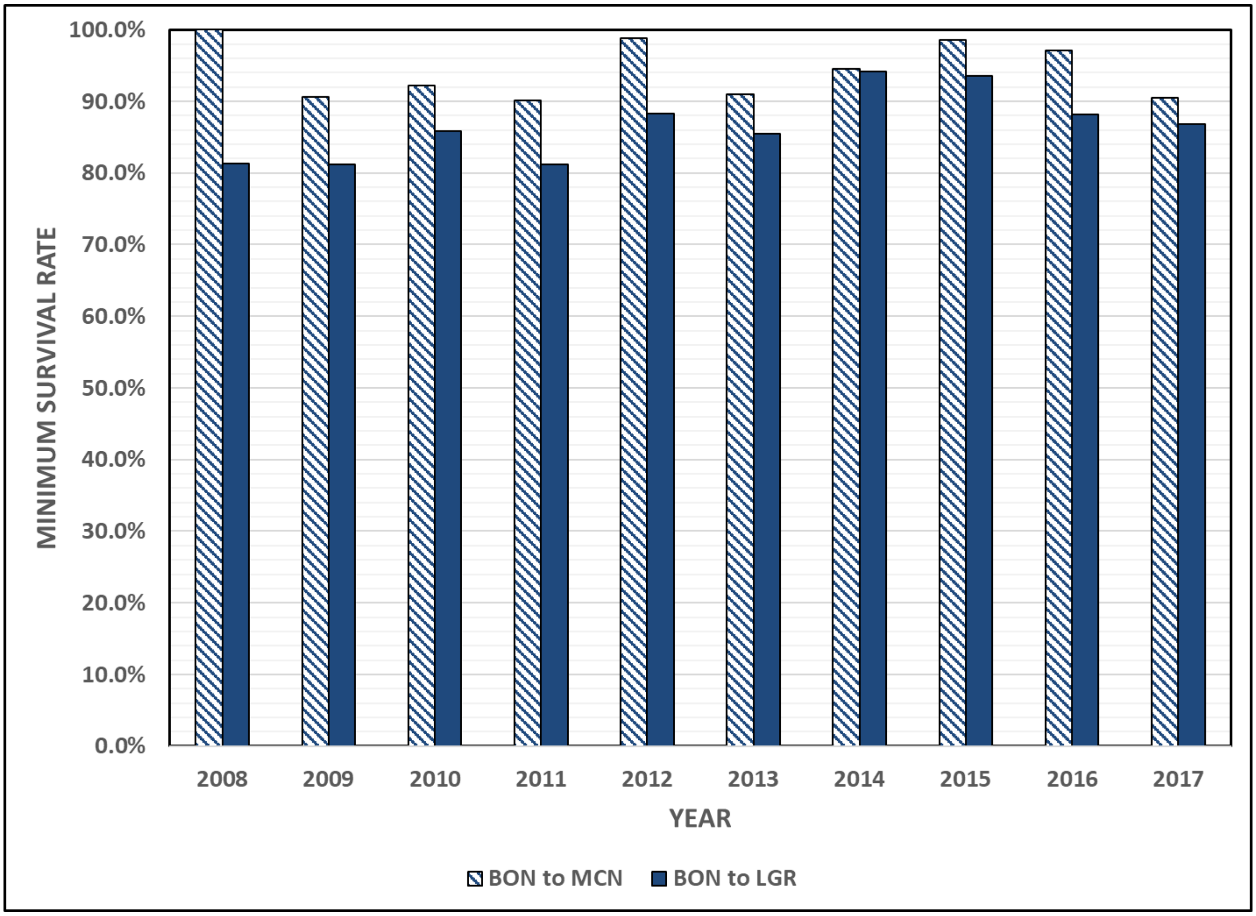

Figure 2.14-4. Minimum survival estimates from Bonneville to McNary and to Lower Granite Dams (2008–17) estimated using known-origin PIT-tagged adult SRB steelhead – natural- and hatchery-origin combined – that migrated in-river as juveniles. Source: NMFS, using data from PITAGIS.

Some SRB steelhead are incidentally killed during turbine maintenance and testing activities associated with the operation of Dworshak Dam. In November of 2016, approximately 200 adult SRB steelhead mortalities were observed after an extended commission and testing operation of unit two. The majority of these fish were estimated to be of hatchery origin from the Clearwater River MPG and did not impact broodstock collection. In testing this unit, an unusually high number of starts and stops and long durations of speed no load operations were used and likely contributed to the mortality event. Efforts to reduce mortality associated with turbine maintenance are occurring with changes in the annual Fish Passage Plan. Maintenance operations and improvements in protocol have resulted in less than ten mortalities observed in 2017 and 2018.

In addition, adult SRB steelhead can be incidentally handled during trapping operations for SR sockeye salmon at Lower Granite Dam. An average of 6,038 steelhead were handled as part of trapping operations each year during 2013–17 at Lower Granite Dam (Ogden 2018b).

CRS related mortality of downstream migrating kelts is not well known at this time. Colotelo et al. (2013) estimated that in 2012 only 40.2 and 44.8 percent of Snake River steelhead kelts survived from the Lower Granite forebay to the Lower Columbia River (RM156) and the Bonneville dam face (RM 234), respectively, and only 60.4 and 67.3 percent survived from the McNary forebay to the Lower Columbia River (RM156) and Bonneville dam face (RM 234), respectively. It is important to note only fair and good condition kelts were selected for tagging in this study, and these survival rates cannot be applied to poor condition kelts. In another acoustic tagging study conducted by Harnish et al. 2014 (using the same fish condition requirements), the survival of steelhead kelt through the four Snake River dams averaged 77 percent in 2012 and 49 percent in 2013. Based on this limited information, up to 60 percent of migrating SR kelts are lost passing all eight Snake River and lower Columbia River dams (less for the Tucannon population) and up to 50 percent arriving at Lower Granite dam are lost before reaching the Ice Harbor dam tailrace.

These data represent total mortality to outmigrating kelts and do not distinguish between mortality caused by factors in the environmental baseline or the effects of the CRS. It is not technically possible to provide separate estimates of these components. Estimates of "natural" mortality rates for these fish are not available, but are thought to be high which have typically gone many months without feeding while expending considerable energy migrating and spawning.

2.14.2.3 Juvenile Migration/Survival

The mainstem dams and reservoirs continue to substantially alter the mainstem migration corridor habitat. The reservoirs have increased the cross-sectional area of the river, reducing water velocity, altering the food web, and creating habitat for native and non-native species which are predators, competitors, or food sources for migrating juvenile steelhead. The travel times of migrating smolts are increased through the reservoirs, increasing exposure to both native and nonnative predators (see predation section below). Some juveniles are injured or killed as they pass through the dams (turbines, bypass systems, spill bays, or surface passage routes) (NMFS 2008a).

However, based on data summarized in Zabel (2018), overall passage conditions and resulting juvenile survival rates in the migration corridor have improved substantially since 1998 when the species was listed. This improved survival correlates with improved structures, operations, and predator-management programs at the Corps' mainstem projects (24-hour volitional spill, surface passage routes, improved juvenile bypass systems, predator-management measures, etc.; NMFS 2017e).

Widener et al. (2018) estimated juvenile SRB steelhead survival rates (wild and hatchery combined) from Lower Granite Dam to McNary Dam (four reservoirs and dams), and from Lower Granite Dam to Bonneville Dam (seven reservoirs and dams). They found that during 2008–17, survival rates averaged 71.7 percent (Lower Granite to McNary Dam; ranging from 62.8 to 79.0 percent) and 55.5 percent (Lower Granite to Bonneville Dam; ranging from 41.6 to 75.7 percent; Figure 2.14-5). These survival rates incorporate multiple sources of mortality such as passage mortality, natural mortality, and predation. The estimated Lower Granite to

Bonneville Dam survival estimate for 2018 (under the court ordered spill operation) was 53.3 percent - close to the recent average. The reduced survival rates in the lower Columbia River (difference of Lower Granite to McNary Dam and Lower Granite to Bonneville Dam) starting in 2015 were likely influenced by increased predation by Caspian terns displaced from Crescent Island to the Blalock Islands in the John Day pool (Roby et al. 2016).

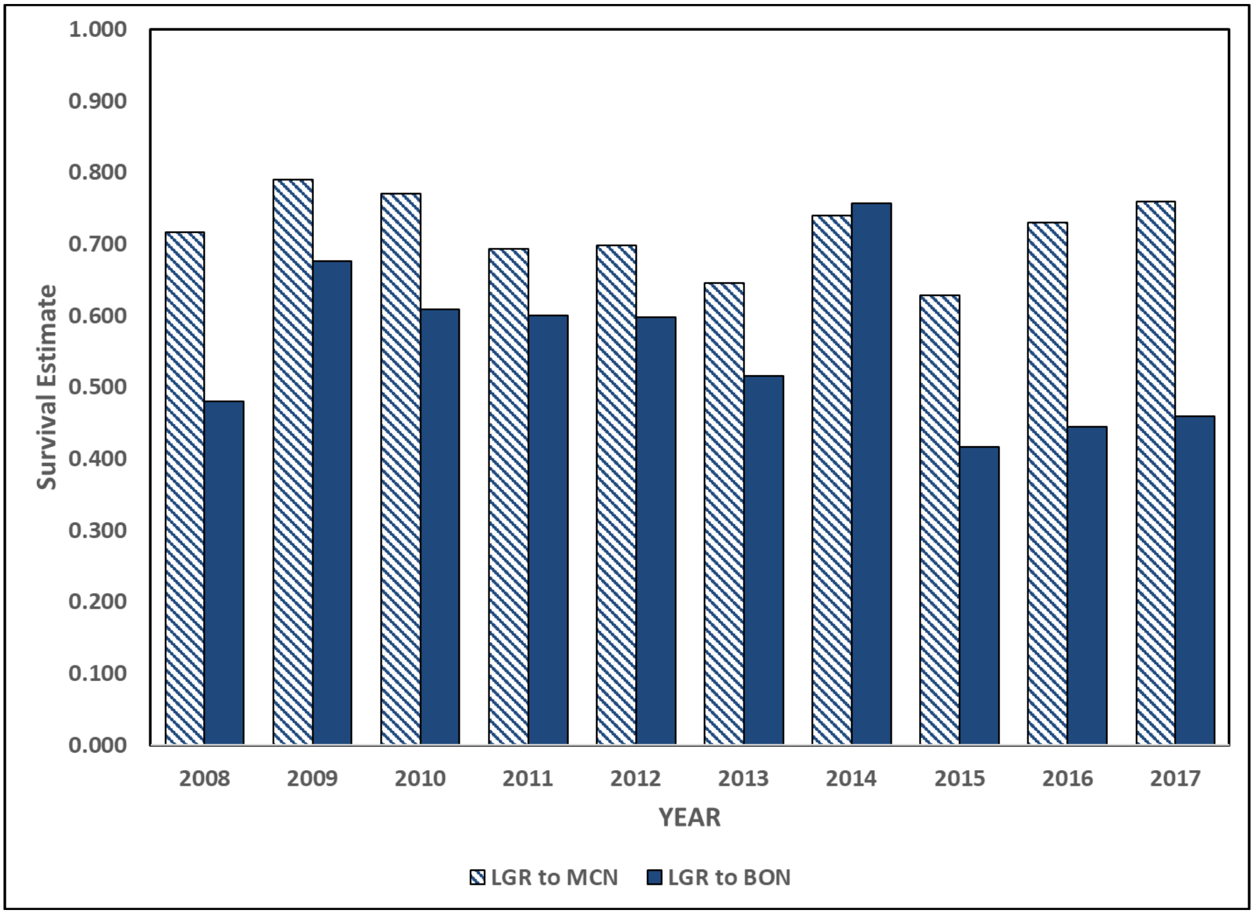

Figure 2.14-5. Survival estimates of SRB steelhead smolts (wild and hatchery combined) from Lower Granite to McNary and Lower Granite to Bonneville Dams (2008–17). Source: Widener et al. 2018.

Preliminary estimates of steelhead smolt (hatchery and wild combined) survival in 2018 (Zabel 2018), resulting from court-ordered “gas cap” spill operations, were 73.3 percent from Lower Granite to McNary Dam and 53.3 percent from Lower Granite to Bonneville Dam. These estimates are well within the range of survival estimates in these reaches observed between 2008 and 2017.

Together, these survival rates represent a substantial improvement in migration conditions and survival rates for juvenile SRB steelhead migrating through the impounded reaches of the lower Snake and lower Columbia Rivers compared to the 1980s and 1990s (NMFS 2008a), which increases the overall productivity of the populations and the abundance of returning adults.

2.14.2.4 Transportation

Turbine intake screens, part of the juvenile bypass systems,[194] divert SRB steelhead smolts away from turbine units and into a system of channels and flumes before delivering them to either the tailrace below the dam (bypassed) or, into raceways where they can be loaded onto barges, transported to below Bonneville Dam, and released to continue their migration (transported). Some SRB steelhead smolts were collected at McNary Dam and transported to below Bonneville Dam until 2012, when the Corps terminated transportation of juveniles from McNary Dam based on a recommendation from NMFS. This action was considered in the 2014 FCRPS biological opinion (NMFS 2014).

Juvenile fish transportation has been a mitigation operation for the FCRPS since 1981 (Baxter et al. 1996). The effectiveness of the program is evaluated annually, and juvenile transport continues to show an overall benefit for SRB steelhead. However, the degree of benefit has decreased as in-river survival has increased and the proportion of fish being transported has decreased subsequent to the increase in spill and the later transport collection dates that were implemented for juvenile yearling spring Chinook and steelhead in 2006.

Recent transport rates (2008 to 2017) have averaged about 34 and 32 percent for wild and hatchery SRB steelhead, respectively, and ranged from about 12 to 14 percent in 2015, up to 47 to 51 percent in 2008. These estimates represent a substantial reduction from the 1990s and early 2000s, when transport rates generally ranged from 70 to 99 percent (Widener et al. 2018). This reduction was due to both increased spill levels (24 hours each day) and a later (May 1) transport start date at the three Snake River collector projects. Estimated transport rates in 2018 were 47.5 and 46.4 percent for wild and hatchery steelhead smolts, respectively (Zabel 2018). This increase was primarily due to implementation of an earlier (April 24) transport start date that corresponded with an early outmigration and higher collection efficiencies resulting from high flow conditions in the lower Snake River.

The primary metric for assessing transport effects is the ratio of SARs of transported fish relative to that of fish remaining in-river and passing the hydrosystem by other routes during migration. Several types of ratios are useful, differing by which fish are included in the ratio. We present two transport ratios to describe effects of transport on adult returns (Table 2.14-5). These ratios are:

1. Transport-in-River Ratio (TIR): The TIR is the ratio of the SAR of fish transported from Lower Granite, Little Goose, or Lower Monumental Dams, relative to the SAR of fish that never entered a collection system at these dams. PIT-tagged fish used for TIR estimates come only from fish tagged upstream of Lower Granite Dam, and smolt number estimates are adjusted to account for mortality between Lower Granite Dam and the downstream transport site. The CSS uses this metric to report transport results.

[194] All of the powerhouses at the four lower Columbia River mainstem dams have juvenile bypass systems with the exception of The Dalles Dam and Bonneville Dam, Powerhouse 1.

2. Transport-Bypass Ratio (T:B): The T:B is the ratio of the SAR of fish transported from a specific collector project (in Lower Granite Dam equivalents for downstream projects) relative to the SAR of fish that entered the same collection system and were then bypassed to the river downstream. The NWFSC generally uses this metric to report transport results.

T:B and TIR ratios greater than one indicate that transported fish are returning as adults to the collection point at higher rates than bypassed or in-river fish respectively. Table 2.14-5 shows that, in most cases, SARs are higher for transported fish than for bypassed or in-river fish.

Because these ratios provide a comparison of transport effects relative to different passage routes, they can address different management questions. A TIR ratio provides information regarding the benefit of increasing or decreasing fish collection (with respect to adult returns), while a T:B ratio provides information about whether to transport or return collected fish to the river. One advantage of T:B ratios is that data on transport effects can be evaluated on a finer temporal scale than annual estimates (TIR), because fish detections can be partitioned by the time they are detected passing a project (T:B). Fish passing through spillway and turbine routes have no detections and, thus, have an unknown passage date. Table 2.14-5 shows T:B and TIR ratios for 2006 through 2015.

The spring juvenile migration begins in April and the fisheries managers generally choose to bypass fish for the first several weeks of April. This decision is supported by data that indicates there is no benefit to transport fish very early in the season. However, as the season progresses, a decision is made in late April or early May to begin the collection process and transport the collected juveniles. When the collection and transport begin, a portion of the juveniles that have PIT tags are returned to the river to assess in-river survival. These fish serve as the bypass (B) fish, and the effectiveness of transportation is measured by comparing the rate of returning adults of transported fish relative to those that were returned to migrate in-river. All fish used in the evaluation have been detected at a collector dam and their PIT tag read, which effectively provides a date stamp when they were bypassed or transported through the season. This allows for the subsequent evaluation of how transported fish performed relative to those bypassed at the projects across the migration season.

The TIR provides a different perspective. It compares the rate of returning adults for fish that were transported relative to those that were not bypassed, and, therefore, never detected at a Snake River collector project. It provides a relative comparison of the annual effect of transport on adult returns compared to fish that passed all of the collector projects by way of the spillways or the turbines. This ratio does not allow a daily evaluation of transport because the fish that passed in-river were never detected and include fish that migrated in-river before transport operations were initiated. This ratio serves as a high standard for comparative purposes because it represents a condition where the in-river, non-transported fish passed all the collector dams without encountering a juvenile bypass system.

Both measures have merits and are best viewed collectively.

The relative effect of transportation as a mitigation measure varies by species. The general pattern is that transportation benefits wild and hatchery steelhead. The annual results of transportation effects on adult returns are provided in the form of T:B and TIR ratios for the years 2006–15 (Table 2.14-6). The T:B ratios presented are based on transport studies conducted by the NWFSC on fish transported from Lower Granite Dam (Smith 2018). The transport results from Little Goose Dam are generally similar, however less benefit is generally observed from transport at Lower Monumental Dam where fewer fish are transported. The year 2006 was chosen as the starting point because that was the first year that spill was provided on a 24-hour basis at all of the Snake River projects.

Table 2.14-6. Analysis of effects of transport on adult return rates for Snake River Basin steelhead yearlings using the NWFSC metric (T:B) versus the CSS metric (TIR).

	T:B (NWFSC metric)		TIR[1] (CSS Metric)	
Year	Hatchery Steelhead	Wild Steelhead	Hatchery Steelhead	Wild Steelhead
2006	1.73	1.68	1.50	0.85
2007	2.46	2.47	1.66	2.89
2008	1.46	1.22	1.23	1.16
2009	1.40	2.00	1.06	1.31
2010	1.17	1.35	0.90	1.45
2011	1.57	1.81	1.11	1.18
2012	1.48	2.30	0.80	0.88
2013	1.43	1.90	1.44	2.15
2014	1.93	2.66	1.22[2]	2.14[2]
2015	15.32	0.78		
Geometric mean	2.00	1.72	1.21	1.56

NOTE: The NWFSC T:B estimates represent a comparison of SARs for fish tagged above Lower Granite and either transported (T) or bypassed (B) at Lower Granite. The CSS TIR estimates come from the 2017 CSS Annual Report, and represent the T0 or Tx SAR, relative to fish never detected at a collector project (C0 SAR).
[1]The mean TIR for Snake River hatcheries reported in the 2017 CSS Annual Report.
[2]Incomplete adult returns at time of analysis.

While the overall result of transportation is positive, it is no panacea (Williams 2005). A regional goal is for survival of in-river migrants to meet or exceed that observed for transported fish. That goal has not yet been met for spring migrants, but transport provides an important benchmark. The alternative to transport is to improve in-river migration conditions to the point where transport provides little benefit. Over the years various transportation strategies have been proposed and have been reviewed by the ISAB, most recently in 2010 (ISAB 2010). The guidance provided by the ISAB has been consistent, which is to “spread the risk” between transport and in-river passage and measure the effects of in-river survival and transport over time.

The efforts made to improve in-river conditions since 2006 have included the provision of 24-hour spill at all of the mainstem projects, the addition of surface passage structures, and the relocation of juvenile bypass outfall locations to improve in-river survival of bypassed fish. While higher spill is anticipated to result in fewer fish being collected for transport, that effect would not be uniform under all flow conditions. Spill passes a greater proportion of fish under low-flow conditions, which occurred in the year 2015. The result was that only 13 percent of the steelhead were transported that year. The year 2015 also had a relatively low in-river survival (48.6 percent), and transport provided a very high benefit for hatchery steelhead (T:B ratio of 15:1) but not for wild steelhead (T:B 0.78:1).

Reconciling the desire to improve in-river conditions when in-river conditions are poor due to low flows and high temperatures, such as those in 2015, is a challenge. It requires an in-season management decision to weigh the potential effects of increasing transport and the desire for many regional managers to improve in-river conditions, with spill as the main strategy. Determining an “optimum” transportation operation is challenging for several reasons. The benefit of transportation (relative to in-river migrating juveniles) varies seasonally, by river flow and temperature conditions, and likely as a result of ocean conditions (when fish arrive at the ocean). Patterns also vary by species and rearing type (hatchery or wild).

In general, transport benefits for both steelhead and Chinook salmon tend to be higher when river flows are lower and when transport occurs later in the migration period when temperatures are warmer. Transport also has unintended consequences, straying being one of them. Spring migrants are transported in barges which follow the course of the river, but the barges move the fish at a rate much faster than their in-river cohorts. Fish that migrate in-river take two weeks or longer to travel from Lower Granite to Bonneville Dam. Fish that are transported make this trip in about three days. It appears this rapid rate of migration in a barge prevents these fish from acquiring waypoints along the migration route, which alters their migration when returning as adults. The result is that previously barged fish often wander into tributaries for some period of time, or fall back over mainstem dams at rates greater than in-river migrants. This behavior generally results in reduced survival of these fish, either from injury or being caught in a fishery. The TIR and T:B incorporate these losses, so the overall effect of transportation is positive. The question is whether alteration of adult homing behavior has important fitness consequences, and may additionally affect non-target populations when adults enter and breed in non-natal streams (Keefer et al 2008). Keefer studied the effects of barged and in-river migrating steelhead during the juvenile migration years 1998–2003. He found that barged steelhead had lower adult homing behavior, higher unaccounted-for losses, and higher straying rates than in-river migrants. The transport effect on straying was significant for wild steelhead but not for hatchery fish. The concern about non-native steelhead breeding with non-target populations in the John Day River was noted by Ruzycki and Carmichael (2010). However, he stated that since 2007, the proportion of hatchery-origin spawners appears to have declined in each subsequent year, with only 6 percent of the fish being non-native in 2009 versus 31 percent being non-native in 2004. This decline has coincided with a similar decline in the number of smolts transported from Snake River dams. The observations made by Keefer were from a time when up to 90 percent of Snake

River smolts were transported, as opposed to the approximate 40 percent transport rate observed since 2006.

2.14.2.5 Hatcheries

There are 13 steelhead hatchery programs in the Snake River basin, plus one kelt reconditioning program. Five of the artificial propagation programs are considered to be part of the DPS: the Tucannon River, Dworshak National Fish Hatchery, South Fork Clearwater, East Fork Salmon River, and the Little Sheep Creek River Hatchery steelhead hatchery programs (71 FR 834). A kelt is the term used for an adult steelhead that has spawned successfully and is returning to the ocean, with the chance to return upstream to spawn at a later time. Typically, shortly after spawning, a kelt is in fairly poor condition, and its chances of surviving the downstream migration may be low. The kelt reconditioning program consists of the collection of post-spawned steelhead greater than 60 cm, and the administration of disease-preventative medications and feed for the purpose of improving survival over what would be expected in the wild. Upon release, these fish are intended to return to natal populations, thereby increasing spawner escapement and productivity if reconditioned individuals successfully spawn (NMFS 2017f).

At present, evidence indicates that several B-Index steelhead populations targeted by the kelt reconditioning program have likely benefited from this program. Since 2008 the Snake River kelt reconditioning program has been operating at a research scale, and the facility is reported to be too small to reach the RPA 33 goal of increasing the Lower Granite Reservoir ladder count of B-Index steelhead by 6 percent (Hatch et al. 2018); however, the program has demonstrated the feasibility of reaching the 6 percent goal. In 2013, 69 reconditioned B-Index steelhead were released (approximately 40 percent of RPA 33's goal). In 2015, 24 reconditioned B-Index steelhead were released below Lower Granite Dam in association with RPA 33, and an additional 21 fish were determined to be skip spawners and retained for release in 2016. Twenty-two fish were released in 2016 and 98 fish were released in 2017. The 2017 release of 98 premature fish was composed of 77 skip spawners, with fecundities approximately 1.51 times those of maiden fish, and 21 consecutive spawners, with fecundities approximately 1.27 times those of maiden fish (Hatch et al. 2018).

Hatchery programs for many SRB steelhead populations serve the dual purpose of providing fish for fisheries and supplemental spawners to help rebuild depressed natural populations. Most hatchery production for SRB steelhead was initiated under the Lower Snake River Compensation Plan (LSRCP) as part of the Water Resources Development Act of 1976 (90 Stat. 2917). The LSRCP included a program to design and construct fish hatcheries to compensate for some of the losses of salmon and steelhead adult returns incurred as a result of the construction and operation of the four lower Snake River hydroelectric dams. Mitigation goals for the LSRCP program include 55,100 adult steelhead. The program is administered by the U.S. Fish and Wildlife Service. Production under the LSRCP generally began in the mid-1980s.

Other hatchery programs also produce steelhead. The Dworshak Dam mitigation program provides for hatchery production of steelhead as compensation for the loss of access to the North Fork Clearwater River (NMFS 2017f). Dworshak National Fish Hatchery, completed in 1969, is the focus for that production. In addition, BPA funds the Nez Perce Tribal Hatchery kelt reconditioning program as mitigation for the CRS, but it is not a steelhead production program. Hatchery fish are also produced as mitigation for fish losses caused by construction of the Hells Canyon Complex in the Snake River Hells Canyon area. None of the Hells Canyon Complex dams, which are owned and operated by Idaho Power Company, have fish passage facilities. The Idaho Power Company built four hatcheries to mitigate for the Hells Canyon Complex's effects on native fish populations: Oxbow, Rapid River, Niagara Springs, and Pahsimeroi Hatcheries. The four hatchery facilities are managed by IDFG.

The management of existing hatchery programs remains a threat for several SRB steelhead populations. The situation is complex, however, because some of the populations may have become extirpated if not for the benefit of hatchery supplementation. Further, the existence of local hatchery stocks may help natural populations to bridge periods of adverse environmental conditions (as occurred in the 1990s). Nevertheless, large releases of hatchery fish can pose risks to natural-origin fish in the SRB steelhead MPGs. For example, approximately four million B-Index steelhead are released into the Salmon River and Clearwater River MPGs, primarily for harvest augmentation. These are large releases of hatchery fish relative to the likely size of natural production, and pose ecological and genetic risks (e.g., spawning site competition and hatchery-influenced selection). Further, some of the non-local B-Index hatchery fish are released into areas where they are not the predominant life history type. Other potential problems include using out-of-MPG stocks and releasing fish without acclimation, which may increase the risk of straying.

Hatchery practices for the Snake River species have evolved as the status of natural populations changed, and new plans are being implemented and evaluated as a result of recent ESA consultations on HGMPs for every hatchery program in the Snake River basin. Several major uncertainties exist regarding the effects of hatchery programs on natural-origin SRB steelhead populations. These uncertainties include a limited understanding of the impact of hatchery releases on natural-origin population abundance, productivity, and genetic integrity, as well as the effects of ecological interactions between hatchery and natural-origin ESA-listed fish in the tributary, mainstem, estuary, and ocean environments. One of the main areas where information is lacking is regarding the relative proportion and distribution of hatchery-origin spawners in natural spawning areas at the population level, particularly for SRB steelhead (NWFSC 2015). Because of this lack of information, the status of most of the populations in the DPS remains highly uncertain. Information is needed to determine where, and to what extent, unaccounted for hatchery steelhead are interacting with depressed ESA-listed populations, particularly in Idaho (NWFSC 2015). In addition, a comprehensive assessment of hatchery benefits and risks is now underway across the Snake River basin. This assessment is expected to result in operational refinements and changes that benefit listed species.

2.14.2.5.1 Recent Changes and Improvements to Hatchery Management

Most of the SRB steelhead hatchery programs are operated to augment harvest for A-Index and B-Index steelhead, but several are managed for conservation purposes. The East Fork Salmon River Natural Program is the only integrated program.[195] Genetic effects on the East Fork population are limited by the use of natural-origin broodstock. An expected PNI of < 0.5 on average is considered a reasonable target for a "maintained" population in the recovery scenario (NMFS 2017f) and is likely to benefit the DPS through increased abundance and productivity for the East Fork Salmon population. Target PNI analyses have also recently been conducted for the Tucannon and Little Sheep conservation programs. The Dworshak Hatchery program is a harvest program, though it also includes the last remnants of the extirpated North Fork Clearwater population and potentially preserves some unique genetic diversity.

2.14.2.6 Harvest

The largest harvest-related effects on SRB steelhead result from the implementation of tribal and nontribal mainstem Columbia River fisheries (NMFS 2017e). These fisheries target harvestable hatchery stocks migrating through commercial fishing zones 1-6 in the lower portion of the mainstem Columbia River, extending from the river mouth to McNary Dam. Mortality associated with tributary fisheries also occurs in some areas. Mortality associated with ocean fisheries, which target fall-run Chinook and coho salmon, is rare for the species (NMFS 2017e). Also, the migration path and ocean distribution of SRB steelhead is such that they are not present in nearshore areas where ocean salmon fisheries traditionally occur (NMFS 2014). In the case of natural-origin SRB steelhead, all fishery mortality is incidental since the harvest of unclipped steelhead is not legal in any fishery. Non-treaty commercial harvest of steelhead has been prohibited since 1975. Before efforts during the last few years to promote commercial selective fisheries, fishery managers used time, area, and gear restrictions to limit handling and mortality of steelhead by the non-treaty fishery to less than two percent of the run (NMFS 2018a). In addition, recreational fisheries have been required to release unmarked, natural-origin steelhead in the Columbia River since 1986. Of the fish that are caught and released, it is assumed that 10 percent will die from handling-related injuries. This release mortality rate is the *U.S. v. Oregon* TAC's scientific recommendation, which is developed, and updated whenever new information becomes available through a combination of reviewing current scientific literature and incorporating Columbia River basin-specific studies examining natural-origin steelhead captured and released from recreational gear used during spring, as seasonal temperature changes are known to affect release mortality rates differently (TAC 2017). Incidental mortality includes mortality of fish that are harvested incidentally to the target species or stock, caught and released, or captured by fishing gear but not landed (NMFS 2014).

[195] A hatchery program is an integrated type if the intent is for the natural environment to drive the adaptation and fitness of a composite population of fish that spawns both in a hatchery and in the wild. In these programs, a high proportion of wild individuals are incorporated in the hatchery broodstock each generation, maintaining genetic similarity of wild and hatchery stocks, but potentially resulting in greater reproductive interactions between the two.

Fisheries in the Columbia Basin, particularly in the mainstem of the Columbia River, are managed pursuant to fishing plans developed by the parties to *U.S. v. Oregon*. Parties to this process include the federal government, the states of Oregon, Washington, and Idaho, the four Columbia River Treaty Tribes, and the Shoshone-Bannock Tribes. The majority of harvest on SRB steelhead occurs in Columbia River mainstem tribal gillnet and dip net fisheries targeting hatchery steelhead, coho, and fall Chinook salmon. The B-Index component of the summer steelhead run, which returns to spawn in Idaho's Salmon and Clearwater River drainages, is thought to be more vulnerable to harvest in gillnet fisheries and experiences higher fishing mortality than the A-Index component. B-Index steelhead also have a run timing distribution similar to fall-run Chinook salmon, and are susceptible to harvest in tribal fisheries directed at these fish (Copeland et al. 2017). Harvest mortality has been reduced substantially in response to evolving conservation concerns.

Steelhead impacts associated with fall season treaty fisheries were managed from 1986 to 1998 pursuant to the guidelines contained in the now expired Columbia River Fisheries Management Plan (CRFMP). That plan allowed for a tribal harvest rate on B-Index steelhead during the fall season of 32 percent. A reduction in the allowable fishing rate was made in hopes of providing necessary protections to B-Index steelhead. The average B-Index harvest rate from 1985 to 1997 was 26.0 percent. Then in 1998, to address ESA constraints, harvest for B-Index steelhead was reduced further to a 15 percent harvest rate cap, and the harvest rate from 1998 to 2008 in the tribal fall season fishery averaged 11.5 percent. The 15 percent harvest rate cap represented a 42 percent reduction from the long-term average harvest rate for the tribal fishery, and a 53 percent reduction from the CRFMP allowed harvest rate of 32 percent (NMFS 2018a). In 2008, a tiered structure for fall harvest rates was introduced: 13 percent at run sizes less than 20,000, 15 percent for run sizes between 20,000 and 35,000, and 20 percent for run sizes above 35,000. These caps included both clipped and unclipped steelhead. Since then, the average harvest rates (including tribal and recreational fisheries) have been 6.5 percent on unclipped A-Index steelhead and 17.9 percent on unclipped B-Index steelhead (TAC 2017, Table 3.3.52).

Summer fisheries since 2008 have averaged 1.5 percent on unclipped A-Index steelhead and 2.4 percent on unclipped B-Index steelhead, and the treaty winter/spring harvest rate on unclipped A-Index steelhead and unclipped B-Index steelhead during winter/spring fisheries has averaged 0.1 and 0 percent, respectively (TAC 2017). For all fishing seasons combined, the average annual treaty harvest rate from 2008–16 on the unclipped portion of the B-Index steelhead stock was 20.2 percent (NMFS 2018a).

For management purposes, the steelhead run year starts on July 1 at Bonneville Dam. From July 1 to July 31, a separate two percent harvest rate limit begins on natural-origin A- and B-Index steelhead in fisheries upstream from the mouth of the Columbia River. A portion of the annual steelhead run is unclipped hatchery-origin fish, and this component is annually calculated to correct for the actual natural-origin steelhead return (TAC 2017). Beginning August 1, a new two percent harvest rate limit on the natural-origin component of each Index applies to fisheries that affect the same set of returning fish that occur through October 31. This fall harvest rate limit extends from November 1 through December 31 for fisheries upstream of The Dalles Dam.

For fisheries upstream of The Dalles Dam to the Washington/Idaho border, January through June 30 (the winter/spring management period) fisheries are limited as part of the same two percent harvest rate limit that occurred in July, since these are the same run of steelhead which have now migrated upstream in the Columbia River basin. In total, each Index is subject to a maximum four percent harvest-rate limit on natural-origin steelhead each run year (NMFS 2018a). Generally, the status of B-Index steelhead is worse than that of A-Index steelhead. B-Index steelhead are subject to higher harvest rates because they are the limiting stock, generally in lower abundance and, therefore, caught at levels closer to their annual limit.

In terms of catch, thousands more A-Index fish are caught, however, the harvest rate of the entire A-Index is lower because there are so many more fish classified as A-Index fish in the river. Consequently, there are no specific management constraints in tribal fisheries for A-Index steelhead because the constraints for B-Index fish are restrictive enough to also provide surrogate protection for A-Index steelhead (NMFS 2018a).

Treaty-tribal fall season fisheries are currently managed using the abundance-based harvest-rate schedule for B-Index steelhead, as contained in the 2*018 U.S. v. Oregon* agreement. Under the abundance-based harvest rate schedule, the harvest rate limit may change depending on the abundance of B-Index steelhead. The harvest rate allowed under the current harvest rate schedule is also limited by the abundance of upriver fall Chinook salmon. The purpose of this provision is to recognize that impacts to B-Index steelhead may be higher when the abundance, and thus fishing opportunity for fall Chinook salmon, is higher and remains consistent with conservation goals. However, higher harvest rates are allowed only if the abundance of B-Index steelhead is also greater than 35,000. This provision is designed to provide greater opportunity for the tribes to satisfy their treaty right to harvest 50 percent of the harvestable surplus of fall Chinook salmon in years when conditions are generally favorable. Even with these provisions, it is unlikely that the treaty right for Chinook salmon or steelhead can be fully satisfied. The harvest rate in tribal fall season fisheries may range from 13 to 20 percent and the non-treaty fall season fishery harvest rate would remain fixed at two percent. B-Index steelhead are used as the primary steelhead-related harvest constraint for tribal fall season fisheries, and are the indicator stock used for management purposes. Several tribes also have treaty rights to fish for steelhead in the Snake River basin. As a consequence, co-managers in the Snake River are developing fishery frameworks that allow for the allocation of available fishery impacts based on what may annually escape *U.S. v. Oregon* fishery management and return to the upper Snake River basin.

Sport fisheries targeting hatchery-run steelhead with incidental impacts on wild returns occur in the mainstem Columbia River and sections of the Snake, Clearwater, and Salmon Rivers. The impacts from these catch and release fisheries are unclear (NWFSC 2015; NMFS 2017e).

2.14.2.7 Tributary Habitat

2.14.2.7.1 DPS Overview

Tributary habitat conditions for steelhead vary significantly throughout the Snake River basin: in some areas, spawning and rearing habitat is in near-pristine condition, while in other areas it is minimally to highly degraded as a result of past or present human activities. Generally, the ability of tributary habitats in the Snake River basin to support the viability of this DPS is limited by one or more of the following factors: (1) impaired fish passage; (2) reduced stream complexity and channel structure; (3) excess fine sediment; (4) elevated summer water temperature; (5) diminished stream flow during critical periods; (6) reduced floodplain connectivity and function; and (7) degraded riparian condition. The combination, intensity, and relative impact of these factors vary locally throughout the basin, depending on historical and current land use activities and natural conditions. Human activities that have contributed to these limiting factors include past and/or current grazing, mining, logging, agricultural practices, road construction, water withdrawals, urban development, and recreational use (NMFS 2017e).

In general, land use practices and regulatory mechanisms have improved from historical practices and regulations (NMFS 2017e). In addition, many tributary habitat restoration actions have been implemented throughout the Snake River basin through the individual and combined efforts of federal, tribal, state, local, and private entities, including the Action Agencies. The CRS Action Agencies have been implementing tributary habitat improvement actions as part of mitigation for the CRS since 2007. These actions have included protecting and improving instream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, removing barriers to spawning and rearing habitat, and other actions targeted toward addressing limiting factors as identified above (BPA et al. 2013, 2016). Cumulative metrics for these action types for SRB steelhead from the years 2007–15 are shown in Table 2.14-7.

Table 2.14-7. Tributary habitat improvement metrics: Snake River Steelhead, 2007-2015 (BPA et al. 2016).

Action Type*	**Amount completed**
Acre-feet/year of water protected (by efficiency improvements and water purchase/lease projects)	58,854.3
Acres protected (by land purchases or conservation easements)	2,203.5
Acres treated (to improve riparian habitat, such as planting native vegetation or control of noxious weeds)	6,210.3
Miles of enhanced or newly accessible habitat (by providing passage or removing barriers)	1,036.9
Miles of improved stream complexity (by adding wood or boulder structures or reconnecting existing habitat, such as side channels)	164.6
Miles protected (by land purchases or conservation easements)	179.3
Screens installed or addressed (for compliance with criteria or by elimination/consolidation of diversions)	69

***** Several of these categories (acres protected, acres treated, miles of enhanced stream complexity, miles protected) also encompass actions directed at reducing sediments and reconnecting floodplains.

NMFS determined, based on best available science, that the actions implemented by the Action Agencies and other entities have improved, and will continue to improve, habitat in the targeted populations as these projects mature, and that fish population abundance and productivity will respond positively.[196] Benefits of some of these actions will continue to accrue over the next several decades (see Appendix A). RM&E, including IMWs and CHaMP sampling, have been underway in this DPS to help confirm improvements in habitat productivity and fish population survival and their magnitude. Available empirical evidence supports our view that these actions are improving tributary habitat capacity and productivity, as well as population abundance and

[196]In most cases, near-term benefits would be expected in abundance and productivity. Depending on the population and the scale and type of action, benefits to spatial structure and diversity might also accrue, either in the near term or over time. In addition, while we expect abundance, productivity, spatial structure, and diversity to respond positively to strategically implemented tributary habitat improvement actions, other factors also influence these viability parameters (e.g., ocean conditions) and any resulting trends. Throughout this tributary habitat discussion, when we discuss improvements in abundance and productivity, it is implied that spatial structure and diversity might also respond positively, and that other factors, as noted here, might influence any resulting trends.

productivity (see Appendix A; NMFS 2014; Hillman et al. 2016; Griswold and Phillips 2018; Haskell et al. 2018).

The best available scientific and technical information also indicates that there is additional potential to improve habitat productivity, although this varies by population. While in most areas, there appears to be adequate potential to improve habitat productivity, in some areas, the potential is more limited or uncertain (NMFS 2016e, 2017e). Strong density dependence has been observed in SRB steelhead populations (ISAB 2015), which also indicates that improvements in tributary habitat capacity or productivity, if targeted at limiting life stage and limiting factors, would be likely to improve overall population abundance and productivity.

In summary, while tributary habitat conditions are likely improving in some areas as a result of habitat improvement actions and improved land use practices, in general tributary habitat conditions are still degraded and continue to negatively affect SRB steelhead abundance, productivity, spatial structure, and diversity. In addition, the potential exists to further improve tributary habitat capacity and productivity in this DPS, although the potential varies by population.

More detail on baseline tributary habitat conditions for the five extant MPGs (and 24 extant populations) that constitute this DPS is provided below.

Salmon River MPG

The Salmon River MPG historically supported twelve Snake River steelhead populations: the Little Salmon River, Chamberlain Creek, Secesh River, South Fork Salmon River, Panther Creek, Lower Middle Fork Salmon River, Upper Middle Fork Salmon River, North Fork Salmon River, Lemhi River, Pahsimeroi River, East Fork Salmon River, and Upper Mainstem Salmon River. All of these populations are extant (NMFS 2017e).

Good to excellent steelhead habitat conditions exist in most sections of this MPG that are included in the Frank Church ─ River Of No Return Wilderness. This wilderness area covers most of the Upper Middle Fork Salmon River, Lower Middle Fork Salmon River, and Chamberlain Creek population areas, and parts of the South Fork Salmon River and Panther Creek population areas. Other habitat in these population areas also lies primarily under U.S. Forest Service management (NMFS 2017g).[197]

The remaining steelhead populations in this MPG contain a mix of public and private lands. Habitat conditions vary among and within these populations. All retain some areas of high-quality steelhead habitat but all also contain degraded areas as a result of mining, agriculture, grazing, forest management, recreational use, and road development. Steelhead habitat for the

[197]Even in the wilderness area habitats, however, some small, localized areas display degraded habitat conditions associated with road development, past mining, livestock grazing, irrigation diversions, timber harvest, off-highway vehicles, and other recreational use. Some amount of degradation also has occurred on private lands. These localized limitations include impacts to passage, flow, sediment inputs, riparian area function, and nutrient supply. In addition, loss of beavers has led to channel simplification.

Secesh, Little Salmon River, and North Fork Salmon River populations is mostly on federal lands and generally highly productive, although there are legacy (and some ongoing) impacts. The Lemhi and Pahsimeroi subbasins have been highly degraded by livestock grazing and instream flow alterations, including tributaries that have been disconnected from the mainstem. The East Fork Salmon River habitat has also been degraded considerably by similar land uses. In the Upper Salmon River population, the extent of habitat degradation varies from extensive (e.g., in the Yankee Fork) to less extensive (NMFS 2017g). The land uses in these areas have reduced riparian function and floodplain connectivity, increased sediment loading, reduced summer base flows, disconnected tributaries from mainstream rivers, elevated summer water temperatures, and reduced instream habitat quality complexity in some areas. Passage barriers continue to restrict steelhead passage to historical habitat in each population area. In several population areas, unscreened irrigation diversions entrain juvenile steelhead into irrigation canals where they become trapped. Presently, some degraded areas are likely on an improving trend due to ongoing habitat restoration efforts (NMFS 2017g).

Restoration actions in this MPG have included fencing and riparian area planting and streambank restoration; road obliteration, decommissioning, and other road-related actions to reduce sediment input into streams; culvert removal or replacement; floodplain and stream channel restoration; reconnecting tributaries to mainstems; screening and modification of water diversions; habitat protection through acquisitions, conservation easements, and other methods; and cessation of certain land use activities in some area to allow habitats to recover (BPA et al. 2013, 2016; NMFS 2017g). These actions have been targeted toward addressing limiting factors, and best available science indicates that they have and will continue to improve habitat function in the targeted populations, and that fish population abundance and productivity will respond positively. Benefits of some of these actions will continue to accrue over several decades (see Appendix A).

The Action Agencies’ efforts in this MPG under the 2008 biological opinion were focused on the Lemhi, Pahsimeroi, and Salmon River Upper Mainstem populations, where they implemented substantial restoration projects (BPA et al. 2016). For example, restoration actions on the Lemhi River focused primarily on reconnecting tributaries by removing barriers, increasing stream area by 22 percent and pool area by 19 percent. Increased abundance of juveniles and adult steelhead has been observed post-restoration (Uthe et al. 2017; Appendix A of Griswold and Phillips 2018). In addition, smaller improvements were implemented in the Lower Middle Fork Mainstem, East Fork Salmon River, Secesh River, and South Fork Salmon River populations. Of the populations where the Action Agencies implemented actions, the Lower Middle Fork and South Fork Salmon River populations must achieve viable or highly viable status for ESA recovery, and the Lemhi, Pahsimeroi, Upper Salmon River Mainstem, East Fork Salmon River, and Secesh River populations must achieve viable or maintained status (NMFS 2017e).[198]

[198] For ESA recovery, at least six populations in this MPG must be viable (low risk; one of these populations must be highly viable. Considering other factors such as size and life history diversity, the Little Salmon, Secesh, Panther Creek, North Fork, Lemhi, Pahsimeroi, East Fork, and Upper Salmon River populations must achieve viable or

In summary, habitat in the Salmon River MPG includes some populations with very high-quality habitat due to the preponderance of wilderness areas and other federal lands, and some populations with highly degraded habitat areas or a mix of habitat quality. While some degraded areas in the Salmon River MPG are likely on an improving trend due to ongoing improvement efforts and improved land use practices, habitat degradation continues to negatively affect the abundance, productivity, spatial structure, and diversity of this MPG. Potential for improvement varies among populations from low or uncertain to high.

Grande Ronde River MPG

The Grande Ronde River MPG historically supported four Snake River steelhead populations: Joseph Creek, Wallowa River, Upper Grande Ronde River, and Lower Grande Ronde River. All four populations are extant (NMFS 2017e).

Habitat conditions vary among these four extant populations. Much of the habitat for the Wallowa River population is in designated wilderness areas, some in near pristine condition, although some effects from past land use linger, and some valley floor reaches are more modified. Habitat for the Joseph Creek population is generally high quality but has been affected by road development, grazing, historical forest management, and agricultural practices. Habitat for the Upper Grande Ronde River population is highly impaired, particularly in valley bottoms, which are privately owned and support grazing and irrigated agriculture. In the Lower Grande Ronde River, headwater streams generally have high road densities, and lower elevation areas are heavily affected by livestock grazing and irrigated agriculture. The Lower Grande Ronde River also serves as a migration corridor and overwintering area for juvenile summer steelhead from other populations in this MPG. Fish that leave upriver areas in fall and spring continue rearing within the lower basin for six months to several years before resuming migration (NMFS 2017h).

The combined effect of the land uses in these subbasins — including agriculture, forestry and grazing practices; dams and other barriers; water withdrawals; and roads and channel manipulations — has contributed to high summer water temperatures, excess fine sediment, alteration of flow (primarily low summer flows), a lack of habitat complexity (e.g., pools and large wood), degraded riparian conditions, and impaired passage. Many reaches also suffer from impaired riparian conditions and loss of floodplain connectivity, which contribute to the above conditions (NMFS 2017e). Habitat conditions in the Grande Ronde River migration corridor (which also serves as rearing habitat), are also limited and affect primarily juvenile rearing and migration (NMFS 2017e).

Many restoration activities have been carried out in this MPG by the individual and combined efforts of federal, state, tribal, local, and private entities, including the Action Agencies. Actions have been targeted toward addressing the identified limiting factors and have included flow

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maintained status, and the South Fork Salmon, Lower Middle Fork, Upper Middle Fork, and Chamberlain Creek populations must achieve viable or highly viable status.

enhancement and protection, screening of irrigation diversions, passage improvements, improved channel complexity, floodplain reconnection, and riparian protection and improvement (BPA et al. 2013, 2016). Best available science indicates that these actions have and will continue to improve habitat function in the targeted populations, and that fish population abundance and productivity will respond positively. Benefits of some of these actions will continue to accrue over several decades (see Appendix A).

Under the 2008 FCRPS biological opinion, the Action Agencies' efforts in this MPG were focused on the Wallowa River, Joseph Creek, and Upper Grande Ronde River populations, with a small amount of work completed for the Lower Grande Ronde population (BPA et al. 2016). For ESA recovery, the Upper Grande Ronde population needs to be viable or highly viable; the Lower Grande Ronde and Wallowa River populations need to be either viable or maintained; and the Joseph Creek population needs to be viable, highly viable, or maintained (NMFS 2017e).

In summary, some degraded areas in the Grande Ronde River MPG are likely on an improving trend due to ongoing habitat restoration efforts and improved land use practices; in general, however, habitat degradation continues to negatively affect the abundance, productivity, spatial structure, and diversity of this MPG. There is high potential for improvement in habitat productivity in most populations in this MPG.

Lower Snake River MPG

The Lower Snake River MPG historically supported two Snake River steelhead populations: Tucannon River and Asotin Creek. Both of these populations are extant (NMFS 2017e).

In these subbasins, historical and current land use practices including grazing and irrigated agriculture, logging, removal of beaver populations, roads, residential development, and diking have led to excess fine sediment, diminished large wood supply, channel straightening and confinement, degraded riparian function, increased summer water temperatures, and diminished flows. Most water diversions without proper passage routes have been fixed but could still disrupt migrations of adult steelhead. Most unscreened diversions have also been fixed but could trap or divert juvenile steelhead and result in reduced survival. These factors have diminished habitat diversity and the availability of key habitat (in particular, summer rearing and overwintering habitat), and have negatively affected the abundance, productivity, and spatial structure of steelhead (Snake River Salmon Recovery Board 2011).

Many restoration activities have been carried out in this MPG in recent years by federal, state, tribal, local, and private entities, including the Action Agencies. Actions have included large-scale efforts to enhance stream complexity and restore floodplain function and side-channel complexity through placement of logjams, riparian restoration, levee removal, and side-channel reconnection (Snake River Salmon Recovery Board 2011; NMFS 2014; BPA et al. 2013, 2016). Best available science indicates that these actions have and will continue to improve habitat function in the targeted populations, and that fish population abundance and productivity will respond positively. Benefits of some of these actions will continue to accrue over several decades (see Appendix A).

Under the 2008 FCRPS biological opinion, the Action Agencies implemented actions to benefit both the Tucannon and the Asotin populations (BPA et al. 2016). For instance, in the Asotin Creek population, from 2012 to 2016 more than 650 log structures were placed in the stream bottom as part of an experimental habitat restoration and monitoring design called the Asotin Creek Intensively Monitored Watershed. The addition of the wood structures was designed to add complexity to the streams and provide refuge for fish, especially juveniles. Early monitoring has documented a 28.8 percent increase in juvenile steelhead abundance in areas with the wood debris compared to those without, and modeling suggests the carrying capacity of the streams has increased by 50 percent following addition of the log structures (Griswold and Phillips 2018). For ESA recovery, both populations should be viable, and one of these should be highly viable (NMFS 2017e).

In summary, while some degraded areas in the Tucannon and Asotin subbasins are likely on an improving trend due to ongoing habitat restoration efforts and improved land use practices, habitat degradation continues to negatively affect the abundance, productivity, spatial structure, and diversity of this MPG. There is potential for improvement in habitat productivity in both populations.

Clearwater River MPG

The Clearwater River MPG historically supported six Snake River steelhead populations: the Lower Mainstem Clearwater, the North Fork Clearwater, Lolo Creek, Lochsa River, Selway River, and the South Fork Clearwater populations. The North Fork Clearwater population is extirpated, and the remaining populations are extant (NMFS 2017e).

Habitat conditions in the Clearwater River MPG span a wide range of quality. Both historical and present-day land uses have significantly altered steelhead habitat in portions of the Clearwater River basin. Steelhead habitat has fewest alterations at higher elevations that are managed primarily as forestlands, and in steeper canyons that are poorly suited for development. Steelhead habitat with the least amount of human alteration in the Clearwater River MPG lies in the Selway River, and parts of the Lochsa River, population areas. The Selway-Bitterroot Wilderness covers nearly all of the Selway River population area and some higher elevations in the Lochsa River drainage, providing protection from human impacts associated with roads. The Selway and Lochsa Rivers are also designated wild and scenic rivers. A large portion of the upper Lochsa River drainage outside the wilderness boundary has a “checkerboard” land-ownership pattern with alternating sections of U.S. Forest Service lands and private lands intensively managed for timber production (NMFS 2017g).

Habitat conditions for the Lolo Creek, South Fork Clearwater River, and Lower Mainstem Clearwater River populations contain a mix of public and private lands. Habitat conditions are not assessed for the North Fork Clearwater River steelhead population, which was extirpated by the construction of Dworshak Dam. While all of the extant population areas continue to contain some high-quality steelhead habitat, habitat degradation in many reaches has resulted from agricultural use, livestock grazing, timber harvest, road development, and past mining activities. In some areas, these land uses have reduced riparian function and floodplain connectivity, increased sediment loading, created passage obstructions, elevated summer water temperatures, and reduced instream habitat complexity. Habitat modification is greatest along valley bottoms in developed areas and in areas under intensive agricultural or timber management. Presently, some degraded areas are likely on an improving trend due to ongoing habitat restoration efforts (NMFS 2017g).

Restoration activities in this MPG have included riparian fencing and planting, road decommissioning and obliteration, culvert replacement, erosion control, barrier removals, dike removal and reconnection of streams to floodplains, stream structure enhancement, and acquisition of land and conservation easements (BPA et al. 2013, 2016; NMFS 2017g). These actions have been targeted toward addressing limiting factors, and best available science indicates that they have and will continue to improve habitat function in the targeted populations, and that fish population abundance and productivity will respond positively. Benefits of some of these actions will continue to accrue over several decades (see Appendix A).

The Action Agencies' efforts in this MPG under the 2008 biological opinion included work to benefit all five extant populations, with the most intensive efforts focused on the Lochsa, Lolo Creek, and South Fork Clearwater populations, with some actions also implemented to benefit the Selway and Lower Mainstem Clearwater populations (BPA et al. 2016). For ESA recovery, the Lower Mainstem Clearwater River, Lolo Creek, and Lochsa River populations need to be viable or highly viable, and the South Fork Clearwater and Selway River populations need to be viable or maintained (NMFS 2017e).

In summary, while some degraded areas in this MPG are likely on an improving trend due to ongoing habitat restoration efforts and improved land use practices, habitat degradation continues to negatively affect the abundance, productivity, spatial structure, and diversity of the populations in this MPG. There is potential for improvement in habitat productivity in all populations in this MPG.

Imnaha River Steelhead MPG

The Imnaha River historically supported a single Snake River steelhead population. The Imnaha River population is extant.

Over two-thirds of the Imnaha River basin is in public ownership. Factors potentially limiting summer steelhead in the Imnaha River include high stream temperatures, impaired riparian conditions, and excessive fine sediment. In addition, reduced large wood, low pool frequency and quality, poor water quality, and low flow conditions may be factors. These factors have the greatest effect on juvenile rearing. Limiting factors for this population primarily reflect stream channel and riparian area degradation resulting from past livestock grazing, timber harvest, and road construction, and low summer stream flows due to water withdrawals (NMFS 2017h).

Some restoration activities have been carried out in this MPG by the individual and combined efforts of federal, state, tribal, local, and private entities, including the Action Agencies. The actions have improved habitat access and habitat complexity, and protected and improved riparian areas (BPA et al. 2016). Under the 2008 FCRPS biological opinion, the Action Agencies implemented a limited amount of improvement actions for this population to improve access, increase stream complexity, and reduce sediment by protecting riparian areas[199] (BPA et al. 2013, 2016). For ESA recovery, the single population in this MPG should be highly viable (NMFS 2017e).

In summary, while some degraded habitat in this MPG is likely on an improving trend due to ongoing habitat restoration efforts and improved land use practices, habitat degradation continues to negatively affect the abundance, productivity, spatial structure, and diversity of the population in this MPG. There is potential for improvement in habitat productivity in this MPG.

2.14.2.8 Estuary Habitat

The estuary provides important migratory habitat for SR steelhead. Since the late 1800s, 68–70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening combined with flow regulation and other modifications (Kukulka and Jay 2003; Bottom et al. 2005; Marcoe and Pilson 2017). Disconnection of tidal wetlands and floodplains has reduced the production of wetland macrodetritus supporting salmonid food webs (Simenstad et al. 1990; Maier and Simenstad 2009), both in shallow water and for larger juveniles migrating in the mainstem (ERTG 2018).

Restoration actions in the estuary, such as those highlighted in the latest 5-year review, have improved access and connectivity to floodplain habitat. From 2004 through 2017, the Action Agencies implemented 58 projects including dike and levee breaching or lowering, tide-gate removal, and tide-gate upgrades that reconnected 5,412 acres of historical tidal floodplain habitat to the mainstem. This represents a 2.5 percent net increase in the connectivity of habitats that produce prey used by yearling steelhead (Johnson et al. 2018). In addition, about 2,500 acres of functioning floodplain habitat were acquired for conservation.

Floodplain habitat restoration can affect juvenile salmonid performance directly (for fish that move onto the floodplain) and indirectly (for fish that stay in the mainstem). Wetland food production supports foraging and growth within the wetland (Johnson et al. 2018), but these prey items (primarily chironomid insects and corophiid amphipods; PNNL and NMFS 2018) are also exported to the mainstem and off-channel habitats behind islands and other landforms where they become available to salmon and steelhead migrating in these locations. Thus, while most steelhead may not directly enter a tidal wetland channel, they derive indirect benefits from

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[199] Improved access to 20 miles, improved stream complexity (.12 miles), riparian improvement (.06 miles), riparian protection (251 acres) (BPA et al. 2013).

wetland habitats. Improved opportunities for feeding on prey that drift into the mainstem are likely to contribute to survival at ocean entry.

Habitat quality and the food web in the estuary are also degraded because of past and continuing releases of toxic contaminants (Fresh et al. 2005; LCREP 2007) from both estuarine and upstream sources. Historically, levels of contaminants in the Columbia River were low, except for some metals and naturally occurring substances (Fresh et al. 2005). Today, levels in the estuary are much higher, as the estuary receives contaminants from more than 1,000 sources that discharge into a river and numerous sources of runoff (Fuhrer et al. 1996). With Portland and other cities on its banks, the Columbia River below Bonneville Dam is the most urbanized section of the river. Sediments in the river at Portland are contaminated with various toxic compounds, including metals, PAHs, PCBs, chlorinated pesticides, and dioxin (ODEQ 2008). Contaminants have been detected in aquatic insects, resident fish species, salmonids, river mammals, and osprey, reinforcing that contaminants are widespread throughout the estuarine food web (Furher et al. 1996; Tetra Tech 1996; LCREP 2007).

Exposure to toxic contaminants can either kill aquatic organisms outright or have sublethal effects that compromise their health and behavior. Sublethal concentrations increase stress and decrease fitness, predisposing organisms to disease, slowing development, and disrupting physiological processes, such as reproduction and smoltification. Acute lethal effects of toxic contaminants, such as fish kills from accidental discharges or spills, are generally rare, but some researchers have described direct mortality of salmonids, including high levels of pre-spawning mortality in Puget Sound coho salmon due to road runoff (McCarthy et al. 2008), synergistic toxicity of agricultural pesticide mixtures causing death in juvenile salmon (Laetz et al. 200p), and increased egg mortality due to PAH exposure (Heintz et al. 1999; Carls et al. 2005).

Sublethal effects are more likely a significant threat to juvenile salmon in the Columbia River estuary. Exposure can reduce immune function and fitness, impair growth and development, and disrupt olfaction; salmonids depend on olfaction for migration, imprinting, homing, and detecting predators, prey, potential mates, and spawning cues. These sublethal effects can interact with other factors like infectious disease, parasites, predation, exhaustion, and starvation by suppressing salmonid immune systems and impairing necessary behaviors such as swimming, feeding, responding to stimuli, and avoiding predators (LCREP 2007).

Toxic contaminants can also affect salmon through the food web, especially through prey such as aquatic and terrestrial insects. Insect bodies accumulate contaminants, which salmon then ingest when they consume insects. Additionally, many toxic contaminants are specifically designed to kill insects and plants, reducing the availability of insect prey or modifying the surrounding vegetation and habitats. Changes in vegetative habitat can shift the composition of biological communities; create favorable conditions for invasive, pollution-tolerant plants and animals; and further shift the food web from macrodetrital to microdetrital sources. Overall, more work is needed on contaminant uptake and impacts on salmon of different populations and life-history types.

2.14.2.9 Predation

A variety of avian and fish predators consume juvenile SRB steelhead on their migration from tributary rearing areas to the ocean. Pinnipeds eat returning adults in the estuary, including the tailrace of Bonneville Dam. Predation in the estuary and in the migration corridor, and management measures to reduce the effects of predation, are discussed below.

2.14.2.9.1 Predation in the Lower Columbia River Estuary

Avian Predators

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, are having a significant impact on the survival of juvenile salmonids (including SRB steelhead) in the Columbia River. Caspian terns on Rice Island, an artificial dredged-material disposal island in the estuary, consumed about 5.4-14.2 million juveniles per year in 1997 and 1998, or 5–15 percent of all the smolts reaching the estuary (Roby et al. 2017). Efforts began in 1999 to relocate the tern colony 13 miles closer to the ocean at East Sand Island where the tern diet would diversify to include marine forage fish. During 2001–15, estimated consumption by terns on East Sand Island averaged 5.1 million smolts per year, about a 59 percent reduction compared to when the colony was on Rice Island. Management efforts are ongoing to further reduce salmonid consumption by terns in the lower Columbia River and similar efforts are in progress to reduce the nesting population of double-crested cormorants in the estuary.

Based on PIT-tag recoveries at East Sand Island, average annual tern and cormorant predation rates for this DPS were about 22.2 and 9.3 percent, respectively, before efforts to manage the size of these colonies (Evans et al. 2018a). The Corps has been implementing the Caspian Tern and Double-crested Cormorant Management Plans, but, in terms of effectiveness, has seen mixed results due to the dispersal of both terns and cormorants to other locations within the estuary. Average predation rates on SRB steelhead have decreased to 9.5 percent for terns nesting on East Sand Island, but in 2017 this improvement was offset to some unknown degree by terns roosting farther upstream on Rice Island (Evans et al. 2018a). Due to failures of the cormorant colony in 2016 and 2017, there are no estimates of predation rates since management of that colony began (Appendix C). Substantial numbers of cormorants have relocated to the Astoria-Megler Bridge (preliminary report of 1,737 in 2018) and hundreds more are observed on the Longview Bridge, navigation aids, and transmission towers in the lower river (Anchor QEA et al. 2017). Smolts may constitute a larger proportion of the diet of cormorants nesting at these sites than if the birds were foraging from East Sand Island. Thus, the success of the East Sand Island tern and cormorant management plans at meeting their underlying goals of reducing salmonid predation is uncertain at this time.

An important question in predator management is whether mortality due to predation is an additive or compensatory source of mortality. Most importantly, do reductions in smolt predation rates by Caspian terns or double-crested cormorants result in higher adult returns because avian predation adds to the other sources of smolt mortality or are the smolts eaten by birds destined to die before returning as adults regardless of the level of predation? The latter case could occur because avian predation could be compensated for by sources of mortality in the ocean phase of the life cycle so that adult returns are unchanged. Haeseker (2015) and Evans et al. (2018b) have begun modeling the degree to which double-crested cormorant and Caspian tern predation, respectively, are additive versus compensatory sources of mortality.

Given the magnitude of bird predation on juvenile steelhead observed in the Columbia basin, and that smolts eaten by birds in the lower river have survived hydrosystem passage, it is likely that some of the smolts consumed by birds could otherwise have survived to adulthood. Therefore, even if avian predation is partially compensatory, we expect that limiting the size of these tern and cormorant colonies will contribute to increased SARs for SRB steelhead.

Pinniped Predators

Numbers of pinnipeds that are predators of adult salmonids have increased considerably in the Pacific Northwest since the MMPA was enacted in 1972 (Carretta et al. 2013). CSLs, SSLs, and harbor seals consume salmonids from the mouth of the Columbia River and its tributaries up to the tailrace of Bonneville Dam. The ODFW has been counting the number of individual CSL hauling out at the East Mooring Basin in Astoria, Oregon, since 1997. Pinniped counts at the East Mooring Basin during September and October, when SRB steelhead are migrating, doubled during 2014–16 (maximum count of 1,318 CSL in September 2015; Wright 2018). A small number of California sea lions have also been observed in Bonneville Reservoir in recent years.

Estimates of steelhead predation by pinnipeds in the lower Columbia River estuary (i.e., downstream of the Bonneville tailrace) are not available for the fall time period. Instead, monitoring efforts have focused on CSL predation on SR spring/summer Chinook salmon during January–May (e.g., Wargo-Rub 2017).

Fish Predators

The native northern pikeminnow is a significant predator of juvenile salmonids in the Columbia River basin (reviewed in ISAB 2015). Before the start of the NPMP in 1990, this species was estimated to eat about 8 percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River (including the hydrosystem reach) each year. Williams et al. (2017) compared current estimates of northern pikeminnow predation rates on juvenile salmonids to those before the start of the program, and estimated a median reduction of 30 percent. The Sport Reward Fishery removed an average of 188,636 piscivorous pikeminnow (> 228 mm fork length) per year during 2013–17 (Williams 2013, 2014; Williams et al. 2015, 2016, 2017).

The removal of the larger, piscivorous individuals from northern pikeminnow populations will result in a sustained survival improvement for migrating juvenile steelhead only if it is not offset by a compensatory response by the remaining northern pikeminnow or other piscivorous fishes, such as walleye or smallmouth bass. Signs of a compensatory response can include increased numbers of other predators, improved condition factors, or diet shifts. Williams et al. (2017) did not observe increases in numbers of pikeminnow, but did report an increasing trend in condition factor. This could be an intra-specific compensatory mechanism or just a response to beneficial environmental conditions. Similarly, Williams et al. (2017) documented increased numbers of smallmouth bass in parts of the lower Columbia River, which could be related to the NPMP or could be due to other factors, including alterations in other parts of the food web or environmental conditions, such as warmer temperature, that affect this species' consumption rates. Williams et al. (2017) concluded that given these analytical constraints, data collected during 2017 provided ambiguous indicators of a compensatory response from the piscivorous fish community. Given the numbers of fish, bird, and marine mammal predators in the Columbia River and the ocean, we do not expect that all of the steelhead that are "saved" from predation by pikeminnows survive to adulthood. However, a 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity of steelhead populations, including SRB steelhead.

An average of 37 adult and 197 juvenile steelhead per year were killed and/or handled in the Sport Reward Fishery, system-wide (i.e., in the lower Columbia River and the hydrosystem reach), during 2013–17 (Williams 2013, 2014; Williams et al. 2015, 2016, 2017). Although it was not practical for the field crews to identify these fish to DPS, we assume that some were SRB steelhead.

Non-native fishes such as walleye, smallmouth bass, and channel catfish are present in the slower moving off-channel habitats below Bonneville Dam, but yearling SRB steelhead mostly stay in the mainstem migration channel where they are not likely to encounter large numbers of these species. The Oregon and Washington Departments of Fish and Wildlife have removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids.

2.14.2.9.2 Predation in the Hydrosystem Reach

The following paragraphs describe predation in the mainstem Columbia and Snake Rivers from the tailrace of Bonneville Dam to the upper extent of Lower Granite Reservoir.

<u>Avian Predators</u>

SRB steelhead survival is affected in the mainstem by avian predators that inhabit the dams and reservoirs. The 2008 FCRPS biological opinion required that the Action Agencies implement avian predation control measures to increase survival of juvenile salmonids in the lower Snake and Columbia Rivers through effective monitoring, hazing, and deterrents at each project. All CRS projects have been using several effective strategies including wire arrays that crisscross the tailrace areas, spike strips along the concrete, water sprinklers at juvenile bypass outfalls, pyrotechnics, propane cannons, and limited amounts of lethal take. These efforts have reduced avian predation on juvenile salmon at the dams. Zorich et al. (2012) estimated that, compared to the numbers of smolts consumed at John Day Dam in 2009 and 2010, 84–94 percent fewer smolts were consumed by gulls in 2011. At The Dalles Dam, 81 percent fewer smolts were consumed in 2011 than in 2010. Zorich et al. (2012) attribute the observed changes in predation rates between years to variation in the number of foraging gulls, but imply that deterrence activities provide some (unquantifiable) level of protection.[200]

SRB steelhead are also vulnerable to predation by terns nesting in the interior Columbia plateau, including colonies on islands in McNary Reservoir, in the Hanford Reach, and in Potholes Reservoir. Smolts come within foraging range of other nesting sites on the plateau (principally Blalock Islands in John Day Reservoir) as they continue to migrate downstream. The objective of the IAPMP (USACE 2014) is to reduce predation rates to less than 2 percent per listed ESU/DPS per tern colony per year. The primary management activities have been to keep terns from nesting on Goose Island in Potholes Reservoir (managed by Reclamation) and on Crescent Island in McNary Reservoir (managed by the Corps). Passive dissuasion, hazing, and revegetation have prevented terns from nesting on Crescent Island since 2015, and similar efforts are in progress at Goose Island. However, the number nesting at the Blalock Islands in John Day Reservoir was ten times higher in 2015 than the year before, and resightings of colored leg-banded terns indicated that large numbers had moved there from Crescent Island. Terns also came to the interior plateau from East Sand Island in the estuary, and from alternative Corps-constructed colony sites in southeastern Oregon and northeastern California in 2015 when those areas experienced severe drought (Collis et al. 2016).

In 2017, the goal of the IAPMP to reduce ESU/DPS-specific predation rates to less than 2 percent was achieved at Goose Island for the second consecutive year and at Crescent Island for the third year (Collis et al. 2018). As a result, predation rates on SRB steelhead by Caspian terns have declined from up to 3.9 percent at these sites during the pre-management period to <0.1 percent (Collis et al. 2018; Appendix D).

Gull predation was not considered in the IAPMP and there are no regional plans to manage these colonies. PIT-tag recoveries indicate that predation rates on smolts from this DPS by gulls on Miller Rock Island ranged from 6.7–9.7 percent during 2015–2016 (Roby et al. 2016, 2017).

Pinniped Predators

Pinniped presence in the Bonneville tailrace has increased in the last six years (Tidwell et al. 2017). Steller sea lions in particular aggregate at the base of the dam in the fall when SRB steelhead are present. Between July 21 and December 31, 2017, Tidwell et al. (2018) documented an average of 14.5 Steller sea lions at Bonneville Dam, and during many sampling periods counted more than 20 individuals. A small number of California sea lions have also been observed in Bonneville Reservoir in recent years.

Due to the repeated entry of sea lions into the adult ladders at Bonneville Dam, the Corps began constructing physical exclusion devices in 2006 to block pinnipeds, but allow fish passage.

[200] "For continued protection against avian predation we recommend the current passive deterrents avian lines be maintained and expanded where possible and active deterrents such as hazing from boats or other novel methods continue to be deployed as necessary to minimize foraging by piscivorous birds at the Corps' dams" (Zorich et al. 2012).

These SLEDs are installed at all eight ladder entrances at Bonneville Dam when SRB steelhead are present (Tidwell et al. 2017). In addition, the Corps has installed smaller physical exclusion gratings on the 16 FOGs along the face of Powerhouse 2 that allow fish to enter the collection channel and pass via the Washington shore ladder. The SLEDs and FOGs successfully prevent pinnipeds from entering the adult fish ladders.

Adjusted consumption estimates for all steelhead at Bonneville Dam by pinnipeds is 1.54 percent (Tidwell et al. 2018). Based on the timing of the observations in the study, that number is a reasonable estimate for SRB steelhead.

Fish Predators

Native pikeminnow are significant predators of juvenile salmonids in the hydrosystem reach, followed by non-native smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011, 2015). In addition to the Sport Reward Fishery in the lower Columbia River estuary and throughout the hydrosystem reach, the Action Agencies conduct a Dam Angling Program to remove large pikeminnow from the tailraces of The Dalles and John Day Dams. Angling crews removed an average of 5,913 northern pikeminnow from these two projects per year during 2013–17 (Williams 2013, 2014; Williams et al. 2015, 2016, 2017). They also reported an average of zero adult or juvenile steelhead killed and/or handled per year.

Juvenile salmonids are also consumed by large numbers of non-native fishes, including walleye, smallmouth bass, and channel catfish, in the reservoirs of hydrosystem reach. As described for the lower Columbia River estuary: (1) yearling SRB steelhead mostly stay in the mainstem migration channel and are not likely to encounter large numbers of these species, and (2) both the Oregon and Washington Departments of Fish and Wildlife have removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids.

2.14.2.10 Research and Monitoring Activities

The primary effects of the past and ongoing CRS-related RM&E program on SRB steelhead are associated with the capturing and handling of fish. The RM&E program is a collaborative, regionally coordinated approach to fish and habitat status monitoring, action effectiveness research, critical uncertainty research, and data management. The information derived from the program facilitates effective adaptive management through better understanding the effects of the ongoing CRS action. Capturing, handling, and releasing fish generally leads to stress and other sublethal effects, but fish sometimes die from such treatment. The mechanisms by which these activities affect fish have been well documented and are detailed in Section 8.1.4 of the 2008 biological opinion (NMFS 2008a). Some RM&E actions also involve sacrificial sampling of fish. We estimated the number of SRB steelhead that have been handled or killed each year during implementation of RM&E under the 2008 RPA as the average annual take reported for 2013–17:

- Average annual estimates for handling and mortality of SRB steelhead associated with the Smolt Monitoring Program and the CSS were: (1) one hatchery and two wild adults handled; (2) zero hatchery and zero wild adults died; (3) 12,020 hatchery and 4,750 wild juveniles handled; and (4) 38 hatchery and 15 wild juveniles died.
- The estimated handling and mortality of SRB steelhead associated with the ISEMP Program was: (1) 2,195 hatchery and 2,357 wild adults handled; (2) zero hatchery and zero wild adults died; (3) nine hatchery and 4,081 wild juveniles handled; and (4) one hatchery juveniles and 71 wild juveniles died.
- Estimates for SRB steelhead handling and mortality for all other RM&E programs are as follows: (1) 136 hatchery and 644 wild adults handled; (2) one hatchery and eight wild adults died; (3) 29,353 hatchery and 16,654 wild juveniles handled; and (4) 45 hatchery and 99 wild juveniles died.

The combined observed mortality associated with these elements of the RM&E program has, on average, affected less than 1 percent of the wild (i.e., natural origin) adult run, or juvenile production, of the SRB steelhead DPS (Bellerud 2018). This relatively small effect is deemed worthwhile because it allows the Action Agencies and NMFS to evaluate the effects of CRS operations, including modifications to facilities, operations, and mitigation actions. However, we estimate that more than 1 percent of the wild adults and wild juveniles was handled in the combined RM&E programs. Based on the history of these programs, we assume that up to 1 percent of the handled adults and juveniles (i.e., 0.06 percent of adults and 0.03 percent of juveniles) died after they were released.

In addition, northern pikeminnow are tagged as part of the Sport Reward Fishery and their rate of recapture is used to calculate exploitation rates. Northern pikeminnow are collected for tagging using boat electrofishing in select reaches of the Columbia River. During 2017, boat electrofishing operations in the Columbia River extended upstream from RM 47 (near Clatskanie, Oregon) to RM 394 (Priest Rapids Dam), and in the Snake River from RM 10 (Ice Harbor Dam) to RM 41 (Lower Monumental Dam) and from RM 70 (Little Goose Dam) to RM 156 (upstream of Lower Granite Dam). Researchers conducted four sampling events consisting of 15 minutes of boat electrofishing effort in shallow water within each 0.6-mile reach during April-July.

A side effect of the electrofishing effort is that salmon and steelhead may be exposed to the electrofishing field, with the potential for injury, stress, and fatigue and even cardiac or respiratory failure (Snyder 2003). Some adult and juvenile SRB steelhead are likely to be present in shallow shoreline areas during the April-July time period. Most sampling occurs in darkness (1800-0500 hours). Operators shut off the electrical field if salmonids are seen and because most stunned fish quickly recover and swim away, they cannot be identified to species (i.e., Chinook, coho, chum, sockeye, sockeye, or steelhead). Barr (2018) reported encountering an annual average of 1,762 adult and 92,260 juvenile salmonids in the lower and middle Columbia River each year during 2013-17 electrofishing operations based on visual estimation methods. It is likely that some of these were SRB steelhead.

2.14.2.11 Critical Habitat

The environmental baseline for the PBFs for SRB steelhead critical habitat are reflected in the same impacts discussed above (e.g., mainstem flows, passage, water quality, predation, etc.) and summarized here in Table 2.14-7. Across the entire action area, widespread development and other land use activities have disrupted watershed processes (e.g., erosion and sediment transport, storage and routing of water, plant growth and successional processes, input of nutrients and thermal energy, nutrient cycling in the aquatic food web, etc.), reduced water quality, and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and/or current land use or water management activities have adversely affected the quality and quantity of stream and side channel areas (e.g., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for steelhead production have been weakened.

Within estuaries, essential PBFs have been defined as “areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation” (NMFS 2008b).

Habitat quality in tributary streams in the Interior Columbia recovery domain varies from excellent in wilderness and roadless areas to poor in areas subject to heavy agricultural and urban development. Critical habitat throughout much of the Interior Columbia recovery domain has been degraded by intense agriculture, alteration of stream morphology (i.e., through channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining, and urbanization. Reduced summer stream flows, impaired water quality, and reduction of habitat complexity are common problems for critical habitat in developed areas, including those within the interior Columbia River recovery domain (NMFS 2016e).

The general effects of mainstem and tributary dams on the functioning of critical habitat include:

- Lost access to historical spawning areas behind dams built without fish passage facilities (safe passage in the migration corridor);
- Decreased juvenile and adult passage survival at dams with passage facilities (reduced safe passage in the migration corridor);

- Changes to water quantity (i.e., flow) and seasonal timing (water quantity and velocity, cover/shelter, food/prey, riparian vegetation, and space in rearing areas, including the estuarine floodplain, and migration corridors);
- Changes in temperature, both in the reaches below the large mainstem storage projects and in rearing areas and migration corridors (water quality and safe passage in the migration corridor);
- Reduced sediment transport and turbidity (water quality and safe passage in the migration corridor);
- Increased total dissolved gas (water quality and safe passage in the migration corridor); and
- Food webs changes, including both predators and prey (food/prey and safe passage in rearing areas and migration corridors).

Habitat quality of migratory corridors in this area have been severely affected by the development and operation of the CRS dams and reservoirs in the mainstem Columbia River, Bureau of Reclamation tributary projects, and privately owned dams in the Snake and Upper Columbia River basins. Hydroelectric development has modified natural flow regimes of the rivers, resulting in warmer late summer/fall water temperatures, changes in fish community structure that lead to increased rates of piscivorous and avian predation on juvenile salmon and steelhead, and delayed migration for both adult and juvenile salmonids. Physical features of dams, such as turbines, also kill out-migrating fish. In-river survival is inversely related to the number of hydropower projects encountered by emigrating juveniles. Additionally, development and operation of extensive irrigation systems and dams for water withdrawal and storage in tributaries have altered hydrological cycles (NMFS 2016e).

Many stream reaches designated as critical habitat are listed on Oregon, Washington, and Idaho Clean Water Act Section 303(d) lists for water temperature. Many areas that were historically suitable rearing and spawning habitat are now unsuitable due to high summer stream temperatures. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water for agricultural or municipal use all contribute to elevated stream temperatures. Furthermore, contaminants, such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste, are common in some areas of critical habitat (NMFS 2016e). They can negatively impact critical habitat and the organisms associated with these areas.

The large numbers of avian predators nesting on man-made or enhanced structures (dredge material deposits that created Rice Island and increased the size of East Sand Island in the lower Columbia River, as well as bridges, aids to navigation, and transmission towers) constitute unnaturally high predation in the lower Snake and Columbia River portions of the juvenile migration corridor. Similarly, sea-lion predation on adult SRB steelhead in the tailrace of Bonneville Dam is excessive predation associated with a man-made structure. Predation associated with sea lions in the estuary is a natural phenomenon and is not unnaturally high predation in the context of an effect on the functioning of critical habitat.

In the mainstem of the Columbia and Snake Rivers, the altered habitats in project reservoirs reduce smolt migration rates and create more favorable habitat conditions for fish predators, including native northern pikeminnow and nonnative walleye and smallmouth bass. The effects of the non-native species and pikeminnows, to the extent the latter's predation rates are enhanced by reservoir and tailrace conditions, are also examples of excessive predation in the juvenile migration corridor.

Restoration activities addressing habitat quality and complexity, migration barriers, and water quality have improved the baseline condition for PBFs; however, the conservation role of critical habitat is to provide PBFs that support populations that can contribute to conservation of the DPS. More restoration is needed before the PBFs can fully support the conservation of SRB steelhead.

Table 2.14-8. Physical and biological features of designated critical habitat for SRB steelhead.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBF
Freshwater spawning sites	Water quantity and quality and substrate to support spawning, incubation, and larval development	● Reduced stream complexity and channel structure (loss of substrate, natural cover, vegetation, and forage) ● Degraded riparian condition (elevated temperatures; loss of natural cover, side channels, vegetation, and forage) ● Diminished stream flow (degraded water quantity, elevated temperatures, loss of juvenile and adult mobility) ● Impaired fish passage (obstructions, water withdrawals) ● Excess fine sediment in spawning gravel (degraded water quantity) ● Reduced floodplain condition and connectivity (loss of side channels, natural cover, vegetation)
Freshwater rearing sites	Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility, water quality and forage, natural cover	● Impaired fish passage (obstructions, water withdrawals) ● Reduced riparian function (urban and rural development, forest and agricultural practices, channel manipulations) ● Elevated water temperatures and toxics accumulations (water withdrawals, urban and rural development, forest and agricultural practices) ● Reduced floodplain condition and connectivity (loss of side channels, natural cover, vegetation, and forage)

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBF
Freshwater migration corridors	Free of obstruction and excessive predation, Adequate water quality and quantity and natural cover	● Delay and mortality of some juveniles and adults at eight mainstem dams ● Concerns about increased opportunities for predators, especially birds and pinnipeds (construction of dredge material islands in the lower river and other human-built structures used by terns and cormorants for nesting)
Estuarine areas	Free of obstruction and excessive predation with water quality, quantity and salinity, natural cover, juvenile and adult forage	● Disconnection of much of the historical tidally influenced wetlands and riverine floodplain below Bonneville Dam (reduced water quantity, natural cover, side channels, and forage) and the presence of toxic contaminants (reduced water quality and forage).
Nearshore marine areas[1]	Free of obstruction and excessive predation with water quality, quantity and forage	● Concerns about increased opportunities for pinniped predators, adequate forage.

2.14.2.12 Future Anticipated Impacts of Completed Federal Formal Consultations

The environmental baseline also includes the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, including the consultation on the operation and maintenance of the Bureau of Reclamation's upper Snake River projects. The 2016 five-year review evaluated new information regarding the status and trends of SRB steelhead, including recent biological opinions issued for the SRB steelhead, and key emergent or ongoing habitat concerns (NMFS 2016e). Since the beginning of 2015 through 2017, we completed 549 formal consultations (158 in 2015, 179 in 2016 and 212 in 2017) that addressed effects to SRB steelhead (PCTS data query July 31, 2018). These numbers do not include the many projects implemented under programmatic consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed salmonids. Some of the completed consultations are large (large action area, multiple species), such as the Mitchell Act consultation, the consultation on the operation and maintenance of the Bureau of Reclamation's upper Snake River projects, and the consultation on the 2018–2027 *U.S. v Oregon* Management Agreement. Many of the completed actions are for a single activity within a single subbasin.

Some of the projects will improve access to blocked habitat and riparian condition, and increase channel complexity and instream flows. For example, under BPA's Habitat Improvement Programmatic consultation, BPA implemented 29 projects in the Columbia River basin that improved fish passage in 2017, and 99 projects that involved river, stream, floodplain, and wetland restoration. These projects will benefit the viability of the affected populations by improving abundance, productivity, and spatial structure. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more, and typically less, than a few weeks).

Other types of federal projects, including grazing allotments, dock and pier construction, and bank stabilization will be neutral or have short- or even long-term adverse effects on viability. All of these actions have undergone section 7 consultation and the actions or the RPA were found to meet the ESA standards for avoiding jeopardy.

Consultations on flow management and irrigation projects typically minimize or avoid negative impacts associated with water use and water management. The estimated effects of water management actions in the Columbia River basin upstream of Bonneville Dam are expected to continue.

Similarly, future federal restoration projects will improve the functioning of the PBFs safe passage, spawning gravel, substrate, water quantity, water quality, cover/shelter, food, and riparian vegetation. Projects implemented for other purposes will be neutral or have short- or even long-term adverse effects on some of these same PBFs. However, all of these actions, including any RPAs, have undergone section 7 consultation and were found to meet the ESA standards for avoiding adverse modification of critical habitat.

2.14.3 Effects of the Action

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

The proposed action is an ongoing action that has been modified over time to reflect capital improvements, as well as changes in operation based on existing conditions and improved information on how CRS operations affect SRB steelhead and other listed species and their critical habitat. The current proposed action includes operational measures (e.g., flood risk management, navigation, fish passage, and hydropower generation) and non-operational measures (e.g., support for conservation hatchery programs, predation management, habitat improvement actions) that will be implemented beginning in 2019. The proposed action, however, is of limited duration. The Action Agencies are developing an EIS in accordance with the NEPA that will assess and update the approach for long-term system operations, maintenance, and configuration, as well as evaluate measures to avoid, offset, or minimize impacts to resources affected by the management of the hydrosystem, including ESA-listed species and designated critical habitat. A court order currently requires the Action Agencies to issue a final EIS on or before March 26, 2021 and to issue Records of Decision on or before September 24, 2021.[201] Based on scoping, the range of alternatives being examined is

[201] *The Presidential Memorandum on Promoting the Reliable Supply and Delivery of Water in the West*, issued on October 19, 2018, required the development of an expedited schedule for completion of the NEPA process. The Council on Environmental Quality has confirmed a revised schedule that calls for completing the Draft EIS in February 2020, the Final EIS in June 2020 and Records of Decision by September 30, 2020. These dates are consistent with, but earlier than, the court-ordered deadlines.

broad and includes potential large-scale changes in the action. Thus, there is substantial uncertainty regarding what system operations, maintenance, and configuration the Action Agencies will propose at the conclusion of the NEPA process. Likewise, it is unknown what measures intended to avoid, offset, or minimize adverse effects will be included in the final preferred alternative.

Accordingly, our analysis of effects for SRB steelhead and their critical habitat extends from 2019 into the future, but emphasizes the evaluation of effects that are reasonably certain to occur as a result of implementing the proposed action pending completion of the EIS and our issuance of a subsequent biological opinion addressing the effects of the final preferred alternative. To the extent our consideration of potential effects beyond that time period assumes the current proposed action remains in place, it is intended, in part, to inform the evaluation of alternatives in the EIS.

The effects of the proposed action for SRB steelhead are generally consistent with the effects caused by a continuation of the CRS operations as described in the environmental baseline section, with the exception of the addition of the following:

- Implementation of the flexible spring spill operation;
- 0.5-ft increase in operating range at John Day Dam and lower Snake River reservoirs;
- The potential for reduction of spill at mainstem projects (August 15 to 31) in 2020 pending consensus among parties
- Targeting April 24 as the transport start date (collection on April 23) at Snake River collector projects.
- Cessation of juvenile transport from June 21 to August 4, starting in 2020.

2.14.3.1 Effects to Species

The Action Agencies will continue to operate the run-of-river lower Snake River and Columbia River CRS projects in accordance with the annual Water Management Plan and Fish Passage Plan (including all appendices). These projects are operated for multiple purposes, including fish and wildlife conservation, irrigation, navigation, power, recreation, and, in the case of John Day Dam, limited flood risk management.

The Action Agencies propose to increase spill at the lower Columbia River and lower Snake River dams during the spring spill period in an effort to improve juvenile survival through the dams (and improve adult returns). The Action Agencies propose to implement the flexible spring spill operation which utilizes 16 hours of gas cap spill per day, and 8 hours of performance spill per day. Performance spill was developed using a combination of 2008 FCRPS biological opinion prescribed spill and performance standard testing guidelines, and gas cap spill uses spill up to state water quality standards with some restrictions for erosion concerns and powerhouse minimums.

System-wide water management operations involving upstream water storage projects will continue under the proposed action. Thus, the seasonal alterations described in the environmental baseline will continue (decreased spring and early summer flows, increased winter flows) to affect the mainstem migration and rearing corridor, estuary, and plume. The effects of these flows on the physical environment and to SRB steelhead juveniles and adults are discussed below.

2.14.3.1.1 Water Quality

The existence and operation of the federal hydrosystem will continue to affect water quality parameters in the mainstem migration corridor, as described in the environmental baseline. This includes delayed spring warming, delayed fall cooling, reduced temperature variability on a daily basis due to the thermal inertia of the reservoirs, and the continued releases of cool water from storage at Dworshak Dam to moderate lower Snake River water temperatures from June through September.

TDG levels will continue to exceed the state-approved standards whenever high flows, or lack of load, result in lack of market or lack of turbine capacity spill. These events will continue to occur most frequently in May and June, but may also occur in other months.

The available information indicates that supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). The proposed flexible spill operation (up to 120 or 125 percent TDG) would increase the exposure of spring migrating juveniles to elevated TDG levels from the tailrace of Lower Granite Dam to at least 35 miles downstream of Bonneville Dam. Individuals from all populations and MPGs would be exposed similarly. Smolts typically migrate at depths which effectively reduce TDG exposure due to pressure compensation mechanisms (Weitkamp et al. 2003). However, the proposed flexible spill operation would likely result in a slight increase in the incidence and severity of GBT symptoms and a very small (not measurable through reach survival studies) increase in mortality.

Adult SRB steelhead typically migrate between Bonneville and Lower Granite Dam during the late summer and fall. About 2.1 percent of the DPS (4.0 percent of the unclipped wild steelhead) hold up in the larger rivers over the winter, and then continue upstream through the mainstem dams in the spring. Thus, only a small portion of the DPS (approximately 2 to 4 percent of overwintering adults on average) would be exposed to the increased spill associated with the flexible spill operation. Adults also migrate at depths which reduce the effective exposure to TDG through depth compensation mechanisms. The proposed flexible spill operation would likely result in a slight increase in the incidence and severity of GBT symptoms and a very small (not measurable) increase in mortality.

The Action Agencies also propose to continue using best management practices to reduce and minimize the effects of oil and grease spills. These actions should result in continued reductions in contaminants, as described in the environmental baseline.

2.14.3.1.2 Sediment Transport

The existence and operation of the federal hydrosystem will continue to affect sediment transport, as described in the environmental baseline. These dams will continue to trap sediment and increase water transparency, especially during the spring freshet, which hypothetically increases the exposure of SRB steelhead juveniles to predators and results in higher mortality rates than would be the case in a system with normative flows.

2.14.3.1.3 Adult Migration/Survival

Average adult survival rates through the lower Columbia River and Snake River dams, as described in the environmental baseline, are expected to continue as a result of the proposed action because very few adults from all populations are in the rivers before June 20 (very low exposure). Thus, only a very small proportion of the migrating adults will experience tailrace conditions influenced by the increased spill levels during the flexible spring spill operation. Keefer et al. (2016) estimated that mean annual fallback rates were about 6 to 9 percent at the lower Columbia River dams, and 3 to 6 percent at the lower Snake River dams. Fallback rates, which are associated at many dams with higher spill levels, will likely increase slightly at several of the eight mainstem dams, but this effect will be small because few adult SRB steelhead will be present. Adaptive, in-season management will be used to identify and remedy any excessive fallback, a process the regional managers have used to address passage delays at Little Goose Dam in recent years. Thus the average survival for SRB steelhead is expected to continue to average about 94 percent in the Bonneville to McNary Dam reach and 87 percent in the Bonneville to Lower Granite reach. In addition, the Action Agencies will continue to handle hundreds of adult SRB steelhead at Lower Granite Dam during any emergency trapping operation for SR sockeye salmon. We expect that less than one percent of the steelhead run will be handled in a given year with no more than ten mortalities.

Upstream travel times are highly variable for adult steelhead, which alter their behavior in response to temperature conditions, and potentially other environmental cues. Individuals can take from less than two weeks to many months to migrate from Bonneville to Lower Granite Dam, sometimes holding in cool-water refuges or overwintering. Increasing the operating range by 6 inches at the lower Snake River dams (MOP 1.5-foot range) and at John Day Dam (MIP 2-foot range) will have relatively little effect on travel time, and thus is not expected to measurably affect adult migration timing or survival rates.

Each turbine unit at Dworshak Dam (DWR) requires annual preventative maintenance to maintain operational condition. The annual maintenance period is September 15 through the end of February to coincide with the refill period after summer flow augmentation and before flood control operations begin. Annual maintenance is typically performed one unit at a time and requires the unit out of service for 2–6 weeks. During the annual maintenance period, adult steelhead from the Clearwater population are present in the tailrace at DWR, and mortalities associated with maintenance operations have been documented. Approximately 200 dead steelhead were observed in 2016. Improvements to the protocol have reduced mortality to less than 10 fish per year in 2017 and 2018. Renholds et al. (2019) provides documentation on the mechanism for the mortality events and investigates simple but effective solutions for physical screening systems that are expected to prevent mortality in the future.

CRS related mortality of downstream migrating kelts (SR, UCR, MCR and LCR steelhead) is not well known at this time. Colotelo et al. (2013) estimated that in 2012 only 40.2 and 44.8 percent of Snake River steelhead kelts survived from the Lower Granite forebay to the Lower Columbia River (RM156) and the Bonneville dam face (RM 234), respectively, and only 60.4 and 67.3 percent survived from the McNary forebay to the Lower Columbia River (RM156) and Bonneville dam face, respectively. It is important to note that in this study, only fair and good condition kelts were selected for tagging, and these survival rates cannot be applied to poor condition kelts. In a similar study conducted by Harnish et al. 2014, the survival of steelhead kelt through the four Snake River dams averaged 77 percent in 2012 and 49 percent in 2013.

Based on this limited information, the best estimate for incidental take of downstream migrating kelts is up to 60 percent of migrating kelts arriving at Lower Granite dam. These data represents total mortality to outmigrating SR steelhead kelts and does not distinguish between mortality caused by factors in the environmental baseline or the effects of the CRS. It is not technically possible to provide separate estimates of these components. Estimates of "natural" mortality rates for these fish are not available, but are thought to be high which have typically gone many months without feeding while expending considerable energy migrating and spawning.

2.14.3.1.4 Juvenile Migration/Survival

The Action Agencies propose to continue to provide beneficial spill (conventional and surface passage), juvenile bypass system, and other operations for juvenile passage described in the environmental baseline. Increased spill levels during the flexible spring spill operation will have little effect on tailrace conditions at Bonneville, The Dalles, or McNary Dams or the Snake River dams, but could cause small eddies to form at John Day Dam under low flow conditions. The latter would be likely to reduce survival of juvenile steelhead passing through the spillway by a small amount. But overall, increased spill levels at the eight mainstem dams would generally be expected to slightly increase the survival rates of inriver migrating smolts.[202]

At this time, we predict that increasing the operating range by 6 inches at the four lower Snake River dams and John Day Dam combined with increased spill resulting from the flexible spill operation (up to 120 percent TDG level) is expected to reduce travel time by 9.7 hours on average.

Transportation

SR steelhead smolts will continue to be collected for transport at the three Snake River collector projects as a result of the proposed action. Overall, transport rates may be reduced slightly, but

[202] Pending agreement among the regional parties, summer spill levels at the Snake River and lower Columbia River dams could be reduced in late August. However, juvenile SRB steelhead migrate to below Bonneville Dam in April and May and therefore will not be affected by the proposed changes in summer spill operations.

should remain within the range observed from 2008 to 2017. Starting transport on April 24 should result in higher transport rates, but increased spill levels at the collector projects as a result of the proposed flexible spring spill (up to 120 or 125 percent TDG level) operation will likely reduce transport rates, especially in the low to medium flow years. Should transport to in-river survival ratios (as described in the environmental baseline) continue, a slight decrease in transport rates resulting from increased spill at the three collector projects would, on average, result in a slight reduction in adult returns. Should the CSS hypothesis prove true, reducing transportation rates could potentially result in higher adult returns, at least at some times during the spring migration period.

The proposed cessation of transport operations in 2020 would have no effect on juvenile SRB steelhead, which migrate earlier during the spring spill period.

COMPASS Model Results

The COMPASS model, developed by NMFS' NWFSC (Zabel et al. 2008), is a tool for comparatively assessing the likely effect of alternative hydropower structures and/or operations on the passage and survival of juvenile yearling Chinook salmon and steelhead smolts migrating through the lower Snake and Columbia Rivers. Information from both PIT-tag (detection efficiencies and project and reach survival estimates) and acoustic-tag (route-specific passage and survival estimates and dam survival estimates) are used to calibrate the model.

For juvenile SRB steelhead, COMPASS estimates that the increased spill levels at the lower Snake and Columbia River dams resulting from the proposed flexible spring spill operation (up to 120 percent TDG) and increase pool elevations at the Snake River projects and John Day Dam will, compared to operations under the environmental baseline, on average:

1. Reduce average juvenile travel time from Lower Granite tailrace to Bonneville Dam tailrace by about 0.4 days to 15.2 days;
2. Increase average juvenile survival from the head of Lower Granite pool to Bonneville Dam tailrace by about 0.4 percent to 48.4 percent;
3. Decrease the proportion of juveniles approaching Lower Granite Dam that are destined for transport by about 10.2 percent to 30.7 percent; and
4. Increase the average number of spill passage events (the inverse of the CSS's PITph metric) by 0.5 (difference between 6.2 – 6.7) out of eight total dams (Lower Granite to Bonneville).

These modeling results support our qualitative expectations that passage conditions and juvenile survival rates of inriver migrating smolts from the lower Snake River to below Bonneville Dam would improve slightly as a result of the proposed flexible spring spill. However, reducing transport rates, especially in May and June, would be expected to reduce SARs because the SARs of transported fish are typically higher than those of in-river migrants during this period. The CSS hypothesizes (for SR spring-summer Chinook salmon) that higher spill reduces latent mortality by reducing the number of powerhouse encounters and estimates that 120/115 percent spill limits (24 hours per day) will reduce latent mortality by about 23 percent compared to "BiOp spill." If this proves to be true for SRB steelhead as well, an increase in adult returns is also possible. The net effect of these factors across the outmigration period is unknown.

2.14.3.1.5 Estuary Habitat

The Action Agencies will continue to implement the CEERP (Ebberts et al. 2018; BPA and USACE 2018). Program goals are to increase the capacity and quality of estuarine ecosystems and to improve access to these resources for juvenile salmonids. Floodplain reconnections are expected to continue to increase the production and availability of commonly consumed prey (chironomid insects and corophiid amphipods; PNNL and NMFS 2018) to SRB steelhead as they migrate through the estuary.

NMFS agrees with ISAB's assessment finding (ISAB 2014) that it has been difficult to quantify the survival benefits of estuary habitat restoration, but the Action Agencies' assessment method, including review by the ERTG,[203] is useful to prioritize projects. For the interim period, the Action Agencies' proposed commitment is to reconnect an average of 300 acres of floodplain per year, a goal that they have a record of meeting in 2008-17 (BPA et al. 2018b), rather than to achieve a specific survival improvement. NMFS also agrees with the ISAB that the Action Agencies' assessment method, including review by the ERTG (Krueger et al. 2017), remains useful for prioritizing projects and for optimizing project design (number of breaches and channels, etc.) to site conditions. Thus, NMFS expects that the proposed implementation of the estuary program during the interim period will continue to partially mitigate for effects flow management that, combined with dikes and levees, have cut much of the floodplain off from the mainstem river. The trend of increasing connected area (Johnson et al. 2018) is expected to continue during the interim period, providing benefits (flux of insect and amphipod prey to the mainstem migration corridor) to juvenile SRB steelhead. It is also likely that benefits will increase as habitat quality matures. Preliminary data indicate that some of these smolts are feeding and actively growing as they migrate between Bonneville Dam and the ocean (Beckman et al. 2018).

The Action Agencies also propose continued implementation of their monitoring program, the component of CEERP that provides the basis for adaptive management of the restoration program. This includes action effectiveness monitoring at each restoration site. A set of "standard" indicators (photo points, water surface elevation, and salinity) are measured at all sites (Level 3); core indicators (plant species composition, percent cover, and biomass) are measured at a subset of the sites (Level 2); and intensive indicators (juvenile salmonid species composition, density, diet, and growth, along with structures and controlling factors) are

[203] As part of the estuary program's adaptive management framework, the Action Agencies will continue to discuss with ERTG and regional partners relevant climate change science in an effort to understand whether their planned estuary projects are resilient to climate change (i.e., sea level rise, temperatures, and mainstem flow levels). In addition, the Action Agencies' annual update of their restoration and monitoring plans for the estuary will document any needed adjustments in design, location, or other elements of a given project to address climate change impacts, both during and beyond the interim period.

measured at a smaller number of sites (Level 1; Johnson et al. 2018). Monitoring will continue at recently built sites and will be initiated for sites constructed during the interim period. Johnson et al. (2018) evaluated the action effectiveness monitoring data collected since 2012 and found they generally indicated that the restoration of physical and biological processes was underway. Continued implementation and evaluation of this monitoring program either will confirm that these floodplain reconnections are enhancing conditions for yearling salmonids, such as SRB steelhead as they migrate through the mainstem, or provide sufficient information to the Action Agencies that site selection or project design will improve through adaptive management.

2.14.3.1.6 Tributary Habitat

For the SRB steelhead DPS, the Action Agencies will implement habitat improvements to achieve the MPG-level metrics outlined in Table 2.14-9. These habitat improvement actions will be implemented in two of the five MPGs: Clearwater River and Salmon River. Actions will be strategically identified, prioritized, and implemented to ameliorate specific limiting factors in specific populations, and will accomplish specific metrics defined for each MPG. The habitat actions that produce these metrics will be completed or in process before completion of the Action Agencies' NEPA process. In addition, actions implemented to benefit SR spring/summer Chinook in the Grande Ronde/Imnaha and Lower Snake MPGs of that ESU, as described below in Section 2.15.3.1.7, would also likely benefit SR steelhead, depending on action type and the extent to which steelhead occupy the habitat being targeted.

The Action Agencies determined this commitment is feasible based on performance and accomplishments under the 2008 FCRPS biological opinion. In addition, the Action Agencies have committed to continuing to improve the strategic implementation of the program, to convene a tributary habitat program steering committee, to report on implementation using metrics that will allow NMFS to evaluate implementation of the program, and to conduct RM&E to assess tributary habitat conditions, limiting factors, and action effectiveness, and to inform associated critical uncertainties.

Table 2.14-9. Proposed tributary habitat metrics (2019–21) for major population groups in the Snake River Steelhead DPS.

Snake River Steelhead DPS Major Population Group	Habitat Improvement Actions[1]					
	Flow Protected (CFS)	Flow Enhanced (Acre feet)	Entrainment Screening (# screens)	Habitat Access (Miles)	Stream Complexity (Miles)	Riparian Habitat Improved (Acres)
Clearwater River	0	0	0	10	0	138
Salmon River	28	3,004	0	8	0	27
Snake River Basin Steelhead DPS Totals[2]	28	3,004	0	18	0	165

[1]The habitat actions that produce these metrics will be completed or in process by the end of the biological opinion period.

[2]The Action Agencies may use surpluses within an MPG from one metric category to augment other metric categories where the biological benefits are comparable.

For an overview of how NMFS analyzed the effects of tributary habitat improvement actions for this biological opinion, see Appendix A. In brief, we reviewed and re-affirmed the strong technical foundation for the tributary habitat program (i.e., that strategically implementing actions to alleviate the factors that limit the function of tributary habitat will improve habitat function and, ultimately, the freshwater survival of salmon and steelhead). We evaluated new RM&E information and found that it also supported the foundation and goals of the program. We determined that the methods we were using to evaluate the effects of tributary habitat actions were based on best available science, as described in Appendix A. For steelhead, we evaluated the effects of those actions qualitatively within the context of our understanding of limiting factors, the effects of the types of habitat improvement actions being proposed, population extinction risk, habitat improvement potential, and our ESA recovery plan framework. Life-cycle models for SRB steelhead are in development and were not used for this analysis; however, we expect to be able to use them to evaluate habitat actions implemented during the term of this biological opinion as part of the baseline for the next CRS biological opinion. We considered short-term negative effects that could result from implementation of habitat improvement actions. We also considered certainty of implementation and effects, as well as the strategic framework within which the Action Agencies were committing to implement the program. In addition, we considered the adequacy of the RM&E and adaptive management framework that is proposed to guide and refine implementation of the habitat improvement actions and inform our understanding of their effects, and the adequacy of the proposed reporting on actions implemented.

Our assessments are described below by MPG, followed by a DPS-level summary.

Salmon River MPG

In this MPG, the Action Agencies have committed to continuing to implement actions to protect and enhance flow, improve habitat access, and improve riparian habitat. Limiting factors in this MPG include reduced flows, passage barriers, and reduced riparian function (see Section 2.14.2.7.1), so these actions would be targeted at addressing identified limiting factors. Effects of these types of actions, and the time frame in which effects would be expected to accrue, are summarized in Table 2.14-10. In general, these actions will have a long-term benefit to SRB steelhead, although the benefit for actions implemented during the interim period pending completion of the NEPA process will be small. The positive changes noted in the table below may contribute to improvements in all four VSP parameters for the targeted populations.[204] (For additional information on action effectiveness, see Appendix A).

Table 2.14-10. Effects and timing of effects of proposed tributary habitat improvement actions for SRB steelhead.

Action Type	Effects of action and timing of effects
Flow protection and enhancement	Reduced flows can affect adult and juvenile salmonids by blocking fish migration, stranding fish, reducing rearing habitat availability, and increasing summer water temperatures (NMFS 2017e). Flow protection or enhancement reduces these impacts, and the literature shows an obvious and clear relationship between increased flows and increases in fish and macroinvertebrate production (Hillman et al. 2016). The response is most dramatic in stream reaches that were previously dewatered or too warm to support fish because of water withdrawals, and the most successful projects are those in which acquired flows are held in trust long term or in perpetuity (Sabaton et al. 2008; Roni et al. 2014). Studies of fish movements following increases in instream flows show rapid fish colonization of newly accessible habitats and the success of these projects (Roni et al. 2008) For example, ongoing studies in the Lemhi River show increased spawner and juvenile abundance of both Chinook salmon and steelhead following enhancement of instream flows in tributaries (Uthe et al. 2017; Appendix A of Griswold and Phillips 2018). The effects of flow augmentation on habitat conditions depend on the amount of flow within the channel and how much water is added. Augmented flow in dewatered channels or streams too warm to support fish will have the greatest effects on habitat condition. In addition, augmenting flood flows can improve floodplain connectivity and off-channel conditions (Hillman et al. 2016).
Improved habitat access	Impaired fish passage can prevent adults from accessing upstream spawning habitat and impede juvenile fish migration. In addition, structures that impede fish passage can disrupt habitat-forming processes related to flow, sediment transport, and large wood (NMFS 2013b, 2017e). Improving fish passage through actions that replace, improve, or remove culverts, dams, and other migration barriers, or that provide fish passage structures, can provide access to previously inaccessible spawning and rearing habitat. In addition, removing barriers can enhance habitat-forming processes related to flow, sediment transport, and movement of large wood and contribute to improvements in stream morphology, substrate, connectivity, stream flow, and stream temperature (NMFS 2013b; Hillman et al. 2016). Studies evaluating the effectiveness of projects that

[204] In most cases, near-term benefits would be expected in abundance and productivity. Depending on the population and the scale and type of action, benefits to spatial structure and diversity might also accrue, either in the near term or over time. In addition, while we expect abundance, productivity, spatial structure, and diversity to respond positively to strategically implemented tributary habitat improvement actions, other factors also influence these viability parameters (e.g., ocean conditions) and any resulting trends. Throughout this tributary habitat discussion, when we discuss improvements in abundance and productivity, it is implied that spatial structure and diversity might also respond positively, and that other factors, as noted here, might influence any resulting trends.

Action Type	Effects of action and timing of effects
	have removed impassable culverts/dams, or have installed fish passage structures in North America and elsewhere, including in the Columbia River basin, have consistently shown rapid colonization by fishes; some studies have also documented the physical impacts of barrier removal on sediment and channel changes (Hillman et al. 2016). The rate at which salmon and trout recolonize habitats following barrier removal is highly dependent on the amount and quality of habitat upstream of the barrier and the size of the downstream or nearby source population (number of salmon or trout returning that could colonize) (Hillman et al. 2016).
Riparian Habitat Improvement	Riparian vegetation provides numerous functions including shading, stabilizing streambanks, controlling sediments, contributing large wood, and regulating the flow of nutrients. Riparian habitat improvement through riparian planting and silvicultural treatment, invasive species control, and riparian fencing and grazing management can lead to increased shade, bank stability, reduction of fine sediment, reduced temperatures, and improvement of water quality (Roni et al. 2014; Hillman et al. 2016; NMFS 2017e). Benefits of riparian planning actions take more than 50 years to fully accrue, although some benefits begin to accrue after five to fifteen years (Justice et al. 2017; Pess and Jordan et al. in press). Few studies have examined the response of instream habitat or fish to riparian planting or thinning, in part because of the long lag time between tree growth and any change in channel conditions or delivery of large wood. However, a retrospective study (Lennox et al. 2011) found that project age was positively correlated with both riparian vegetation and instream anadromous fish habitat at revegetated sites. Modeling work in the Grande Ronde indicates that riparian enhancement action should reduce water temperatures and increase juvenile's salmonid abundance up to 377 percent in the Upper Grande Ronde and 61 percent in Catherine Creek (McCullough et al. 2016). Justice et al. (2017) utilized a stream temperature model to explore potential benefits of channel and riparian restoration on stream temperatures in the Upper Grande Ronde River and Catherine Creek Basins in Oregon. They focused on streams that had been degraded by intensive land use leading to reduced riparian vegetation and widened channels and concluded that restoration of such streams could more than make up for expected increase in summer stream temperature through 2080. Studies of fish response to livestock exclusion projects have shown variable results. Some have shown increases in salmonid abundance while others have shown no response. Those showing no response were linked to short duration of monitoring, small size of enclosures, and upstream habitat processes that limited habitat conditions in the project area (Hillman et al. 2016).

Potential for improvement in habitat productivity varies among populations in this MPG. As noted above, actions will be strategically identified, prioritized, and implemented to ameliorate specific limiting factors in specific populations. Actions implemented to ameliorate limiting factors for any population in the MPG would provide localized habitat benefits and potential improvements in abundance and productivity for the targeted population. To the extent that actions are implemented consistent with best available science and modeling information about the value (in terms of increased biological benefit) to be gained from implementing the appropriate actions in the appropriate location and at the appropriate scale, benefits would be enhanced (Appendix A; also see Hillman et al. 2016; Pess and Jordan et al. in press).[205]

In terms of extent, benefits to habitat and populations in this MPG as a result of tributary habitat improvement actions implemented during the interim period pending completion of the NEPA process, are likely to be small. In almost all cases, we would not expect implementation of habitat actions for only a few years to yield significant improvements, because it is not feasible to implement actions of sufficient scope and scale in that time frame to yield substantial effects. It is important to put results of the habitat actions to be implemented in the relatively short time frame of the interim period pending completion of the NEPA process into the context of the effects of longer-term implementation of habitat actions.

The Action Agencies have well-developed partnerships with local implementing groups in this MPG. Implementation of habitat actions within this MPG occurs primarily through the Upper Salmon Basin Watershed Program, which includes staff from state, federal, and local natural resource management agencies; more than 75 ranchers in the upper Salmon River basin; private interest groups; and others. This group has created an effective process for working together, providing technical reviews of proposed projects and working with interested parties to accomplish conservation on the ground. It has a strong record of implementing projects that have made contributions to salmon recovery (NMFS 2017g). In collaboration with these local partners, the Action Agencies have used a variety of tools, including the Screening and Habitat Improvement Prioritization for the Upper Salmon Subbasin, to prioritize and select projects. This team also has relied on guiding documents and information, such as the ESA Recovery Plan (NMFS 2017e), tributary assessments, and additional technical analysis to sequence actions and areas to implement habitat actions in priority watersheds within this MPG. This on-the-ground infrastructure, combined with the Action Agencies' commitments to work with NMFS to continue to enhance strategic implementation of the program, provides confidence that appropriate actions will be implemented in appropriate locations.

[205] Ultimately, implementation should be focused where short-term efforts might yield the highest benefit in terms of reducing both short- and long-term risk, reducing climate vulnerability, and moving toward ESA recovery. In conversations with NMFS, the Action Agencies indicated that their tributary habitat focus during the interim period pending completion of the NEPA process was likely to continue to include the Lemhi, Pahsimeroi, and Upper Mainstem Salmon River populations. For ESA recovery, the South Fork Salmon, Lower Middle Fork Salmon, Upper Middle Fork Salmon, Lemhi, Chamberlain Creek, and Panther Creek populations must achieve at least viable status, and the Secesh, Pahsimeroi, East Fork Salmon, Little Salmon, Upper Mainstem Salmon, and North Fork Salmon River populations must achieve maintained status (NMFS 2017e). NMFS' focal population concept (Cooney in press) will further inform decisions about which populations have the highest potential to benefit MPG status in the near term from directed habitat actions. NMFS intends to work with the Action Agencies during implementation of the proposed action to ensure alignment of implementation efforts with focal population priorities to the extent they are not currently aligned. However, due to the limited duration of the proposed action, and the time required to design and implement habitat improvement actions, shifts in focus are not likely to be realized on the ground before completion of the Action Agencies' NEPA process.

Grande Ronde River MPG

The Action Agencies have not proposed tributary habitat improvement actions for implementation specifically in this MPG. However, they have proposed actions to benefit the SR spring/summer Chinook Grande Ronde/Imnaha River MPG, as described below in Section 2.15.3.1.7. Depending on action type and the extent to which steelhead occupy the habitat being targeted for improvement in this area, the actions would also likely benefit steelhead in the Grande Ronde River MPG.

Lower Snake River MPG

The Action Agencies have not proposed tributary habitat improvement actions for implementation specifically in this MPG. However, they have proposed actions to benefit the SR spring/summer Chinook Lower Snake River MPG, as described below in Section 2.15.3.1.7. Depending on action type and the extent to which steelhead occupy the habitat being targeted for improvement in this area, the actions would also likely benefit steelhead in the Lower Snake River MPG.

Clearwater River MPG

In this MPG, the Action Agencies have committed to continuing to implement actions to improve habitat access and riparian habitat. Limiting factors in this MPG include passage obstructions and reduced riparian function (see Section 2.14.2.7.1), so these actions will be targeted toward addressing identified limiting factors. Effects of these types of actions, and the time frame in which effects would be expected to accrue, are summarized above in Table 2.14-11. In general, these actions will have a long-term benefit to SRB steelhead, although the benefit for actions implemented during the interim period pending completion of the NEPA process will be small. The positive changes noted in the table below may contribute to improvements in all four VSP parameters for the targeted populations. (For additional information on action effectiveness, see Appendix A.)

There is potential for improvement in habitat productivity in all populations in this MPG. As noted above, actions will be strategically identified, prioritized, and implemented to ameliorate specific limiting factors in specific populations. Actions implemented to ameliorate limiting factors for any population in the MPG would provide localized habitat benefits and potential improvements in abundance and productivity for the targeted population. To the extent that actions are implemented consistent with best available science and modeling information about the value (in terms of increased biological benefit) to be gained from implementing the appropriate actions in the appropriate location and at the appropriate scale, benefits would be enhanced (Appendix A; also see e.g., Hillman et al. 2016, Pess and Jordan et al. in press).[206]

[206] Ultimately, implementation should be focused where short-term efforts might yield the highest benefit in terms of reducing both short- and long-term risk, reducing climate vulnerability, and moving toward ESA recovery. In conversations with NMFS, the Action Agencies indicated that their tributary habitat focus during the interim period pending completion of the NEPA process was likely to continue to be on populations where they focused effort

In terms of extent, benefits to habitat and populations in this MPG as a result of tributary habitat improvement actions implemented during the interim period pending completion of the NEPA process, are likely to be small. In almost all cases, we would not expect implementation of habitat actions for only a few years to yield significant improvements because it is not feasible to implement actions of sufficient scope and scale in that time frame to yield substantial effects. It is important to put results of the habitat actions to be implemented during the interim period pending completion of the NEPA process into the context of the effects of longer-term implementation of habitat actions.

The Action Agencies have well-developed relationships with state, federal, and tribal implementing partners in the Clearwater River MPG. For example, the Action Agencies have been working with their partners in the Lochsa River subbasin to develop, implement, and adaptively manage a strategic, evidence-based habitat improvement prioritization framework known as Atlas. The Atlas is a multi-criteria decision analysis framework that utilizes the best available empirical fish and habitat data; peer-reviewed, published research evidence; and local knowledge to determine the highest-priority areas and actions for habitat improvement within a watershed, based on widely accepted principles of watershed restoration such as outlined in Beechie et al. 2008, 2010; Roni et al. 2002. The Atlas framework has resulted in the implementation of habitat improvement projects that target high-priority reaches for steelhead. This on-the-ground infrastructure, combined with the Action Agencies commitments to work with NMFS to continue to enhance strategic implementation of the program, provides confidence that appropriate actions will be implemented in appropriate locations.

Imnaha River MPG

The Action Agencies have not proposed tributary habitat improvement actions for implementation in this MPG.

Summary of Effects to Tributary Habitat

Implementation of the proposed tributary habitat actions, if implemented as anticipated, and as described in the proposed action (i.e., consistent with scientifically sound identification and prioritization of limiting factors and geographic locations and principles of watershed restoration), will provide benefits to the targeted populations. These benefits will accrue specifically in two of the five MPGs in this DPS (the Salmon River and Clearwater River MPGs) (i.e., the MPGs where the Action Agencies have proposed to implement actions). In addition,

under the 2008 biological opinion. For this MPG, the Action Agencies implemented actions to benefit all five extant populations, although their efforts were most intensive for the Lochsa, Lolo Creek, and Clearwater populations. Of the five extant populations in this MPG, the recovery plan calls for the Lower Mainstem Clearwater, Selway, and Lochsa populations to achieve at least viable status (NMFS 2017e). NMFS' focal population concept (Cooney in press) will inform decisions about which populations have the highest potential to benefit MPG status in the near term from directed habitat actions. NMFS intends to work with the Action Agencies during implementation of the proposed action to ensure alignment of implementation efforts with focal population priorities to the extent they are not currently aligned. However, due to the interim nature of the proposed action, and the time required to design and implement habitat improvement actions, shifts in focus are not likely to be realized on the ground before completion of the Action Agencies' NEPA process.

while no actions have been proposed specifically for the Grande Ronde and Lower Snake River steelhead MPGs, actions implemented to benefit SR spring/summer Chinook in the Grande Ronde/Imnaha and Lower Snake MPGs of that ESU, as described below in Section 2.15.3.1.7, would also likely benefit SR steelhead in the Grande Ronde and Lower Snake River MPGs, depending on action type and the extent to which steelhead occupy the habitat being targeted.

This biological opinion covers a proposed action with a limited duration and, thus, the improvements from tributary habitat actions will be small, as a large scope and scale of actions are required to achieve significant change at the population level. While it is possible that effects of some actions, such as actions to improve stream flow or remove barriers to passage, could be immediate, for other actions, benefits will take several years to fully accrue (and will take 50 years or more for actions such as restoring riparian areas). In addition, fish response in terms of improved viability will not begin until the progeny of fish spawning in new habitat conditions begin to return, and can only be detected over multiple life cycles. Therefore, it is unlikely that the benefits of these actions will be realized before the Action Agencies complete the NEPA process.

2.14.3.1.7 Kelt Reconditioning Program

Take for the Snake River steelhead kelt reconditioning program at Dworshak NFH is covered under a NMFS (2017f) Biological Opinion for “Nine Snake River Steelhead Hatchery Programs and One Kelt Reconditioning Program in Idaho” (WCR-2017-7286), including the annual collection of 450–700 kelts at Lower Granite Dam and 100 at Dworshak NFH (including associated research and monitoring efforts). Therefore, it is not part of the proposed action.

2.14.3.1.8 Predation Management in the Lower Columbia River Estuary

Avian Predators

The Action Agencies propose continued implementation of the Caspian Tern Nesting Habitat Management Plan (USACE 2015a) and the Double-crested Cormorant Management Plan (USACE 2015b). Tern habitat on East Sand Island will continue to be maintained at no less than one acre for the interim period covered by this consultation. Management actions for double-crested cormorants on East Sand Island will be limited to passive dissuasion and hazing, except that limited egg take (up to 500 eggs) may be requested from USFWS each year to preclude cormorants from nesting in new or different areas on East Sand Island. These ongoing actions are likely to continue current levels of predation by birds nesting on East Sand Island, which in the case of Caspian terns has been shown to be an improvement compared to the pre-colony management period. Due to the dispersal of the colony in 2016 and 2017, predation rates for East Sand Island cormorants are not available for the management period. Monitoring results from 2018, and the data compilation expected in the avian predation-synthesis report, will be needed to confirm the expectation that this program is meeting its management goals.

In addition, the Action Agencies propose to synthesize colony size and predation-rate data collected under the tern and cormorant colony management plans. The intent of the synthesis report is to summarize data on predation by piscivorous waterbirds on ESA-listed salmonids in the Columbia River basin before, during, and after the management actions in order to assess their effectiveness on a basinwide scale. For example, the dispersal of double-crested cormorants from East Sand Island to nest sites on the Astoria-Megler Bridge in recent years, and observations of thousands of Caspian terns roosting on Rice Island in 2017, indicate that the numbers of avian predators in the estuary are still in flux and their effects on the viability of salmonids such as SRB steelhead are variable. The synthesis report will help managers assess whether to recommend that the Action Agencies or other regional parties consider additional measures for implementation over the long term.

Ongoing annual monitoring will include estimates of double-crested cormorant abundance, nesting density, and PIT-tag detection on East Sand Island. The average estimated three-year peak colony size will be used to evaluate management activities relative to plan objectives (2019–21); the management plan will be considered successful when the average three-year peak colony size estimate does not exceed 5,939 nesting pairs while no management actions are conducted. Annual PIT-tag detection will continue for 5–10 years to assess overall trends in predation rates (through the 2023 breeding season, at minimum), accounting for annual variability in predation impacts.

These measures are likely to effectively constrain double-crested cormorant predation on SRB steelhead at Corps-managed sites in the estuary at current levels. The proposed RM&E will provide NMFS and the Action Agencies with the data needed to quantify those levels as management activities continue.

Fish Predators

The Action Agencies will continue to implement the NPMP, including the Sport Reward Fishery in the lower Columbia River estuary, as described under the environmental baseline. We expect that this ongoing measure will continue the 30 percent reduction in predation rates achieved under the 2008 RPA. We estimate that numbers of steelhead, including some from the SRB steelhead DPS, handled and/or killed in the Sport Reward Fishery, system-wide, will be no more than 100 adults and 600 juveniles per year, system-wide, during the interim period.

2.14.3.1.9 Predation Management in the Hydrosystem Reach

Avian Predators

The Corps will continue to implement and improve, as needed, avian predator deterrent programs at lower Columbia River and Snake River dams. At each dam, bird numbers will be monitored, feeding birds will be hazed, and passive predation deterrents, such as irrigation sprinklers and bird wires, will be deployed. Hazing, including launching long-range pyrotechnics at concentrations of feeding birds near the spillway and powerhouse discharge areas and near juvenile bypass outfall areas, will also continue. These measures will continue to reduce predation on juvenile SRB steelhead, although the amount of protection has not been quantified (Zorich et al. 2012).

The Action Agencies propose to continue to address Caspian tern predation at lands that they manage on the interior Columbia plateau: Crescent Island (Corps) and Goose Island (Reclamation). The Corps has excluded tern use on Crescent Island via revegetation since 2015, but will continue to monitor that site to ensure that conditions remain unfavorable for nesting. If tern use does resume during the interim period, the Corps will work with NMFS and USFWS to address concerns, perform any necessary environmental compliance, and seek permits and funding for active hazing, if warranted. If no nesting of concern to the Corps and NMFS is identified, the Corps will discontinue monitoring after three years. These measures are likely to preclude use of Crescent Island by Caspian terns during the interim period of this consultation.

Reclamation has excluded Caspian terns from Goose Island using ropes and flagging, and is currently experimenting with revegetation. They propose to maintain the ropes and flagging and to monitor for tern presence on a regular basis between late February and early July each year. If terns resume nesting, and if the number of terns exceeds metrics identified in the Inland Avian Predation Management Plan (more than 40 nesting pairs on Goose Island or more than 200 pairs at sites across the interior Columbia Basin; USACE 2014), Reclamation will work with NMFS to identify management actions and tools that can be put in place to dissuade tern use of the island before the next nesting season (e.g., permits from USFWS for hazing and egg take). These measures are likely to successfully preclude use of Goose Island by Caspian terns during the interim period of this consultation.

Pinniped Predators

The Corps will continue to install, and improve as needed, sea-lion excluder gates at all adult fish ladder entrances at Bonneville Dam each year. In addition, the Corps and Bonneville will continue to support land and water-based harassment efforts by ODFW, WDFW, and CRITFC to keep sea lions away from the area downstream of Bonneville Dam. The Corps will continue estimating sea lion abundance, spatial distribution, temporal distribution, predation attempts, and predation rates in the Bonneville Dam tailrace annually from early August through May 31. Collection of predation data will occur when sea lion abundance is greater than, or equal to, 20 animals. The Corps will continue to use adaptive management, including recommendations from the Fish Passage Operations and Management Coordination Team and the Sea Lion Task Force, to address changing circumstances as they relate to sea lion harassment efforts and predation monitoring at Bonneville Dam. These ongoing measures are expected to maintain current levels of sea lion predation on SRB steelhead in the Bonneville tailrace at 1.54 percent (Tidwell et al. 2018). If pinnipeds are observed at The Dalles Dam, the Corp may respond with hazing at adult fish ladder entrances.

Fish Predators

The Action Agencies will continue to implement the Northern Pikeminnow Sport Reward Fishery in the hydrosystem reach and the Dam Angling Program at The Dalles and John Day Dams, as described under the environmental baseline. These ongoing measures will continue the reduction in predation rates achieved under the 2008 RPA. We estimate that the 2013-2017 annual average numbers of steelhead, including SR steelhead, which will be handled and/or killed in the in the Sport Reward Fishery will continue as described above (Predation Management in the Lower Columbia River Estuary). In addition, we estimate that no more than ten adult and 20 juvenile steelhead, including some from the SRB steelhead DPS, will be killed and/or handled in the Dam Angling Program per year during the interim period.

2.14.3.1.10 Research and Monitoring Activities

The Action Agencies' RM&E program will be similar to the current program, or will be implemented at a reduced scale. Thus, the level of injury and mortality discussed in the environmental baseline, primarily from the capture and handling of fish, is likely to continue at a similar or reduced level. We estimate that, on average, the following number of SRB steelhead will be affected each year during the interim period:

- Projected estimates of SRB steelhead handling and mortality during activities associated with the Smolt Monitoring Program and CSS: (1) five hatchery and five wild adults handled; (2) zero hatchery or wild adults killed; (3) 37,883 hatchery and 28,279 wild juveniles handled; and (4) 611 hatchery and 855 wild juveniles killed.
- Projected estimates of SRB steelhead handling and mortality during activities associated with Fish Status Monitoring:[207] (1) 23,371 hatchery and 11,479 wild adults handled; (2) 234 hatchery and 115 wild adults killed; (3) 22,103 hatchery and 45,762 wild juveniles handled; and (4) 221 hatchery and 458 wild juveniles killed.
- Projected estimates of SRB steelhead handling and mortality for all other RM&E programs: (1) 1,519 hatchery and 387 wild adults handled; (2) 15 hatchery and four wild adults killed; (3) 303,326 hatchery and 64,356 wild juveniles handled; (4) 3,033 hatchery and 644 wild juveniles killed.

The combined observed mortality associated with these elements of the RM&E program will, on average, affect less than 1 percent of the wild (i.e., natural origin) adult returns or juvenile production for the SRB steelhead DPS (Bellerud 2018). Although we estimate that 22.90 percent of the wild adult run and 20.29 percent of the wild juvenile production will be handled each year, on average, we expect that only up to 1 percent of these will die after release (in this case, 0.23 percent of adults and 0.20 percent of juveniles handled). This relatively small effect is deemed worthwhile because it will allow the Action Agencies and NMFS to continue to evaluate the effects of CRS operations including modifications to facilities, operations, and mitigation actions.

Electrofishing operations for the NPMP during the interim period are expected to continue at the same level of effort as in recent years (four 15-minute sampling events per 0.6-mile reach between RM 47 near Clatskanie, Oregon, and RM 394 on the Columbia River and to RM 156 on the lower Snake River during April-July; a total of 550 hours system-wide). Some adult and

[207] Fish Status Monitoring is intended to include individuals handled/killed during status and trend, "fish-in/fish out," and habitat effectiveness monitoring projects.

juvenile SRB steelhead are likely to be present in shallow shoreline areas during electrofishing activities and may be stunned and even killed. However, because the operator releases the electrical field as soon as salmonids are observed and most of these fish quickly recover and swim away, we are unable to use observations from past operations to estimate the number of fish from this DPS that will be affected. Information obtained through electrofishing supports management of the NPMP, which is reported to have reduced salmonid predation by about 30 percent (Williams et al. 2017). This level of take is anticipated to occur for the duration of this proposed action, pending completion of the NEPA process.

2.14.3.2 Effects to Critical habitat

Implementation of the flexible spring spill operation will affect the freshwater migration corridor for all juvenile SRB steelhead and approximately two percent of adult SRB steelhead (4 percent of adults move through at least one dam during the spring)). Implementation of the proposed action will also affect the volume and timing of flow in the Columbia and Snake Rivers which has the potential to alter habitat in the mainstem and the lower Columbia River estuary. The PBFs that will be affected by the proposed action are described in Table 2.14-11.

Table 2.14-11. Effects of the proposed action on the physical and biological features essential for the conservation of the SRB steelhead DPS.

Physical and Biological Feature (PBF)	Effects of the Proposed Action
Freshwater spawning sites	● The principal effect of habitat improvements in spawning areas used by SR steelhead will be that over 3,000 acre-feet of flow will be enhanced and 165 acres of riparian habit will be improved across subbasins used by SRB steelhead (Clearwater River and Salmon River MPGs) for spawning and rearing. This will improve water quality, floodplain connectivity, and natural cover at the local scale in HUC5 watersheds used for spawning and rearing.
Freshwater migration corridors	● Continuation of altered seasonal flows (decreased spring and early summer flows and increased winter flows) due to system-wide storage operations including those at CRS reservoirs (reduced water quantity in the juvenile migration corridor) ● Continuation of delayed spring warming, delayed fall cooling, and reduced daily temperature variability due to the thermal inertia of the CRS reservoirs (reduced water quality in juvenile and adult migration corridors) ● Continuation of decreased survival through the CRS dams (safe passage) ● The proposed flexible spring spill operation will slightly increase the incidence of adult fallback and will have small effects on juvenile travel time (reduced) and survival (increased) (safe passage) ● Increasing the operating range by 6 inches at lower Snake River dams (MOP 1.5-foot range) and at John Day Dam (MIP 2-foot range) and increasing spill levels under the proposed flexible spill operation will reduce juvenile travel times and exposure to predators (obstructions and excessive predation in juvenile migration corridors) ● Sediment will continue to accumulate behind CRS dams, reducing turbidity in the migration corridor during the spring smolt outmigration, which could

Physical and Biological Feature (PBF)	Effects of the Proposed Action
	affect the safe passage PBF by increasing the risk of predation ● Continuation of current levels of predation with ongoing implementation of the avian and pikeminnow management programs (safe passage) ● Increase in TDG levels up to the state-approved limits (up to 120 or 125 percent TDG) at the CRS run-of-river projects) will result in only a slight increase in the incidence and severity of GBT symptoms (water quality in the juvenile and adult migration corridor)
Estuarine areas	● This PBF will continue to improve with the proposed reconnection of an average of 300 acres of floodplain habitat per year during implementation of this proposed action (increased access to forage) ● Because estuary bird colonies and predation rates are in flux, it is not clear whether tern and cormorant colony management has reduced predation rates. Any existing survival benefits will continue under the proposed action. Thus we expect the predation risk to remain unchanged.

2.14.4 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation (50 CFR 402.02). Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing nonfederal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult, if not impossible, to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the Environmental Baseline (Section 2.4).

Non-federal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. These projects also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth-management programs (planning and regulation); a variety of stream and riparian habitat projects; watershed planning and implementation; acquisition of water rights for instream purposes and sensitive areas; instream flow rules;

stormwater and discharge regulation; TMDL implementation to achieve water-quality standards; hydraulic project permitting; and increased spill and bypass operations at hydropower facilities. NMFS determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. These activities are likely to improve conditions for the salmon and steelhead, including SRB steelhead.

NMFS also noted that some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects are activities that occurred in the recent past and were included in the environmental baseline. Some of these activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the action area, nonfederal actions are likely to include effects associated with human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Continuing commercial and sport fisheries, which have some incidental catch of listed species will have adverse impacts through removal of fish that would contribute to spawning populations.

Overall, we anticipate that projects to restore and protect habitat, restore access and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area.

2.14.5 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.14.3) to the environmental baseline (Section 2.14.2) and the cumulative effects (Section 2.14.4), taking into account the status of the species and critical habitat (Section 2.14.1), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat for the conservation of the species.

2.14.5.1 Species

The SRB steelhead DPS includes all natural-spawned steelhead originating below natural and manmade barriers in stream in the Snake River basin of Washington, Oregon, and Idaho. The DPS is comprised on 24 historical populations within six MPGs. Five hatchery programs are included in the DPS.

NMFS' recent status review affirmed SRB steelhead as threatened (NWFSC 2015). The level of natural production in the two populations with full data series and the Asotin Creek index reaches are encouraging, but the status of most populations in the DPS remain highly uncertain. Population-level natural-origin abundance and productivity, inferred from aggregate data and juvenile indices, indicate that many populations are likely below the minimum combination defined by the ICTRT viability criteria (NWFSC 2015). Hatchery-origin spawner estimates are low for the two populations where data are available, and the spatial structure ratings for most SRB steelhead populations are low or very low risk.

The proposed action will continue to affect juvenile and adult steelhead survival between the Snake River basin and the ocean. Passage through the eight dams is slightly improved to about 48 percent (which includes both natural and dam related losses) for juveniles (Lower Granite to Bonneville Dam) compared to the most recent ten-year average (2008–17). The proposed flexible spring spill operation is expected to reduce juvenile travel time by almost one half day. If latent mortality improves, as suggested by CSS, abundance and productivity will improve at the DPS level.

The other proposed changes to CRS operations are not anticipated to affect SRB steelhead survival. In particular, the changes in usable forebay ranges (MOP 1.5-foot range) at the lower Snake River reservoirs and the change in operating range at the John Day forebay (MIP 2-foot range) in the lower Columbia River will result in inconsequential variations in the timing and amount of flow.

The Action Agencies propose continued implementation of the avian, pinniped, and fish predation management programs in the estuary and mainstem hydrosystem reach. Predators consume large numbers of SRB steelhead as they migrate between the Snake River basin and the ocean. These programs are expected to maintain the ongoing benefits of reduced predation rates.

Implementation of the tributary habitat actions analyzed in this biological opinion, if implemented as anticipated (i.e., achieving at least the minimum commitments included in the proposed action in a manner consistent with scientifically sound identification and prioritization of limiting factors and geographic locations and principles of watershed restoration), will provide benefits to the targeted populations in two of the five MPGs in this DPS: the Clearwater River and Salmon River MPGs. Some degraded areas in the Salmon River MPG are likely on an improving trend because of ongoing restoration efforts and improved land use practices, and the MPG includes some populations with high-quality habitat and others with highly degraded habitat. Overall, however, habitat degradation continues to negatively affect the populations in this MPG. The status of most populations in this MPG are considered maintained, which means that the populations do not meet the criteria for a viable population but do support ecological functions and preserve options for recovery of the DPS.

The Clearwater River MPG includes a wide range of habitat quality, with quality best in the high elevation reaches and habitat modification greatest along valley bottoms in developed areas and areas under intensive agricultural or timber management. For ESA recovery, the Lower

Mainstem Clearwater River, Lolo Creek, and Lochsa River populations need to be viable or highly viable, and the South Fork Clearwater and Selway River populations need to be viable or maintained. The current status of the populations is at high risk or maintained, primarily due to concerns with abundance and productivity. While many degraded areas in this MPG are likely on an improving trend due to ongoing restoration efforts and improved land use practices, habitat degradation continues to negatively affect the populations in this MPG.

In addition, tributary habitat actions actions implemented to benefit SR spring/summer Chinook in the Grande Ronde/Imnaha and Lower Snake MPGs of that ESU would also likely benefit SRB steelhead in the Grande Ronde and Lower Snake steelhead MPGs, depending on action type and the extent to which steelhead occupy the habitat being targeted.

This biological opinion covers a proposed action with a limited duration, and thus the improvements from tributary habitat actions will be small, as a large scope and scale of actions are required to achieve significant change at the population level. While it is possible that effects of some habitat improvement actions (e.g., removal of passage barriers) could be immediate, for other actions, benefits will take several years to fully accrue (and will take 50 years or more for some actions, such as restoring riparian areas). In addition, fish response in terms of improved viability will not begin until the progeny of fish spawning in new habitat conditions begin to return, which can only be detected over multiple life cycles, and will be influenced by the backdrop of ecosystem variability. The proposed tributary habitat improvement program is consistent with recommendations in the recovery plan and will support the improving status of the DPS.

All SRB steelhead MPGs migrate downstream through the estuary; according to the status review and the recovery plan, degraded estuarine habitat is a key factor limiting survival and recovery, including floodplain connectivity and function. The Action Agencies' proposed commitment to reconnect an average of 300 acres of floodplain per year in the estuary will be a continuation of the implementation of the ongoing estuary program. Further, this work will continue the trend of increasing connected area during the interim period, increasing prey availability for juvenile SRB steelhead in the mainstem migration corridor.

As a general matter, the effects of the proposed action are very similar to a short-term continuation of the same effects caused by the current operations and maintenance of the CRS, as well as the associated measures implemented to avoid, minimize, or offset adverse effects. Therefore, we do not anticipate large changes in mortality caused by the CRS or substantial new risks to SRB steelhead or their habitat, and we do not expect considerable changes in the effects on reproduction, numbers, or distribution. However, we do anticipate additional improvements in habitat conditions in the estuary and tributaries that will accrue over time.

The environmental baseline includes the past and present impacts of hydropower, changes in tributary and mainstem habitat (both beneficial and adverse), harvest, and hatcheries on SRB steelhead. The baseline provides important context for assessing the effects of the action described above.

Harvest and hatcheries will continue to affect the status of SRB steelhead. The hatchery programs for SRB steelhead serve the dual purpose of providing fish for fisheries, as well as supplemental spawners to help rebuild depressed natural populations. Although the issue is complex, existing hatchery programs remain a threat for several SRB steelhead populations. The concerns are discussed in the environmental baseline above, and includes a discussion of critical uncertainties where information is lacking regarding the relative proportion and distribution of hatchery-origin spawners in natural spawning areas at the population scale.

Continued implementation of the kelt reconditioning program (including trapping, transport, and reconditioning of steelhead kelts) should continue to benefit SRB steelhead by increasing the productivity and abundance of the targeted B-Index populations.

The largest harvest-related effects on SRB steelhead result from the tribal and nontribal mainstem Columbia River fisheries. The recent *U.S. v. Oregon* consultation addressed this fishery, and that the harvest rate in tribal fall season fisheries may range from 13 to 20 percent, and the non-Treaty fall season fishery harvest rate remains fixed at 2 percent.

Improvements, including tributary hydrosystem modification and habitat restoration (e.g., in the estuary), coupled with significant harvest reductions from historic levels, have allowed for progress in improving SRB steelhead abundance, productivity, spatial structure, and diversity. However, these improvements also occur in the context of natural fluctuations in environmental conditions, such as cyclical changes in ocean circulation and the unusually warm ocean conditions seen predominating during 2015, which can temporarily adversely affect survival and adult returns of all salmonid species, even if freshwater habitat conditions are improving.

The status of SRB steelhead is also likely to be affected by climate change. Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycle. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream-flow patterns in freshwater and changes to food webs in freshwater, estuarine, and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management actions may help alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations, increased riparian vegetation to control water temperatures, etc.).

Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life history types that will be successful in the future are neither static nor predictable. Therefore, maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including those in the SRB steelhead DPS. Because of its location in the Columbia River basin, the DPS is likely to be more affected by climate-related effects in the estuary, and in tributary streams (altered seasonal flows and temperatures) that support spawning and early rearing. Emerging research using complex life-cycle modeling indicates a potentially strong link between SST and survival of Snake River spring/summer Chinook salmon populations. However, the apparent link between SST and survival is presumably caused by food web interactions, relationships which could be disrupted by major transformations of community dynamics, as well as ocean acidification and other factors under a changing climate. The degree to which SST is linked to survival of SRB steelhead, and how that relationship interacts with other variables throughout the SRB steelhead life cycle, will likely be an important area of future research.

When evaluating the effects of the action, those effects must be taken together with the effects on SRB steelhead of future state or private activities, not involving federal activities that are reasonably certain to occur within the action area. NMFS anticipates that human development activities will continue to have adverse effects on SRB steelhead in the action area. Many of these activities and their effects occurred in the recent past and were included in the environmental baseline, but are also reasonably certain to occur in the future. Within the action area, nonfederal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Habitat restoration efforts led by state and local agencies, tribes, environmental organizations, and local communities are likely to continue. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives that, in some cases, are identified through ESA recovery plans. Larger, more region-wide, restoration and conservation efforts are either underway or planned throughout the Columbia River basin. These state and private actions have helped restore habitat, improve fish passage, and reduce pollution. While these efforts are reasonably certain to continue to occur, funding levels may vary on an annual basis.

The recovery plan (NMFS 2017e) outlines specific objectives for each of the five MPGs, and four of the five MPGs are not currently meeting the identified viability objectives. The recovery plan addresses the underlying limiting factors and threats for SRB steelhead, including hydropower projects, predation, harvest and hatchery effects, tributary habitat, and ocean conditions. The recovery plan identifies recovery actions to be implemented, generally over a 25-year period, as specified in the management unit plans and estuary recovery plan module. Effective implementation requires that the recovery efforts of diverse private, local, state, tribal, and federal parties across three states be coordinated at multiple levels. The proposed action will not result in reductions to SRB steelhead reproduction, numbers, or distribution that would impede the ability to successfully carry out the identified recovery measures and actions over the time frames considered in the recovery plan.

After reviewing and analyzing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, and considering the interim nature of this proposed action pending the decision to implement a new action as a result of the NEPA process, it is NMFS' biological opinion that the proposed action is not likely to reduce appreciably the likelihood of both survival and recovery of SRB steelhead.

2.14.5.2 Critical Habitat

Critical habitat for this DPS encompasses 25 subbasins, as well as 58 miles of the lower Snake River, 320 miles of the Columbia River rearing/migration corridor, and the Columbia River estuary. Watersheds with PBFs for SRB steelhead in the Interior Columbia recovery domain vary from excellent in wilderness and roadless areas, to poor in areas subject to heavy agricultural and urban development. Migratory habitat quality has been affected by the development and operation of the CRS dams and reservoirs and privately owned dams in the Snake River basin. However, most of these watersheds have some, or high, potential for improvement. Similar to the discussion above for species, the status of critical habitat is likely to be affected by climate change with predicted rising temperatures and alterations in stream-flow patterns. Past and future modifications to the hatchery program, improved passage in tributaries, and habitat restoration efforts will help ameliorate those effects to critical habitat.

The environmental baseline includes a broad range of past and present actions and activities that have affected the conservation value of critical habitat for SRB steelhead. These include the effects of hydropower, changes in tributary and mainstem habitat (both positive and negative), and hatcheries on freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine areas, and nearshore marine areas. Across the designated area, widespread development and other land use activities have disrupted watershed processes, reduced water quality, and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and/or current land use or water management activities have adversely affected the quality and quantity of stream and side channel areas, riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for salmon and steelhead production have been weakened. Despite a long-term trend in degradation of these habitats, there have been localized improvements in their conservation value through the combined efforts of federal, state, and local agencies; tribes; and other stakeholders. Tributary dams and other barriers have been removed, estuarine habitats restored and reconnected to the floodplain, and water quality has improved. Despite significant losses to predators in the migration corridor, the combined efforts of multiple parties has reduced the effect of predation, and the Action Agencies propose to continue predator management activities.

Continued operation of the CRS will continue to affect the function of critical habitat in the migration corridor, including the loss of access to historical spawning habitat upstream of Dworshak Dam (obstructions in the adult migration corridor). Despite improvements to the dams and their operations, the CRS will continue to increase passage times, and reduce survival of juvenile and adult SRB steelhead compared to an unmanaged system (affecting the safe passage PBF). The proposed flexible spring spill operation improve juvenile travel times and survival rates from the lower Snake River to below Bonneville Dam. Seasonal flows and temperatures will continue to be altered with negative effects on water quantity and quality. TDG concentrations will increase up to the state-approved water quality limits, but will not result in significant increases in the incidence and severity of GBT without lack of market or lack of turbine capacity spill events (water quality).

Increased numbers of predators, including birds and native and non-native fishes that prey on yearling steelhead will continue to be present in the hydrosystem reach (excessive predation in the juvenile migration corridor). The reduced levels of predation by Caspian terns and double-crested cormorants in the estuary, terns nesting on Goose and Crescent Islands on the interior Columbia plateau, and northern pikeminnows in project tailraces and reservoirs that were achieved under the 2008 biological opinion and associated RPA will be maintained by the continued implementation of the respective predator management plans (reduction in the level of excessive predation).

In the lower Columbia River estuary, the proposed habitat restoration program will continue to reconnect the historical floodplain, increasing the availability of wetland-derived prey to yearling steelhead migrating to the ocean (improved forage in estuarine areas). In addition, the Action Agencies will provide a total of over 3,000 acre-feet of instream flow, and will improve a total 165 acres of riparian habitat in subbasins used by SRB steelhead for spawning and rearing. This will improve the functioning of critical habitat at the local scale in some HUC5 watersheds (improvements in water quantity in spawning and rearing areas and forage and natural cover in rearing areas). The benefits of instream flow will improve the function of critical habitat during the implementation period of this opinion; the benefits of the riparian improvement will increase over time as the habitat improvements mature.

Considering the ongoing and future effects of the environmental baseline and cumulative effects, and in light of the status of critical habitat, the proposed action will not appreciably reduce the value of designated critical habitat for the conservation of SRB steelhead.

2.14.6 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, and considering the interim nature of this proposed action pending the decision to implement a new action as a result of the NEPA process, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of SRB steelhead or destroy or adversely modify its designated critical habitat.

2.15 Snake River (SR) Spring/Summer Chinook Salmon

This section applies the analytical framework described in section 2.1 to the SR spring/summer Chinook salmon ESU and provides NMFS' finding regarding whether the proposed action is likely to jeopardize the continued existence of SR spring/summer Chinook salmon ESU or destroy or adversely modify its critical habitat.

2.15.1 Rangewide Status of the Species and Critical Habitat

The status of the SR spring/summer Chinook salmon ESU is determined by the level of extinction risk that SR spring/summer Chinook salmon face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The condition of critical habitat throughout the designated area is determined by the current function of the PBFs that help to form its conservation value

2.15.1.1 Status of the Species

This section summarizes the status of SR spring/summer Chinook salmon and its designated critical habitat. More detailed information on the status and trends of these listed resources, and their biology and ecology, are in the listing regulations and critical habitat designations published in the Federal Register.

On June 3, 1992, NMFS listed the Snake River spring/summer-run Chinook salmon ESU as a threatened species (57 FR 23458). The threatened status was reaffirmed on June 28, 2005 (70 FR 37160) and again on April 14, 2014 (79 FR 20802). Critical habitat was originally designated on December 28, 1993 (58 FR 68543) but updated most recently on October 25, 1999 (65 FR 57399). Additional information can be found in the recovery plan (NMFS 2017e) and the most recent status review (NMFS 2016e), which can be found on the NMFS website.[208]

The SR spring/summer-run Chinook salmon ESU includes all naturally spawned populations of spring/summer-run Chinook salmon in the mainstem Snake River and the Tucannon River, Grande Ronde River, Imnaha River, and Salmon River subbasins, as well as 10 artificial propagation programs (Table 2.15-1; NWFSC 2015; NMFS 2017e). Eight additional spring-summer Chinook salmon artificial propagation programs are also currently operational but not included in the ESU, even though they occur within its geographic range (Jones 2015; NMFS 2017e). Genetic resources can be housed in a hatchery program; for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU, see NMFS (2005b).

[208]http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/salmon_and_steelhead_listings/chinook/snake_river_spring_summer/snake_river_spring_summer_run_chinook.html. Last accessed March 2019.

Table 2.15-1. Snake River spring/summer-run Chinook Salmon ESU description and major population groups (Jones 2015; NWFSC 2015; NMFS 2017e).

Major Population Group	***Populations***
Lower Snake River	Tucannon River
Grande Ronde/Imnaha River	Wenaha, Lostine/Wallowa, Minam, Catherine Creek, Upper Grande Ronde, Imnaha
South Fork Salmon River	Secesh, East Fork/Johnson Creek, South Fork Salmon River Mainstem, Little Salmon River
Middle Fork Salmon River	Bear Valley, Marsh Creek, Sulphur Creek, Loon Creek, Camas Creek, Big Creek, Chamberlain Creek, Lower Middle Fork (MF) Salmon, Upper MF Salmon
Upper Salmon	Lower Salmon Mainstem, Lemhi River, Pahsimeroi River, Upper Salmon Mainstem, East Fork Salmon, Valley Creek, Yankee Fork, North Fork Salmon
Artificial ***Production***	
Hatchery programs included in ESU (10)	Tucannon River Spr/Sum, Lostine River Spr/Sum, Catherine Creek Spr/Sum, Lookingglass Hatchery Reintroduction Spr/Sum, Upper Grande Ronde Spr/Sum, Imnaha River Spr/Sum (including Big Sheep Creek Spr/Sum Adult Outplanting program), McCall Hatchery summer, Johnson Creek Artificial Propagation Enhancement summer, Pahsimeroi Hatchery summer, Sawtooth Hatchery spring
Hatchery programs not included in ESU (8)	South Fork Chinook Eggbox spring (formerly Dollar Creek spring), Panther Creek summer, Yankee Fork spring, Rapid River Hatchery spring, Dworshak NFH spring, Kooskia spring, Clearwater Hatchery spring, Nez Perce Tribal Hatchery spring.

Twenty-eight natural populations (plus four extirpated populations) within five MPGs comprise the SR spring/summer-run Chinook salmon ESU. The natural populations are aggregated into the five MPGs based on genetic, environmental, and life-history characteristics. Figure 2.15-1 shows a map of the current ESU and the MPGs within the ESU. Figure 2.15-2 depicts the eight Columbia and lower Snake River dams that SR spring/summer-run Chinook salmon migrate through to reach spawning habitat.

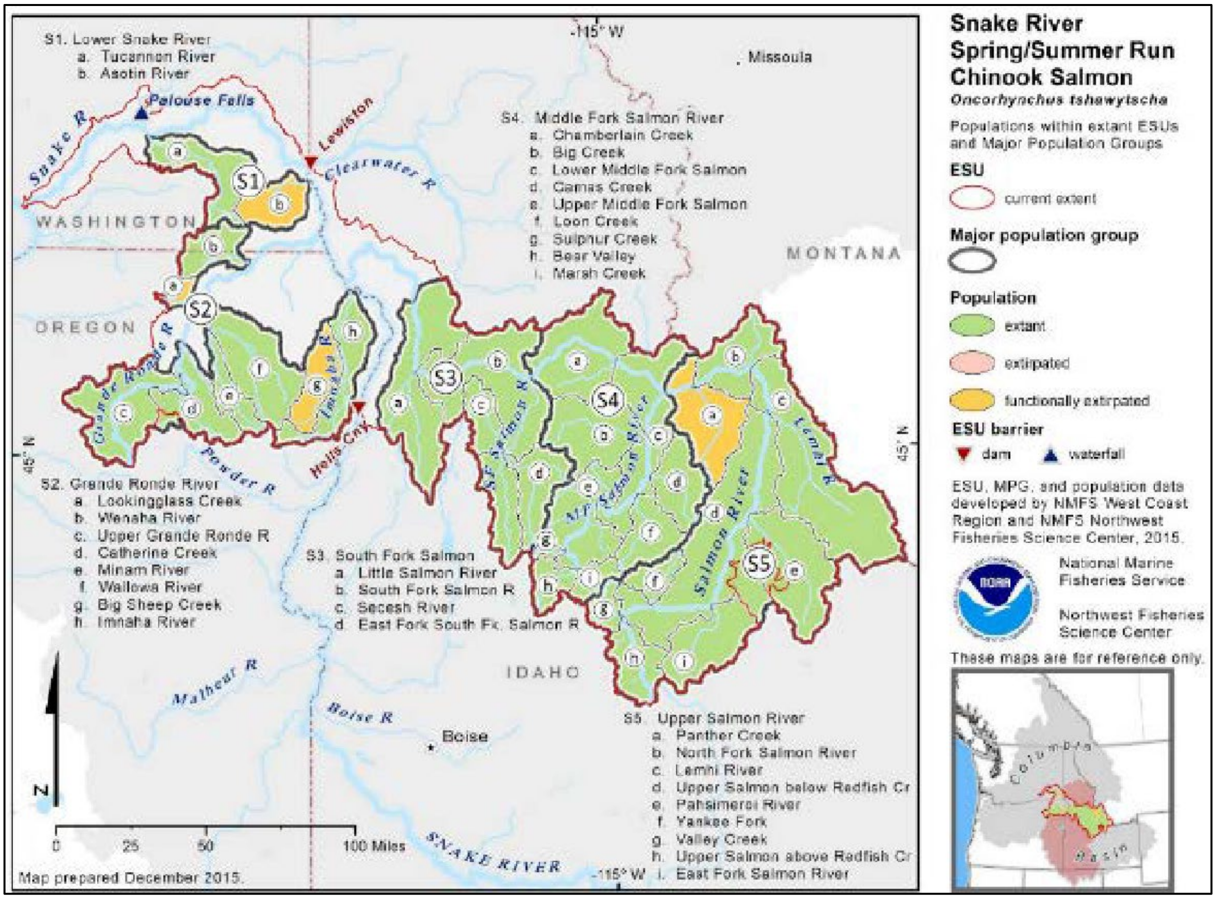


Figure 2.15-1. Map depicting the location of the major population groups (MPGs) and the component populations of the Snake River spring/summer Chinook salmon ESU.

Figure 2.15-2. All populations of Snake River spring/summer Chinook salmon migrant through four Columbia River mainstem dams (Bonneville, The Dalles, John Day and McNary Dams), and four dams on the Snake River Ice Harbor, Lower Monumental, Little Goose, and Lower Granite Dams).

Chinook salmon have a wide variety of life-history patterns that include: variation in age at seaward migration; length of freshwater, estuarine, and oceanic residence; ocean distribution; ocean migratory patterns; and age and season of spawning migration. The SR spring/summer Chinook salmon ESU consists of "stream-type" Chinook salmon, which spend two to three years in ocean waters and exhibit extensive offshore ocean migrations (Myers et al. 1998). In general, Chinook salmon tend to occupy streams with lower gradients than steelhead, but there is considerable overlap between the distributions of the two species (NMFS 2012).

Historically, the Snake River drainage is thought to have produced more than 1.5 million adult spring/summer-run Chinook salmon in some years during the late 1800s (Matthews and Waples 1991). By the 1950s, abundance of spring/summer-run Chinook salmon had declined to an annual average of 125,000 adults, and it continued to decline through the 1970s. In 1995, only 1,797 spring/summer-run Chinook salmon adults returned (hatchery and wild fish combined). Returns at Lower Granite Dam dramatically increased after 2000, with 185,693 adults (hatchery and wild fish combined) returning in 2001. The large increase in 2001 was due primarily to hatchery returns, with only 10 percent of the returns from fish of natural-origin (NMFS 2012).

The causes of oscillations in abundance are uncertain, but likely are due to a combination of factors. Over the long term, population size is affected by a variety of factors, including: ocean conditions, harvest, increased predation in riverine and estuarine environments, construction and continued operation of Snake River and Columbia River dams; increased smolt mortality from poor downstream passage conditions; competition with hatchery fish; and widespread alteration of spawning and rearing habitats. Spawning and rearing habitats are commonly impaired in places due effects from past and current practices, such as agricultural tilling, water withdrawals, road construction, timber harvest, grazing, mining, and alteration of floodplains and riparian vegetation. Climate change is also recognized as a factor in Snake River salmon declines (Tolimieri and Levin 2004; Scheuerell and Williams 2005; NMFS 2012).

2.5.1.1.1 Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. The SR spring/summer-run Chinook salmon ESU remains at high overall risk, with the exception of one population (Chamberlain Creek in the Middle Fork Salmon River MPG). NMFS has finalized recovery planning for the Snake River drainage, organized around a subset of management unit plans corresponding to state boundaries (NMFS 2017e). A tributary recovery plan for one of the major management units, the Lower Snake River tributaries within Washington state boundaries, was developed under the auspices of the Lower Snake River Recovery Board (LSRB). The LSRB plan provides recovery criteria, targets, and tributary habitat action plans for the two populations of the spring/summer-run Chinook salmon in the Lower Snake River MPG, as well as the populations in the Touchet River (Mid-Columbia Steelhead DPS) and the Washington sections of the Grande Ronde River (NWFSC 2015).

The recovery plans developed by NMFS incorporated viability criteria recommended by the ICTRT. The ICTRT recovery criteria are hierarchical in nature, with ESU-level criteria being based on the status of natural-origin Chinook salmon assessed at the population level. The population-level assessments are based on a set of metrics designed to evaluate risk across the four VSP elements: abundance, productivity, spatial structure, and diversity (McElhany et al. 2000). The ICTRT approach calls for comparing estimates of current natural-origin abundance and productivity against predefined viability curves (NWFSC 2015). Achieving recovery (i.e., delisting the species) of the ESU through sufficient improvement in the abundance, productivity, spatial structure, and diversity is the long-term goal of the recovery plan. Table 2.15-2 shows the most recent metrics for the SR spring/summer-run Chinook Salmon ESU.

The majority of natural populations in the ESU remain at high risk overall, with one population (Chamberlain Creek in the Middle Fork Salmon River MPG) improving to an overall rating of maintained due to an increase in abundance. Natural-origin abundance has increased over the levels reported in a prior status review (Ford 2011) for most populations in this ESU, although the increases were not substantial enough to change viability ratings (NWFSC 2015). Relatively high ocean survivals immediately before 2015 were a major factor in recent abundance patterns. Eleven natural populations increased in both abundance and productivity (Catherine Creek, Upper Grande Ronde River, Minam River, Lostine/Wallowa River, Imnaha River, Sulphur Creek, Lemhi River, Valley Creek, Upper Salmon River, East Fork Salmon River, and Pahsimeroi River), although the natural spawner abundance is far below the ICTRT minimum threshold for many of these population (e.g., Upper Grande Ronde). Nine populations increased in abundance while their updated productivity estimates decreased (Tucannon, South Fork Salmon, East Fork South Fork Salmon, Big Creek, Bear Valley Creek, March Creek, Camas Creek, and Yankee Fork). Two populations decreased in abundance and increased in productivity (Wenaha and Lower Salmon River populations). One population, Loon Creek in the Middle Fork Salmon River MPG, decreased in both abundance and productivity. Overall, all but one population in this ESU remains at high risk for abundance and productivity, and there is a considerable range in the relative improvements to life-cycle survivals or limiting life-stage capacities required to attain viable status. There is no consistent pattern of response across populations or across MPGs. In general, populations within the South Fork Salmon River MPG are the closest to viability among the MPGs. The other multiple population MPGs each have a range of viability (NWFSC 2015). Since the last status review in 2015, observations of coastal ocean conditions suggested that the 2015–17 outmigrant year classes experienced below average ocean survival during a marine heatwave and its lingering effects, which led researchers to predict a corresponding drop in adult returns through 2019 (Werner et al. 2017). The negative impacts on juvenile salmonids associated with the marine heatwave had subsided by spring 2018, but other aspects of the ecosystem (e.g., temperatures below the 25-m surface layer) had not returned to normal (Harvey et al. 2019).

Table 2.15-2. MPGs, populations, and scores for the key elements (A&P, diversity, and SS/D) used to determine current overall viability risk for Snake River spring/summer-run Chinook salmon (NWFSC 2015). Risk ratings included very low (VL), low (L), moderate (M), high (H), very high (VH), and extirpated (E). ← =improved since prior review. → = decreased since prior review. □ = no change. Shaded populations are the most likely combinations within each MPG to be improved to viable status. Current abundance and productivity estimates expressed as geometric means (standard error).

MPG	Population	ICTRT Minimum Threshold	Natural Spawning Abundance	ICTRT Productivity	Integrated A/P Risk	Natural Processes Risk	Diversity Risk	Integrated SS/D Risk	Overall Viability Rating
Lower Snake	Tucannon River	750	267 (.19) ←	.69 (.23) →	High	Low	Moderate	Moderate	High Risk
	Asotin Creek**	500							Extirpated
Grande Ronde/Imnaha	Catherine Creek	1,000	110 (.31) ←	.95 (.15) ←	High	Moderate	Moderate	Moderate	High Risk
	Upper Grande Ronde	1,000	43 (.26) ←	.59 (.28) ←	High	High	Moderate	High	High Risk
	Minam River	750	475 (.12) ←	.94 (18) ←	High (M)	Low	Moderate	Moderate	High Risk
	Wenaha River	750	399 (.12) →	.93 (.21) ←	High	Low	Moderate	Moderate	High Risk
	Lostine/Wallowa R.	1,000	332 (.24) ←	.98 (.12) ←	High	Low	Moderate	Moderate	High Risk
	Imnaha River	750	328 (.21) ←	1.2 (.09) ←	High (M)	Low	Moderate	Moderate	High Risk
	Big Sheep Creek**								extirpated
	Lookingglass Creek**	500							extirpated
South Fork Salmon	South Fork Salmon R	1,000	791 (.18) ←	1.21 (.20) →	High (M)	Low	Moderate	Moderate	High Risk
	Secesh River	750	472 (.18) ←	1.25 (.2) □	High (M)	Low	Low	Low	High Risk
	E Fork S Fork Salmon R.	1,000	208 (.24)←	1.15 (.2) →	High	Low	Low	Low	High Risk

MPG	**Population**	**ICTRT Minimum Threshold**	**Natural Spawning Abundance**	**ICTRT Productivity**	**Integrated A/P Risk**	**Natural Processes Risk**	**Diversity Risk**	**Integrated SS/D Risk**	**Overall Viability Rating**
	Little Salmon River	750	Insuf. data	Insuf. Data	Insuf. Data	Low	Low	Low	High Risk
Middle Fork Salmon	Big Creek	1,000	164 (.23) ←	1.10 (.21) →	High	Very Low	Moderate	Moderate	High Risk
	Bear Valley Creek	750	474 (.27) ←	1.37 (.17) →	High (M)	Very Low	Low	Low	High Risk
	Marsh Creek	500	253 (.27) ←	1.21 (.24) →	High	Low	Low	Low	High Risk
	Sulphur Creek	500	67 (.99) ←	.92(.26) ←	High	Low	Moderate	Moderate	High Risk
	Camas Creek	500	38 (.20) ←	.80 (.29) →	High	Low	Moderate	Moderate	High Risk
	Loon Creek	500	54 (.10) →	.98 (.40) →	High	Low	Moderate	Moderate	High Risk
	Chamberlain Creek	750	641 (.17) ←	2.26 (.45) →	Moderate	Low	Low	Low	Maintained
	L Middle Fork Salmon	500	Insuf. data	Insuf data	-	Moderate	Moderate	Moderate	High Risk
	U Middle Fork Salmon	750	71 (.18) ←	.50 (.72) →	High	Low	Moderate	Moderate	High Risk
Upper Salmon	Lemhi River	2,000	143 (.23) ←	1.30 (.23) ←	High	High	High	High	High Risk
	Valley Creek	500	121 (.20) ←	1.45 (.15) ←	High	Low	Moderate	Moderate	High Risk
	Yankee Fork Salmon R	500	44 (.45) ←	.72 (.39) →	High	Moderate	High	High	High Risk
	Upper Salmon River	1,000	411 (.14) ←	1.22 (.19) ←	High (M)	Low	Low	Low	High Risk
	North Fork Salmon R	500	Insuf. data	Insuf data		Low	Low	Low	High Risk

MPG	**Population**	**ICTRT Minimum Threshold**	**Natural Spawning Abundance**	**ICTRT Productivity**	**Integrated A/P Risk**	**Natural Processes Risk**	**Diversity Risk**	**Integrated SS/D Risk**	**Overall Viability Rating**
	Lower Salmon River	2,000	108 (.18) →	1.18 (.17) ←	High	Low	Low	Low	High Risk
	East Fork Salmon R	1,000	347 (.22) ←	1.08 (.28) ←	High	Low	High	High	High Risk
	Pahsimeroi River	1,000	267 (.16) ←	1.37 (.20) ←	High (M)	Moderate	High	High	High Risk
	Panther Creek*	750	Insuf data	Insuf data					Extirpated

Spatial structure ratings remain unchanged or stable with low or moderate risk levels for the majority of the populations in the ESU. Four populations from three MPGs (Catherine Creek and Upper Grande Ronde of the Grande Ronde/Imnaha River MPG, Lemhi River of the Upper Salmon River MPG, and Lower Middle Fork Salmon of the Middle Fork Salmon River MPG) remain at high risk for spatial structure loss. Three MPGs in this ESU have populations that are undergoing active supplementation with local broodstock hatchery programs. In most cases, those programs evolved from mitigation efforts and include some form of sliding-scale management guidelines that limit hatchery contribution to natural spawning based on the abundance of natural-origin fish returning to spawn – the more natural-origin fish that return, the fewer hatchery fish that are needed to spawn naturally. Sliding-scale management is designed to maximize hatchery benefits in low abundance years and reduce hatchery risks at higher spawning levels.

While there have been improvements in the abundance/productivity in multiple populations relative to prior reviews (Ford 2011), those changes have not been sufficient to warrant a change in ESU status (NWFSC 2015). All extant populations (except Chamberlain Creek) face a "high" risk of extinction (NWFSC 2015).

2.15.1.1.2 Limiting Factors

Understanding the limiting factors and threats that affect the SR spring/summer-run Chinook salmon ESU provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. There are many factors that affect the abundance, productivity, spatial structure, and diversity of the SR spring/summer-run Chinook salmon ESU. Factors that limit the ESU (in no particular order) have been, and continue to be, survival through the CRS; the degradation and loss of estuarine areas that help the fish survive the transition between fresh and marine waters; spawning and rearing areas that have lost deep pools, cover, side-channel refuge areas, and high-quality spawning gravels; interbreeding and competition with hatchery fish that far outnumber fish of natural-origin; and ocean conditions including climate change.

NMFS released a recovery plan for this species in November 2017 (NMFS 2017e) that describes MPG-level recovery strategies. Recovery plan targets are described in Table 2.15-3. NMFS divided the Snake River basin into three different "management units" for recovery planning based on jurisdictional boundaries, as well as areas where local planning efforts were underway. The three separate management units for SR spring/summer Chinook salmon are: the Northeast Oregon unit, Southeast Washington unit, and Idaho unit. Separate plans have been developed for each management unit. All three plans were developed in coordination with respective state, federal, and local agencies; tribes; and others. Each plan recommended biological viability criteria, or targets, that are based on the biological parameters of abundance, productivity, spatial structure, and diversity, which help to define when a species is healthy enough to warrant delisting.

Table 2.15-3. Recovery plan information for SR spring/summer Chinook salmon.

MPG	Population	Current Status (Overall viability rating)	Recovery Plan Proposed Target	
Lower Snake	Tucannon	high	highly viable	The basic ICTRT criteria would call for both populations being restored to viable status. The ICTRT recommended that recovery planners should give priority to restoring the Tucannon River to highly viable status, and evaluate the potential for reintroducing production in Asotin Creek as recovery planning progresses.
	Asotin Creek	extirpated	reintroduction	
Grande Ronde/ Imnaha	Catherine Creek	high risk	viable	The basic ICTRT criteria call for a minimum of four populations at viable or highly viable status. The potential scenario identified by the ICTRT would include viable populations in the Imnaha River (representing important run-timing diversity), the Lostine/Wallowa River (representing a large-size population), and at least one from each of the following pairs: Catherine Creek or Upper Grande Ronde River (representing large-size populations); and Minam River or Wenaha River.
	Upper Grande Ronde	high risk	maintained	
	Minam River	high risk	viable	
	Wenaha River	high risk	viable	
	Lostine/Wallowa Rivers	high risk	viable	
	Imnoha River	high risk	viable	
	Big Sheep Creek (ext.)	?	reintroduction	
	Lookinglass Creeks	extirpated	reintroduction	
South Fork Salmon	South Fork Salmon Mainstem	high risk	viable	Two of the historical populations in this MPG should be at restored to viable or highly viable status for the MPG to be considered viable. The ICTRT recommends that the populations in the South Fork Salmon River drainages be given priority given the relatively small size and the high level of potential hatchery integration for the Little Salmon River population.
	Secesh River	high risk	highly viable	
	East Fork S. Fork Salmon	high risk	maintained	
	Little Salmon River	high risk	maintained	

MPG	Population	Current Status (Overall viability rating)	Recovery Plan Proposed Target	
Middle Fork Salmon	Big Creek	high risk	highly viable	The basic ICTRT criteria call for at least five of the nine populations in this MPG to be rated as viable, with at least one demonstrating highly viable status. The ICTRT example recovery scenario included Chamberlain Creek (geographic position), Big Creek (large-size category), Bear Valley Creek, Marsh Creek, and either Loon Creek or Camas Creek. The Loon Creek and Marsh Creek populations are targeted for desired viable status
	Bear Valley/Elk Creek	high risk	viable	
	Marsh Creek	high risk	viable	
	Sulphur Creek	high risk	maintained	
	Camas Creek	high risk	maintained	
	Loon Creek	high risk	viable	
	Chamberlain Creek	maintained	viable	
	Lower Middle Fork Salmon	high risk	maintained	
	Upper Middle Fork Salmon	high risk	maintained	
Upper Salmon	Lemhi River	high risk	viable	The basic ICTRT criteria scenario for this MPG includes the Pahsimeroi River (summer Chinook life history), the Lemhi River and Upper Salmon Mainstem (very large-size category), and East Fork Salmon River (large-size category) and Valley Creek.
	Valley Creek	high risk	viable	
	Yankee Fork	high risk	maintained	
	Upper Salmon River	high risk	highly viable	
	North Fork Salmon River	high risk	maintained	
	Lower Salmon River	high risk	maintained	
	East Fork Salmon River	high risk	viable	

MPG	Population	Current Status (Overall viability rating)	Recovery Plan Proposed Target	
	Pahsimeroi River	high risk	viable	
	Panther Creek	extirpated	reintroduction	

2.15.1.2 Status of Critical Habitat

This section examines the rangewide status of designated critical habitat for the affected species. Critical habitat includes the stream channels within designated stream reaches and a lateral extent defined by the ordinary high-water line. NMFS (2017e) determined the rangewide status of critical habitat for the ESU by examining the condition of its PBFs that were identified when critical habitat was designated.

For SR spring/summer Chinook salmon, NMFS ranked watersheds within designated critical habitat at the scale of the fifth-field HUC_5 in terms of the conservation value they provide.[209] The conservation rankings are high, medium, or low. To determine the conservation value of each watershed to species viability, NMFS' CHARTs evaluated the quantity and quality of habitat features (for example, spawning gravels, wood and water condition, side channels), the relationship of the area compared to other areas within the species' range, and the significance to the species of the population occupying that area (NMFS 2005a). Thus, even a location that has poor quality of habitat could be ranked with a high conservation value if it was essential due to factors such as limited availability (e.g., one of a very few spawning areas), a unique contribution of the population it served (e.g., a population at the extreme end of geographic distribution), or if it serves another important role (e.g., obligate area for migration to upstream spawning areas).

The PBFs identified when critical habitat was designated are essential to the conservation of the SR spring/summer Chinook salmon because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration, and foraging). For example, the PBFs of freshwater spawning and rearing areas for SR spring/summer Chinook salmon include substrate (e.g., spawning gravel), water quality and quantity, water temperature, cover/shelter, food, and space (Table 2.15-4).

[209] The conservation value of a site depends upon "(1) the importance of the populations associated with a site to the ESU [or DPS] conservation, and (2) the contribution of that site to the conservation of the population through demonstrated or potential productivity of the area" (NMFS 2005a).

Table 2.15-4. Physical and biological features (PBFs) of critical habitat designated for SR spring/summer-run Chinook salmon and corresponding species life history events.

Physical and Biological Features (PBFs)	Component of the PBF
Spawning and juvenile rearing areas	Spawning gravel Water quality Water quantity Cover/shelter Food Riparian vegetation Space
Adult and juvenile migration corridors	Substrate Water quality Water quantity Water temperature Water velocity Cover/shelter Food Riparian vegetation Space Safe passage

The complex life cycle of SR spring-summer Chinook salmon gives rise to complex habitat needs, particularly in freshwater. The gravel used for spawning must be a certain size and largely free of fine sediments to allow for successful incubation of the eggs and later emergence or escape from the gravel as alevins. Eggs also require cool, clean, and well-oxygenated waters for proper development. Juveniles need abundant food sources, including insects, crustaceans, and other small fish. They need instream places to hide from predators (mostly birds and larger fish), such as under logs, root wads, and boulders, as well as beneath overhanging vegetation. They also need refuge from periodic high flows in side channels and off-channel areas, and from warm summer water temperatures in cold-water springs and deep pools. Returning adults generally do not feed in freshwater, but instead, rely on limited stored energy to migrate, mature, and spawn. Like juveniles, the returning adults also require cool water that is free of contaminants, and migratory corridors with adequate passage conditions (timing, water quality/quantity) to allow access to the various habitats required to complete their life cycle (NMFS 2005a).

In the following paragraphs, we discuss the current status of the functioning of the PBFs of critical habitat in the Interior Columbia and Lower Columbia River Estuary recovery domains.

2.15.1.2.1 Interior Columbia Recovery Domain

Critical habitat has been designated in the Interior Columbia recovery domain, which includes the Snake River basin, for SR spring/summer-run Chinook salmon. Habitat quality in tributary streams in the Interior Columbia recovery domain varies from excellent in wilderness and roadless areas to poor in areas subject to heavy agricultural and urban development (Wissmar et al. 1994). Critical habitat throughout much of the recovery domain has been degraded by intense agriculture, alteration of stream morphology (i.e., channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining, and urbanization. Reduced summer stream flows, impaired water quality, and reduced habitat complexity are common problems for critical habitat in developed areas.

Migratory habitat quality in this area has been severely affected by the development and operation of the CRS dams and reservoirs in the mainstem Columbia and lower Snake Rivers, Bureau of Reclamation tributary projects, and privately owned dams in the Snake River and Upper Columbia River basins. For example, construction of the Hells Canyon Complex of dams eliminated access to several likely historical production areas in Oregon and Idaho, including the Burnt, Powder, Weiser, Payette, Malheur, Owyhee, and Boise River basins (Good et al. 2005).

Hydroelectric development modified natural flow regimes, resulting in warmer late summer/fall water temperatures, changes in fish community structure leading to increased rates of piscivorous and avian predation on juvenile salmon and steelhead, and delayed migration for both adult and juveniles. Physical features of dams, such as turbines, also kill migrating fish. In-river survival is inversely related to the number of hydropower projects encountered by emigrating juveniles. Similarly, development and operation of extensive irrigation systems and dams for water withdrawal and storage in tributaries have altered hydrological cycles.

Many stream reaches designated as critical habitat in the Interior Columbia recovery domain are over-allocated, with more allocated water rights than existing stream flow. Withdrawal of water, particularly during low-flow periods that commonly overlap with agricultural withdrawals, often increases summer stream temperatures, blocks fish migration, strands fish, and alters sediment transport (Spence et al. 1996). Reduced tributary stream flow has been identified as a major limiting factor for all listed salmon and steelhead species in this recovery domain, except SR fall-run Chinook salmon and SR sockeye salmon.

Many stream reaches designated as critical habitat are listed on state Clean Water Act section 303(d) lists for water temperature. Many areas that were historically suitable rearing and spawning habitat are now unsuitable due to high summer stream temperatures. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water all contribute to elevated stream temperatures. Contaminants, such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste, are common in some areas of critical habitat.

The Interior Columbia recovery domain is a very large and diverse area. The CHART determined that few watersheds with PBFs for Chinook salmon are in good to excellent condition with no potential for improvement. Overall, most watersheds in the recovery domain are in fair-to-poor or fair-to-good condition. In Oregon, only the Minam, Wenaha, and Upper and Lower Imnaha Rivers HUC_5 watersheds are in good-to-excellent condition with no potential for improvement. Additionally, several lower Snake River HUC_5 watersheds in the Hells Canyon area, straddling Oregon and Idaho, are in good-to-excellent condition with no potential for improvement.

2.15.1.2.2 Lower Columbia River Estuary Recovery Domain

Critical habitat has also been designated for SR spring/summer Chinook salmon in the lower Columbia River estuary. The estuary is broadly defined to include the entire reach where tidal forces and river flows interact, regardless of the extent of saltwater intrusion. This encompasses areas from Bonneville Dam (RM 146) to the mouth of the Columbia River. It also includes the tidally influenced portions of tributaries below Bonneville Dam, including the lower 26 miles of the Willamette River. This region experiences ocean tides that extend from the mouth of the Columbia River up to Bonneville Dam.

Historically, the downstream half of the Columbia River estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. The mouth of the Columbia River was about four miles wide. Winter and spring floods, low flows in late summer, large woody debris floating downstream, and a shallow bar at the mouth of the Columbia River maintained a dynamic environment. Today, navigation channels have been dredged, deepened, and maintained, jetties and pile-dike fields have been constructed to stabilize and concentrate flow in navigation channels, marsh and riparian habitats have been filled and diked, and causeways have been constructed across waterways. These actions have decreased the width of the mouth of the Columbia River to two miles and increased the depth of the Columbia River channel at the bar from less than 20 to more than 55 feet (NMFS 2008a).

Over time, more than 50 percent of the original marshes and spruce swamps in the estuary have been converted to industrial, transportation, recreational, agricultural, or urban uses. More than 3,000 acres of intertidal marsh and spruce swamps have been converted to other uses since 1948. Many wetlands along the shore in the upper reaches of the estuary were converted to industrial and agricultural lands after levees and dikes were constructed. Furthermore, water storage and release patterns from reservoirs upstream of the estuary have changed the seasonal pattern and volume of discharge. The peaks of spring/summer floods have been reduced, and the amount of water discharged during winter has increased (NMFS 2008a).

In addition, model studies indicate that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of suspended particulate matter to the lower river and estuary by about 40 percent (as measured at Vancouver, Washington) and have reduced fine sediment transport by 50 percent or more. The significance of these changes for SR spring/summer Chinook salmon is unclear, although estuarine habitat provides food for yearling migrants that move rapidly downstream to the ocean (Johnson et al. 2018; PNNL and NMFS 2018).

Functioning estuarine areas are essential to conservation because, without them, juvenile SR spring/summer Chinook salmon cannot reach the ocean in a timely manner. They use the variety of habitats to avoid predators, compete successfully, and complete the behavioral and physiological changes needed for life in the ocean. Similarly, these features are essential to the conservation of adult salmonids because these features in the estuary provide a final source of abundant forage that will provide the energy stores needed to make the physiological transition to freshwater, migrate upstream, avoid predators, and develop to maturity upon reaching spawning areas (NMFS 2005b).

2.15.1.3 Climate Change Implications for SR Spring/Summer Chinook Salmon and Critical Habitat

One factor affecting the rangewide status of SR spring/summer Chinook salmon and aquatic habitat is climate change. The USGCRP[210] reports average warming of about 1.3ºF from 1895 to 2011, and projects an increase in average annual temperature of 3.3ºF to 9.7ºF by 2070 to 2099 (CCSP 2014). Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004; Scheuerell and Williams 2005; Zabel et al. 2006; ISAB 2007). According to the ISAB,[211] these effects pose the following impacts into the future:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season;
- With a smaller snowpack, watersheds will see their runoff diminished earlier in the season, resulting in lower stream flows in the June through September period. River flows in general and peak river flows are likely to increase during the winter due to more precipitation falling as rain rather than snow; and
- Water temperatures are expected to rise, especially during the summer months when lower stream flows co-occur with warmer air temperatures.

These changes will not be spatially homogeneous across the entire Pacific Northwest. Low-lying areas are likely to be more affected. Climate change may have long-term effects that include, but are not limited to, depletion of important cold-water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, premature emergence of fry, and increased competition among species. Overall, climate change

[210] http://www.globalchange.gov

[211] The Independent Scientific Advisory Board (ISAB) serves the National Marine Fisheries Service (NOAA Fisheries), Columbia River Indian Tribes, and Northwest Power and Conservation Council by providing independent scientific advice and recommendations regarding scientific issues that relate to the respective agencies' fish and wildlife programs. https://www.nwcouncil.org/fw/isab/

effects are likely to occur to some degree over the next ten years at a similar rate as the last ten years.

Climate change is predicted to cause a variety of impacts to Pacific salmon and their ecosystems (Mote et al. 2003; Crozier et al. 2008a; Martins et al. 2012; Wainwright and Weitkamp 2013). The complex life cycles of anadromous fishes, including salmon, rely on productive freshwater, estuarine, and marine habitats for growth and survival, making them particularly vulnerable to environmental variation. Ultimately, the effects of climate change on salmon and steelhead across the Pacific Northwest will be determined by the specific nature, level, and rate of change and the synergy between interconnected terrestrial/freshwater, estuarine, nearshore, and ocean environments.

The primary effects of climate change on SR spring/summer Chinook salmon include:

- Direct effects of increased water temperatures on fish physiology;
- Temperature-induced changes to stream-flow patterns;
- Alterations to freshwater, estuarine, and marine food webs; and
- Changes in estuarine and ocean productivity.

While all habitats used by Pacific salmon will be affected, the impacts and certainty of the change vary by habitat type. Some effects (e.g., increasing temperature) affect salmon at all life stages in all habitats, while others are habitat-specific, such as stream-flow variation in freshwater, sea-level rise in estuaries, and upwelling in the ocean. How climate change will affect each stock or population of salmon also varies widely depending on the level or extent of change, the rate of change, and the unique life-history characteristics of different natural populations (Crozier et al. 2008b). For example, a few weeks' difference in migration timing can have large differences in the thermal regime experienced by migrating fish (Martins et al. 2011). Current research looking at species-specific vulnerability to climate change will help guide future species recovery planning efforts, including for SR spring/summer Chinook salmon.

2.15.1.3.1 Temperature Effects

Like most fishes, salmon are poikilotherms (cold-blooded animals); therefore, increasing temperatures in all habitats can have pronounced effects on their physiology, growth, and development rates (see review by Whitney et al. 2016). Increases in water temperatures beyond their thermal optima will likely be detrimental through a variety of processes, including increased metabolic rates (and therefore food demand), decreased disease resistance, increased physiological stress, and reduced reproductive success. All of these processes are likely to reduce survival (Beechie et al. 2013; Wainwright and Weitkamp 2013; Whitney et al. 2016).

By contrast, increased temperatures at ranges well below thermal optima (i.e., when the water is cold) can increase growth and development rates. Examples of this include accelerated emergence timing during egg incubation stages, or increased growth rates during fry stages

(Crozier et al. 2008a; Martins et al. 2011). Temperature is also an important behavioral cue for migration (Sykes et al. 2009), and elevated temperatures may result in earlier-than-normal migration timing. While there are situations or stocks where this acceleration in processes or behaviors is beneficial, there are also others where it is detrimental (Martins et al. 2012; Whitney et al. 2016). We have no information specific to SR spring/summer Chinook salmon at this time.

2.15.1.3.2 Freshwater Effects

Climate change is predicted to increase the intensity of storms, reduce winter snow pack at low and middle elevations, and increase snowpack at high elevations in northern areas. Middle and lower-elevation streams will have larger fall/winter flood events and lower late-summer flows, while higher elevations may have higher minimum flows. How these changes will affect freshwater ecosystems largely depends on their specific characteristics and location, which vary at fine spatial scales (Crozier et al. 2008b; Martins et al. 2012). For example, within a relatively small geographic area (the Salmon River basin in Idaho), survival of some Chinook salmon populations was shown to be determined largely by temperature, while in others it was determined by flow (Crozier and Zabel 2006). Certain salmon populations inhabiting regions that are already near or exceeding thermal maxima will be most affected by further increases in temperature and, perhaps, the rate of the increases. The effects of altered flow are less clear and likely to be basin-specific (Crozier et al. 2008b; Beechie et al. 2013). River flow is already becoming more variable in many rivers, and is believed to negatively affect anadromous fish survival more than other environmental parameters (Ward et al. 2015). It is likely this increasingly variable flow is detrimental to SR spring/summer Chinook.

Stream ecosystems will likely change in response to climate change in ways that are difficult to predict (Lynch et al. 2016). Changes in stream temperature and flow regimes will likely lead to shifts in the distributions of native species and provide "invasion opportunities" for exotic species. This will result in novel species interactions, including predator–prey dynamics, where juvenile native species may be either predators or prey (Lynch et al. 2016; Rehage and Blanchard 2016). How juvenile native species will fare as part of "hybrid food webs," which are constructed from natives, native invaders, and exotic species, is difficult to predict (Naiman et al. 2012).

2.15.1.3.3 Estuarine Effects

In estuarine environments, the two big concerns associated with climate change are rates of sea-level rise and temperature warming (Wainwright and Weitkamp 2013; Limburg et al. 2016). Estuaries will be affected directly by sea-level rise: as sea level rises, terrestrial habitats will be flooded and tidal wetlands will be submerged (Kirwan et al. 2010; Wainwright and Weitkamp 2013; Limburg et al. 2016). The net effect on wetland habitats depends on whether rates of sea-level rise are sufficiently slow that the rates of marsh plant growth and sedimentation can compensate (Kirwan et al. 2010).

Due to subsidence, sea-level rise will affect some areas more than others, with the largest effects expected for the lowlands, like southern Vancouver Island and central Washington coastal areas

(Verdonck 2006; Lemmen et al. 2016). The widespread presence of dikes in Pacific Northwest estuaries will restrict upward estuary expansion as sea levels rise, likely resulting in a near-term loss of wetland habitats for salmon (Wainwright and Weitkamp 2013). Sea-level rise will also result in greater intrusion of marine water into estuaries, resulting in an overall increase in salinity, which will also contribute to changes in estuarine floral and faunal communities (Kennedy 1990). While not all anadromous fish species are generally highly reliant on estuaries for rearing, extended estuarine use may be important in some populations (Jones et al. 2014), especially if stream habitats are degraded and become less productive.

2.15.1.3.4 Marine Effects

In marine waters, increasing temperatures are associated with observed and predicted poleward range expansions of fish and invertebrates in both the Atlantic and Pacific Oceans (Lucey and Nye 2010; Asch 2015; Cheung et al. 2015). Rapid poleward species shifts in distribution in response to anomalously warm ocean temperatures have been well documented in recent years, confirming this expectation at short time scales. Range extensions were documented in many species from southern California to Alaska during unusually warm water associated with “the blob” in 2014 and 2015 (Bond et al. 2015; Di Lorenzo and Mantua 2016) and past strong El Niño events (Pearcy 2002; Fisher et al. 2015).

Expected changes to marine ecosystems due to increased temperature, altered productivity, or acidification will have large ecological implications through mismatches of co-evolved species and unpredictable trophic effects (Cheung et al. 2015; Rehage and Blanchard 2016). These effects will certainly occur, but predicting the composition or outcomes of future trophic interactions is not possible with current models. Interestingly, Daly and Brodeur (2015) showed that bioenergetic demand increased during warm-ocean conditions, suggesting that, at a minimum, bottom-up drivers of growth and survival may become more important in the future.

Wind-driven upwelling is responsible for the extremely high productivity in the California Current ecosystem (Bograd et al. 2009; Peterson et al. 2014). Minor changes to the timing, intensity, or duration of upwelling, or the depth of water-column stratification, can have dramatic effects on the productivity of the ecosystem (Black et al. 2015; Peterson et al. 2014). Current projections for changes to upwelling are mixed: some climate models show upwelling unchanged, but others predict that upwelling will be delayed in spring, and more intense during summer (Rykaczewski et al. 2015). Should the timing and intensity of upwelling change in the future, it may result in a mismatch between the onset of spring ecosystem productivity and the timing of salmon entering the ocean (Tomaro et al. 2012), and a shift toward food webs with a strong sub-tropical component (Bakun et al. 2015).

Columbia River anadromous fish also use coastal areas of British Columbia and Alaska and midocean marine habitats in the Gulf of Alaska, although their fine-scale distribution and marine ecology during this period are poorly understood (Morris et al. 2007; Pearcy and McKinnell 2007). Increases in temperature in Alaskan marine waters have generally been associated with increases in productivity and salmon survival (Mantua et al. 1997; Martins et al. 2012), thought to result from temperatures that have been below thermal optima (Gargett 1997). Warm ocean temperatures in the Gulf of Alaska are also associated with intensified downwelling and increased coastal stratification, which may result in increased food availability to juvenile salmon along the coast (Hollowed et al. 2009; Martins et al. 2012). Predicted increases in freshwater discharge in British Columbia and Alaska may influence coastal current patterns (Foreman et al. 2014), but the effects on coastal ecosystems are poorly understood.

In addition to becoming warmer, the world's oceans are becoming more acidic as increased atmospheric CO_2 is absorbed by water. The North Pacific Ocean is already acidic compared to other oceans, making it particularly susceptible to further increases in acidification (Lemmen et al. 2016). Laboratory and field studies of ocean acidification show it has the greatest effects on invertebrates with calcium-carbonate shells, and relatively little direct influence on finfish; see reviews by Haigh et al. (2015) and Mathis et al. (2015). Consequently, the largest impact of ocean acidification on salmon will likely be its influence on marine food webs, especially its effects on lower trophic levels, which are largely composed of invertebrates (Haigh et al. 2015; Mathis et al. 2015). Marine invertebrates fill a critical gap between freshwater prey and larval and juvenile marine fishes, supporting juvenile salmon growth during the important early-ocean residence period (Daly et al. 2009, 2014).

2.15.1.3.5 Uncertainty in Climate Predictions

There is considerable uncertainty in the predicted effects of climate change on the globe as a whole, and on the Pacific Northwest in particular, and there is also the question of indirect effects of climate change and whether human "climate refugees" will move into the range of salmon and steelhead, increasing stresses on their respective habitats (Dalton et al. 2013; Poesch et al. 2016).

Many of the effects of climate change (e.g., increased temperature, altered flow, coastal productivity, etc.) will have direct impacts on the food webs that species rely on in freshwater, estuarine, and marine habitats to grow and survive. Such ecological effects are extremely difficult to predict even in fairly simple systems, and minor differences in life-history characteristics among stocks of salmon may lead to large differences in their response (e.g., Crozier et al. 2008b; Martins et al. 2011, 2012). This means it is likely that there will be "winners and losers," meaning some salmon populations may enjoy different degrees or levels of benefit from climate change while others will suffer varying levels of harm.

Climate change is expected to impact anadromous fish during all stages of their complex life cycle. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream-flow patterns in freshwater and changes to food webs in freshwater, estuarine, and marine habitats. Moreover, impacts of climate in one habitat can have carry-over effects in later life stages. For example, warmer stream and river temperatures may lead to earlier outmigration and potential mismatches between ocean entry and peak prey availability or predator dynamics. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty.

2.15.2 Environmental Baseline

The “environmental baseline” includes the past and present impacts of all federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

For SR spring/summer Chinook salmon, we focus our description of the environmental baseline on where SR spring/summer juveniles and adults are exposed to the effects of the proposed action, including in tributary habitats where the Action Agencies propose to implement habitat restoration actions.

To determine the upstream extent of SR spring/summer Chinook salmon distribution and thus exposure, we reviewed information relative to the distribution of SR spring/summer Chinook salmon in the Columbia River basin. The area where SR spring/summer Chinook salmon experience the greatest exposure to the effects of the proposed action is the Columbia River from the confluence with the Snake River downstream to the plume, and the Snake River from the Hells Canyon Dam to the confluence with the Columbia River. The area includes tributaries and their confluences in this reach to the extent that they are affected by flow management and habitat mitigation actions in the Columbia River basins.

2.15.2.1 Mainstem Habitat

Mainstem habitat in the lower Snake and Columbia Rivers has been substantially altered by basinwide water management operations, the construction and operation of mainstem hydroelectric projects, the growth of native avian and pinniped predator populations, the introduction of non-native species (e.g., fishes and invertebrates), and other human practices that have degraded water quality and habitat.

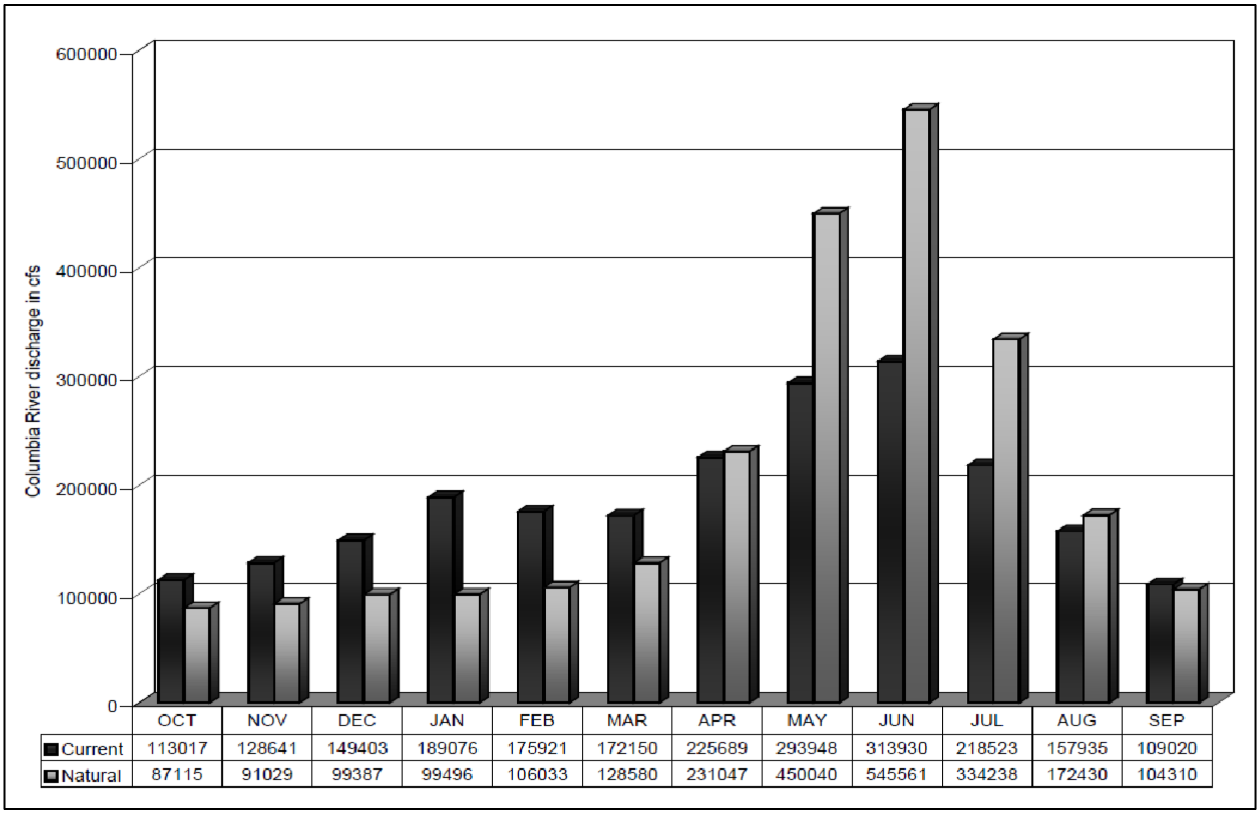
Water diversions for a variety of purposes (agricultural, municipal, etc.) and the management of stored water (including runoff stored in Canadian reservoirs, in the U.S. portion of the Columbia Basin, and in the upper Snake River basin, Yakima River basin, Deschutes River basin) have altered the quantity and timing of flows entering the lower Snake and Columbia Rivers compared to historical conditions.

On the mainstem of the Snake and Columbia Rivers, hydropower projects (including the CRS), water-storage projects (including reservoirs in Canada operated under the Columbia River Treaty), and the withdrawal of water for irrigation and urban uses have significantly degraded salmon and steelhead habitats (Bottom et al. 2005; Fresh et al. 2005; NMFS 2013a). The volume of water discharged by the Columbia River varies seasonally according to runoff, snowmelt, and hydropower demands. Mean annual discharge is estimated to be 265 kcfs, but may range from lows of 71–106 kcfs to highs of 530 kcfs (Hamilton 1990; NMFS 1998; Prahl et al. 1998; USACE 1999). Naturally occurring maximum flows on the river occur in May, June, and July as a result of snowmelt in the headwater regions. Minimum flows occur from September to March, with periodic peaks due to heavy winter rains (Holton 1984). Interannual variability in stream flow is strongly correlated with two recurrent climate phenomena, the ENSO and the PDO (Newman et al. 2016).

Water storage projects (dams and reservoirs) and water management activities have reduced flows at Bonneville Dam (especially during the spring months), representing basinwide effects on flows in the lower Columbia River (from McNary Reservoir to the mouth of the Columbia River; NMFS 2008b). On average, this reduction can range from nearly 15 kcfs in August to over 230 kcfs in May (Figure 2.15-3). Proportional flow reductions of similar magnitude also occur in the middle Columbia River (Chief Joseph tailrace to the Columbia River's confluence with the Snake River within McNary Reservoir).

Recognizing that the flow versus survival relationships for some interior basin ESUs/DPSs (including SR spring/summer Chinook) displayed a plateau over a wide range of flows but declined markedly as flows dropped below some threshold (NMFS 1995b, 1998), NMFS and the CRS Action Agencies have attempted to manage Columbia River and Snake River water resources to maintain seasonal flows above threshold objectives given the amount of runoff in a given year. This has been accomplished by avoiding excessive reservoir drafts going into spring to minimize the flow reductions needed for refill, and by drafting the storage reservoirs during summer to augment flows.[212] These flow objectives have guided preseason reservoir planning and in-season flow management. Nonetheless, since the development of the hydrosystem, average monthly flows at Bonneville Dam have been substantially lower during May–July and higher in October–March than in an unregulated system. Reduced flows have increased travel times for outmigrating juvenile Chinook salmon and resulted in reduced access to high-quality estuarine habitats from May through July during low tides.

[212] Even though several million acre feet of water are released annually from storage during the summer months to augment flows (and from Dworshak Dam, to reduce mainstem temperatures), these volumes do not offset the consumption of water in the basin in July and August.



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Current	113017	128641	149403	189076	175921	172150	225689	293948	313930	218523	157935	109020
Natural	87115	91029	99387	99496	106033	128580	231047	450040	545561	334238	172430	104310

Figure 2.15-3. Comparison of monthly discharge (flow) in the Columbia River between current conditions (black) and normative flows (gray). These data show that pre-development flows were lower in the winter and higher in the summer months.

Table 2.15-5 depicts the FOP for spring spill during 2017 and 2018. There was a substantial increase in spill over the dam spillways in the spring during 2018 in response to a court order requiring additional spill. Spill, as a percentage of flow at Snake River dams, averaged 37.2 percent, with daily mean spill percentages above the long-term spill average (1993–2018) for nearly the entire migration period. Transportation rates were substantially higher than in recent years, reversing decreases in transportation observed from 2015–17. Travel times from Lower Granite to Bonneville Dam were substantially shorter than the 1997–2018 mean. This coincided with the high flows and spill percentages in 2018, when flows decreased in June, travel times were similar to those observed in recent years. Preliminary PIT-tag based survival estimates (Zabel 2018) indicate that survival of Snake River yearling Chinook salmon from Lower Granite to Bonneville Dam was substantially below the 1998–2018 average of 52.1 percent.

Table 2.15-5. Summary of 2017 and 2018 Fish Operations Plan (FOP) spring spill levels at lower Snake River and Columbia River projects.

Project	2017 Spring Spill Operations (Day/Night)	2018 Operations
Lower Granite	20 kcfs/20 kcfs	120% TDG tailrace (gas cap)/115% to the next forebay
Little Goose	30%/30%	120% TDG tailrace (gas cap)/115% to the next forebay
Lower Monumental	Gas Cap/Gas Cap (approximate Gas Cap range: 20-29 kcfs)	120% TDG tailrace (gas cap)/115% to the next forebay
Ice Harbor	April 3-April 28: 45 kcfs/Gas Cap **April 28-June 20:** 30%/30% vs. 45 kcfs/Gas Cap (approximate Gas Cap range: 75-95 kcfs)	120% TDG tailrace (gas cap)/115% to the next forebay
McNary	40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay
John Day	April 10-April 28: 30%/30% **April 28-June 15:** 30%/30% and 40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay
The Dalles	40%/40%	120% TDG tailrace (gas cap)/115% to the next forebay
Bonneville	100 kcfs/100 kcfs	120% TDG tailrace (gas cap) to a cap of 150 kcfs because of erosion concerns (no next forebay)

2.15.2.2 Water Quality

Water quality in the action area is impaired as a result of chemical contaminants from municipal, agricultural, industrial, and urban land uses (NMFS 2017e). Common toxic contaminants found in the Columbia River system include PCBs, PAHs, PBDEs, DDT and other legacy pesticides, current use pesticides, pharmaceuticals and personal care products, and trace elements (LCREP 2007). The LCREP (2007) report noted widespread presence of PCBs and PAHs, both geographically and in the food web. Urban and industrial portions of the lower river contribute significantly to contaminant levels in juvenile salmon; juvenile salmon are absorbing toxic contaminants during their time rearing and feeding in the lower Columbia River (LCREP 2007). Likewise, juvenile salmon are accumulating DDT in their tissues and are exposed to estrogen-like compounds in the lower river, likely associated with pharmaceuticals and personal care products. Concentrations of copper are present at levels that could interfere with crucial salmon behaviors.

Growing population centers throughout the Columbia River and Snake River basins and numerous smaller communities contribute municipal and industrial waste discharges to the lower Columbia River. Industrial and municipal wastes from the Portland/Vancouver metro areas, including the superfund-designated reach in the lower Willamette River, also contribute to degraded water quality in the lower river. Legacy and active mining areas scattered around the basin deliver high background concentrations of metals. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river.

The most extensive urban development in the lower Columbia River basin has occurred in the Portland/Vancouver area. Common water-quality issues both in areas with urban development and rural residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff (LCREP 2007). Similar effects are likely to be proportionally associated with smaller urban areas as well (e.g., Lewiston, Idaho; Tri-Cities, Washington; The Dalles and Hood River, Oregon). While it is not clear what the magnitude of effects are to juvenile or adult spring/summer Chinook from exposure to these factors (see previous discussion relating to chemical contaminants), they are likely to negatively affect fitness and survival to some extent.

Outside of urban areas, the majority of residences and businesses rely on septic systems. Common water-quality issues with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff. Under these environmental conditions, fish in the action area are stressed. Stress may lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival).

Oils, greases, and other lubricants (derived from animal, fish, vegetable, petroleum or marine mammal origin) are used at each of the CRS projects (and all other dams in the Columbia River Basin), including, but not limited to, the following: hydropower turbines, hydraulic systems, lubricating systems, gear boxes, machining coolant systems, heat transfer systems, transformers, circuit breakers, and electrical systems. Leakage of oils, greases, or other lubricants into rivers has the potential to affect salmon and steelhead (avoidance, exposure to toxic compounds, or even, in some circumstances death). In response to increased concerns regarding the releases of oils and greases from lower Columbia and lower Snake River dams (and Dworshak and Chief Joseph Dams) the Corps has taken steps to minimize these risks. For equipment in contact with the water, the Corps has developed best management practices to avoid accidental releases and to minimize the adverse effects in the case of an accidental release. The Corps has also begun using, where feasible, "environmentally acceptable lubricant" greases and in some cases has replaced greased equipment with greaseless equipment. The Corps has also developed and is implementing oil accountability plans with enhanced inspection protocols and is reporting annually.

The extent to which leaked grease or oil, occurring under the environmental baseline in the Clearwater River (Dworshak Dam), upper Columbia River (Chief Joseph), or lower Snake or lower Columbia Rivers, has affected the behavior, health, or survival of SR spring/summer Chinook salmon in the past is unknown, but likely to be small given that the size of these river systems. For comparison, a large leak of 100 gallons per day is the equivalent of 0.00016 cubic feet per second and the average annual discharge of the Columbia River has ranged from roughly 125,000 to 250,000 cubic feet per second since about 1940 (ISAB 2000). Nevertheless, to the extent past leakages have potentially affected passage or survival, these effects would be encompassed by annual juvenile or adult reach survival estimates. Recent actions (adoption of best management practices, use of environmentally acceptable lubricants, use of greaseless equipment, etc.) would further reduce the potential for negative effects stemming from these materials and slightly improve conditions for juvenile and adult migrants.

Our understanding of the effects on aquatic life of many contaminants, alone or in combination with other chemicals (potential for synergistic effects), is incomplete, especially when considering exposure of rearing juveniles to multiple contaminants, or when considering their interactions with other stressors, food web-mediated effects, and effects in complex mixtures (NMFS 2017e). Together, these contaminants are likely affecting the productivity and abundance of SR spring/summer Chinook, especially during the rearing and juvenile migration phases of their life cycle. The effects can be direct or indirect, and lethal or more likely sublethal; the interaction of co-occurring stressors may have a greater impact on salmon than if they occur in isolation (Dietrich et al. 2014).

Recent actions (adoption of best management practices, use of environmentally acceptable lubricants, use of greaseless equipment, etc.) would further reduce the potential for negative effects stemming from these materials and slightly improve conditions for juvenile and adult migrants.

Water temperatures in the Snake and Columbia Rivers are a concern; both rivers are included on the Clean Water Act §303(d) list of impaired waters established by the relevant states because of temperature-standard exceedances. Temperature conditions in the Columbia River basin area are affected by many factors, including:

- Natural variation in weather and river flow;
- Construction of the dam and reservoir system (the large surface areas of reservoirs and resulting slower river velocities contribute to warmer late summer/fall water temperatures);
- Increased temperatures of tributaries;
- Water managed for irrigated agriculture;
- Point-source discharges such as cities and industries; and
- Climate change (Overman 2017; EPA 2018).

Since the mid-1990s, the Corps has released up to 1.2 million acre-feet of cool water from Dworshak Dam on the North Fork Clearwater River to reduce temperatures in the lower Snake River from June or July to September. Operators manage water releases from Dworshak to not exceed 68°F at the tailrace of Lower Granite Dam. This action appears to have little to no effect on temperature in the Columbia River downstream of the Snake River confluence.

Temperatures in the middle Columbia River are affected by Grand Coulee Dam, completed in 1942. Thermal inertia from the large mass of water in the reservoir (total storage capacity of 9.6 million acre-feet, active capacity of about 5.2 million acre-feet) results in delayed warming in the spring (cooler temperatures) and delayed cooling in the late summer and fall (warmer temperatures). However, even in the extremely warm year of 2015, the average temperature of the Columbia River was less than 68°F (Figure 2.15-4; NMFS 2016e). Cooler spring (April and May) temperatures in the middle Columbia River would reduce exposure to high temperatures and would be expected to enhance the survival of spring migrating smolts and adult spring-run Chinook salmon. According to DART/PIT-tag data (accessed November 2, 2018), 95 percent of the fish from both spring and summer-run populations have passed Bonneville Dam by the end of June, and it is very rare to see a fish pass Lower Granite Dam after the end of July. Warmer August and September temperatures would have little effect on adult SR spring and summer Chinook salmon populations because they should already have migrated into their natal tributaries by this time of year.

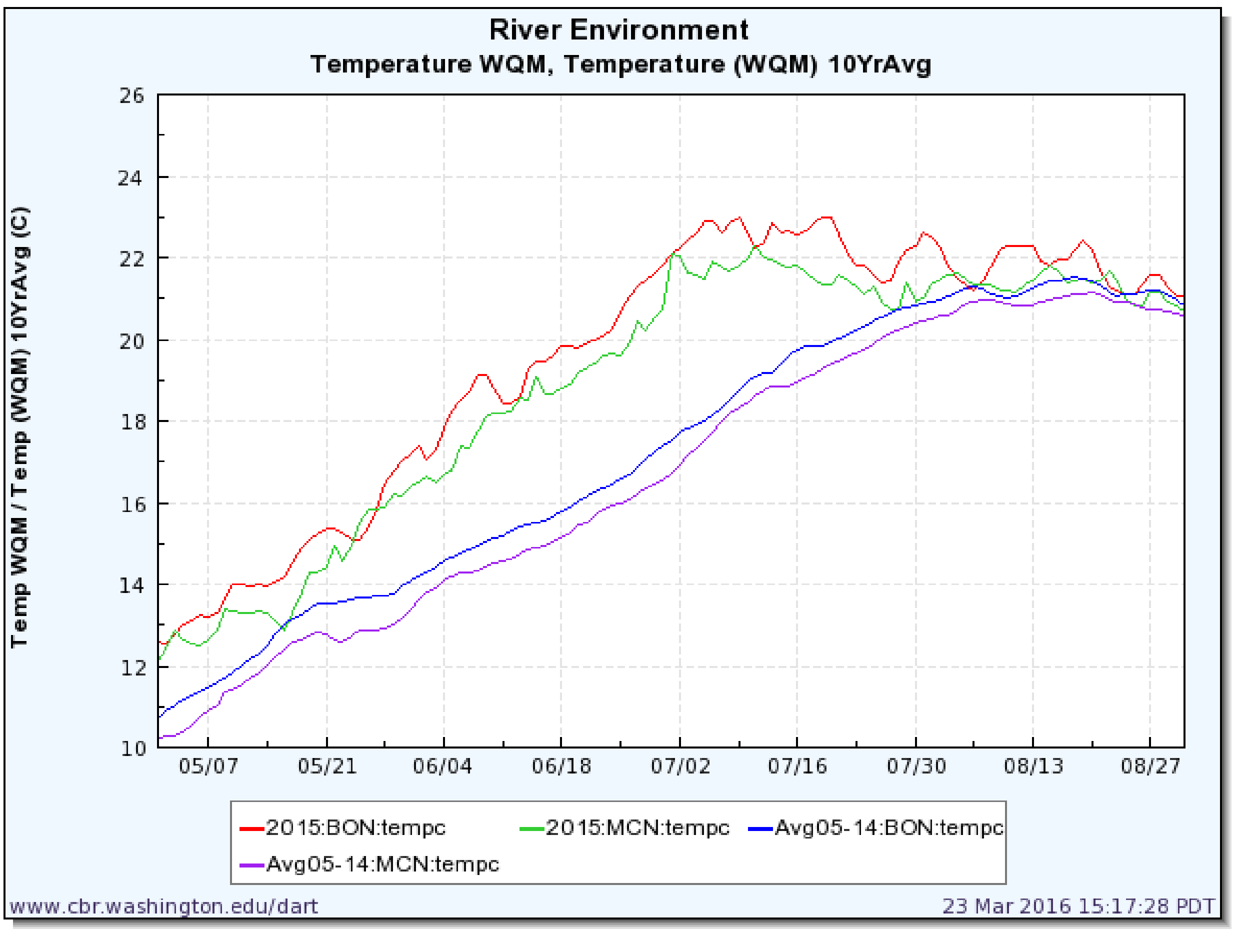


Figure 2.15-4. Columbia River temperature at Bonneville Dam and McNary Dam (forebays) in 2015 relative to the prior 10-year average.

The EPA is working with federal and state agencies, tribes, and other stakeholders to develop water-quality improvement plans (total maximum daily loads) for temperature in the Columbia

River and lower Snake River. As part of the 2015 biological opinion on EPA's approval of water-quality standards, including temperature (NMFS 2015a), EPA committed to work with federal, state, and tribal agencies to identify and protect thermal refugia and thermal diversity in the lower Columbia River and its tributaries. These areas could be important to summer migrating SR spring/summer Chinook salmon.

Comparisons of long-term temperature monitoring in the migration corridor before and after impoundment reveal a change in the thermal regime of the Snake River that influences temperatures downstream of its confluence with the Columbia River. Using historical flows and environmental records for the 35-year period 1960–95, Perkins and Richmond (2001) compared water temperature records in the lower Snake River with and without the lower Snake River dams. They found three notable differences between the current versus unimpounded river:

- Maximum summer water temperature has been slightly reduced;
- Water temperature variability has decreased; and
- Post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall, a phenomenon termed thermal inertia.

These general effects should also apply to dams in the middle and lower reaches of the Columbia River. The hydrosystem effects (influenced by the temperatures of tributary streams entering the Snake and Columbia Rivers both upstream of, within, and downstream of the mainstem dams) continue downstream and influence temperature conditions in the lower Columbia River. At a macro scale, water temperature affects salmonid distribution, behavior, and physiology (Groot and Margolis 1991); at a finer scale, temperature influences migration swim speed of salmonids (Salinger and Anderson 2006), timing of river entry (Peery et al. 2003), susceptibility to disease and predation (Groot and Margolis 1991), and, at temperature extremes, survival.

TDG levels also affect mainstem water quality and habitat. To facilitate the downstream movement of juvenile salmonids, Oregon and Washington regulatory agencies issue criteria adjustments for TDG as measured in the forebay and tailrace (NMFS 1995b). Specifically, water that passes over the spillway at a mainstem dam can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). Historically, TDG supersaturation was a major contributor to juvenile salmon mortality; to reduce TDG supersaturation, the Corps installed spillway improvements, typically "flip lips" to create a hydraulic jump and deflect water upwards, at each mainstem dam except The Dalles Dam. Biological monitoring shows that the incidence of GBT in both migrating smolts and adults remains between 1–2 percent when TDG concentrations in the upper water column do not exceed 120 percent of saturation in CRS project tailraces.[213] When those levels are exceeded,

[213] Monitoring at the Lower Granite Dam trap showed that GBT and headburn symptoms on adult steelhead and Chinook in 2018 (experiencing higher court-ordered spill operations in 2018) were similar in prevalence to past years (Odgen 2018b).

there is a corresponding increase in the incidence of signs of GBT symptoms. Fish migrating at depth avoid exposure to the higher TDG levels due to pressure compensation mechanisms (Weitkamp et al. 2003). For the 2018 spill season, the Action Agencies operated to meet, but not exceed, the 120 percent tailrace/115 forebay TDG caps to comply with a court order.

2.15.2.3 Sediment Transport

The series of dams and reservoirs have also blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is less than one-third of nineteenth-century levels (Simenstad et al. 1982 and 1990; Sherwood et al. 1990; Weitkamp 1994; NRC 1996; NMFS 2008a). Similarly, Bottom et al. (2005) estimated that the delivery of suspended sediment to the lower river and estuary has been reduced by about 60 percent (as measured at Vancouver, Washington), and fine sediment transport reduced by 50 percent or more. These estimates reflect the combined total of all activities throughout the Columbia River basin on sediment transport. Similar reductions would be expected throughout the mainstem action area. The overall reduction in sediment has altered the development of habitat along the margins of the river and likely increased the risk of predation (birds and fishes) to migrating juveniles (Bottom et al. 2005).

Industrial harbor and port development are also significant influences on the lower Snake and lower Columbia Rivers (Bottom et al. 2005; Fresh et al. 2005; NMFS 2013a). Since 1878, the Corps has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the Willamette River as a navigation channel. Originally dredged to a 20-foot minimum depth, the federal navigation channel of the lower Columbia River is now maintained at a depth of 43 feet and a width of 600 feet. The navigation channel supports many ports on both sides of the river, resulting in several thousand commercial ships traversing the river every year. The dredging, along with diking, draining and fill material placed in wetlands and shallow habitat, also disconnects the river from its floodplain resulting in the loss of shallow-water rearing habitat and the ecosystem functions that floodplains provide (e.g., supply of prey, refuge from high flows, temperature refugia, etc.; Bottom et al. 2005).

2.15.2.4 Adult Migration/Survival

Adults must migrate from the ocean, upstream through the estuary, and pass up to eight mainstem dams and reservoirs (Tucannon River population is the only population to migrate past seven dams, all other populations migrate past eight dams) to reach their spawning areas. Factors that affect the survival rates of migrating adults include harvest (either reported or unreported), dam passage (adults must find and ascend ladders and reascend the ladders if they fall back through spillways or other routes), straying (either naturally or as a result of impaired homing stemming from transport or other factors), pinniped predation, and temperature and flow conditions that can increase energetic demands of migrating fish (NMFS 2008a).

PIT-tag detectors placed near the exits of adult ladders at the mainstem dams provide a unique ability to monitor the upstream survival of adults that were tagged as juveniles. Starting with the number of adults detected at Bonneville Dam, minimum survival estimates can be derived from detections at upstream dams. Termed "conversion rates," these survival estimates are adjusted for reported harvest and the expected rate of straying of natural-origin adults. Figure 2.15-5 depicts minimum estimated survival rates from Bonneville to McNary Dam (three reservoirs and dams) and to Lower Granite Dam (seven reservoirs and dams) during 2008–17, years that include recent hydropower operations and harvest rates within the "zone 6" fishery (as designated in the *U.S. v. Oregon* Management Agreement).

Based on data depicted in Figure 2.15-5, the ten-year average (2008–17) minimum survival estimate for SR spring/summer Chinook salmon from Bonneville to McNary Dam is 88.7 percent (range of 82.8–100.0 percent).[214] The ten-year average minimum survival estimate from Bonneville to Lower Granite Dam is 84.3 percent (range of 77.2–93.5 percent).

These survival estimates account for total losses from the dams and reservoirs, as well as any losses in these reaches resulting from elevated temperatures, disease, injury, or other natural causes. Expressed on a "per project" basis (1/3rd root of 88.7 percent), about 96.1 percent of adult SR spring/summer Chinook salmon are surviving passage through each project (dam and reservoir) in the lower Columbia River, after accounting for reported harvest and natural stray rates. From Bonneville to Lower Granite Dam, per project survival rates are averaging around 97.6 percent (1/7th root of 84.3). These relatively high survival rates indicate that upstream passage conditions are not substantially impaired for adult SR spring/summer Chinook migrating through impounded reaches of the lower Columbia and lower Snake Rivers.

In addition, 770 summer-run Chinook salmon from the Snake River ESU were handled during the 2015 emergency trapping operation at Lower Granite Dam for SR sockeye with no reported injuries or mortalities (Ogden 2018b).

[214] Conversion rates close to, or higher than, 100 percent are possible if estimates of harvest rates (or natural rates of straying) are higher than what actually occurred in a given year (biased high). Conversely, if harvest rates are underestimated, the resulting conversion rate estimates would be biased low. For this analysis, 100 percent was used as a maximum value for calculating the ten-year average survival estimate.

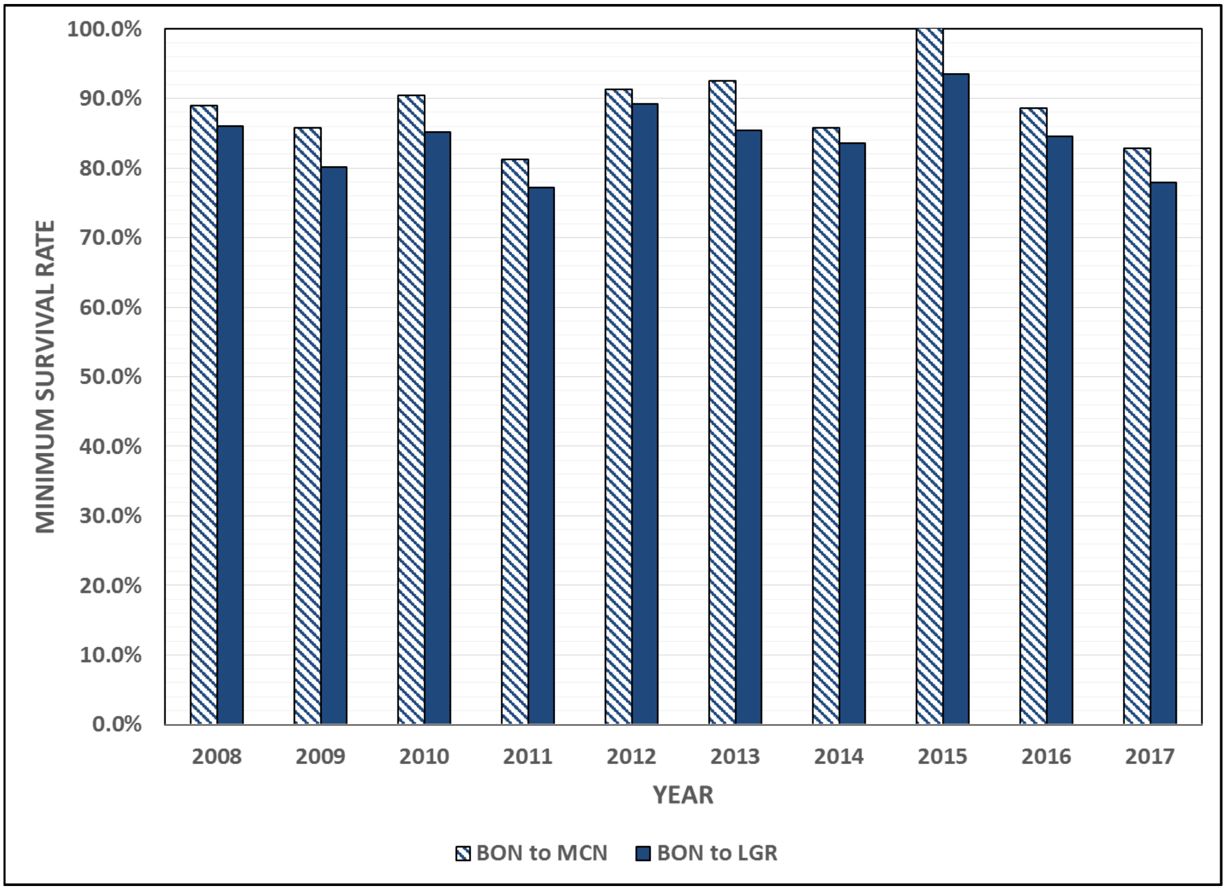


Figure 2.15-5. Minimum survival estimates from Bonneville to McNary and to Lower Granite Dams (2008–17) estimated using known-origin PIT-tagged adult SR spring-summer Chinook salmon — natural- and hatchery-origin combined — that migrated in-river as juveniles. Source: NMFS, using data from PITAGIS.

2.15.2.5 Juvenile Migration/Survival

The mainstem dams and reservoirs continue to substantially alter the mainstem migration corridor habitat. The reservoirs have increased the cross-sectional area of the river, reducing water velocity, altering the food web, and creating habitat for native and non-native species which are predators, competitors, or food sources for migrating juvenile Chinook. The travel times of migrating smolts are increased through the reservoirs, increasing exposure to both native and nonnative predators (see predation section below), and some juveniles are injured or killed as they pass through the dams (turbines, bypass systems, spill bays, or surface passage routes; NMFS 2008a).

Overall, however, passage conditions and resulting juvenile survival rates in the migration corridor have improved substantially since 1992, when the species was listed. This is most likely the result of improved structures and operations and predator-management programs at the Corps' mainstem projects (24-hour volitional spill, surface passage routes, improved juvenile bypass systems, predator-management measures, etc.; NMFS 2017e).

Widener et al. (2018) estimates that juvenile SR spring/summer Chinook salmon survival rates (wild and hatchery combined) from Lower Granite to McNary Dam (four reservoirs and dams) averaged 76.2 percent (ranging from 69.4 to 79.0 percent) from 2008–17, and survival rates from Lower Granite to Bonneville Dam (seven reservoirs and dams) averaged 53.3 percent (ranging from 43.7 to 64.3 percent) for the same time period (Figure 2.15-6). These survival rates incorporate multiple sources of mortality such as passage mortality, natural mortality, and predation.The estimated Lower Granite to Bonneville Dam survival estimate for 2018 (under the court ordered spill operation) was 43.2 percent - somewhat lower than the recent average. The reduced survival rates in the lower Columbia River (difference of Lower Granite to McNary Dam and Lower Granite to Bonneville Dam) starting in 2015 were likely influenced by increased predation by Caspian terns displaced from Crescent Islands to Blalock Island in the John Day pool (Roby et al. 2016).

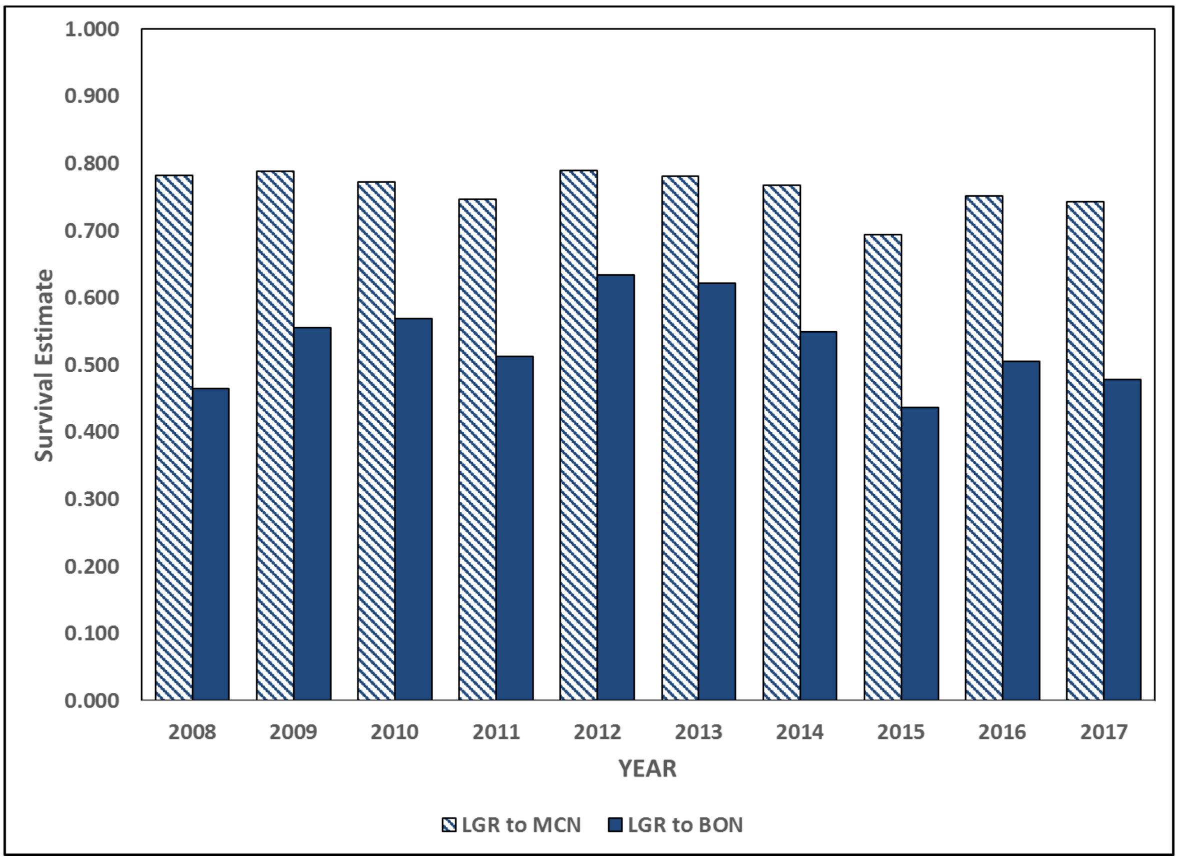


Figure 2.15-6. Survival estimates of SR spring-summer Chinook salmon smolts (wild and hatchery combined) from Lower Granite to McNary and Lower Granite to Bonneville Dams (2008–17). Source: Widener et al. 2018.

Together, these survival rates represent a substantial improvement in migration conditions and survival rates for juvenile SR spring/summer Chinook salmon migrating through the impounded reaches of the lower Snake and lower Columbia Rivers compared to the 1980s and 1990s (NMFS 2008a), which increases the overall productivity of the populations and the abundance of returning adults.

2.15.2.6 Transportation

Turbine intake screens, part of the juvenile bypass systems,[215] divert SR yearling Chinook smolts away from turbine units and into a system of channels and flumes before delivering them to either the tailrace below the dam (bypassed), or into raceways where they can be loaded onto barges and transported to below Bonneville Dam and released to continue their migration to the ocean. Some SR yearling Chinook salmon smolts were collected at McNary Dam and transported to below Bonneville Dam until 2012, when the Corps terminated transportation of juveniles from McNary Dam based on a recommendation from NMFS. This action was adopted in the 2014 FCRPS biological opinion (NMFS 2014).

Juvenile fish transportation has been a mitigation operation for the CRS since 1981 (Baxter et al. 1996). The effectiveness of the program is evaluated annually and juvenile transport continues to show an overall benefit. However, the degree of benefit has decreased because in-river survival has increased and the proportion of fish being transported has decreased, subsequent to the increase in spill and the later transport collection dates that were implemented for juvenile yearling spring Chinook salmon and steelhead in 2006.

The primary metric for assessing transport effects is the ratio of SARs of transported fish relative to that of fish remaining in-river and passing the hydrosystem by other routes during migration. Several types of ratios are useful, differing by which fish are included in the ratio. This document will present two transport ratios to describe effects of transport on adult returns (Table 2.15-5). These ratios are:

1. Transport-in-River Ratio (TIR): The TIR is the ratio of the SAR of fish transported from Lower Granite, Little Goose, or Lower Monumental Dams, relative to the SAR of fish that never entered a collection system at these dams. PIT-tagged fish used for TIR estimates come only from fish tagged upstream of Lower Granite Dam, and smolt number estimates are adjusted to account for mortality between Lower Granite Dam and the downstream transport site. The CSS uses this metric to report transport results.
2. Transport-Bypass Ratio (T:B): The T:B is the ratio of the SAR of fish transported from a specific collector project (in Lower Granite Dam equivalents for downstream projects), relative to the SAR of fish that entered the same collection system and were then bypassed to the river downstream. The NWFSC generally uses this metric to report transport results.

T:B and TIR ratios greater than one indicate that transported fish are returning as adults to the collection point at higher rates than bypassed or in-river fish respectively. Table 2.15-5 shows that, in most cases, SARs are higher for transported fish than for bypassed or in-river fish.

[215] All of the powerhouses at the four lower Columbia River mainstem dams have juvenile bypass systems with the exception of The Dalles Dam and Bonneville Dam, Powerhouse 1.

Because these ratios provide a comparison of transport effects relative to different passage routes, they can address different management questions. A TIR ratio provides information regarding the benefit of increasing or decreasing fish collection (with respect to adult returns), while a T:B ratio provides information about whether to transport or return collected fish to the river. One advantage of T:B ratios is that data on transport effects can be evaluated on a finer temporal scale than annual estimates (TIR), because fish detections can be partitioned by the time they are detected passing a project (T:B). Fish passing through spillway and turbine routes have no detections and, thus, have an unknown passage date. Table 2.15-5 shows T:B and TIR ratios for 2006 through 2013.

The spring juvenile migration begins in April and the fisheries managers generally choose to bypass fish for the first several months of April. This decision is supported by data that indicates there is no benefit to transport fish very early in the season. However, as the season progresses, a decision is made in late April or early May to begin the collection process and transport the collected juveniles. When the collection and transport begin, a portion of the juveniles that have PIT tags are returned to the river to assess in-river survival. These fish serve as the bypass (B) fish, and the effectiveness of transportation is measured by comparing the rate of returning adults of transported fish relative to those that were returned to migrate in-river. All fish used in the evaluation have been detected at a collector dam and their PIT-tag read, which effectively provides a date stamp when they were bypassed or transported through the season. This allows for the subsequent evaluation of how transported fish performed relative to those bypassed at the projects across the migration season.

The TIR provides a different perspective. It compares the rate of returning adults for fish that were transported relative to those that were not bypassed, and therefore never detected, at a Snake River collector project. It provides a relative comparison of the annual effect of transport on adult returns compared to fish that passed all of the collector projects by way of the spillways or the turbines. This ratio does not allow a daily evaluation of transport because the fish that passed in-river were never detected and include fish that migrated in-river before transport operations were initiated. This ratio serves as a high standard for comparative purposes because it represents a condition where the in-river, non-transported fish passed all the collector dams without encountering a juvenile bypass system. Both measures have merits and are best viewed collectively.

The relative effect of transportation as a mitigation measure varies by species. The general pattern is that transportation benefits wild and hatchery SR spring/summer Chinook. The annual results of transportation effects on adult returns are provided in the form of T:B and TIR ratios for the years 2006–15 (Table 2.15-6). The T:B ratios presented are based on transport studies conducted by the NWFSC on fish transported from Lower Granite Dam (Smith 2018). The transport results from Little Goose Dam are generally similar, however less benefit is generally observed from transport at Lower Monumental Dam where fewer fish are transported.The year 2006 was chosen as the starting point because that was the first year that spill was provided on a

24-hour basis at all of the Snake River projects which represents the adoption of a spill strategy that is likely to continue in some form.

Table 2.15-6. Analysis of effects of transport on adult return rates for SR spring/summer Chinook salmon using the NWFSC metric (T:B) versus the CSS metric (TIR).

	T:B (NWFSC metric)		**TIR[1] (CSS Metric)**	
Year	**Hatchery Chinook**	**Wild Chinook**	**Hatchery Chinook**	**Wild Chinook**
2006	1.66	1.21	0.91	0.78
2007	2.90	1.87	1.76	1.27
2008	1.55	1.67	1.43	1.19
2009	1.71	1.82	2.00	1.11
2010	1.28	1.28	1.29	1.21
2011	0.91	0.86	0.93	0.68
2012	1.41	1.58	1.09	0.71
2013	1.58	1.44	1.25	1.17
2014	2.92	4.65	1.60	2.03
2015	3.70	29.94	2.87[2]	3.79[2]
Geometric mean	1.8	2.18	1.42	1.21

NOTE: NMFS T:B estimates represent a comparison of SARs for fish tagged above Lower Granite and either transported (T) or bypassed (B) at Lower Granite. The CSS TIR estimates come from the 2017 CSS Annual Report, and represent the T_0 or T_x SAR, relative to fish never detected at a collector project (C_0 SAR).

1The mean TIR for Snake River hatcheries reported in the 2017 CSS Annual Report.

2 Incomplete adult returns at time of analysis.

While the overall result of transportation is positive, it is no panacea (Williams 2005). A regional goal is for survival of in-river migrants to meet or exceed that observed for transported fish. That goal has not yet been met for spring migrants, but transport provides an important benchmark. The alternative to transport is to improve in-river migration conditions to the point where transport provides little benefit. Over the years various transportation strategies have been proposed and have been reviewed by the ISAB, most recently in 2010 (ISAB 2010). The guidance provided by the ISAB has been consistent, which is to "spread the risk" between transport and in-river passage and measure the effects of in-river survival and transport over time.

The efforts made to improve in-river conditions since 2006 have included the provision of 24-hour spill during juvenile migration at all of the mainstem projects, the addition of surface passage structures, and the relocation of juvenile bypass outfall locations to improve in-river survival of bypassed fish. The most recent change was the provision of spring spill to the 115/120 percent TDG level at all of the mainstem federal dams in 2018. While higher spill is anticipated to result in fewer fish being collected for transport, that effect would not be uniform under all flow conditions. Spill passes a greater proportion of fish under low-flow conditions, which occurred in 2015; only 12.5 percent of the spring Chinook salmon were transported that year. The year 2015 also had a relatively low in-river survival (45.7 percent), and transport provided a very high benefit for hatchery spring Chinook salmon (T:B ratio of 3.7:1) and wild spring Chinook salmon (T:B of 29.7:1). Reconciling the desire to improve in-river conditions when in-river conditions are poor due to low flows and high temperatures, such as those in 2015, is a challenge. It requires an in-season management decision to weigh the potential effects of increasing transport and the desire for many regional managers to improve in-river conditions, with spill as the main strategy. Determining an "optimum" transportation operation is challenging for several reasons. The benefit of transportation (relative to in-river migrating juveniles) varies seasonally, by river flow and temperature conditions, and likely as a result of ocean conditions (when fish arrive at the ocean). Patterns also vary by species and rearing type (hatchery or wild).

Transport also has unintended consequences, such as straying. Spring migrants are transported in barges which follow the course of the river but the barge moves the fish at a rate much faster than their in-river cohorts. Fish that migrate in-river take two weeks or longer to travel from Lower Granite to Bonneville Dam. Fish that are transported make this trip in about three days. It appears this rapid rate of migration in a barge prevents these fish from acquiring waypoints along the migration route, which alters their migration when returning as adults. The result is that returning fish that were transported as juveniles often wander into tributaries for some period of time, or fall back over mainstem dams at rates greater than in-river migrants. This behavior generally results in reduced survival of these fish, either from injury or being caught in a fishery. The TIR and T:B incorporate these losses, so the overall effect of transportation on the population is positive. The question is whether alteration of adult-homing behavior has important fitness consequences, and may additionally affect non-target populations when adults enter and breed in non-natal streams (Keefer et al 2008). Keefer studied the effects of barged and in-river migrating spring Chinook salmon during the juvenile migration years 1998–2003. He found comparisons between Chinook salmon adults that homed versus strayed, and found there was a strong association between straying and barging for hatchery-origin fish, though stray sample sizes were small.

2.15.2.7 Hatcheries

Hatchery programs can negatively affect naturally produced populations of salmon and steelhead in a variety of ways: competition (for spawning sites and food), predation effects, disease effects, genetic effects (outbreeding depression), broodstock collection and facility effects (hatchery-influenced selection) (NMFS 2018a). Emphasis on hatchery fish may also deny marine nutrients to infertile rearing streams used by relatively few naturally produced spring Chinook salmon.

However, NMFS also recognizes that there are benefits that may outweigh these risks under circumstances where demographic or short-term extinction risk to the population is greater than risks to population diversity and productivity. Safety net or conservation hatchery programs can provide short-term demographic benefits, such as increases in abundance, during periods of low natural abundance. They also can help preserve genetic resources until limiting factors can be addressed. Conversely, the long-term use of artificial propagation may pose risks to natural productivity and diversity. Even when a hatchery program uses genetic resources that represent the ecological and genetic diversity of the target or affected natural population(s), they may pose a risk to the fitness of the population based on the proportion of natural-origin fish being used as hatchery broodstock and the proportion of hatchery-origin fish spawning in the wild (Lynch and O'Hely 2001; Ford 2002). The magnitude and type of the risk depends on the status of affected populations and on specific practices in the hatchery program.

A major advance since the data compilation efforts leading to the 2011 NMFS status review has been the cooperative efforts of regional fish managers to maintain regionally compatible databases, using standardized formats and methods, to promote efficiency and access to population-level estimates of key status indicators including spawning abundance, hatchery/natural proportions and age structure. Hatchery programs have continued to be reviewed and modified since the 2011 status review to support survival of natural-origin populations. New information available since the 2011 status review indicates that there have been improvements in our knowledge of the extent to which hatcheries present risks to the persistence of these species; however, further research and investigation is needed (NWFSC 2015).

There are currently 18 spring/summer Chinook salmon hatchery programs in the Snake River basin. Most of these programs release hatchery fish into rivers with ESA-listed natural-origin spring/summer Chinook. Snake River spring/summer Chinook salmon hatchery program production levels have remained stable since the last review. Many captive broodstock programs initiated during the 1990s to conserve SR spring/summer Chinook salmon genetic resources were terminated after the status of these fish improved. The following discussion provides information on hatchery programs within in each MPG, or watersheds outside of SR spring/summer Chinook salmon critical habitat (Clearwater).

2.15.2.7.1 Clearwater

The Clearwater hatchery programs operate where ESA-listed SR spring/summer Chinook salmon are not present. According to NMFS' site-specific biological opinion (NMFS 2018a), these hatchery programs have implemented new strategies to limit straying of program fish into areas where ESA-listed fish are present.

2.15.2.7.2 South Fork Salmon River MPG

Over the years, hatchery programs in the Salmon River have made improvements to their programs. In particular, program managers have better integrated natural-origin fish into their broodstock, thereby creating integrated components of their hatchery programs. The South Fork Salmon River summer Chinook salmon hatchery program, out of McCall Fish Hatchery, created an integrated component and now has two components (segregated and integrated), with a recently implemented genetic relationship between them. In other words, a percentage of returning fish from the integrated component will be used as broodstock in the segregated component. This type of genetic linkage is sometimes referred to as a "stepping stone" system (HSRG 2014). Initial analysis by NMFS of programs connected this way shows that these linked programs pose considerably less risk of hatchery-influenced selection than solely segregated programs because they maintain a genetic linkage with the naturally spawning population (Busack 2015). In this case, the presence of returning segregated hatchery-origin adults on the South Fork Salmon River spawning grounds poses little additional risk compared to integrated hatchery-origin adults.

The South Fork Salmon River summer Chinook salmon hatchery program also contributes eyed-eggs to the South Fork Chinook salmon egg box program, meaning segregated hatchery fish produced with this program are also genetically linked, which is an improvement from when this program operated as the "Dollar Creek Egg Box Program."

According to NMFS' site-specific biological opinion (NMFS 2018a), genetic analyses using a PNI model indicates that, depending on natural-origin returns, the PNI will range from 0.5 to 0.67 on any given year in the South Fork Salmon River population. NMFS considers this to be a considerable improvement to the genetic structure of the population, compared to when these components were not genetically linked.

The Rapid River (Little Salmon/South Fork Salmon River) and Hells Canyon programs (Upper Snake River) are segregated and used for harvest purposes. In the most recent biological opinion, these programs have developed new strategies to limit straying and ecological interactions between hatchery and ESA-listed natural-origin fish (NMFS 2018a). The Johnson Creek Artificial Propagation Enhancement (East Fork, South Fork Salmon River) program has always used 100 percent natural-origin fish in their broodstock, so there are only minor genetic risks associated with this program, and this program will continue to operate with these same conservation considerations and standards.

2.15.2.7.3 Upper Salmon River MPG

The Lemhi River, East Fork Salmon River, and West Fork Yankee Fork captive-rearing experiments have all been terminated and removed from the ESU.

The Sawtooth Hatchery program in the Upper Salmon River has also recently employed a genetically linked aspect to its integrated and segregated program components. This reduced the genetic risk to the ESU. The Pahsimeroi and Yankee Fork Hatchery programs have implemented sliding-scale management strategies to manage genetic interactions between hatchery-origin fish with natural-origin fish on spawning grounds.

2.15.2.7.4 Grande Ronde/Imnaha Rivers MPG

There have also been some improvements in recent years to hatchery programs located in northeast Oregon. The Catherine Creek, Imnaha, and Lostine hatchery programs use sliding scales sensitive to population abundance (NMFS 2016e). Under sliding-scale management, the programs allow some hatchery-origin fish to spawn in the wild at all abundance levels, but reduce proportions as natural-origin abundance increases. Outplanting of adults is, in addition to the pHOS (percent of hatchery fish on spawning grounds), determined by the sliding scales. This strategy attempts to balance the risk of extinction (low natural-origin abundance) with the risk of hatchery influence.

2.15.2.8 Harvest

Snake River spring/summer Chinook salmon are exposed to fisheries in the Columbia River estuary, mainstem Columbia, Snake River, and to varying degrees, in the ocean and in Snake River tributaries. The ocean fishery mortality on upriver spring/summer Chinook salmon is very low and, for practical purposes, assumed to be zero, based on the rare occurrence of coded-wire tag (CWT) recoveries in ocean fisheries (2014 SR harvest module). We believe the migration path and ocean distribution of SR spring/summer Chinook salmon are such that they are not present in nearshore areas where ocean salmon fisheries traditionally occur (2014 SR Harvest Module).

Fisheries are currently managed to focus on different stocks and populations, and to take fish in order to meet commercial, recreational, and tribal needs. Fisheries influence salmonid population viability by causing direct and incidental mortality to natural-origin fish (NMFS 2018a). Information made available since the last ESA status review indicates that harvest impacts remain relatively constant for SR spring/summer Chinook salmon (TAC 2017).

Fisheries in the Columbia River basin, particularly in the mainstem of the Columbia River, are managed pursuant to fishing plans developed by the parties to *U.S. v. Oregon*. Parties to this process include the federal government; the states of Oregon, Washington, and Idaho; and the four Columbia River Treaty Tribes and the Shoshone-Bannock Tribes. Incidental take of ESA-listed SR spring/summer and UCR Chinook salmon occurs in spring and summer-season fisheries in the mainstem Columbia River that target harvestable hatchery and natural-origin stocks (SR Harvest Module). Allowable harvest depends on the total (hatchery + natural-origin) abundance of upriver spring Chinook salmon. The aggregate upriver spring Chinook salmon run includes, and may be limited by, either natural-origin SR spring/summer Chinook salmon or natural-origin UCR spring Chinook salmon. Under these rules, the allowable harvest rate (on natural-origin fish), including treaty and non-treaty Columbia River fisheries combined, may range from 5.5 to 17 percent of the predicted Columbia River return per year (NMFS 2018a). The average annual harvest rate on these fish from 2008–17 under *U.S. v. Oregon* jurisdiction averaged 12.1 percent (NMFS 2018a).

Salmon and steelhead fishing also occurs in the Snake River mainstem and its tributaries in the states of Washington, Oregon, and Idaho. Fisheries occurring in the lower Snake River (downstream of the Washington/Idaho border to the confluence with the mainstem Columbia River) during the spring are under *U.S. v. Oregon* jurisdiction and incorporated into the harvest rates reported above. For fisheries operating upstream in Idaho, co-managers currently develop and submit to NMFS yearly Fishery Implementation Plans (FIP). The FIPs include annual pre-season fishery impact rates consistent with fishery management frameworks developed through the Snake Basin Harvest Forum (SBHF), an offshoot of the *U.S. v. Oregon* process. These frameworks were developed based on sliding scales that tie allowed fishery impact rates to forecast returns of natural-origin adults (SR Harvest Module). The framework for allowable total mortality is based on whether a population is supplemented with hatchery fish or not. The sliding scale of allowable total mortality impacts is applied against the expected aggregate adult run size of natural populations as a percentage of the pooled Minimum Abundance Thresholds (MATs) of affected populations (Tables 2.15-7 and 2.15-8). Pooled MATs occur across specific Fishery Management Areas (FMAs) — Mainstem Snake River, Lower Salmon River, South Fork Salmon River, Upper Salmon River, and Clearwater River. Fisheries are managed within the allowable total mortality framework. The FIPs are implemented in the Snake River basin in the state of Idaho, including the mainstem Snake River and the Salmon and Clearwater subbasins.

Table 2.15-7. Proposed allowable total mortality rate and combined tribal and non-tribal fisheries (shaded) for spring/summer Chinook salmon in populations with returning hatchery-origin adults.

%Minimum Abundance Thresholds (MAT)		**Total Allowable Natural-origin Mortality Rate**
Lower	**Upper**	
	30%	1%
30.1%	50%	4%
50.1%	75%	9%
75.1%	108%	12%
108.1%		42% of margin

*Recreational fishery is managed to same incidental mortality rates as for unsupplemented populations (up to 108% MAT). Below 30% MAT, no recreational mortality impacts requested within Fisheries Management Area.

**Tribal Mortality Rate is actually defined in Tribal Resource Management Plans currently under development or consideration, and the approximate rate displayed here is for reference.

Table 2.15-8. Proposed allowable total mortality rate and combined tribal and non-tribal fisheries (shaded) of spring/summer Chinook salmon in unsupplemented populations.

% MAT Sum		**Total Allowable Natural-origin Mortality Rate**
Lower	**Upper**	
	30%	0%
30.1%	50%	3%
50.1%	75%	5%
75.1%	108%	8%
108.1%		35% of margin

*Below 30% MAT, no recreational mortality impacts requested within Fisheries Management Area.

**Tribal Mortality Rate is actually defined in Tribal Resource Management Plans currently under development or consideration, and the approximate rate displayed here is for reference.

Fisheries operating in the Grande Ronde and Inmaha Rivers and tributaries targeting adult spring Chinook salmon are subject to separate FIPs. Fishery management expects to achieve natural escapement or hatchery broodstock goals as the first priority using the harvest management for SR natural- origin adult spring/summer Chinook salmon framework, described in Table 2.15-9. The parties in these fisheries manage their fisheries subject to total population-specific ESA take limits, regardless of which entity kills the fish. Calculations of allowable ESA take, using Table 2.15-9, account for direct (immediate mortality) and indirect effects (delayed mortality) (NMFS 2013b).

Table 2.15-9. General sliding-scale harvest-rate schedule for total and tribal ESA* impacts resulting from the implementation of fisheries that target adult spring Chinook salmon runs in Grande Ronde and Imnaha Rivers and tributaries (from NMFS 2013b).

FISHERY SCENARIO	EXPECTED RETURN OF NATURAL-ORIGIN FISH	TOTAL COLLECTIVE NATURAL-ORIGIN MORTALITY
A	Below Critical Threshold	1%
B	Critical to MAT	A + 11% of margin above A (8%)
C	MAT to 1.5X MAT	B + 22% of margin above B (16%)
D	1.5X MAT to 2X MAT	C + 25% of margin above C (19%)
E	Greater than 2X MAT	D + 40% of margin above D (28%)

2.15.2.9 Tributary Habitat

2.15.2.9.1 ESU Overview

Tributary habitat conditions for SR spring/summer Chinook salmon vary significantly throughout the Snake River basin: in some areas, spawning and rearing habitat is in near-pristine condition, while in other areas it is minimally to highly degraded as a result of past or present human activities. Generally, the ability of tributary habitats in the Snake River basin to support the viability of this ESU is limited by one or more of the following factors: (1) impaired fish passage, (2) reduced stream complexity and channel structure, (3) excess fine sediment, (4) elevated summer water temperature, (5) diminished stream flow during critical periods, (6) reduced floodplain connectivity and function, and (7) degraded riparian condition. The combination, intensity, and relative impact of these factors vary locally throughout the basin, depending on historical and current land use activities and natural conditions. Human activities that have contributed to these limiting factors are primarily past and/or current grazing, mining, logging, agricultural practices, road construction, water withdrawals, urban development, and recreational use (NMFS 2017e).

In general, land use practices and regulatory mechanisms have improved from past practices and regulations (NMFS 2017e). In addition, many habitat restoration actions have been implemented throughout the Snake River basin through the individual and combined efforts of federal, tribal, state, local, and private entities, including the CRS Action Agencies. The CRS Action Agencies have been implementing tributary habitat improvement actions as part of mitigation for the CRS since 2007. These actions have included protecting and improving instream flow, improving habitat complexity, improving riparian area condition, reducing fish entrainment, and removing barriers to spawning and rearing habitat (BPA et al. 2016, 2013). The actions have been targeted toward addressing the limiting factors identified above. Cumulative metrics for these action types for SR spring/summer Chinook salmon from the years 2007–15 are shown in Table 2.15-10.

Table 2.15-10. Tributary habitat improvement metrics: SR spring/summer Chinook salmon, 2007–15 (BPA et al. 2016). The categories acres protected, acres treated, miles of enhanced stream complexity and miles protected also encompass actions directed at reducing sediments and reconnecting floodplains.

Action Type*	**Amount completed**
Acre-feet/year of water protected (by efficiency improvements and water purchase/lease projects)	58,854.3
Acres protected (by land purchases or conservation easements)	2,203.5
Acres treated (to improve riparian habitat, such as planting native vegetation or control of noxious weeds)	5,095.5
Miles of enhanced or newly accessible habitat (by providing passage or removing barriers)	980.0
Miles of improved stream complexity (by adding wood or boulder structures or reconnecting existing habitat, such as side channels)	142.1
Miles protected (by land purchases or conservation easements)	140.6
Screens installed or addressed (for compliance with criteria or by elimination/consolidation of diversions)	69

***** Several of these categories (acres protected, acres treated, miles of enhanced stream complexity, miles protected) also encompass actions directed at reducing sediments and reconnecting floodplains.

NMFS determined, based on best available science, that the actions implemented by the Action Agencies and other entities have and will continue to improve habitat in the targeted populations as these projects mature, and that fish population abundance and productivity, will respond positively.[216] Benefits of some of these actions will continue to accrue over several decades (see Appendix A). RM&E, including IMWs and CHaMP sampling, have been underway in this ESU to help confirm improvements in habitat productivity and fish population response, and the magnitude of the changes. Available empirical evidence supports our view that these actions are improving habitat capacity and productivity, as well as population abundance and productivity (see Appendix A; NMFS 2014; Hillman et al. 2016; Griswold and Phillips 2018; Haskell et al. 2018).

For some populations in this ESU, NMFS used life-cycle models to evaluate how the tributary habitat improvement actions implemented to date. Results of these evaluations are summarized below, and the models and results are described in more detail elsewhere in this chapter and in supporting documents (Pess and Jordan et al. in press; Zabel and Jordan in press).

The best available science and technical information also indicate that, in most areas, there is additional potential to improve habitat productivity, although in some areas the potential is limited or uncertain (NMFS 2016e, 2017e; Pess and Jordan et al. in press). Strong density dependence has been observed in SR spring/summer Chinook salmon populations (ISAB 2015), which also indicates that improvements in tributary habitat capacity or productivity, if targeted at limiting life stages and limiting factors, would likely improve overall population abundance and productivity.

In summary, while tributary habitat conditions are likely improving in some areas as a result of habitat improvement actions and improved land use practices, in general tributary habitat conditions are still degraded and continue to negatively affect SR spring/summer Chinook salmon abundance, productivity, spatial structure, and diversity. In addition, the potential exists to further improve tributary habitat capacity and productivity in this ESU, although the potential appears to be limited in some populations.

More detail on baseline tributary habitat conditions for the five MPGs (and 32 populations) that constitute this ESU is provided below.

2.15.2.9.2 South Fork Salmon River MPG

The South Fork Salmon River MPG historically supported four SR spring/summer Chinook salmon populations: the Little Salmon River, South Fork Salmon River, Secesh River, and East Fork South Fork Salmon River. All of these populations are extant (NMFS 2017e).

[216] In most cases, near-term benefits would be expected in abundance and productivity. Depending on the population and the scale and type of action, benefits to spatial structure and diversity might also accrue, either in the near term or over time. In addition, while we expect abundance, productivity, spatial structure, and diversity to respond positively to strategically implemented tributary habitat improvement actions, other factors also influence these viability parameters (e.g., ocean conditions) and any resulting trends. Throughout this tributary habitat discussion, when we discuss improvements in abundance and productivity, it is implied that spatial structure and diversity might also respond positively, and that other factors, as noted here, might influence any resulting trends.

The spawning and rearing areas used by these four populations are mostly on federal land, including areas that provide high-quality, intact habitat. Many other areas, however, including areas of both federal and private lands, have been degraded to some extent by human activities, primarily road construction, mining, timber harvest, livestock grazing, and recreational use. These land uses have resulted in reduced riparian function and vegetation, decreased recruitment of large wood, accelerated sediment loading, and increased water temperatures above thresholds for salmon in some areas. In addition, passage barriers restrict access to historical spawning and rearing habitat in places. Habitat for the Secesh River population is generally highly productive, as is habitat for the South Fork Salmon River population, although there are greater legacy impacts in the South Fork Salmon drainage from human land use, and from major wildfires that occurred in the 1990s and in 2007. In 2007, the Cascade Complex Fire burned riparian areas in important spawning and rearing reaches, resulting in increased sediment and reduced shading (leading to warmer water temperatures).[217] In the East Fork, spawning in one branch of the population was extirpated in the 1940s by sediment and pollutants from mining activities, contributing to current low abundance. Many areas occupied by the Little Salmon River population are degraded from their historical condition (NMFS 2017g).

Restoration actions in this MPG have included road obliteration, decommissioning, and other actions to reduce sediment input into streams; culvert removal or replacement to improve passage; channel restoration to restore stream structure; riparian planting or fencing to restore or protect riparian areas; and habitat protection through acquisitions, conservation easements, and other methods (BPA et al. 2013, 2016; NMFS 2017g). These actions have been targeted at addressing limiting factors, and best available science indicates that they continue to improve habitat function in the targeted populations, and that fish population abundance and productivity will respond positively. Benefits of some of these actions will continue to accrue over several decades (see Appendix A).

The Action Agencies' efforts in this MPG under the 2008 FCRPS biological opinion were focused on the Secesh and South Fork Salmon River populations (BPA et al. 2013, 2016). Both of these populations are targeted for viable or highly viable status in the ESA recovery plan for SR spring/summer Chinook salmon (NMFS 2017e).[218]

In summary, while some degraded areas in the South Fork Salmon MPG are likely on an improving trend due to ongoing habitat restoration efforts and improved land use practices, in general tributary habitat conditions are still degraded and continue to negatively affect spring/summer Chinook salmon abundance, productivity, spatial structure, and diversity. There is potential for improvement in habitat productivity in all populations in this MPG.

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[217] In some areas, vegetation was re-planted or is being reestablished. These areas will take time to fully mature, but there will be interim benefits as banks stabilize and shade increases.
[218] For ESA recovery, the South Fork Salmon River and Secesh River populations must achieve viable or highly viable status; the East Fork Salmon River population must achieve viable or maintained status; and the Little Salmon River population must achieve maintained status (NMFS 2017e).

2.15.2.9.3 Middle Fork Salmon River MPG

The Middle Fork Salmon MPG historically supported nine SR spring/summer Chinook salmon populations: Chamberlain Creek, Big Creek, the Lower Middle Fork Salmon River, Camas Creek, the Upper Middle Fork Salmon River, Sulphur Creek, Bear Valley Creek, and Marsh Creek. All of these populations are extant (NMFS 2017e).

Public forestlands cover much of the Middle Fork Salmon River MPG, with large portions protected in the Frank Church ─ River of No Return Wilderness Area. As a result, most spawning and rearing habitat for these spring/summer Chinook salmon populations remains in good to excellent condition and protected from human impacts. For instance, the Chamberlain Creek, Big Creek, and Lower Middle Fork Salmon populations are entirely, or almost entirely, in the wilderness area; the Camas Creek, Loon Creek, Upper Middle Fork Salmon, and Sulphur Creek populations are mostly in the wilderness area; and the Bear Creek and Marsh Creek populations are predominantly on U.S. Forest Service lands and include some wilderness areas (NMFS 2017g). For the most part, the habitat for these populations is high functioning. Even in the wilderness area habitats, however, some small, localized areas display degraded habitat conditions associated with road development, past mining, livestock grazing, irrigation diversions, timber harvest, off-highway vehicles, and other recreational use. Some amount of degradation also has occurred on private lands. These localized limitations include impacts to passage, flow, sediment inputs, riparian area function, and nutrient supply. In addition, loss of beavers has led to channel simplification (NMFS 2017g).

Some entities, primarily the U.S. Forest Service and the Nez Perce Tribe, have implemented actions such as mine rehabilitation, riparian restoration, road decommissioning, and culvert replacements targeted at addressing localized impacts for populations in this MPG. The CRS Action Agencies have implemented a limited amount of habitat improvement actions in this MPG, targeted at addressing localized limiting factors. Best available science indicates that the actions have and will continue to improve habitat function in the targeted populations, but in general, opportunities to improve habitat in this MPG are much more limited than in other MPGs in this ESU. Continuing to implement actions targeted toward addressing localized impacts may provide some additional benefits. It is also possible that other actions, such as reintroduction of beaver in populations with significant marsh habitat, could be beneficial, as could nutrient supplementation and management of non-native brook trout (NMFS 2017g). However, further evaluation is needed to understand the potential for these actions to improve the function of spawning and rearing habitat and provide population benefits.

In summary, habitat in the Middle Fork Salmon MPG is generally of high quality due to the preponderance of wilderness areas and other federal lands; there appears to be relatively low potential for improving habitat productivity in most populations in this MPG, although further exploration of ways to improve habitat is warranted.

2.15.2.9.4 Upper Salmon River MPG

The Upper Salmon River MPG historically supported nine SR spring/summer Chinook salmon populations: the North Fork Salmon River, Lemhi River, Upper Salmon River Lower Mainstem, Pahsimeroi River, East Fork Salmon River, Yankee Fork Salmon River, Valley Creek, Upper Salmon River Upper Mainstem, and Panther Creek. The Panther Creek population is extirpated; the other eight are extant (NMFS 2017e).

For most populations in this MPG, federal lands managed by the U.S. Forest Service and Bureau of Land Management cover much of the upper elevation areas; lower elevation lands are in private ownership and overlap with significant areas of salmon spawning and rearing habitat. Land uses influencing habitat quality in the MPG include livestock grazing, timber harvest, agricultural practices, recreation, and mining; in many cases, habitat impacts of these activities are extensive (NMFS 2017g).

In both the Lemhi River and Pahsimeroi Rivers, irrigation diversions have extensively modified habitat by disconnecting tributaries from the mainstem, or have otherwise substantially reduced availability of habitat. In the Yankee Fork, historical mining activities extensively and drastically modified habitat by removing vegetation, exposing and compacting soils, altering drainage patterns, modifying substrate, and disconnecting the river from its floodplain. In the Upper Salmon River Lower Mainstem, Upper Salmon River above Redfish Lake, North Fork, East Fork, and Valley Creek populations, salmon habitat has also been degraded by effects of grazing, water diversions, residential development, and the impacts of historical and current mining. In general, land uses in this MPG have reduced riparian function, channelized rivers and streams, disconnected floodplains and tributaries, created low flows, accelerated sediment loading, increased water temperatures to critical levels, and caused entrainment of juvenile and adult fish in irrigation facilities. While legacy impacts of activities on public lands have generally been declining, impacts of land uses on private lands continue to be significant and to negatively affect the abundance, productivity, and spatial structure of the populations in this MPG (NMFS 2017g).

Many restoration activities have been carried out in this MPG through the individual and combined efforts of federal, state, tribal, local, and private entities, including the Action Agencies. These actions have been targeted toward addressing the identified limiting factors and have included riparian fencing, planting, and streambank restoration; consolidating and reducing water diversions to improve efficiency and stream flow; improving stream structure and complexity; reconnecting tributaries and floodplains to the mainstem; and protecting habitat through acquisitions, conservation easements, and other cooperative landowner agreements (BPA et al. 2013, 2016; Appendix C of NMFS 2017). Best available science indicates that these actions have and will continue to improve habitat function in the targeted populations, and that fish population abundance and productivity will respond positively. Benefits of some of these actions will continue to accrue over several decades (see Appendix A).

The Action Agencies' efforts in this MPG under the 2008 FCRPS biological opinion were focused on the Lemhi, Pahsimeroi, Upper Salmon River above Redfish Lake, Valley Creek, and Yankee Fork populations (BPA et al. 2013, 2016). The Lemhi, Pahsimeroi, Valley Creek, East Fork Salmon River, and Upper Mainstem Salmon River populations are targeted for viable or highly viable status in the ESA recovery plan for SR spring/summer Chinook salmon (NMFS 2017e). Ultimately, the Yankee Fork population will also need to improve to "maintained" status to meet ESA recovery criteria (NMFS 2017e).

NMFS used life-cycle models to predict the effects of tributary habitat actions implemented in 2009 through 2015 on populations in the Upper Salmon River MPG. The model for the Upper Salmon populations evaluated the effects on juvenile rearing capacity and spawning capacity of instream actions (i.e., instream actions to improve stream complexity or floodplain/side-channel connectivity), and actions to improve access. Based on the model results, actions of this type implemented in 2009 through 2015 increased juvenile rearing capacity by 7 percent in the Lemhi, 9 percent in the Pahsimeroi, 2 percent in the North Fork, less than 1 percent in the East Fork and Upper Mainstem, and 1 percent in the Yankee Fork. The actions increased spawning capacity by less than 1 percent in most of these populations, and by 2 percent in the Lemhi population. Because this model does not evaluate the effects of actions such as returning flow to the stream, screening diversions, and restoring riparian areas, benefits of such actions are not included in the modeled increases in capacity. Modeling methods, assumptions, and results are documented in Pess and Jordan et al. in press and in Jordan et al. in press.

In summary, while some degraded areas in the Upper Salmon River MPG are likely on an improving trend as a result of habitat improvement actions and improved land use practices, in general tributary habitat conditions are still degraded and continue to negatively affect spring Chinook salmon abundance, productivity, spatial structure, and diversity. There is high potential for additional improvement in habitat productivity in all populations in this MPG.

2.15.2.9.5 Grande Ronde/Imnaha MPG

The Grande Ronde/Imnaha Rivers MPG historically supported eight SR spring/summer Chinook salmon populations: Lostine/Wallowa, Upper Grande Ronde, Catherine Creek, Imnaha, Minam, Wenaha, Big Sheep Creek, and Lookingglass Creek. The Big Sheep and Lookingglass Creek populations are extirpated, leaving six extant populations (NMFS 2017e).

Habitat conditions vary among the six extant populations — some habitats are nearly pristine while others are highly degraded. Habitat for the Wenaha and Minam populations is in good condition; nearly all the habitat for these populations is in designated wilderness areas, although some effects from past land use activities linger. Over two-thirds of the Imnaha basin is also in public ownership. While habitat is in relatively good condition, limiting factors assessments have identified high temperatures, elevated levels of fine sediment, and reduced instream structure within the middle reaches of the mainstem Imnaha as significant limiting factors. Habitat for the Lostine/Wallowa population is in mixed condition, ranging from nearly pristine in high-elevation reaches (which are in designated wilderness areas), to more modified conditions in some valley floor reaches. Habitat for the Catherine Creek and Upper Grande Ronde River populations is highly degraded. Spawning in Catherine Creek is predominantly limited to public lands in the upper watershed, with the lower elevation valley bottoms no longer supporting spawning due to low flow and warmer water temperatures. Overwintering habitat in lower and middle Catherine Creek reaches is also impaired. In the Upper Grande Ronde population, lower elevation habitats that once supported spawning and rearing have also been extensively modified, primarily by livestock grazing and irrigated agriculture. Artificial barriers restrict passage in the Catherine Creek, Upper Grande Ronde, and Imnaha populations (NMFS 2017e, 2017h).

Impaired habitat conditions in this MPG generally stem from the combined effects of agricultural and grazing practices, forest management, dams and other barriers, water withdrawals, roads, and channel manipulations, particularly from practices in the late 19th to mid-20th centuries. These land uses have contributed to excess fine sediment, water quality (primarily temperature) impairment, water quantity impairment (primarily low summer flows), and impaired habitat quantity/diversity (primarily limited pools and large wood). Sediment levels are also above historical levels throughout the area, except in wilderness area watersheds. Summer water temperatures are generally elevated in streams across the Grande Ronde River basin. Summer flows are lower than they were historically due to water withdrawals and land management practices. Large wood and pool habitat in streams across the area are reduced relative to historic levels. Many reaches also suffer from impaired riparian conditions and loss of floodplain connectivity, which contribute to the above conditions. Habitat conditions in the Grande Ronde River migration corridor (which also serves as rearing habitat), are also limited and affect primarily juvenile rearing and migration (NMFS 2017h).

Many restoration activities have been carried out in this MPG in recent years by federal, state, tribal, local, and private entities, including the Action Agencies. Catherine Creek and the Grande Ronde Upper Mainstem are the most severely degraded habitats and have been a primary focus of effort; work has also been completed in the Lostine/Wallowa populaion. In Catherine Creek, work has focused on creating more summer rearing habitat and reducing relatively high juvenile mortality associated with downstream spring out-migration through the lower Catherine Creek mainstem/lower Grande Ronde Valley reach. In the Grande Ronde, efforts have focused on improving habitat complexity and restoring riparian areas in remaining available spawning and rearing habitat (NMFS 2014; BPA et al. 2016). Over time, these actions have been increasingly strategically targeted to address the limiting factors. Best available science indicates that the actions implemented by the Action Agencies and other entities have and will continue to improve habitat function, and that fish population abundance and productivity will respond positively. Benefits of some of these actions will continue to accrue over several decades (Appendix A). The Lostine/Wallowa and Catherine Creek populations must achieve viable or highly viable status for ESA recovery, and the Grande Ronde population must improve to viable or maintained status.

NMFS used life-cycle models to project the effects of actions implemented in 2009 through 2016 for populations in the Grande Ronde/Imnaha Rivers MPG. Modeling methods, assumptions, and results are documented in Pess and Jordan et al. (in press) and Cooney (in press). In Catherine Creek, for example, actions implemented from 2009-16 were designed to increase flows in key rearing reaches, and to increase the amount of functional pool habitat through stream structure improvements and side-channel reconnections. Actions also included some riparian restoration in reaches with high summer stream temperatures that currently impair or inhibit summer rearing. Some of these actions (e.g., those designed to improve stream structure and floodplain connectivity) would yield benefits in the relatively short-term, while benefits of other actions (e.g., riparian restoration) would accrue over a longer time frame. The most limiting life stage that would be affected by the actions is summer parr rearing capacity. Modelers concluded that the 2009-16 actions would increase summer parr rearing capacity by 4 percent within a few years of implementation. They also concluded that, while the temperature reductions associated with shading would not be fully realized for several decades, shading levels would be expected to start contributing to reducing temperatures after 5-10 years. After 24 years, the projected benefits of temperature reductions associated with the actions implemented in 2009-16 would further increase functional parr capacity to 23 percent over baseline. Additional shading resulting from maturing riparian plantings would be projected to further reduce temperatures, and at 48 years the cumulative change in functional parr capacity would increase by 26 percent relative to baseline.

In summary, while some degraded areas in the Grande Ronde/Imnaha Rivers MPG are likely on an improving trend, as a result of habitat improvement actions and improved land use practices, in general tributary habitat conditions are still degraded and continue to negatively affect spring Chinook salmon abundance, productivity, spatial structure, and diversity. In addition, there is high potential for improvement in habitat productivity in several populations in this MPG, including three out of four targeted for viable status in the ESA recovery plan.

2.15.2.9.6 Lower Snake MPG

The Lower Snake MPG historically supported two SR spring/summer Chinook salmon populations: the Tucannon River and the Asotin Creek. The Asotin Creek population is extirpated, leaving the one extant population (NMFS 2017e).

In this MPG, historical and current land use practices including grazing and irrigated agriculture, logging, removal of beaver populations, roads, residential development, and diking have led to excess fine sediment, diminished large wood supply, channel straightening and confinement, degraded riparian function, increased summer water temperatures, diminished flows, and passage impairments at artificial barriers and diversions. These factors have diminished habitat diversity and the availability of key habitat, particularly summer rearing and overwintering capacity, and have negatively affected the abundance, productivity, and spatial structure of spring Chinook salmon (Snake River Salmon Recovery Board 2011; NMFS 2017).

Many restoration activities have been carried out in this MPG in recent years by federal, state, tribal, local, and private entities, including the Action Agencies. These actions have been targeted toward addressing identified limiting factors and have included large-scale efforts to enhance stream complexity and restore floodplain function and side-channel complexity through placement of logjams, riparian restoration, levee removal, and side-channel reconnection (Snake River Salmon Recovery Board 2011; BPA et al. 2013, 2016; NMFS 2014). Best available science indicates that these actions have and will continue to improve habitat function in the targeted populations, and that fish population abundance and productivity will respond positively. Benefits of some of these actions will continue to accrue over several decades (see Appendix A). For ESA recovery, the Tucannon River population, the only extant population in the MPG, must achieve highly viable status (NMFS 2017e).

In summary, while some degraded areas in the Tucannon River basin are likely on an improving trend as a result of ongoing habitat improvement actions and improved land use practices, in general tributary habitat conditions are still degraded and continue to negatively affect the abundance, productivity, and spatial structure of the population in this MPG. There is high potential for improvement in habitat productivity in the Tucannon River population.

2.15.2.10 Estuary Habitat

The estuary provides important migratory habitat for SR spring/summer Chinook salmon. Since the late 1800s, 68–70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening combined with flow regulation and other modifications (Kukulka and Jay 2003; Bottom et al. 2005; Marcoe and Pilson 2017). Disconnection of tidal wetlands and floodplains has reduced the production of wetland macrodetritus supporting salmonid food webs (Simenstad et al. 1990; Maier and Simenstad 2009), both in shallow water and for larger juveniles migrating in the mainstem (ERTG 2018).

Restoration actions in the estuary, such as those highlighted in the latest five-year review, have improved access and connectivity to floodplain habitat. From 2004 through 2017, the Action Agencies implemented 58 projects including dike and levee breaching or lowering, tide-gate removal, and tide-gate upgrades that reconnected 5,412 acres of historical tidal floodplain habitat to the mainstem. This represents a 2.5 percent net increase in the connectivity of habitats that produce prey used by yearling Chinook salmon (Johnson et al. 2018). In addition, about 2,500 acres of functioning floodplain habitat were acquired for conservation.

Floodplain habitat restoration can affect juvenile salmonid performance directly (for fish that move onto the floodplain) and indirectly (for fish that stay in the mainstem). Wetland food production supports foraging and growth within the wetland (Johnson et al. 2018), but these prey items (primarily chironomid insects and corophiid amphipods; PNNL and NMFS 2018) are also exported to the mainstem and off-channel habitats behind islands and other landforms where they become available to salmon and steelhead migrating in these locations. Thus, while most yearling Chinook salmon may not directly enter a tidal wetland channel, they derive indirect benefits from wetland habitats. Improved opportunities for feeding on prey that drift into the mainstem are likely to contribute to survival at ocean entry. Blood serum levels of insulin-like growth factor one for juvenile SR spring/summer Chinook salmon collected in the estuary during

April and May, 2016 and 2017, were as high as those of fish collected in the ocean, suggesting similar active feeding rates (PNNL and NMFS 2018).

Habitat quality and the food web in the estuary are also degraded because of past and continuing releases of toxic contaminants (Fresh et al. 2005; LCREP 2007), from both estuarine and upstream sources. Historically, levels of contaminants in the Columbia River were low, except for some metals and naturally occurring substances (Fresh et al. 2005). Today, levels in the estuary are much higher, as the estuary receives contaminants from more than 1,000 sources that discharge into a river and numerous sources of runoff (Fuhrer et al. 1996). With Portland and other cities on its banks, the Columbia River below Bonneville Dam is the most urbanized section of the river. Sediments in the river at Portland are contaminated with various toxic compounds, including metals, PAHs, PCBs, chlorinated pesticides, and dioxin (ODEQ 2008). Contaminants have been detected in aquatic insects, resident fish species, salmonids, river mammals, and osprey, reinforcing that contaminants are widespread throughout the estuarine food web (Furher et al. 1996; Tetra Tech 1996; LCREP 2007).

Exposure to toxic contaminants can either kill aquatic organisms outright or have sublethal effects that compromise their health and behavior. Sublethal concentrations increase stress and decrease fitness; which predispose organisms to disease, slow development, and disrupt physiological processes, such as reproduction and smoltification. Acute lethal effects of toxic contaminants, such as fish kills from accidental discharges or spills, are generally rare; however, some researchers have described direct mortality of salmonids, including high levels of prespawning mortality in Puget Sound coho salmon due to road runoff (McCarthy et al. 2008), synergistic toxicity of agricultural pesticide mixtures causing death in juvenile salmon (Laetz et al. 2009), and increased egg mortality due to PAH exposure (Heintz et al. 1999; Carls et al. 2005).

Sublethal effects are more likely a significant threat to juvenile salmon in the Columbia River estuary. Exposure can reduce immune function and fitness, impair growth and development, and disrupt olfaction; salmonids depend on olfaction for migration, imprinting, homing, and detecting predators, prey, potential mates, and spawning cues. These sublethal effects can interact with other factors, including infectious disease, parasites, predation, exhaustion, and starvation by suppressing salmonid immune systems and impairing necessary behaviors such as swimming, feeding, responding to stimuli, and avoiding predators (LCREP 2007).

Toxic contaminants can also affect salmon via the food web, especially through prey such as aquatic and terrestrial insects. Insect bodies accumulate contaminants, which salmon in turn ingest when they consume insects. Additionally, many toxic contaminants are specifically designed to kill insects and plants, reducing the availability of insect prey or modifying the surrounding vegetation and habitats. Changes in vegetative habitat can shift the composition of biological communities, create favorable conditions for invasive, pollution-tolerant plants and animals, and further shift the food web from macrodetrital to microdetrital sources. Overall, more work is needed on contaminant uptake and impacts on salmon of different populations and life-history types.

2.15.2.11 Predation

A variety of avian and fish predators consume juvenile SR spring/summer Chinook salmon on their migration from tributary rearing areas to the ocean. Pinnipeds eat returning adults in the estuary, including the tailrace of Bonneville Dam. In the following paragraphs we discuss predation rates and describe management measures to reduce the effects of the growth of predator populations within the action area.

2.15.2.11.1 Predation in the Lower Columbia River Estuary

Avian Predators

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, are having a significant impact on the survival of juvenile salmonids (including SR spring/summer Chinook salmon) in the Columbia River. Caspian terns on Rice Island, an artificial dredged-material disposal island in the estuary, consumed about 5.4-14.2 million juveniles per year in 1997 and 1998, or 5-15 percent of all the smolts reaching the estuary (Roby et al. 2017). Efforts began in 1999 to relocate the tern colony 13 miles closer to the ocean at East Sand Island where the tern diet would diversify to include marine forage fish. During 2001-15, estimated consumption by terns on East Sand Island averaged 5.1 million smolts per year, about a 59 percent reduction from when the colony was on Rice Island. Management efforts are ongoing to further reduce salmonid consumption by terns in the lower Columbia River and similar efforts are in progress to reduce the nesting population of double-crested cormorants in the estuary.

Based on PIT-tag recoveries at East Sand Island, average annual tern and cormorant predation rates for this ESU were about 4.8 and 5.2 percent, respectively, before efforts to manage the size of these colonies (Evans et al. 2018a). The Corps has been implementing the Caspian Tern and Double-crested Cormorant Management Plans, but, in terms of effectiveness, has seen mixed results due to the dispersal of both terns and cormorants to other locations within the estuary. Average predation rates on SR spring/summer Chinook salmon have decreased to 1.5 percent for terns nesting on East Sand Island, but in 2017 this improvement was offset to some unknown degree by terns roosting farther upstream on Rice Island (Evans et al. 2018a). Due to failures of the cormorant colony in 2016 and 2017, there are no estimates of predation rates since management of that colony began (Appendix C). Substantial numbers of cormorants have relocated to the Astoria-Megler Bridge (preliminary report of 1,737 in 2018) and hundreds more are observed on the Longview Bridge, navigation aids, and transmission towers in the lower river (Anchor QEA et al. 2017). Smolts may constitute a larger proportion of the diet of cormorants nesting at these sites than if the birds were foraging from East Sand Island. Thus, the success of the East Sand Island tern and cormorant management plans at meeting their underlying goals of reducing salmonid predation is uncertain at this time.

An important question in predator management is whether mortality due to predation is an additive or compensatory source of mortality. Most importantly, do reductions in smolt predation rates by Caspian terns or double-crested cormorants result in higher adult returns because avian predation adds to the other sources of smolt mortality or are the smolts eaten by birds destined to die before returning as adults regardless of the level of predation? The latter case could occur because avian predation could be compensated for by sources of mortality in the ocean phase of the life cycle so that adult returns are unchanged. Haeseker (2015) and Evans et al. (2018b) have begun modeling the degree to which double-crested cormorant and Caspian tern predation, respectively, are additive versus compensatory sources of mortality.

Given the magnitude of bird predation on juvenile salmon observed in the Columbia Basin, and that smolts eaten by birds in the lower river have survived hydrosystem passage, it is likely that some of them could otherwise have survived to adulthood. Therefore, even if avian predation is partially compensatory, we expect that limiting the size of these tern and cormorant colonies will contribute to increased SARs for SR spring/summer Chinook salmon.

Pinniped Predators

Numbers of pinnipeds that are predators of adult salmonids have increased considerably in the Pacific Northwest since the MMPA was enacted in 1972 (Carretta et al. 2013). CSLs, SSLs, and harbor seals consume salmonids from the mouth of the Columbia River and its tributaries up to the tailrace Bonneville Dam. The ODFW has been counting the number of individual CSLs hauling out at the East Mooring Basin in Astoria, Oregon since 1997. Up to 50 percent of the mortality from pinnipeds of adult spring-run Chinook salmon destined for tributaries above Bonneville occurred within the 10-mile reach just below the dam, which is part of the lower gorge (i.e., the reach just below Bonneville Dam is a hotspot for pinniped predation on adult spring-run Chinook). An authorization from NMFS under the MMPA has allowed the states of Oregon and Washington to implement hazing and removal measures in an effort to improve the survival of adult salmonids in the lower river.

The abundance of CSL is highest in the spring when SR spring/summer Chinook salmon adults are migrating through the estuary. Based on a recent five-year mark-recapture study, survival of spring Chinook salmon through the estuary ranged from 0.46 to 0.80 annually, with survival lowest during the last two years of the study when pinniped abundance was highest (Appendix B). While all the mortality is not attributable to pinnipeds, the researchers found strong evidence that recent increases in spring Chinook salmon loss estimates were a function of the large increase in pinnipeds, and that earlier migrating populations suffered the greatest losses to pinnipeds.

Fish Predators

The native northern pikeminnow is a significant predator of juvenile salmonids in the Columbia River basin (reviewed in ISAB 2015). Before the start of the NPMP in 1990, this species was estimated to eat about 8 percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River (including the hydrosystem reach) each year. Williams et al. (2017)

compared current estimates of northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 30 percent. The Sport Reward Fishery removed an average of 188,636 piscivorous pikeminnow (> 228 mm fork length) per year during 2013–17 (Williams 2013, 2014; Williams et al. 2015, 2016, 2017).

The removal of the larger, piscivorous individuals from northern pikeminnow populations will result in a sustained survival improvement for migrating juvenile Chinook salmon, but only if it is not offset by a compensatory response by the remaining northern pikeminnow, or other piscivorous fishes such as walleye or smallmouth bass. Signs of a compensatory response can include increased numbers of other predators, improved condition factors, or diet shifts. Williams et al. (2017) did not observe increases in numbers of pikeminnow, but did report an increasing trend in condition factor. This could be an intra-specific compensatory mechanism or just a response to beneficial environmental conditions. Similarly, Williams et al. (2017) documented increased numbers of smallmouth bass in parts of the lower Columbia River, which could be related to the NPMP or could be due to other factors, including alterations in other parts of the food web or environmental conditions such as warmer temperature that affect this species' consumption rates. Williams et al. (2017) concluded that given these analytical constraints, data collected during 2017 provided ambiguous indicators of a compensatory response from the piscivorous fish community. Given the numbers of fish, bird, and marine mammal predators in the Columbia River and the ocean, we do not expect that all of the Chinook salmon that are "saved" from predation by pikeminnows survive to adulthood. However, a 30 percent decrease in predation by northern pikeminnows is large enough that there is likely to be a net gain in productivity of Chinook salmon populations, including SR spring/summer Chinook salmon.

An average of 27 adult, 15 jack, and 67 juvenile Chinook salmon per year, were incidentally caught in the Sport Reward Fishery, system-wide (i.e., in the lower Columbia River and the hydrosystem reach), during 2013–17 (Williams 2013, 2014; Williams et al. 2015, 2016, 2017). Although it was not practical for the field crews to identify these fish to ESU, we assume that some were SR spring/summer Chinook salmon.

Non-native fishes such as walleye, smallmouth bass, and channel catfish are present in the slower moving off-channel habitats below Bonneville Dam, but yearling SR spring/summer Chinook salmon mostly stay in the mainstem migration channel and are not likely to encounter large numbers of these species. The Oregon and Washington Departments of Fish and Wildlife have removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids

2.15.2.11.2 Predation in the Hydrosystem Reach

The following paragraphs describe predation in the mainstem lower Snake and Columbia Rivers from Bonneville Dam to the head of Lower Granite Reservoir.

Avian Predators

SR spring/summer Chinook salmon survival in the mainstem is affected by avian predators that inhabit the dams and reservoirs. The 2008 FCRPS biological opinion required that the Action Agencies implement avian predation control measures to increase survival of juvenile salmonids in the lower Snake and Columbia Rivers through effective monitoring, hazing, and deterrents at each project. All CRS projects have been using several effective strategies, including wire arrays that crisscross the tailrace areas, spike strips along the concrete, water sprinklers at juvenile bypass outfalls, pyrotechnics, propane cannons, and limited amounts of lethal take. These efforts have reduced avian predation on juvenile salmon at the dams. Zorich et al. (2012) estimated that, compared to the numbers of smolts consumed at John Day Dam in 2009 and 2010, 84–94 percent fewer smolts were consumed by gulls in 2011. At The Dalles Dam, 81 percent fewer smolts were consumed in 2011 than in 2010. Zorich et al. (2012) attribute the observed changes in predation rates between years to variation in the number of foraging gulls, but imply that deterrence activities provide some (unquantifiable) level of protection.[219]

SR spring/summer Chinook salmon are also vulnerable to predation by terns nesting in the interior Columbia plateau, including colonies on islands in McNary Reservoir, in the Hanford Reach, and in Potholes Reservoir. Although predation rates on this ESU are much lower than for SR or UCR steelhead, smolts do come within foraging range of these and other nesting sites on the plateau (principally the Blalock Islands in John Day Reservoir) as they migrate downstream. The objective of the IAPMP (USACE 2014) is to reduce predation rates to less than 2 percent per listed ESU/DPS per tern colony per year. The primary management activities have been to keep terns from nesting on Goose Island in Potholes Reservoir (managed by Reclamation) and on Crescent Island in McNary Reservoir (managed by the Corps). Passive dissuasion, hazing, and revegetation have prevented terns from nesting on Crescent Island since 2015, and similar efforts are in progress at Goose Island. However, the number nesting at the Blalock Islands in John Day Reservoir was ten times higher in 2015 than the year before, and resightings of colored leg-banded terns indicated that large numbers had moved there from Crescent Island. Terns also came to the interior plateau from East Sand Island in the estuary and from alternative Corps-constructed colony sites in southeastern Oregon and northeastern California in 2015 when those areas experienced severe drought (Collis et al. 2016).

In 2017, the goal of the IAPMP to reduce ESU/DPS-specific predation rates to less than 2 percent was achieved at Goose Island for the second consecutive year, and at Crescent Island for the third year (Collis et al. 2018). Predation rates on SR spring/summer by Caspian terns at these sites have been relatively low, varying from <0.1 to <1.0 percent (Collis et al. 2018; Appendix C).

[219] "For continued protection against avian predation we recommend the current passive deterrents avian lines be maintained and expanded where possible and active deterrents such as hazing from boats or other novel methods continue to be deployed as necessary to minimize foraging by piscivorous birds at the Corps' dams" (Zorich et al. 2012).

Gull predation was not considered in the IAPMP and there are no regional plans to manage these colonies. PIT-tag recoveries indicate that predation rates on smolts from this ESU by gulls on Miller Rock Island ranged from 1.0–1.7 percent during 2015–2016 (Roby et al. 2016, 2017).

Pinniped Predators

Pinniped presence in the Bonneville tailrace has increased in the last six years (Appendix B). Rub et al. (2018) found up to 50 percent of the mortality from pinnipeds of adult spring-run Chinook salmon destined for tributaries above Bonneville Dam occurred within the ten-mile reach just below the dam. Hydroelectric dams can delay upstream fish passage and congregate fish searching for ladder entrances (Kareiva et al. 2000; Quinones et al. 2015). Such delays can make fish vulnerable to predation by pinnipeds (Stansell 2004; Naughton et al. 2011). Tidwell et al (2017) reports that an estimated 4,951 adult spring Chinook salmon (all ESUs) were consumed by both pinniped species in 2017, which equates to 4.5 percent of the adult spring Chinook salmon that passed. Consumption rates of spring Chinook salmon in the last three years (2015-17) have ranged from 4.3-5.9 percent and are the highest consumption rates since monitoring begun in 2002 (Appendix B). A small number of California sea lions have also been observed in Bonneville Reservoir in recent years.

Based on evidence of high rates of predation on SR spring/summer Chinook, NMFS has provided the states of Oregon and Washington with a Letter of Authorization under the MMPA to haze and remove CSLs through June 30, 2021. In 2017, the states trapped and euthanized 24 individually identifiable CSLs that were having a significant negative impact on ESA-listed salmonids at Bonneville Dam (Brown et al. 2017).

Fish Predators

Native pikeminnow are significant predators of juvenile salmonids in the hydrosystem reach, followed by non-native smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011, 2015). In addition to the Sport Reward Fishery in the lower Columbia River estuary and throughout the hydrosystem reach, the Action Agencies conduct a Dam Angling Program to remove large pikeminnows from the tailraces of The Dalles and John Day Dams. Angling crews removed an average of 5,913 northern pikeminnow from these two projects per year during 2013–17 (Williams 2013, 2014; Williams et al. 2015, 2016, 2017). They reported that one adult and zero jack or juvenile Chinook salmon were killed and/or handled during the five year period.

Juvenile salmonids are also consumed by large numbers of non-native fishes, including walleye, smallmouth bass, and channel catfish in the reservoirs of hydrosystem reach. As described for the lower Columbia River estuary: (1) yearling SR spring/summer Chinook salmon mostly stay in the mainstem migration channel and are not likely to encounter large numbers of these species, and (2) both the Oregon and Washington Departments of Fish and Wildlife have removed size and bag limits for these species in their sport fishing regulations in an effort to reduce predation pressure on juvenile salmonids.

2.15.2.12 Life-Cycle Models

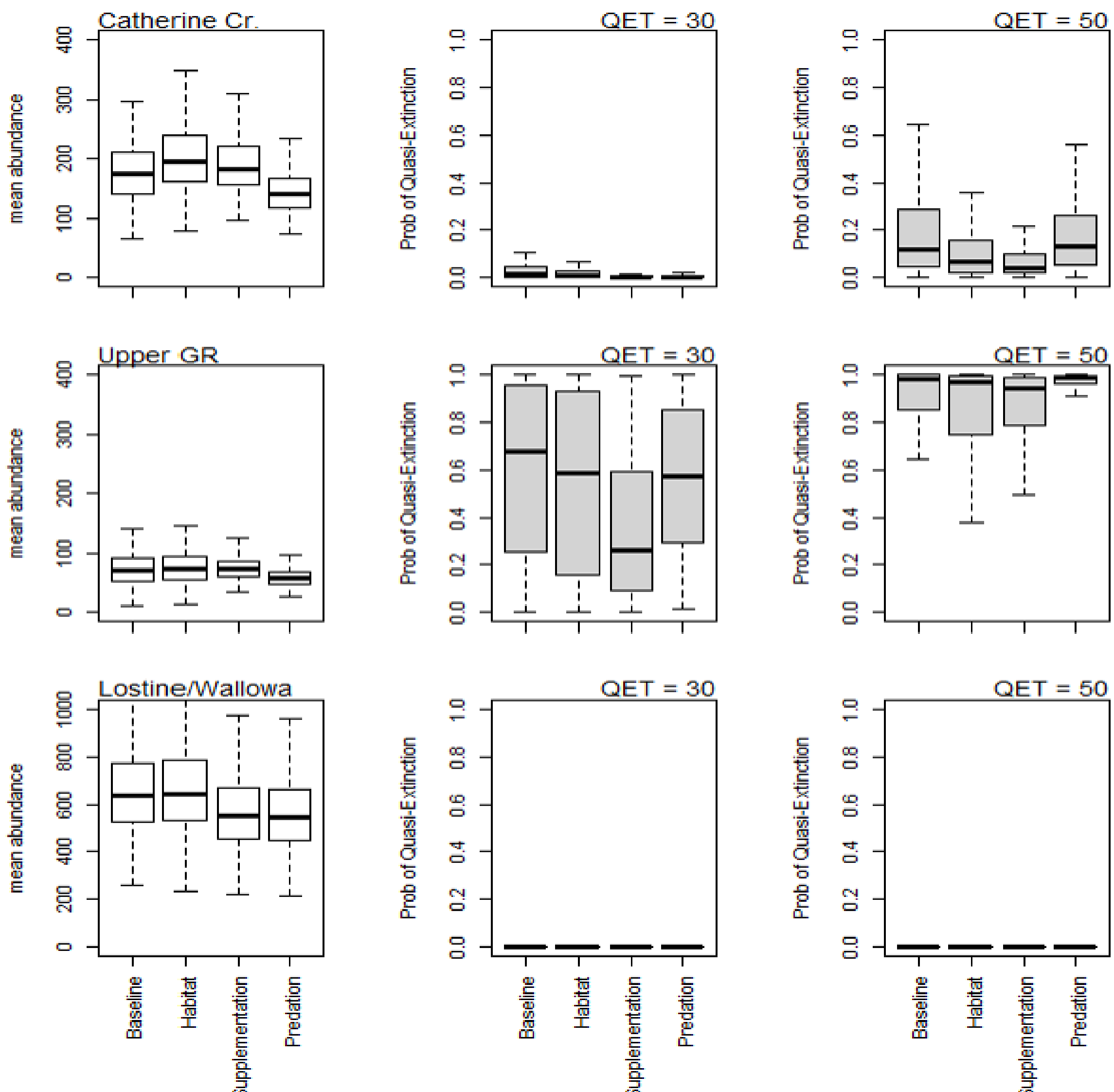
Life-cycle models were used to assess the effect of continuing to operate the hydropower system in accordance with the 2017 FOP; the future effect of recent habitat restoration actions (where they could be quantified); the effect of continuing hatchery production - in accordance with the most recent HGMPs; and the effect of recent, seasonally variable increases in sea-lion predation (earlier migrating populations suffer higher mortality rates) in the lower Columbia River from the mouth to Bonneville Dam. To assess the effects of tributary habitat restoration actions, the NWFSC and state and tribal partners relied upon (1) descriptions of habitat availability and (2) summaries of how actions changed the habitat at the reach level for key factors (e.g., summer flows, pool structure, floodplain/side channel connections, and riparian condition). They then estimated how changes (if there were changes) would affect the total habitat currently supporting production, and translated these changes in total habitat into changes in juvenile stage capacity or survival. The estimates of projected (in 24 years) median geomean abundance and productivity of populations under the environmental baseline (and resulting estimates of quasi-extinction at the 30 and 50 adult levels) include improvements in productivity and abundance that occurred in past decades as the result of both positive (e.g., hydrosystem improvements, reduced harvest, pikeminnow and avian predator management actions, etc.) and negative (e.g. continuing negative effects of hydropower projects, land use practices, etc.) factors which have affected the recruit-per-spawner estimates in the time series available for each population.

Model results projecting out 24 years was selected as a reasonable timeframe to assess near-term extinction and is consistent with past CRSO biological opinions. Quasi-extinction Thresholds represent levels at which populations may be too small to reliably reproduce. Because the exact population levels at which this condition occurs for Chinook salmon populations is unknown (and is likely variable due to a number of factors), past biological opinions (e.g., NMFS 2008a) provided QET projections for 50, 30, 10, and 1 individual (for four consecutive years) because of concern about populations with extremely low numbers. In this consultation, NMFS presents QET projections for 30 and 50 adults (for four consecutive years) as a useful means of illustrating differences resulting from factors affecting the abundance and productivity of the modeled populations.

Grande Ronde River MPG

Within the Grande Ronde River MPG, five populations have sufficient information available to support complex life-cycle modeling. These populations are all affected by ongoing hydropower actions and, to a lesser or greater extent, by increased sea-lion predation. Three of these populations (Lostine/Wallowa, Minam, and Wenaha) inhabit systems in which the spawning and rearing habitat is relatively intact. Two of these populations (Catherine Creek and Upper Grande Ronde) inhabit systems in which the spawning and rearing habitat has been substantially degraded. Figure 2.15-7 depicts life-cycle modeling results for the Grande Ronde River MPG. From left to right, each panel describes the projected additive effect of: (1) Baseline hydropower operations, then (2) recent tributary habitat improvements, then (3) continued supplementation at recent levels, then (4) increased pinniped predation in the Columbia River below Bonneville

Dam. As would be expected, baseline conditions (projected in 24 years) under recent hydropower operations showed little short-term improvement in projected median abundance as a result of the small number of habitat improvement projects affecting the Lostine/Wallowa population (no habitat improvement projects were implemented in the Minam or Wenaha systems). Slight improvements from recent habitat actions were projected in the Upper Grande Ronde population, and more substantial improvements were projected for the Catherine Creek population. The modelled projected abundance of naturally produced spawners decreased slightly as a result of hatchery operations (supplementation) in the Lostine/Wallowa population, likely due to naturally produced fish being removed from the population to support the integrated hatchery program. Little change was observed in the Catherine Creek or Upper Grande Ronde populations. Lastly, the projected median abundance in 24 years for all populations decreased as a result of recent increased pinniped predation estimates, but most notable for the Catherine Creek and Upper Grande Ronde populations, which tend to migrate earlier in the season and suffer higher average predation rates than the other populations in this MPG.



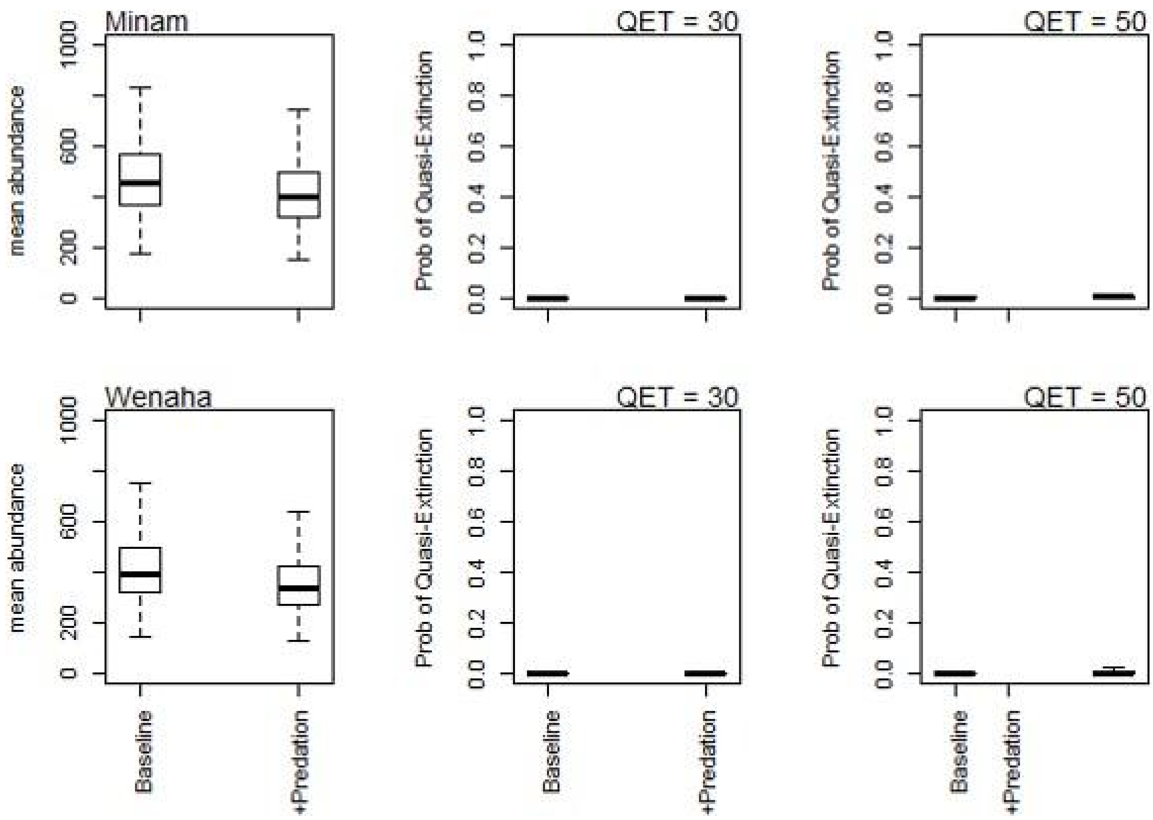


Figure 2.15-7. Grande Ronde Basin Life-cycle modeling results for the projected environmental baseline (mean 24-year abundance, and 24-year QET thresholds of 30 and 50 adults) assuming recent (2017 Fish Operations Plan) baseline hydropower operations, habitat actions, hatchery production (supplementation), and increased sea-lion predation.

Model projections (median geomean abundance and QET estimates for thresholds of 30 and 50 adults for four consecutive years in 24 years), considering quantifiable estimates of hydropower, habitat, and hatchery actions and continued high level of pinniped predation, are presented in Table 2.15-11. The Lostine/Wallowa, Wenaha, and Minam populations have very low projected probabilities of dropping below the QET = 50 threshold (< 1 percent); even the 95th percentile is only projected to have a zero percent, 6 percent, or 5 percent probability, respectively. The more habitat-limited populations have increased projected probabilities of median abundance falling below either the QET of 30 or 50 adult thresholds for four consecutive years. The Catherine Creek population has a projected median probability of about one percent, and 13 percent, respectively; the Upper Grande Ronde population is highest with nearly a 60 percent projected median chance of dropping below a QET of 30 adults, and a 99 percent chance of dropping below a QET of 50 adults for four consecutive years within 24 years.

Table 2.15-11. Life-Cycle Model projections of median abundance and quasi-extinction risk thresholds of 30 and 50 (5th and 95th percentiles) for populations of naturally produced fish in 24 years.

Grande Ronde MPG	**Abundance**			**QET = 30**			**QET = 50**		
Population	**Median geomeans**	**5th**	**95th**	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**
Catherine Creek	140	93	209	0.004	0	0.038	0.132	0.013	0.548
Upper Grande Ronde	57	35	87	0.571	0.047	0.975	0.990	0.698	1.000
Minam	399	231	638	0	0	0.005	0.002	0	0.045
Wenaha	340	198	565	0	0	0.007	0.002	0	0.063
Lostine/Wallowa	543	316	891	0	0	0	0	0	0

South Fork Salmon River MPG

Within the South Fork Salmon River MPG, two populations have sufficient information available to support complex life-cycle modeling. These populations are all affected by ongoing hydropower actions and, to a lesser or greater extent, by increased sea-lion predation. Both populations (South Fork Salmon and Secesh) inhabit systems in which the spawning and rearing habitat is relatively intact. These populations have not been targeted for extensive habitat restoration actions and are not substantively influenced by hatchery-produced fish. Model projections (median geomean abundance and QET estimates for thresholds of 30 and 50 adults for four consecutive years in 24 years) are presented in Table 2.15-12. Based on these model projections, median abundance would be about 660 adults for the South Fork Salmon and 500 adults in the Secesh population in 24 years. The projected median probability of either population falling below a QET of 50 adults for four consecutive years is less than 1 percent for the South Fork, and 3 percent, for the Secesh populations, respectively.

Table 2.15-12. Life-Cycle Model projections of median abundance and Quasi-Extinction Risk thresholds of 30 and 50 (5th and 95th percentiles) for populations of naturally produced fish in 24 years.

South Fork Salmon MPG	**Abundance**			**QET = 30**			**QET = 50**		
Population	**Median geomeans**	**5th**	**95th**	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**
South Fork Salmon	662	12	1,627	0	0	0.007	0.004	0	0.051
Secesh	495	6	1,613	0.003	0	0.091	0.026	0	0.374

Middle Fork Salmon River MPG

Within the Middle Fork Salmon River MPG, six populations have sufficient information available to support complex life-cycle modeling. These populations are all affected by ongoing hydropower actions and, to a lesser or greater extent, by increased sea-lion predation. These populations generally inhabit systems in which the spawning and rearing habitat is relatively intact, and consequently, have not been targeted for habitat restoration actions, and are not substantively influenced by hatchery-produced fish. Model projections (median geomean abundance and QET estimates for thresholds of 30 and 50 adults for four consecutive years in 24 years) are presented in Table 2.15-13. Based on these model projections, median abundance is expected to exceed 170 adults for the Big Creek population, and 500 adults for the Bear Valley Creek population in 24 years. The median probability of these populations falling below the QET of 30 adults for four consecutive years is projected to be about 8 precent for Big Creek and 11 percent for Bear Valley. The median probability of these populations falling below the QET of 50 adults is projected to be about 30 percent for Big Creek population and less than 20 percent for Bear Valley Creek population. The Marsh Creek model projects a median abundance in 24 years of over 200 adults; with about a two percent probability (median) of falling below the QET of 30 adults, and about a 13 percent chance (median) of falling below a QET of 50 adults in 24 years. The models project that median abundance for the Sulphur Creek, Camas Creek, and Loon Creek populations will remain quite low (50 to 70 adults), with correspondingly high probabilities of falling below the QET of 30 adults (medians ranging from about 60 to 77 percent) and QET of 50 adults (medians ranging from about 87 to 97 percent).

Table 2.15-13. Life-Cycle Model projections of median abundance and Quasi-Extinction Risk thresholds of 30 and 50 (5th and 95th percentiles) for populations of naturally produced fish in 24 years.

Middle Fork Salmon MPG	Abundance			QET = 30			QET = 50		
Population	**Median geomeans**	**5th**	**95th**	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**
Big Creek	171	3	526	0.080	0	0.770	0.319	0	0.999
Bear Valley Creek	516	0	2,928	0.114	0	0.812	0.179	0	1.000
Marsh Creek	211	9	568	0.018	0	0.271	0.127	0	0.842
Sulphur Creek	60	2	179	0.681	0.002	1.000	0.897	0.480	1.000
Camas Creek	52	6	116	0.768	0.104	0.999	0.967	0.829	1.000
Loon Creek	70	3	204	0.604	0.001	1.000	0.869	0.345	1.000

Upper Salmon River MPG

Within the Upper Fork Salmon River MPG, seven extant populations have sufficient information available to support complex life-cycle modeling. These populations are all affected by ongoing hydropower actions and, to a lesser or greater extent, by increased sea-lion predation. The Upper Salmon River Lower Mainstem, Upper Salmon River above Redfish Lake, North Fork, East Fork, and Valley Creek populations inhabit systems in which the spawning and rearing habitat has been substantially degraded. The Yankee Fork, Upper Salmon mainstem, and Pahsimeroi populations are also affected by hatchery production.

Model projections (median geomean abundance and QET estimates for thresholds of 30 and 50 adults for four consecutive years in 24 years) are presented in Table 2.15-14. Based on these projections, the Upper Salmon Mainstem population would be expected to be the largest (median of about 400 adults) and the least likely to fall below a QET of 50 adults (median probability < 4 percent) under the environmental baseline. The Pahsimeroi River population would be expected to be next most abundant (median of 285 adults) and the next least likely to fall below a QET of 30 or 50 adults (median probability of about 2 percent and 117 percent, respectively). The Lemhi

River and Valley Creek (Crozier model) populations are projected to have median abundance of 107 and 83 adults, respectively; with correspondingly higher probabilities of falling below the QET of 30 (about 43 and 54 percent, respectively) or 50 adults (about 75 percent). Two populations (Valley Creek and East Fork) are projected to have continued low median abundance (about 40 adults) and a high probability of falling below a QET of 30 within 24 years (80 to 90 percent). Finally, two populations (Yankee Fork and North Fork) are projected to remain at extremely low abundance (median of four to seven adults), and are certain (100 percent) to fall below a QET of 30 adults within 24 years.

Table 2.15-14. Life-Cycle Model projections of median abundance and Quasi-Extinction Risk thresholds of 30 and 50 (5th and 95th percentiles) for populations of naturally produced fish in 24 years.

South Fork Salmon MPG	Abundance			QET = 30			QET = 50		
Population	**Median geomeans**	**5th**	**95th**	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**
Lemhi River	107	12	588	0.428	0.061	0.985	0.740	0.192	0.996
Valley Creek (Crozier model)	83	1	304	0.543	0	1.000	0.765	0	0.999
Valley Creek	44	3	220	0.872	0.173	1.000	0.960	0.694	1.000
Yankee Fork	7	0	93	1.000	1.000	1.000	1.000	1.000	1.000
Upper Salmon Mainstem	397	102	1,736	0	0	0	0.038	0.001	0.663
North Fork	4	0	42	1.000	1.000	1.000	1.000	1.000	1.000
East Fork	39	3	288	0.845	0.226	0.999	0.981	0.630	1.000
Pahsimeroi	288	67	1,142	0.017	0	0.711	0.169	0.008	0.848

Summary

Life-cycle models are limited by the amount and quality of the available data that can be used to estimate or infer relationships to factors that influence the survival and productivity of individuals within a population throughout their life cycle. The life-cycle models presently do not incorporate interactions between populations (straying, source-sink dynamics, etc.) or between MPGs, though these dynamics are known to occur. That said, they provide useful frameworks for assessing how populations are likely to respond to factors that are correlated with survival, abundance, or juvenile production capacity.

The life-cycle model results generally indicate that the productivity and abundance of populations in each of the four MPGs for which modeling was possible, will likely remain substantially below the abundance and productivity objectives established in the recovery plan at the end of 24 years. Each MPG, excepting the South Fork Salmon River MPG, has examples of modelled populations that are expected to have very low median abundance (< 50 adults), and high (90 percent or greater) probabilities of falling below the QET, or 50 or even 30 adults for four consecutive years. These populations tend to inhabit areas that have suffered from severe habitat degradation (e.g., Catherine Creek, Upper Grande Ronde, and Yankee Fork populations), or inhabit higher elevation, less productive habitat (e.g., Sulphur Creek, Camas Creek, North Fork Upper Salmon and East Fork Upper Salmon).

Each of the MPGs also has one or more populations that is expected to be relatively abundant (i.e., a median of greater than 300 adults) and have relatively high likelihoods of persistence (low probabilities of dropping below the QET of 30 or 50 adults for four consecutive years) through the next 24 years. These larger, more productive populations are very important to the persistence and integrity of each MPG. Adults from these populations undoubtedly stray into, and spawn with, adults in nearby, less productive and abundant populations, supporting their persistence and increasing the overall demographic and genetic resiliency of each MPG.

Though not explicitly modeled, this resiliency (straying of adults between proximal populations of fish) are likely incorporated into recruit estimates that form the base of the recruit-per-spawner estimates, which lie at the core of the life-cycle models. Larger, more productive “source” populations tend to support nearby smaller, less productive “sink” populations, which contributes to the persistence of these populations (and the MPG structure as a whole) and helps to explain how some populations may be persisting at low levels for relatively long periods of time — even though models of individual, isolated populations may suggest high probabilities of extinction.

There are also examples of populations that would be expected to be intermediate, between these two groups of populations.

2.15.2.12 Research and Monitoring Activities

The primary effects of the past and ongoing CRS-related RM&E program on SR spring/summer Chinook salmon are associated with the capturing and handling of fish. The RM&E program is a collaborative, regionally coordinated approach to fish and habitat status monitoring, action effectiveness research, critical uncertainty research, and data management. The information derived from the program facilitates effective adaptive management through better understanding the effects of the ongoing CRS action. Capturing, handling, and releasing fish generally leads to stress and other sublethal effects, but fish sometimes die from such treatment. The mechanisms by which these activities affect fish have been well documented and are detailed in Section 8.1.4 of the 2008 biological opinion. Some RM&E actions also involve sacrificial sampling of fish.

We estimated the number of SR spring/summer Chinook salmon that have been handled or killed each year during the implementation of RM&E under the 2008 RPA as the average annual take reported for 2013–17:

- Average annual estimates for handling and mortality of SR spring/summer Chinook salmon associated with the Smolt Monitoring Program and the CSS were: (1) two hatchery and five wild adults handled; (2) zero hatchery and zero wild adults died; (3) 25,588 hatchery and 14,738 wild juveniles handled; and (4) 83 hatchery and 30 wild juveniles died.

- The estimated handling and mortality of SR spring/summer Chinook salmon associated with the ISEMP was: (1) 3,282 hatchery and 2,369 wild adults handled; (2) one hatchery and one wild adult died; (3) one hatchery and 1,682 wild juveniles handled; and (4) zero hatchery and 82 wild juveniles died.
- Estimates for SR spring/summer Chinook salmon handling and mortality for all other fish RM&E programs are as follows: (1) 104 hatchery and 56 wild adults handled; (2) one hatchery and one wild adult died; (3) 22,867 hatchery and 18,231 wild juveniles handled; and (4) 72 hatchery and 69 wild juveniles died.

The combined observed mortality associated with these elements of the RM&E program has, on average, affected less than one percent of the wild (i.e., natural-origin) adult run or juvenile production of the SR spring/summer Chinook salmon ESU. This relatively small effect is deemed worthwhile because it allows the Action Agencies and NMFS to evaluate the effects of CRS operations, including modifications to facilities, operations, and mitigation actions. However, we estimate that more than 1 percent of the wild adults and wild juveniles was handled in the combined RM&E programs. Based on the history of these programs, we assume that up to 1 percent of the handled adults and juveniles (i.e., 0.10 percent of adults and 0.03 percent of juveniles) died after they were released.

In addition, northern pikeminnow are tagged as part of the Sport Reward Fishery and their rate of recapture is used to calculate exploitation rates. Northern pikeminnow are collected for tagging using boat electrofishing in select reaches of the Columbia River. During 2017, boat electrofishing operations in the Columbia River extended upstream from RM 47 (near Clatskanie, Oregon) to RM 394 (Priest Rapids Dam), and in the Snake River from RM 10 (Ice Harbor Dam) to RM 41 (Lower Monumental Dam) and from RM 70 (Little Goose Dam) to RM 156 (upstream of Lower Granite Dam). Researchers conducted four sampling events consisting of 15 minutes of boat electrofishing effort in shallow water within each 0.6-mile reach during April-July.

A side effect of the electrofishing effort is that salmon and steelhead may be exposed to the electrofishing field, with the potential for injury, stress, and fatigue and even cardiac or respiratory failure (Snyder 2003). Some adult and juvenile SR spring/summer Chinook salmon are likely to be present in shallow shoreline areas during the April-July time period. Most sampling occurs in darkness (1800-0500 hours). Operators shut off the electrical field if salmonids are seen and because most stunned fish quickly recover and swim away, they cannot be identified to species (i.e., Chinook, coho, chum, sockeye, sockeye, or steelhead). Barr (2018) reported encountering an annual average of 1,762 adult and 92,260 juvenile salmonids in the lower and middle Columbia River each year during 2013-17 electrofishing operations based on visual estimation methods. It is likely that some of these were SR spring/summer Chinook salmon.

5.15.2.13 Critical Habitat

The environmental baseline for the PBFs for SR spring/summer Chinook salmon critical habitat are reflected in the same impacts discussed above (e.g., mainstem flows, passage, tributary habitat, water quality, predation, etc.) and summarized here in Table 2.15-15. Across the entire action area, widespread development and other land use activities have disrupted watershed processes (e.g., erosion and sediment transport, storage and routing of water, plant growth and successional processes, input of nutrients and thermal energy, nutrient cycling in the aquatic food web, etc.), reduced water quality, and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and/or current land use or water management activities have adversely affected the quality and quantity of stream and side channel areas (e.g., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for SR spring/summer Chinook salmon production have been weakened.

Within estuaries, essential PBFs have been defined as “areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation” (NMFS 2008b).

Habitat quality in tributary streams in the Interior Columbia recovery domain varies from excellent in wilderness and roadless areas to poor in areas subject to heavy agricultural and urban development. Critical habitat throughout much of the Interior Columbia recovery domain has been degraded by intense agriculture, alteration of stream morphology (i.e., through channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining, and urbanization. Reduced summer stream flows, impaired water quality, and reduction of habitat complexity are common problems for critical habitat in developed areas, including those within the Interior Columbia recovery domain (NMFS 2016e).

The general effects of mainstem and tributary dams on the functioning of critical habitat include:

- Lost access to historical spawning areas behind dams built without fish passage facilities (safe passage in the migration corridor);
- Reduced juvenile and adult passage survival at dams with passage facilities (safe passage in the migration corridor);
- Altered water quantity (i.e., flow) and seasonal timing (water quantity and velocity, cover/shelter, food/prey, riparian vegetation, and space in rearing areas, including the estuarine floodplain, and migration corridors);

- Altered temperature, both in the reaches below the large mainstem storage projects and in rearing areas and migration corridors (water quality and safe passage in the migration corridor);
- Reduced sediment transport and turbidity (water quality and safe passage in the migration corridor);
- Increased total dissolved gas (water quality and safe passage in the migration corridor); and
- Altered food webs, including both predators and prey (food/prey and safe passage in rearing areas and migration corridors).

Habitat quality of migratory corridors in this area has been severely affected by the development and operation of the CRS dams and reservoirs in the mainstem Columbia River, Bureau of Reclamation tributary projects, and privately owned dams in the Snake River basin.

Hydroelectric development has modified natural flow regimes of the rivers, resulting in warmer late summer/fall water temperatures, changes in fish community structure that lead to increased rates of piscivorous and avian predation on juvenile salmon and steelhead, and delayed migration for both adult and juvenile salmonids. Physical features of dams, such as turbines, also kill out-migrating fish. In-river survival is inversely related to the number of hydropower projects encountered by emigrating juveniles. Additionally, development and operation of extensive irrigation systems and dams for water withdrawal and storage in tributaries have altered hydrological cycles (NMFS 2016e).

In previous CRS consultations, the Action Agencies have implemented improvements in the juvenile and adult migration corridor, including 24-hour volitional spill, improved surface passage routes, improved juvenile bypass systems, and predator management measures. These improvements have improved the safe passage PBF.

Many stream reaches designated as critical habitat are listed on Oregon, Washington, and Idaho Clean Water Act Section 303(d) lists for water temperature. Many areas that were historically suitable rearing and spawning habitat are now unsuitable due to high summer stream temperatures. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water for agricultural or municipal use all contribute to elevated stream temperatures. Furthermore, contaminants, such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste, are common in some areas of critical habitat (NMFS 2016h). They can negatively impact critical habitat and the organisms associated with these areas.

The large numbers of avian predators nesting on man-made or enhanced structures (dredge material deposits that created Rice Island and increased the size of East Sand Island in the lower Columbia River as well as bridges, aids to navigation, and transmission towers) constitute higher rates of predation than would occur naturally in the lower Snake and Columbia River portions of the juvenile migration corridor. Similarly, sea-lion predation on adult SR spring/summer Chinook salmon in the tailrace of Bonneville Dam is excessive predation associated with a man-made structure. Predation associated with sea lions in the estuary is a natural phenomenon and is not excessive predation in the context of an effect on the functioning of critical habitat.

In the mainstem of the Columbia and Snake Rivers, the altered habitats in project reservoirs reduce smolt migration rates and create more favorable habitat conditions for fish predators, including native northern pikeminnow and nonnative walleye and smallmouth bass. The effects of the non-native species and pikeminnows, to the extent the latter's predation rates are enhanced by reservoir and tailrace conditions, are also examples of excessive predation in the juvenile migration corridor.

Restoration activities addressing habitat quality and complexity, migration barriers, and water quality have improved the baseline condition for PBFs; however, the conservation role of critical habitat is to provide PBFs that support populations that can contribute to conservation of the ESU. More restoration is needed before the PBFs can fully support the conservation of SR spring/summer Chinook salmon.

Table 2.15-15. Status of physical and biological features of designated critical habitat within the action area for SR spring/summer Chinook salmon.

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBF in the Action Area
Spawning and juvenile rearing sites	Spawning gravel Water quality Water quantity Cover/shelter Food Riparian vegetation Space	Physical passage barriers (culverts, push-up dams, low flows) that have impaired fish passage Reduced tributary stream flow, which limits usable stream area and alters channel morphology by reducing the likelihood of scouring flows (water withdrawals) Altered tributary channel morphology (bank hardening for roads or other development, and by livestock on soft riparian soils and streambanks) that has reduced stream complexity and channel structure, and reduced floodplain connectivity and function Excessive sediment in spawning gravel (roads, mining, agricultural practices; livestock on soft riparian soils and streambank; and recreation) Degraded tributary water quality including high summer temperatures and in some cases, chemical pollution from mining (water withdrawals, degraded riparian condition)

Physical and Biological Feature (PBF)	Components of the PBF	Principal Factors affecting Environmental Baseline Condition of the PBF in the Action Area
Adult and juvenile migration corridors	Substrate Water quality Water quantity Water temperature Water velocity Cover/shelter Food Riparian vegetation Space Safe passage	Tributary barriers (push-up dams, culverts, water withdrawals that dewater streams, unscreened water diversions that entrain juveniles) Juvenile and adult passage mortality (hydropower projects in the mainstem lower Snake and Columbia Rivers) Water quality (toxics, temperatures, TDG) Pinniped predation on adults due to habitat changes in the lower river (existence and operation of Bonneville Dam and an increased sea lion population) Diking off areas of the estuary floodplain (land use), combined with reduced peak spring flows (water diversions and water storage and hydroelectric projects) have reduced access to floodplain habitat for rearing and prey production Juvenile mortality due to habitat changes in the estuary that have increased the number of avian predators (Caspian terns and double-crested cormorants)

5.15.2.14 Future Anticipated Impacts of Completed Federal Formal Consultations

The environmental baseline also includes the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, including the consultation on the operation and maintenance of the Bureau of Reclamation's upper Snake River projects. The 2016 five-year review evaluated new information regarding the status and trends of SR spring/summer Chinook salmon, including recent biological opinions issued for the SR spring/summer Chinook salmon, and key emergent or ongoing habitat concerns (NMFS 2016e). Since the beginning of 2015 through 2017, we completed 518 formal consultations (152 in 2015, 162 in 2016, and 204 in 2017) that addressed effects to SR spring/summer Chinook salmon (PCTS data query July 31, 2018). These numbers do not include the many projects implemented under programmatic consultations, including projects that are implemented for the specific purpose of improving habitat conditions for ESA-listed salmonids. Some of the completed consultations are large (large action area, multiple species), such as the Mitchell Act consultation and the consultation on the 2018-2027 *U.S. v. Oregon* Management Agreement. In 2008, NMFS issued a biological opinion to the Bureau of Reclamation for operations and maintenance actions at the Upper Snake River projects. The proposed action included adjustments to the timing of flow augmentation from the Upper Snake projects to better meet the needs of listed fish. Many of the completed actions are for a single activity within a single subbasin.

Some of the projects will restore access to blocked habitat, improve riparian condition and channel complexity, and increase instream flows. For example, under BPA's Habitat Improvement Programmatic consultation, BPA implemented 29 projects in the Columbia River basin that improved fish passage in 2017, and 99 projects that involved river, stream, floodplain, and wetland restoration. These projects will benefit the viability of the affected populations by improving abundance, productivity, and spatial structure. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more and typically less than a few weeks).

Other types of federal projects, including grazing allotments, dock and pier construction, and bank stabilization will be neutral or have short- or even long-term adverse effects on viability. All of these actions have undergone section 7 consultation and the actions or the RPA were found to meet the ESA standards for avoiding jeopardy.

Similarly, future federal restoration projects that have completed ESA consultation will improve the functioning of the PBFs safe passage, spawning gravel, substrate, water quantity, water quality, cover/shelter, food, and riparian vegetation. Projects implemented for other purposes will be neutral or have short- or even long-term adverse effects on some of these same PBFs.

However, all of these actions, including any RPAs, have undergone section 7 consultation and were found to meet the ESA standards for avoiding adverse modification of critical habitat.

2.15.3 Effects of the Action

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

The proposed action is an ongoing action that has been modified over time to reflect capital improvements, as well as changes in operation based on existing conditions and improved information on how CRS operations affect SR spring/summer Chinook and other listed species and their critical habitats. The current proposed action includes operational measures (e.g., flood risk management, navigation, fish passage, and hydropower generation) and non-operational measures (e.g., support for conservation hatchery programs, predation management, habitat improvement actions) that will be implemented beginning in 2019.

As described in Section 2.1 above, our analysis of effects for SR spring/summer Chinook salmon extends from 2019 into the future, but emphasizes the evaluation of effects that are reasonably certain to occur as a result of implementing the proposed action pending completion of the EIS and our issuance of a subsequent biological opinion addressing the effects of the final preferred alternative. To the extent our consideration of potential effects beyond that time period assumes the current proposed action remains, it is intended, in part, to inform the evaluation of alternatives in the EIS.

The effects of the proposed action for SR spring/summer Chinook salmon are generally consistent with the effects caused by a continuation of the CRS operations as described in the environmental baseline section, with the exception of the addition of the following:

- Implementation of the flexible spring spill operation
- 0.5-ft increase in operating range at John Day Dam and the lower Snake River reservoirs;
- The potential for reduction of spill at mainstem projects (August 15 to 31) in 2020 pending consensus among parties
- Targeting April 24 as the transport start date (collection on April 23) at Snake River collector projects
- Cessation of juvenile transport from June 21 to August 4, starting in 2020.

2.15.3.1 Effects to Species

The Action Agencies will operate the run-of-river lower Columbia River projects (McNary, John Day, The Dalles, and Bonneville Dams) and lower Snake River dams (Ice Harbor, Lower Monumental, Little Goose and Lower Granite Dams) in accordance with the annual Water Management Plan and Fish Passage Plan (including all appendices). These projects are operated for multiple purposes, including fish and wildlife conservation, irrigation, navigation, power, recreation, and, in the case of John Day Dam, limited flood risk management.

The Action Agencies propose to increase spill at the lower Columbia and lower Snake River dams during the spring spill period in an effort to improve juvenile survival through the dams and adult returns. The Action Agencies propose to operate to gas cap spill for 16 hours per day and performance spill for 8 hours per day. Performance spill was developed using a combination of 2008 FCRPS biological opinion prescribed spill and performance standard testing guidelines, and gas cap spill uses spill up to state water quality standards with some restrictions for erosion concerns and powerhouse minimums. The spill operation changes are consistent with rules adopted in the "Federal Columbia River Power System Juvenile Dam Passage Performance Standard and Metrics" paper (2012) governing the adoption of operations to meet 2008 biological opinion Juvenile Dam Passage Performance Standards. During the 16-hour gas cap spill portion of each day, each project will operate up to state-approved water quality standards which are expected to be up to 120 percent tailrace TDG in 2019 and up to 125 percent tailrace TDG in 2020 pending adjustments to the state water quality standards.

System-wide water management operations involving upstream water storage projects will continue under the proposed action. Thus, the seasonal alterations described in the environmental baseline section will continue (decreased spring and early summer flows, increased winter flows) to affect the mainstem migration and rearing corridor, estuary, and plume. Juvenile survival and adult returns will be monitored using ongoing RM&E programs.

2.15.3.1.1 Water Quality

The existence and operation of the federal hydrosystem will continue to affect water quality parameters in the mainstem migration corridor, as described in the environmental baseline. This includes delayed spring warming, delayed fall cooling, reduced temperature variability on a daily basis due to the thermal inertia of the reservoirs, and the continued releases of cool water from storage at Dworshak Dam to moderate lower Snake River water temperatures from June through September.

TDG levels will continue to exceed the state-approved standards) whenever lack of market or lack of turbine capacity spill events occur. These events will continue to occur most frequently in May and June, but may also occur other months.

The available information indicates that supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). The proposed flexible spill operation (up to 120 or 125 percent TDG) would increase the exposure of spring migrating juveniles to elevated TDG levels from the tailrace of Lower Granite Dam to at least 35 miles downstream of Bonneville Dam. Individuals from all populations and MPGs would be exposed similarly. Smolts typically migrate at depths which effectively reduce TDG exposure due to pressure compensation mechanisms (Weitkamp et al. 2003). However, the proposed flexible spill operation would likely result in a slight increase in the incidence and severity of GBT symptoms and a very small (not measurable through reach survival studies) increase in mortality.

Adult SR spring/summer Chinook salmon typically migrate between Bonneville and Lower Granite Dam during the period that the flexible spill operation would occur (April through June). Adults also migrate at depths which reduce the effective exposure to TDG through depth compensation mechanisms. The proposed flexible spill operation would likely result in a slight increase in the incidence and severity of GBT symptoms and a very small (not measurable) increase in mortality.

The Corps proposes to continue a program of best management practices to avoid accidental releases of oil and grease, and to minimize any adverse effects from equipment in contact with the water. The Corps will also implement oil accountability plans with enhanced inspection protocols and prepare annual oil accountability reports. The adoption of these practices should continue the slight, but positive, improvement in conditions for juvenile and adult migrants, but would not be expected to detectably affect reach survival estimates. Any impacts, given dilution, are likely to be very small, if not negligible.

2.15.3.1.2 Sediment Transport

The existence and operation of the federal hydrosystem will continue to affect sediment transport, as described in Section 2.15.2.6. These dams will continue to trap sediment and increase water transparency, especially during the spring freshet, which hypothetically increases the exposure of SR spring/summer Chinook salmon juveniles to predators and results in higher mortality rates than would be the case in a natural system.

2.15.3.1.3 Adult Migration/Survival

Average adult survival rates through the lower Columbia and Snake River dams, as described in the Section 2.15.2.4, are expected to continue as a result of the proposed action. Fallback rates, which are associated at many dams with higher flow and spill levels (Boggs et al. 2004), will likely increase slightly at several of the eight mainstem dams. A radio-tracking study conducted from 1995 to 2003 found that reascension rates wete highest at downstream dam, 19 percent of spring/summer Chinook salmon fell back at least once, and that fallback rates and flows were correlated at most Snake or Columbia River dams (Keefer et al. 2005). The fish that fell back were significantly less likely to reach their spawning areas compared to fish that never fell back. When looking at PIT-tag data from Bonneville Dam during 2006–11, a mean of 9.6 percent of spring/summer Chinook salmon that fell back reascended (Dart 2019d). Thus, we expect that the proposed operation will result in a small increase in the fallback of SR spring/summer Chinook salmon adults as they migrate upstream during the flexible spring spill operation. However, fallback would most likely happen through a non-powerhouse route which would be expected to increase survival Normandeau et. al. 2014, Colotello et al. 2013), offsetting any potential impact of increased fallback rates. In addition, the regional managers will use in-season adaptive management to identify and remedy any excessive fallback. Thus, the average survival for SR spring/summer Chinook salmon adults may decrease slightly from the recent averages of about 89 percent in the Bonneville to McNary Dam reach and 84 percent in the Bonneville to Lower Granite Dam reach. In addition, hundreds of summer-run Chinook salmon from the Snake River spring/summer Chinook salmon ESU will be handled at Lower Granite Dam during any emergency trapping operations for SR sockeye. We expect that less than one percent of the run will be handled in a given year, with no more than 20 mortalities.

If the regional parties reach agreement, the Action Agencies propose to reduce summer spill at the eight mainstem dams in late August. This change would affect very small numbers of adult summer-run Chinook salmon that were still migrating after that date in August by reducing fallback rates of SR summer Chinook. However, individuals that fell back would experience greater risk because they would be more likely to pass via turbines and juvenile bypass systems instead of the spillway.

Increasing the operating range by 6 inches at the lower Snake River dams (MOP 1.5-foot range) and at John Day Dam (MIP 2-foot range) will have little effect on flow, and thus is not expected to affect adult migration timing or survival rates.

Potential spill reduction starting in August (15-31) of 2020, pending consensus among parties, would likely have negligible effects on summer migrating adults (fallback related impacts) and no effects on spring migrating adults.

2.15.3.1.4 Juvenile Migration/Survival

The Action Agencies propose to continue to provide beneficial spill (conventional and surface passage), the juvenile bypass system, and other operations for juvenile passage as described in Section 2.15.2.5. Average juvenile survival rates through the lower Columbia and Snake River dams are expected to continue, with a few small exceptions, as a result of the proposed action. Increased spill levels during the spring are expected to have little effect on tailrace conditions at Bonneville, The Dalles, or McNary Dams or the Snake River dams, but could cause small eddies to form at John Day Dam under low flow conditions. The latter would be likely to increase the exposure to predators of juvenile Chinook salmon passing through the spillway, thereby reducing survival by a small amount. Overall, the survival of all in-river migrating juvenile SR spring-summer Chinook salmon should increase slightly as a result of implementing the flexible spring spill levels at each of the eight mainstem dams.

The proposed action (flexible spill up to 120 percent TDG) would reduce Lower Granite to Bonneville travel times by 0.9 days (based on COMPASS model run February 2019). This would have the effect of slightly decreasing the exposure of smolts to bird and fish predators, which would slightly improve juvenile survival rates.

Because SR spring-summer Chinook salmon juveniles migrate during the spring, they will not be affected by a reduction in summer spill in late August of 2020.

<u>COMPASS Model Results</u>

The COMPASS model, developed by NMFS' NWFSC (Zabel et al. 2008), is a tool for comparatively assessing the likely effect of alternative hydropower structures and/or operations on the passage and survival of juvenile yearling Chinook salmon and steelhead smolts migrating through the lower Snake and Columbia Rivers. Information from both PIT-tags (detection efficiencies and project and reach survival estimates) and acoustic tags (route-specific passage and survival estimates and dam survival estimates) are used to calibrate the model.

For SR spring/summer Chinook salmon, COMPASS estimates that the increased spill levels at the lower Columbia River dams (up to 120 percent TDG) will, compared to operations under the 2017 FOP, on average:

1. Reduce average juvenile travel times from the Lower Granite tailrace to the Bonneville Dam tailrace by about 0.9 days;
2. Increase average juvenile survival from the head of Lower Granite pool to the Bonneville Dam tailrace by about 0.7 percent to 58.2 percent;
3. Decrease the proportion of juveniles approaching Lower Granite Dam that are destined for transport by about 8.1 percent to 24.3 percent; and
4. Increase the average number of spill passage events (the inverse of the CSS's PITph metric) by 0.7 to 6.4 out of eight total dams (Lower Granite to Bonneville Dam).

These modeling results support our qualitative expectations that the proposed flexible spring spill operation would have a small effect of juvenile travel time (reduced by about one day) fand survival rates (increased by about 0.70 percent) from the lower Snake River to below Bonneville Dam . However, reducing transport rates, especially in May and June, would be expected to reduce SARs because those of transported fish are typically higher than those of in-river migrants during this period. The CSS hypothesizes that Gas Cap spill would reduce latent mortality by reducing the number of powerhouse encounters. If this proves to be true (see Life Cycle Modeling, below), we would expect an additional incremental increase adult returns. The net effect of these factors across the outmigration period is unknown.

2.15.3.1.5 Transportation

SR spring/summer Chinook salmon smolts will continue to be collected for transportation at the three Snake River collector projects as a result of the proposed action. However, the increased spill will result in more juvenile fish going over the spillway and fewer fish being transported. Should transport to in-river survival ratios continue, the expected slight decrease in transport rates resulting from increased spill at the three collector projects would, on average, result in a slight reduction in adult returns. The earlier start date (April 24) enacted in 2018, resulted in an increase in the estimated proportion of wild (44.1 percent) and hatchery (45.4 percent) spring-summer Chinook salmon smolts transported. These numbers represent increases since 2008. The Action Agencies propose to continue transporting on this start date, which will allow information to be collected in late April to determine what, if any, transport benefits are occurring in this period.

Potential spill reduction starting in August (15-31) of 2020, pending consensus among parties, would not affect juvenile SR spring/summer Chinook which migrate in the spring. The proposed cessation of transport from June 21 to August 4, starting in 2020 would also not affect juvenile SR spring/summer Chinook salmon.

2.15.3.1.6 Estuary Habitat

The Action Agencies will continue to implement the CEERP (Ebberts et al. 2018; BPA and USACE 2018). Program goals are to increase the capacity and quality of estuarine ecosystems and to improve access to these resources for juvenile salmonids. Floodplain reconnections are expected to continue to increase the production and availability of commonly consumed prey (chironomid insects and corophiid amphipods; PNNL and NMFS 2018) to SR spring/summer Chinook salmon as they migrate through the estuary.

NMFS agrees with the ISAB's assessment (ISAB 2014) that it has been difficult to quantify the survival benefits of estuary habitat restoration. For the interim period, the Action Agencies' proposed commitment is, therefore, to reconnect an average of 300 acres of floodplain per year, a goal that they have a record of meeting in 2008-17 (BPA et al. 2018b), rather than to achieve a survival improvement. NMFS also agrees with the ISAB that the Action Agencies' assessment method, including review by the ERTG (Krueger et al. 2017), remains useful for prioritizing projects and for optimizing project design (number of breaches and channels, etc.) to site conditions. Thus, NMFS expects that the proposed implementation of the estuary program during the interim period will continue to partially mitigate for effects from flow management that, combined with dikes and levees, have cut much of the floodplain off from the mainstem river. The trend of increasing connected area (Johnson et al. 2018) is expected to continue during the interim period, providing benefits (flux of insect and amphipod prey to the mainstem migration corridor) to juvenile SR spring/summer Chinook salmon. It is also likely that benefits will increase as habitat quality matures.

The Action Agencies also propose continued implementation of their monitoring program, the component of CEERP that provides the basis for adaptive management. This includes action effectiveness monitoring at each restoration site. A set of “standard” indicators (photo points, water surface elevation, and salinity) are measured at all sites (Level 3); core indicators (plant species composition, percent cover, and biomass) are measured at a subset of the sites (Level 2); and intensive indicators (juvenile salmon species composition, density, diet, and growth, along with structures and controlling factors) are measured at a smaller number of sites (Level 1; Johnson et al. 2018). Monitoring will continue at sites built as recently as 2016–17 and will be initiated for sites constructed during the interim period. Johnson et al. (2018) evaluated the action effectiveness monitoring data collected since 2012 and found they generally indicated that the restoration of physical and biological processes was underway. Continued implementation and evaluation of this monitoring program either will confirm that these floodplain reconnections are enhancing conditions for yearling salmonids, such as SR spring/summer Chinook salmon as they migrate through the mainstem, or provide sufficient information to the Action Agencies that site selection or project design will improve through adaptive management.

As part of the estuary program’s adaptive management framework, the Action Agencies will continue to discuss with the ERTG and regional partners relevant climate change science in an effort to understand whether their planned estuary projects are resilient to climate change (i.e., sea-level rise, temperatures, and mainstem flow levels). In addition, the Action Agencies’ annual update of their restoration and monitoring plans for the estuary will document any needed adjustments in design, location, or other elements of a given project to address climate change impacts, both during and beyond the interim period.

2.15.3.1.7 Tributary Habitat

For SR spring/summer Chinook, the Action Agencies will implement tributary habitat improvements in order to achieve the MPG-level metrics outlined in Table 2.15-16. These habitat improvement actions will be implemented in three of the five MPGs: Grande Ronde/Imnaha, Upper Salmon River, and Lower Snake River. Actions will be strategically identified, prioritized, and implemented to ameliorate specific limiting factors in specific populations, and will accomplish specific metrics defined for each MPG. The habitat actions that produce these metrics will be completed, or in process, before completion of the Action Agencies’ NEPA process.

The Action Agencies determined this commitment is feasible based on performance and accomplishments under the 2008 FCRPS biological opinion. In addition, the Action Agencies have committed to continuing to improve the strategic implementation of the program; to convene a tributary habitat program steering committee; to report on implementation using metrics that will allow NMFS to evaluate implementation of the program; and to conduct RM&E to assess tributary habitat conditions, limiting factors, and action effectiveness, and to inform associated critical uncertainties.

Table 2.15-16. Proposed tributary habitat metrics (2019–2021) for major population groups in the SR Spring/Summer Chinook Salmon ESU.

	Snake River Spring/Summer Chinook Salmon ESU Metrics[1]					
	Flow Protected (CFS)	**Flow Enhanced (Acre feet)**	**Entrainment Screening (# screens)**	**Habitat Access (Miles)**	**Stream Complexity (Miles)**	**Riparian Habitat Improved (Acres)**
ESU Totals	44	4,488	9	41	20	179
Major Population Groups [2]						
Grande Ronde/Imnaha	16	1,484	0	23	8	109
Upper Salmon River	28	3,004	9	16	10	36
Lower Snake	0	0	0	2	2	34

[1]The habitat actions that produce these metrics will be completed, or in process, by the end of the biological opinion period.

[2] The Action Agencies may use surpluses within an MPG from one metric category to augment other metric categories where the biological benefits are comparable.

For an overview of how NMFS analyzed the effects of tributary habitat improvement actions for this biological opinion, see Appendix A. In brief, we reviewed and re-affirmed the strong technical foundation for the tributary habitat program (i.e., that strategically implementing actions to alleviate the factors that limit the function of tributary habitat will improve habitat function and, ultimately, the freshwater survival of salmon and steelhead). We evaluated new RM&E information and found that it also supported the foundation of the program. We determined that the methods we were using to evaluate the effects of tributary habitat actions were based on best available science, as described in Appendix A. We evaluated the effects of those actions quantitatively for some populations and qualitatively for all populations within the context of our understanding of limiting factors, the effects of the types of habitat improvement actions being proposed, population extinction risk, habitat improvement potential, and our ESA recovery plan and focus population frameworks. We considered short-term negative effects that could result from implementation of habitat improvement actions. We also considered certainty of implementation and effects, as well as the strategic framework within which the Action Agencies were committing to implement the program. In addition, we considered the adequacy of the RM&E and adaptive management framework that is proposed to guide and refine

implementation of the habitat improvement actions and inform our understanding of their effects, and the adequacy of the proposed reporting on actions implemented.

Our assessments are described below by MPG, followed by an ESU-level summary.

South Fork Salmon River MPG

The Action Agencies have not proposed tributary habitat improvement actions for implementation in this MPG as part of the proposed action.

Middle Fork Salmon River MPG

The Action Agencies have not proposed tributary habitat improvement actions for implementation in this MPG as part of the proposed action.

Upper Salmon River MPG

In this MPG, the Action Agencies have committed to continuing to implement actions to protect and enhance flow, reduce entrainment by screening water diversions, improve habitat access, improve stream complexity, and improve riparian habitat. Limiting factors in this MPG include reduced flows, loss of habitat complexity, reduced riparian function, passage barriers, and entrainment of juvenile and adult fish in irrigation facilities (see Section 2.15.2.9), so these actions would be targeted at addressing identified limiting factors. Effects of these types of actions, and the time frame in which effects would be expected to accrue, are summarized in Table 2.15-17. In general, these actions will have a long-term benefit to SR spring/summer Chinook, although the benefit for actions implemented during the interim period pending completion of the NEPA process will be small. The positive changes noted in the table below may contribute to improvements in all four VSP parameters for the targeted populations.[220] (For additional information on action effectiveness, see Appendix A.)

[220]In most cases, near-term benefits would be expected in abundance and productivity. Depending on the population and the scale and type of action, benefits to spatial structure and diversity might also accrue, either in the near term or over time. In addition, while we expect abundance, productivity, spatial structure, and diversity to respond positively to strategically implemented tributary habitat improvement actions, other factors also influence these viability parameters (e.g., ocean conditions) and any resulting trends. Throughout this tributary habitat discussion, when we discuss improvements in abundance and productivity, it is implied that spatial structure and diversity might also respond positively, and that other factors, as noted here, might influence any resulting trends.

Table 2.15-17. Effects and timing of effects of proposed tributary habitat improvement actions for SR spring/summer Chinook.

Action Type	Effects of action and timing of effects
Flow protection and enhancement	Reduced flows can affect adult and juvenile salmonids by blocking fish migration, stranding fish, reducing rearing habitat availability, and increasing summer water temperatures (NMFS 2017e). Flow protection or enhancement reduces these impacts, and the literature shows an obvious and clear relationship between increased flows and increases in fish and macroinvertebrate production (Hillman et al. 2016). The response is most dramatic in stream reaches that were previously dewatered or too warm to support fish because of water withdrawals, and the most successful projects are those in which acquired flows are held in trust long term or in perpetuity (Sabaton et al. 2008; Roni et al. 2014). Studies of fish movements following increases in instream flows show rapid fish colonization of newly accessible habitats and the success of these projects (Roni et al. 2008). For example, ongoing studies in the Lemhi River show increased spawner and juvenile abundance of both Chinook salmon and steelhead following enhancement of instream flows in tributaries (Uthe et al. 2017; Appendix A of Griswold and Phillips 2018). The effects of flow augmentation on habitat conditions depends on the amount of flow within the channel and how much water is added. Augmented flow in dewatered channels or streams too warm to support fish will have the greatest effects on habitat condition. In addition, augmenting flood flows can improve floodplain connectivity and off-channel conditions (Hillman et al. 2016).
Improved habitat access	Impaired fish passage can prevent adults from accessing upstream spawning habitat and impede juvenile fish migration. In addition, structures that impede fish passage can disrupt habitat-forming processes related to flow, sediment transport, and large wood (NMFS 2013b, 2017e). Improving fish passage through actions that replace, improve, or remove culverts, dams, and other migration barriers, or that provide fish passage structures, can provide access to previously inaccessible spawning and rearing habitat. In addition, removing barriers can enhance habitat-forming processes related to flow, sediment transport, and movement of large wood and contribute to improvements in stream morphology, substrate, connectivity, stream flow, and stream temperature (Hillman et al. 2016; NMFS 2013b). Studies evaluating the effectiveness of projects that have removed impassable culverts/dams or have installed fish passage structures in North America and elsewhere, including in the Columbia River basin, have consistently shown rapid colonization by fishes; some studies have also documented the physical impacts of barrier removal on sediment and channel changes (Hillman et al. 2016). The rate at which salmon and trout recolonize habitats following barrier removal is highly dependent on the amount and quality of habitat upstream of the barrier, and the size of the downstream or nearby source population (number of salmon or trout returning that could colonize) (Hillman et al. 2016).
Improved stream complexity	Stream complexity created by large wood, boulders, coarse substrate, undercut banks, and overhanging vegetation (in concert with adequate flow regimes and other habitat-forming processes) is an essential feature of productive salmon habitat, providing the features needed for adequate spawning and rearing. Functioning floodplains and side-channels with hydrologic connectivity are also key features of productive salmon habitat because they provide rearing, resting, and refuge habitat; increase availability of prey; and enhance other stream and watershed processes (NMFS 2013b, 2017e). Habitat improvement actions commonly implemented to enhance stream complexity include placement of large wood, boulders, and cover structures; gravel addition; floodplain reconnection; side channel and pond construction and reconnection; levee removal and setback; channel re-meandering; and, more recently, the construction of beaver enhancement structures (Roni et al. 2014; Hillman et al. 2016). These actions can be expected to aid in reestablishment of hydrologic regimes, increase availability of rearing habitat, improve access to rearing habitat, increase the hydrologic capacity of side channels, increase channel diversity and complexity, provide resting areas for salmonids, provide flood water attenuation, and enhance native plant

Action Type	Effects of action and timing of effects
	communities (NMFS 2013b). The placement of instream structures includes a wide variety of actions that can affect many different habitat factors, so salmonid responses documented in the literature are quite diverse, ranging from small negative responses to large increases in abundance, growth, and survival. Most studies of this type of actions indicate a positive response (increased abundance and density) for salmonids. The lack of response or decrease in abundance identified in some studies was often because the projects did not address upstream watershed processes (e.g., sediment, water quality, etc.), the actions did not address the factors limiting fish, the duration of monitoring was too short to demonstrate a positive effect, or the treatments resulted in little change in physical habitat. Salmonids have also been shown to respond rapidly to reconnected or constructed floodplains, side channels, and wetlands. These habitats provide critical rearing habitat for juvenile Chinook, coho, and steelhead. Studies indicate that these actions increase salmonid abundance, individual growth rates, overwinter survival, and smolt production (Hillman et al. 2016). While benefits of actions to improve stream complexity may be rapid in terms of fish occupying restored habitats, they also will continue to accrue over some time as habitat continues to respond.
Riparian Habitat Improvement	Riparian vegetation provides numerous functions including shading, stabilizing streambanks, controlling sediments, contributing large wood, and regulating the flow of nutrients. Riparian habitat improvement through riparian planting and silvicultural treatment, invasive species control, and riparian fencing and grazing management can lead to increased shade, bank stability, reduction of fine sediment, reduced temperatures, and improvement of water quality (Roni et al. 2014; Hillman et al. 2016; NMFS 2017e). Benefits of riparian planting actions take more than 50 years to fully accrue, although some benefits begin to accrue after five to ten years (Justice et al. 2017; Pess and Jordan et al. in press). Few studies have examined the response of instream habitat or fish to riparian planting or thinning, in part because of the long lag time between tree growth and any change in channel conditions or delivery of large wood. However, a retrospective study (Lennox et al. 2011) found that project age was positively correlated with both riparian vegetation and instream anadromous fish habitat at revegetated sites. Modeling work in the Grande Ronde indicates that riparian enhancement action should reduce water temperatures and increase juvenile salmonid abundance up to 377 percent in the Upper Grande Ronde and 61 percent in Catherine Creek (McCullough et al. 2016). Justice et al. (2017) utilized a stream temperature model to explore potential benefits of channel and riparian restoration on stream temperatures in the Upper Grande Ronde River and Catherine Creek Basins in Oregon. They focused on streams that had been degraded by intensive land use leading to reduced riparian vegetation and widened channels and concluded that restoration of such streams could more than make up for expected increase in summer stream temperature through 2080. Studies of fish response to livestock exclusion projects have shown variable results. Some have shown increases in salmonid abundance while others have shown no response. Those showing no response were linked to short duration of monitoring, small size of enclosures, and upstream habitat processes that limited habitat conditions in the project area (Hillman et al. 2016).
Entrainment	Diversion of water from rivers can negatively affect salmon and steelhead populations. For example, open, unmodified water diversions can act as a source of injury or mortality to resident or migratory fishes from entrainment and impingement, and can cause habitat degradation and fragmentation. Fish-protection devices, such as exclusion screens, can physically or behaviorally deter fish from approaching or being entrained into water diversions. Most monitoring of screening projects is compliance monitoring rather than effectiveness monitoring, with a focus on whether installation or upgrading screens has reduced entrainment of fish into irrigation or water withdrawal systems. In one evaluation, however, Walters et al. (2012) conducted modeling which indicated that an extensive

Action Type	Effects of action and timing of effects
	program to screen diversions in the Lemhi River had potentially significantly reduced mortality of out-migrating Chinook salmon smolts. Screening irrigation or water withdrawal systems and reconnecting spawning and rearing streams often provide immediate and important survival and carrying capacity benefits (Hillman et al. 2016).

There is generally high potential for improvement in habitat productivity in all populations in this MPG. As noted above, actions will be strategically identified, prioritized, and implemented to ameliorate specific limiting factors in specific populations. Actions implemented to ameliorate limiting factors for any population in the MPG would provide localized habitat benefits and potential improvements in abundance and productivity for the targeted population. To the extent that actions are implemented consistent with best available science and modeling information about the value (in terms of increased biological benefit) to be gained from implementing the appropriate actions in the appropriate location and at the appropriate scale, benefits would be enhanced (Appendix A; also see Hillman et al. 2016; Pess and Jordan et al. in press).[221]

In terms of extent, benefits to habitat and populations in this MPG as a result of tributary habitat improvement actions implemented during the interim period pending completion of the NEPA process are likely to be relatively small. NMFS used life-cycle models to predict the effects of some categories of proposed tributary actions on populations in this MPG. The model for the Upper Salmon MPG populations evaluated the effects on juvenile rearing capacity and spawning capacity of instream actions (i.e., instream actions to improve stream complexity or floodplain/side-channel connectivity), and actions to improve access. For the analysis, modelers assumed that the Action Agencies' efforts would be focused in the near term on the same populations that received the highest level of effort under the 2008 biological opinion (i.e., the Lemhi, Pahsimeroi, Upper Mainstem, and Yankee Fork populations). Modelers also made other assumptions, documented in Pess and Jordan et al (in press) (e.g., habitat access projects were assumed to open habitat of similar type and quality to that currently available, and complexity actions were applied to improve the quality of habitat currently in moderate or good condition). Based on model results, the proposed actions would increase juvenile rearing capacity by 5.5

[221] Ultimately, implementation should be focused on where short-term efforts might yield the highest benefit in terms of reducing both short- and long-term risk, reducing climate vulnerability, and moving toward ESA recovery. In discussions with NMFS, the Action Agencies indicated that their tributary habitat focus during the interim period pending completion of the NEPA process was likely to include the Lemhi, Pahsimeroi, Upper Mainstem Salmon River, Valley Creek, and Yankee Fork populations. The Lemhi, Pahsimeroi, Valley Creek, East Fork Salmon River, and Upper Mainstem Salmon River populations are targeted for viable or highly viable status in the ESA recovery plan for SR spring/summer Chinook salmon (NMFS 2017e). Ultimately, the Yankee Fork population will also need to improve to "maintained" status to meet ESA recovery criteria (NMFS 2017e). NMFS focal population analysis identified the Lemhi and Pahsimeroi populations as having the highest potential to benefit MPG status in the near term from directed habitat actions, followed by the East Fork and Upper Mainstem populations (Appendix A; Cooney in press). NMFS will work with the Action Agencies during implementation of the proposed action to ensure alignment of implementation efforts with focal population priorities to the extent that they are not currently aligned. However, due to the interim nature of the proposed action and the time required to design and implement habitat improvement actions, shifts in focus are not likely to be realized on the ground before completion of the Action Agencies' NEPA process.

percent in the Lemhi, 13.7 percent in the Pahsimeroi, 5.3 percent in the Upper Mainstem, and 6.4 percent in the Yankee Fork; spawning capacity would increase by 5 percent in the Lemhi, 13.7 percent in the Pahsimeroi, 4.1 percent in the Upper Mainstem, and 4.6 percent in the Yankee Fork. Because the models do not evaluate the effects of actions such as returning flow to the stream, screening diversions, and restoring riparian areas, benefits of those types of actions are not included in the modeled increases in capacity. Modeling methods, assumptions, and results are documented in Pess and Jordan et al. (in press) and Jordan et al. (in press). In almost all cases, we would not expect implementation of habitat actions for only a few years to yield significant improvements, because it is not feasible to implement actions of sufficient scope and scale in that time frame to yield substantial effects. It is important to put results of the habitat actions to be implemented in the relatively short time frame of the interim period pending completion of the NEPA process into the context of the effects of longer-term implementation of habitat actions.

The Action Agencies have well-developed partnerships with local implementing groups in this MPG. Implementation of habitat actions within this MPG occurs primarily through the Upper Salmon Basin Watershed Program, which includes staff from state, federal, and local natural resource management agencies; more than 75 ranchers in the upper Salmon River basin; private interest groups; and others. This group has created an effective process for working together, providing technical reviews of proposed projects and working with interested parties to accomplish conservation on the ground. It has a strong record of implementing projects that have made contributions to salmon recovery (NMFS 2017g). In collaboration with this these local partners, the Action Agencies have used a variety of tools, including the Screening and Habitat Improvement Prioritization for the Upper Salmon Subbasin (SHIPUSS), to prioritize and select projects. This team has also relied on guiding documents and information such as the recovery plan (NMFS 2017e), tributary assessments, and additional technical analysis to sequence actions and areas to implement habitat actions in priority watersheds within this MPG. This on-the-ground infrastructure, combined with the Action Agencies commitments to work with NMFS to continue to enhance strategic implementation of the program, provides confidence that appropriate actions will be implemented in appropriate locations.

Grande Ronde/Imnaha MPG

In this MPG, the Action Agencies have committed to continuing to implement actions to protect and enhance flow, improve habitat access, improve stream complexity, and improve riparian habitat. Limiting factors in this MPG include reduced flows, loss of habitat complexity, reduced riparian function, and passage barriers (see Section 2.15.2.9). The actions would be targeted at addressing these identified limiting factors. Effects of these types of actions, and the time frame in which effects would be expected to accrue, are summarized in Table 2.15-18. In general, these actions will have a long-term benefit to SR spring/summer Chinook, although the benefit for actions implemented during the interim period pending completion of the NEPA process will be small. The positive changes noted in the table may contribute to improvements in all four VSP parameters for the targeted populations (for additional information on action effectiveness, see Appendix A.)

There is high potential for improvement in habitat productivity in most populations in this MPG. As noted above, actions will be strategically identified, prioritized, and implemented to ameliorate specific limiting factors in specific populations. Actions implemented to ameliorate limiting factors for any population in the MPG would provide localized habitat benefits and potential improvements in abundance and productivity for the targeted population. To the extent that actions are implemented consistent with best available science and modeling information about the value (in terms of increased biological benefit) to be gained from implementing the appropriate actions in the appropriate location and at the appropriate scale, benefits would be enhanced (Appendix A; also see e.g., Hillman et al. 2016; Pess and Jordan et al. in press).[222]

In terms of extent, benefits to habitat and populations in this MPG as a result of tributary habitat improvement actions implemented during the interim period pending completion of the NEPA process are likely to be small. For example, the Action Agencies have committed to pursue additional actions within the Grande Ronde MPG. Assuming that they target the same strategic priorities they were focusing on under the 2008 FCRPS biological opinion, and that they accomplish the levels of habitat improvement identified in Table 2.15-16, NMFS life-cycle modeling indicates that for the Catherine Creek population, the actions would increase summer-rearing capacity by an additional 1 percent over the baseline within a few years of implementation. As benefits of those actions implemented during this biological opinion continue to accrue, functional parr capacity would increase by 26 and 29 percent relative to the baseline at 24 and 48 years post-implementation (Cooney in press; Pess and Jordan et al. in press). In almost all cases, we would not expect implementation of habitat actions for only a few years to yield significant improvements, because it is not feasible to implement actions of sufficient scope and scale in that time frame to yield substantial effects. It is important to put results of the habitat actions to be implemented in the relatively short time-frame during the interim period pending completion of the NEPA process into the context of the effects of longer-term implementation of habitat actions.

The Action Agencies have well-developed partnerships with local implementing groups in this area. To help guide restoration priorities in the severely degraded Catherine Creek and Grande Ronde subbasins, the Action Agencies worked with local partners beginning in 2011 to develop, implement, and adaptively manage a systematic approach —the so-called “Atlas” process — to identify and prioritize the actions that would be most likely to improve habitat. The Atlas process

[222] Ultimately, implementation should be focused on where short-term efforts might yield the highest benefit in terms of reducing both short- and long-term risk, reducing climate vulnerability, and moving toward ESA recovery. In conversations with NMFS, the Action Agencies indicated that their tributary habitat focus during the interim period pending completion of the NEPA process was likely to include the Grande Ronde, Catherine Creek, and Lostine/Wallowa populations. Based on NMFS’ focal population analysis, addressing tributary habitat limiting factors in the Catherine Creek population has the highest potential to contribute to near-term MPG status improvements, followed by actions directed at limiting factors in the Lostine/Wallowa and Upper Grande Ronde populations (Appendix A; Cooney in press). NMFS intends to work with the Action Agencies during implementation of the proposed action to ensure alignment of implementation efforts with focal population priorities to the extent they are not currently aligned. However, due to the interim nature of the proposed action and the time required to design and implement habitat improvement actions, shifts in focus are not likely to be realized on the ground before the Action Agencies complete their NEPA process.

includes key elements from the watershed restoration principles articulated in Roni et al. (2002, 2008) and Beechie et al. (2008, 2010). It is a multi-criteria decision analysis framework that utilizes the best available empirical fish and habitat data; peer-reviewed, published research evidence; and local knowledge to determine the highest-priority areas and actions for habitat improvement within a watershed. The Atlas framework has resulted in implementation of habitat improvement actions that target high-priority reaches for the Upper Grande Ronde and Catherine Creek populations (NMFS 2014; BPA et al. 2016). This on-the-ground infrastructure, combined with the Action Agencies' commitments to work with NMFS to continue to enhance strategic implementation of the program, provides confidence that appropriate actions will be implemented in appropriate locations.

Lower Snake River MPG

In this MPG, the Action Agencies have committed to continuing to implement actions to improve habitat access, improve stream complexity, and improve riparian habitat. Limiting factors in this MPG include loss of habitat complexity, reduced riparian function, and passage barriers (see Section 2.15.2.9), so these actions would be targeted toward addressing identified limiting factors. Effects of these types of actions, and the time frame in which effects would be expected to accrue, are summarized in Table 2.15-17. In general, these actions will have a long-term benefit to SR spring/summer Chinook, although the benefit for actions implemented during the interim period pending completion of the NEPA process will be small. The positive changes noted in the table may contribute to improvements in all four VSP parameters for the targeted populations. (For additional information on action effectiveness, see Appendix A.)

There is potential for additional improvement in habitat productivity in the Tucannon River population (the single extant population in this MPG). As noted above, actions will be strategically identified, prioritized, and implemented to ameliorate specific limiting factors in specific populations. Actions implemented to ameliorate limiting factors for the single extant population in the MPG would provide localized habitat benefits and potential improvements in abundance and productivity for the targeted population. To the extent that actions are implemented consistent with best available science and modeling information about the value (in terms of increased biological benefit) to be gained from implementing the appropriate actions in the appropriate location and at the appropriate scale, benefits would be enhanced (Appendix A; also see e.g., Hillman et al. 2016; Pess and Jordan et al. in press).

The Tucannon River population is the only extant population in this MPG, and for ESA recovery it must achieve highly viable status (NMFS 2017e). Thus, it is appropriate to focus near-term habitat improvement actions on this population.

In terms of extent, benefits to the Tucannon River population as a result of tributary habitat improvement actions implemented during the interim period pending completion of the NEPA process are likely to be small. In almost all cases, we would not expect implementation of habitat actions for only a few years to yield significant improvements, because it is not feasible to implement actions of sufficient scope and scale in that time frame to yield substantial effects. It is important to put results of the habitat actions to be implemented during the interim period pending completion of the NEPA process into the context of the effects of longer-term implementation of habitat actions.

The Action Agencies have well-developed partnerships in this area with local implementing partners, including the Snake River Salmon Recovery Board, the Confederated Tribes of the Umatilla Indian Reservation, the U.S. Forest Service, and the WDFW. A regional technical team, composed of fish biologists and other natural resource specialists with extensive field experience and knowledge of local watershed conditions, reviews actions before implementation (Appendix A of BPA et al. 2013). Specific reach-scale actions carried out under the Tucannon River Programmatic Habitat Project, funded by BPA, will be identified and prioritized based on detailed assessment information and taking into account key elements from the watershed restoration framework recommended by Beechie et al. 2010. Since 2012, the Action Agencies have used a geomorphic assessment to strengthen the technical understanding of physical conditions and geomorphic processes in the basin, and to identify and prioritize habitat improvement opportunities. This assessment characterized channel and floodplain conditions, channel confinement, the historic channel area, and the source, magnitude, and distribution of hydrologic and sediment inputs through the basin. This information was used to delineate reaches throughout the river that offer potential improvement opportunities. This on-the-ground infrastructure, combined with the Action Agencies commitments to work with NMFS to continue to enhance strategic implementation of the program, provides confidence that actions will be implemented strategically.

Summary of Effects to Tributary Habitat

Implementation of the proposed tributary habitat actions, if implemented as anticipated, and as described in the proposed action (i.e., consistent with scientifically sound identification and prioritization of limiting factors and geographic locations and principles of watershed restoration), will provide benefits to the targeted populations. These benefits will accrue in three of the five MPGs in this ESU (the Upper Salmon, Grande Ronde/Imnaha, and Lower Snake River MPGs). For two of the five MPGs (the South Fork Salmon and the Middle Fork Salmon), the proposed tributary habitat actions will have no effect on the populations in the MPGs, because the Action Agencies have not proposed to implement any actions in those MPGs.

This biological opinion covers a proposed action with a limited duration, and thus improvements from tributary habitat actions will be small, as a large scope and scale of actions are required to achieve significant change at the population level. While it is possible that effects of some actions, such as actions to improve stream flow or remove barriers to passage, could be immediate, for other actions, benefits will take several years to fully accrue (and will take 50 years or more for actions such as restoring riparian areas). In addition, fish response in terms of improved viability will not begin until the progeny of fish spawning in new habitat conditions begin to return, and can only be detected over multiple life cycles. Therefore, it is unlikely that the benefits of these actions will be realized before the Action Agencies complete the NEPA process.

2.15.3.1.8 Hatcheries

Hatchery production goals for SR spring/summer Chinook salmon that are included in the proposed action and covered under this biological opinion include:

1. Up to 1,000,000 smolts for release in Yankee Fork (600,000) and Panther Creek (400,000) as part of an integrated recovery program operated by the Shoshone-Bannock Tribes; and
2. Up to 150,000 smolts for release in Johnson Creek as part of an integrated recovery program operated by the Nez Perce Tribe.

The Panther Creek program is a new proposal and has not yet begun operations. It will use hatchery-origin fish from the Pahsimeroi program because the historical natural population in Panther Creek is extirpated. Once the stock becomes localized and the program is self-sustaining, the program will support an integrated population in Panther Creek. The proposed program may also reduce risk to the ESU by reestablishing a natural-origin population. It is committed to adhering to PNI values according to the sliding-scale management objectives described in the biological opinion (NMFS 2017a). In fact, all hatchery programs in the Upper Salmon River have committed to strategies to limit hatchery straying and ecological interactions with ESA-listed natural-origin fish.

The Yankee Fork reintroduction program will support an integrated population in the Yankee Fork Salmon River. If the new Yankee Fork and Panther Creek programs can successfully achieve the ultimate goal of establishing naturally spawning populations, while also limiting stray rates, keeping PNI high, and making sure that broodstock collection goals for the Sawtooth and Pahsimeroi programs continue to be met, this action would help reduce risk to the Upper Salmon MPG.

2.15.3.1.9 Predation

Predation Management in the Lower Columbia River Estuary

The Action Agencies propose continued implementation of the Caspian Tern Nesting Habitat Management Plan (USACE 2015a) and the Double-crested Cormorant Management Plan (USACE 2015b). Tern habitat on East Sand Island will continue to be maintained at no less than one acre for the period covered by this interim consultation. Management actions for double-crested cormorants on East Sand Island will be limited to passive dissuasion and hazing, except that limited egg take (up to 500 eggs) may be requested from USFWS each year to preclude cormorants from nesting in new or different areas on East Sand Island. These ongoing actions are likely to continue current levels of predation by birds nesting on East Sand Island, which, in the case of Caspian terns, has been shown to be an improvement from the pre-colony management period. Due to dispersal of the colony in 2016 and 2017, predation rates for East Sand Island cormorants are not available for the management period. Predation rates may have decreased, but monitoring results from 2018 and the interim period and the data compilation expected in the

Avian Predation Synthesis Report will be needed to confirm the expectation that this program is meeting its management goals. In addition, the Action Agencies propose to synthesize colony size and predation rate data collected under the tern and cormorant colony management plans. The intent of the synthesis report is to summarize data on predation by piscivorous waterbirds on ESA-listed salmonids in the Columbia River basin before, during, and after the management actions in order to assess their effectiveness on a basinwide scale. For example, the dispersal of double-crested cormorants from East Sand Island to nest sites on the Astoria-Megler Bridge in recent years, and observations of thousands of Caspian terns roosting on Rice Island in 2017, indicate that the numbers of avian predators in the estuary and their effects on the viability of salmonids such as SR spring/summer Chinook salmon are still in flux. The synthesis report will help managers assess whether to recommend that the Action Agencies or other regional parties consider additional measures for implementation after the interim period.

Ongoing annual monitoring will include estimates of double-crested cormorant abundance, nesting density, and PIT-tag detection on East Sand Island. The average estimated three-year peak colony size will be used to evaluate management activities relative to plan objectives (2019–2021); the management plan will be considered successful when the average three-year peak colony size estimate does not exceed 5,939 nesting pairs while no management actions are conducted. Annual PIT-tag detection will continue for 5 to 10 years to assess overall trends in predation rates (through the 2023 breeding season, at minimum), accounting for annual variability in predation impacts. These measures are likely to effectively constrain and evaluate double-crested cormorant predation on listed salmonids such as SR spring/summer Chinook salmon at Corps-managed sites in the estuary.

Pinniped Predators

The proposed action does not include measures to address pinniped predation in the free-flowing lower Columbia River estuary.

Fish Predators

The Action Agencies will continue to implement the NPMP, including the Sport Reward Fishery, in the lower Columbia River estuary as described under the environmental baseline. We expect that this ongoing measure will continue the 30 percent reduction in predation rates achieved under the 2008 RPA. We estimate that numbers of Chinook salmon, including some from the SR spring/summer Chinook salmon ESU, killed and/or handled in the Sport Reward Fishery, system-wide, will be no more than 100 adults and 200 juveniles per year during the interim period.

<u>Predation Management in the Hydrosystem Reach</u>

Avian Predators

The Corps will continue to implement and improve, as needed, avian predator deterrent programs at lower Columbia and Snake River dams. At each dam, bird numbers will be monitored, feeding birds will be hazed, and passive predation deterrents, such as irrigation sprinklers and bird wires will be deployed. Hazing, including launching long-range pyrotechnics at concentrations of feeding birds near the spillway and powerhouse discharge areas and juvenile bypass outfall areas, will also continue. These measures will continue to reduce predation on juvenile SR spring/summer Chinook salmon, although the amount of protection has not been quantified (Zorich et al. 2012).

The Action Agencies propose to continue to address Caspian tern predation at lands that they manage on the Columbia plateau: Crescent Island (Corps) and Goose Island (Reclamation). The Corps has excluded tern use on Crescent Island via revegetation since 2015, but will continue to monitor that site to ensure that conditions remain unfavorable for nesting. If tern use does resume during the interim period, the Corps will work with NMFS and USFWS to address concerns, perform any necessary environmental compliance, and seek permits and funding for active hazing, if warranted. If no nesting of concern to the Corps and NMFS is identified, the Corps will discontinue monitoring after three years. These measures are likely to preclude use of Crescent Island by Caspian terns during the interim period.

Reclamation has excluded terns from Goose Island using ropes and flagging, and is currently experimenting with revegetation. They propose to maintain the ropes and flagging and to monitor for tern presence on a regular basis between late February and early July. If terns resume nesting despite these activities and efforts to establish vegetative cover, and if the number of terns exceeds metrics identified in the Inland Avian Predation Management Plan (more than 40 nesting pairs on Goose Island or more than 200 pairs at sites across the interior Columbia Basin; USACE 2014), Reclamation will work with NMFS to identify management actions and tools that can be put in place to dissuade tern use of the island before the next nesting season (e.g., permits from USFWS for hazing and egg take). These measures are likely to successfully preclude use of Goose Island by Caspian terns during the interim period of this consultation.

Pinniped Predators

The Corps will continue to install, and improve as needed, sea-lion excluder gates at all adult fish ladder entrances at Bonneville Dam each year. In addition, the Corps and Bonneville will continue to support land and water-based harassment efforts by ODFW, WDFW, and CRITFC to keep sea lions away from the area downstream of Bonneville Dam. The Corps will continue estimating sea lion abundance, spatial distribution, temporal distribution, predation attempts, and predation rates in the Bonneville Dam tailrace annually from early August through May 31. Collection of predation data will occur when sea lion abundance is greater than or equal to 20 animals. The Corps will continue to use adaptive management, including recommendations from the Fish Passage Operations and Management Coordination Team (FPOM) and the Sea Lion Task Force, to address changing circumstances as they relate to sea lion harassment efforts and predation monitoring at Bonneville Dam. These ongoing measures are expected to maintain current levels of sea-lion predation on SR spring/summer Chinook salmon in the Bonneville Dam tailrace, ranging from 4.3 to 5.9 percent in the last three years (2015–17; Appendix B).

If pinnipeds are observed at The Dalles Dam, the Corp may respond with hazing at adult fish ladder entrances.

Fish Predators

The Action Agencies will continue to implement the Northern Pikeminnow Sport Reward Fishery in the hydrosystem reach and the Dam Angling Program at The Dalles and John Day Dams, as described under the environmental baseline. These ongoing measures will continue the reduction in predation rates achieved under the 2008 RPA. We estimate that the 2013-2017 annual average numbers of Chinook salmon, including SR spring/summer Chinook salmon, which will be handled and/or killed in the Sport Reward Fishery will continue as described above (Predation Management in the Lower Columbia River Estuary). In addition, we estimate that no more than ten adult and 20 juvenile Chinook salmon, including some from the SR spring/summer Chinook salmon ESU, will be killed and/or handled in the Dam Angling Program per year during the interim period.

Life-Cycle Models

Life-cycle models were used to develop projections of median abundance and probabilities of falling below a Quasi-Extinction Risk threshold of 30 and 50 adults for four consecutive years to assess projected population responses to quantifiable factors evaluated in the environmental baseline: continued implementation of recent hydropower actions (consistent with the 2017 FOP) and habitat restoration actions, and continued evaluation of the effects of recent hatchery production (where applicable) and the effect of increased sea lion predation (see environmental baseline discussion).

In this section, we discuss the model results used to quantitatively project the effects of the proposed action on the abundance and QET parameters for a period of 24 years. The life-cycle model (which includes the COMPASS juvenile passage and survival model) projects the estimated direct survival effect from the proposed up to 120 percent (and up to125 percent) flexible spill operation; the likely effect of three additional years of tributary habitat actions (where applicable); and three scenarios to consider the potential productivity increases (as hypothesized by the CSS) if increased spill levels were to reduce latent mortality for inriver migrating smolts, thus increasing adult returns (productivity) (see Methods Section). [223]

Assumptions relating to the continued implementation of the tributary habitat actions included: (1) tributary habitat projects would continue to be implemented in strategic locations within the populations identified in Table 5 of the 2014 biological opinion; (2) the habitat projects would

[223] Comparing model results (24-year projections of geomean abundance and QETs of 30 and 50 adults for four consecutive years) of different hydropower operations (and associated hypothesis about how these operations might reduce latent mortality) and mitigation actions (i.e. habitat restoration, changes in hatchery operations etc.) is important for understanding how different actions or key uncertainties might affect these parameters, and by extension, the populations being modeled. Consideration of modeling information is but one element of NMFS's effects analysis, which considers the full scope of the likely effects of the proposed action, including proposed, hydropower operations.

address the same limiting factors in the same general reaches as in the 2012–16 program; and (3) the Action Agencies could annually implement at least the minimum level of habitat improvements achieved in recent years (a conservative assumption).

The NWFSC also considered three latent mortality reduction scenarios that were deemed to roughly represent the ranges of potential outcomes (increased productivity) indicated by the CSS (2017) for the up to 120 percent flexible spill operation compared to recent or biological opinion spill operations: 10 percent (1.10 multiplier), 25 percent (1.25 multiplier) and 50 percent (1.50 multiplier). In these scenarios only the proportion of the population of smolts that were estimated to have migrated inriver (those not collected and transported at Lower Granite, Little Goose, or Lower Monumental Dams) were modelled as receiving this potential benefit.

Grande Ronde River MPG

As previously noted, within the Grande Ronde MPG, five populations have sufficient information available to support life-cycle modeling. Model results are displayed in Figure 2.15-9 and in Table 2.15-19. In general, the proposed action, including the up to 120 percent flexible spill operation (making no assumptions about reductions in latent mortality) and proposed habitat restoration work, where applicable, results in little or no substantial change in median abundance projections for all five of the populations in this MPG (compared to the environmental baseline): Catherine Creek (142), Upper Grande Ronde (57), Minam (397), Wenaha (340), and Lostine / Wallowa (535). The proposed habitat restoration program, implemented for three years, is expected to have some small, but positive effect on the projected productivity the Catherine Creek, Upper Grande Ronde, and Lostine/Wallowa populations.

Projected median probabilities of falling below the QET of 30 adults remain relatively low (<1 percent) for all populations except for the for the Upper Grande Ronde population (58 percent). The projected median probability of dropping below the QET of 50 adults is about 99 percent for the Upper Grande Ronde population, and 13 percent for the Catherine Creek population.

Projected median probabilities of falling below the Quasi-Extinction threshold of 50 adult threshold remained low (< 1 percent) for the Lostine/Wallowa, Minam, and Wenaha populations.

As a sensitivity analysis, Figure 2.15-8 and Table 2.15-18 also display the projected results of increasing productivity an additional 10, 25, or 50 percent, which roughly bounds the benefits hypothesized by the CSS (2017 and 2018) to the result from increasing spill to the 120 tailrace TDG limits. In general, an increase in productivity of 10 percent does little to substantively improve the projected median abundance or decrease the projected probability of falling below QETs of 30 or 50 adults. Increasing productivity by 50 percent would result in substantially increased projected median abundance estimates (in 24 years) for the Minam, Wenaha, and Lostine/Wallowa populations; and would reduce the projected median probability of dropping below a QET of 50 adults to zero. The projected median abundance estimates would increase somewhat for the Catherine Creek (142 to 191) and the Upper Grande Ronde (57 to 77), populations; which are severely constrained by juvenile habitat limitations. However, the projected probability of falling below a QET of 50 would be reduced for the Catherine Creek population (13 down to about 3 percent), and the projected probability of falling below a QET of 30 would be substantially reduced for the Upper Grande Ronde population (58 down to about 12 percent). Increasing productivity by 25 percent results in intermediate increases in projected abundance and reduced probabilities of dropping below QETs of 30 or 50 adults, as would be expected.

Analysis of the up to 125 percent gas cap flexible spill operation indicated there is little difference between this operation and the estimates for the up to 120 percent gas cap flexible spill operation assuming direct survival improvements only, or 10, 25, and 50 percent improvements in productivity that could result from increased spill (Figure 2.15-8). Simply put, Life Cycle Modeling indicates that assumptions about improved productivity (from potential latent mortality reductions) dominates projected estimates of abundance or probabilities of falling below QETs of 30 or 50 adults.

Table 2.15-18. Life-cycle model projections of median abundance and Quasi-Extinction Risk thresholds of 30 and 50 (5th and 95th percentiles) for populations of naturally produced fish in 24 years under the projected baseline (italicized text), proposed action (120% flexible spill operations and tributary enhancement actions, if applicable), and assuming a 10%, 25%, or 50% increase in survival resulting from hypothesized reductions in latent mortality.

Grande Ronde MPG	Abundance			QET = 30			QET = 50		
Population	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**
Catherine Creek									
Env. Baseline	**140**	93	209	**0.004**	0	0.038	**0.132**	0.013	0.548
Prop. Action 120% Flex Gas Cap	**142**	93	211	**0.004**	0	0.036	**0.130**	0.012	0.494
PA + 10%	**152**	100	225	**0.004**	0	0.038	**0.092**	0.009	0.416
PA + 25%	**167**	110	252	**0.002**	0	0.024	**0.056**	0.005	0.318
PA + 50%	**191**	123	294	**0.001**	0	0.018	**0.030**	0.002	0.211
Upper Grande Ronde									
Env. Baseline	**57**	35	87	**0.571**	0.047	0.975	**0.990**	0.698	1.000
Prop. Action 120% Flex Gas Cap	**57**	35	85	**0.584**	0.049	0.979	**0.991**	0.689	1.000
PA + 10%	**61**	38	93	**0.429**	0.026	0.965	**0.983**	0.552	1.000
PA + 25%	**67**	42	102	**0.277**	0.014	0.919	**0.956**	0.354	0.999
PA + 50%	**77**	52	117	**0.115**	0.005	0.731	**0.864**	0.142	.996
Minam									
Env. Baseline	**399**	231	638	**0**	0	0.005	**0.002**	0	0.045
Prop. Action 120% Flex Gas Cap	**397**	217	658	**0**	0	0.005	**0.002**	0	0.045
PA + 10%	**439**	48	697	**0**	0	0.001	**0.001**	0	0.021
PA + 25%	**489**	86	797	**0**	0	0	**0**	0	0.007
PA + 50%	**596**	362	924	**0**	0	0	**0**	0	.002
Wenaha									
Env. Baseline	**340**	198	565	**0**	0	.007	**0.002**	0	0.063

Grande Ronde MPG	**Abundance**			**QET = 30**			**QET = 50**		
Population	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**
Prop. Action 120% Flex Gas Cap	**340**	191	559	**0.001**	0	0.009	**0.001**	0	0.009
PA + 10%	**377**	14	639	**0**	0	.003	**0.001**	0	0.003
PA + 25%	**428**	254	705	**0**	0	.001	**0**	0	0.009
PA + 50%	**529**	314	848	**0**	0	0	**0**	0	0.002
Lostine/Wallowa									
Env. Baseline	**543**	316	891	**0**	0	0	**0**	0	0
Prop. Action 120% Flex Gas Cap	**535**	321	870	**0**	0	0	**0**	0	0
PA + 10%	**585**	343	971	**0**	0	0	**0**	0	0
PA + 25%	**670**	405	1,053	**0**	0	0	**0**	0	0
PA + 50%	**774**	512	1,247	**0**	0	0	**0**	0	0

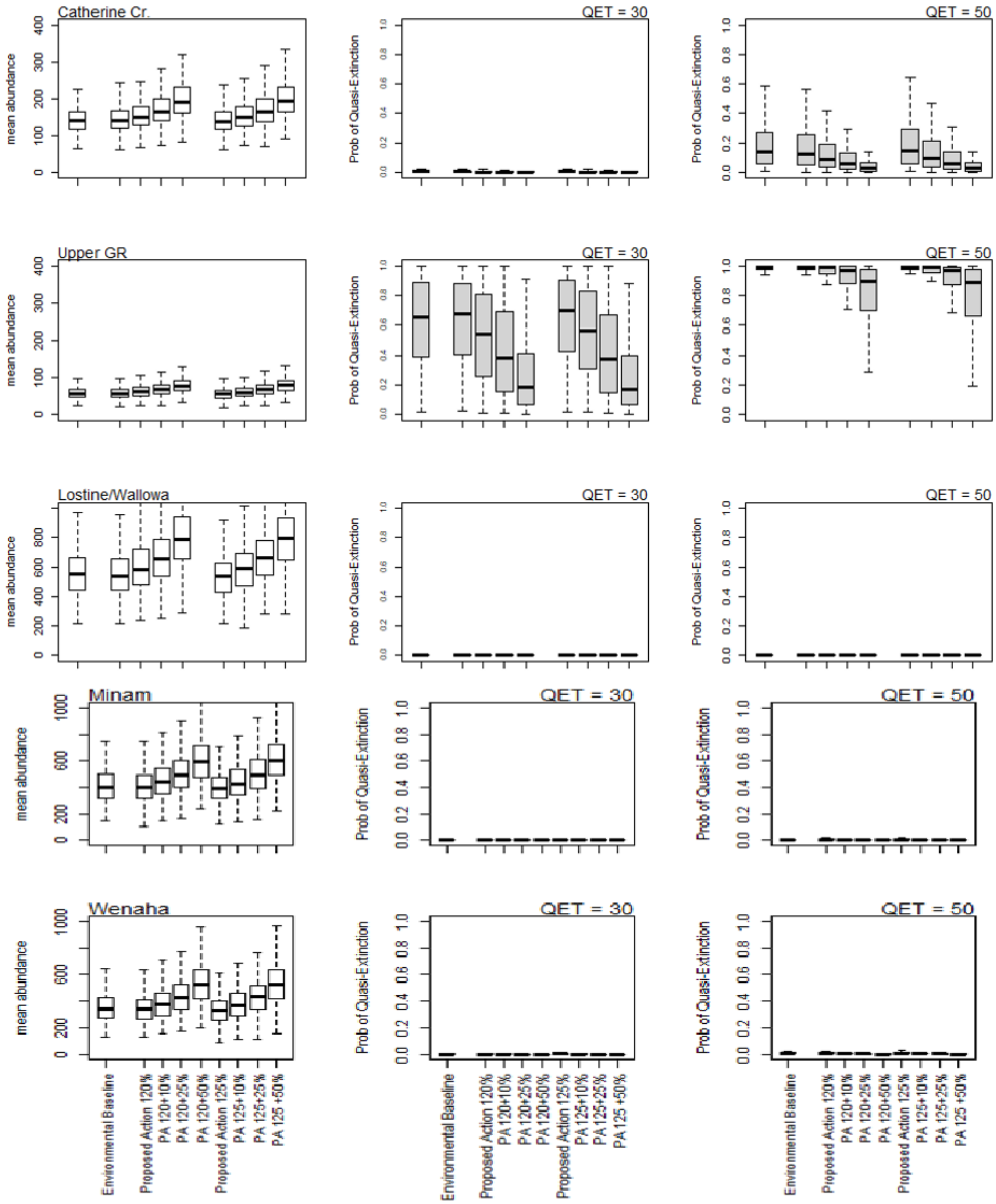


Figure 2.15-8. Life-cycle model projections of median abundance and Quasi-Extinction Risk thresholds of 30 and 50 for Grande Ronde River MPG populations of naturally produced fish in 24 years under (from left to right) the Environmental Baseline, proposed action (up to 120% flexible spill hydro operation and tributary enhancement actions, if applicable), and assuming a 10, 25, or 50 percent increase in productivity as a result of hypothesized reductions in latent mortality stemming from increased spill operations; and the proposed action (up to 125% flexible spill hydro operation and tributary enhancement actions, if applicable), and assuming a 10, 25, or 50 percent increase in productivity as a result of hypothesized reductions in latent mortality stemming from increased spill operations Boxes display 25th, 50th, and 75th percentiles; whiskers display 5th and 95th percentiles.

South Fork Salmon River MPG

As previously noted, within the South Fork Salmon River MPG, two populations have sufficient information available to support life-cycle modeling. Model results are displayed in Figure 2.15-9 and in Table 2.15-20. In general, the proposed action (making no assumptions about reductions in latent mortality) and proposed habitat restoration work, where applicable, results in little substantial difference to the median abundance projections assuming a continuation of previous operations for the South Fork Salmon (667) and Secesh River (466) populations. No habitat restoration actions are expected to occur in these systems. The projected probability of falling below QETs of 50 remains extremely low (less than 1 percent).

As a sensitivity analysis, Figure 2.15-9 and Table 2.15-19 also display the projected results of increasing productivity an additional 10, 25, or 50 percent, which roughly bounds the benefits hypothesized by the CSS (2017 and 2018) to result from increasing spill to the 120 tailrace TDG limits. In general, a projected increase in productivity of 10 percent would result in a small projected improvement in median abundance or the probability of falling below QETs of 50 adults (which is already essentially zero). Increasing projected productivity by 50 percent would result in substantially increased median abundance estimates (in 24 years) for both the South Fork Salmon (1,079) and Secesh River (981) populations. Increasing productivity by 25 percent results in intermediate increases in projected abundance and persistence for these populations, as would be expected.

Analysis of the up to 125 percent gas cap flexible spill operation indicated there is little difference between this operation and the estimates for the up to 120 percent gas cap flexible spill operation assuming direct survival improvements only, or 10, 25, and 50 percent improvements in productivity that could result from increased spill (Figure 2.15-9). Simply put, Life Cycle Modeling indicates that assumptions about improved productivity (from potential latent mortality reductions) dominates projected estimates of abundance or probabilities of falling below QETs of 30 or 50 adults.

Table 2.19-19. Life-cycle model projections of median abundance and Quasi-Extinction Risk thresholds of 30 and 50 (5th and 95th percentiles) for populations of naturally produced fish in 24 years under the projected baseline (italicized text), proposed action (up to 120% flexible spill operations and tributary enhancement actions, if applicable), and assuming a 10%, 25%, or 50% increase in survival resulting from hypothesized reductions in latent mortality.

South Fork Salmon MPG	**Abundance**			**QET = 30**			**QET = 50**		
Population	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**
South Fork Salmon									
Env. Baseline	***662***	*12*	*1,627*	**0**	0	*0.007*	***0.004***	*0*	*0.051*
Prop. Action 120% Flex Gas Cap	**667**	15	1,639	**0**	0	0.009	**0.004**	0	0.060
PA + 10%	**732**	49	1,806	**0**	0	0.007	**0.003**	0	0.049
PA + 25%	**846**	14	2,016	**0**	0	0.003	**0.002**	0	0.023
PA + 50%	**1,079**	86	2,445	**0**	0	0.001	**0.001**	0	0.014
Secesh River									
Env. Baseline	***495***	*6*	*1,613*	**0.003**	0	0.091	***0.026***	*0*	*0.374*
Prop. Action 120% Flex Gas Cap	**466**	5	1,620	**0.004**	0	0.133	**0.030**	0	0.485
PA + 10%	**560**	11	1,904	**0.001**	0	0.062	**0.015**	0	0.281
PA + 25%	**745**	18	2,228	**0**	0	0.016	**0.004**	0	0.109
PA + 50%	**981**	27	2,859	**0**	0	0.003	**0.001**	0	0.030

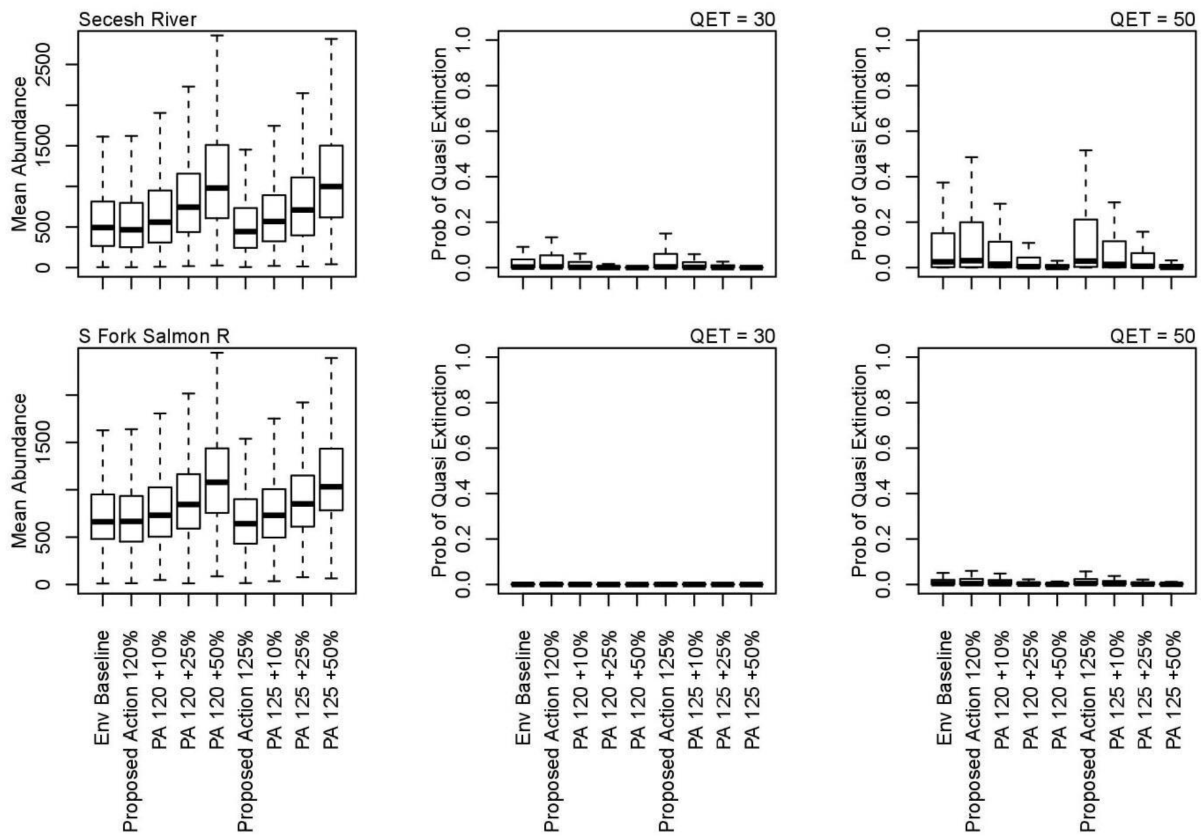


Figure 2.15-9. Life-cycle model projections of median abundance and Quasi-Extinction Risk thresholds of 30 and 50 for Grande Ronde River MPG populations of naturally produced fish in 24 years under (from left to right) the Environmental Baseline, proposed action (up to 120% flexible spill hydro operation andtributary enhancement actions, if applicable), and assuming a 10, 25, or 50 percent increase in productivity as a result of hypothesized reductions in latent mortality stemming from increased spill operations; and the proposed action (up to 125% flexible spill hydro operation and tributary enhancement actions, if applicable), and assuming a 10, 25, or 50 percent increase in productivity as a result of hypothesized reductions in latent mortality stemming from increased spill operations Boxes display 25th, 50th, and 75th percentiles; whiskers display 5th and 95th percentiles.

Middle Fork Salmon River MPG

As previously noted, within the Middle Fork Salmon River MPG, six populations have sufficient information available to support life-cycle modeling. Model results are displayed in Figure 2.15-10 and in Table 2.15-21. In general, the proposed action (making no assumptions about reductions in latent mortality) and proposed habitat restoration work, where applicable, results in similar (to those projected for conditions representing the environmental baseline) projected median abundance estimates for each of the six populations: Big Creek (167), Bear Valley Creek (482), Marsh Creek (210), Sulphur Creek (61), Camas Creek (51), and Loon Creek (68). The projected probability of falling below QETs of 30 is low (about 2 percent) for the Marsh Creek population; somewhat higher (about 10 percent) for the Big Creek and Bear Valley populations; and high (64 to 80 percent) for the Sulphur, Camas and Loon Creeks.

As a sensitivity analysis, Figure 2.19-10 and Table 2.19-20 also display the projected results of increasing productivity an additional 10, 25, or 50 percent, which roughly bounds the benefits hypothesized by the CSS (2017 and 2018) to result from increasing spill to the 120 tailrace TDG limits. In general, a projected increase in productivity of 10 percent somewhat improves the projected median abundance and correspondingly decreases the probability of falling below QETs of 30 or 50 adults. Increasing projected productivity by 50 percent would result in substantially increased median abundance estimates (in 24 years) for the Big Creek (332), Bear Valley Creek (1,447), and Marsh Creek (357) populations. The projected median abundance of the smaller three populations (Sulphur Creek, Camas Creek, and Loon Creek) would be expected to increase as well, but would remain at very low numbers 76 to 123 adults) as these systems are constrained by juvenile production (capacity).

Increasing average productivity by 50 percent would reduce the projected median probability of falling below a QET of 30 adults: Big Creek, Bear Valley, and Marsh Creek (< 2 percent).

Similarly, increasing average productivity by 50 percent would reduce the projected median probability of falling below a QET of 50 adults: Big Creek, Bear Valley, and Marsh Creek (2 to 6 percent). The projected median probabilities (QET = 30) for the remaining, smaller populations would remain high, about 20 percent for Sulphur and Loon Creek and about 50 percent for Camas Creek. Increasing productivity by 25 percent results in intermediate increases in projected abundance and persistence, as would be expected.

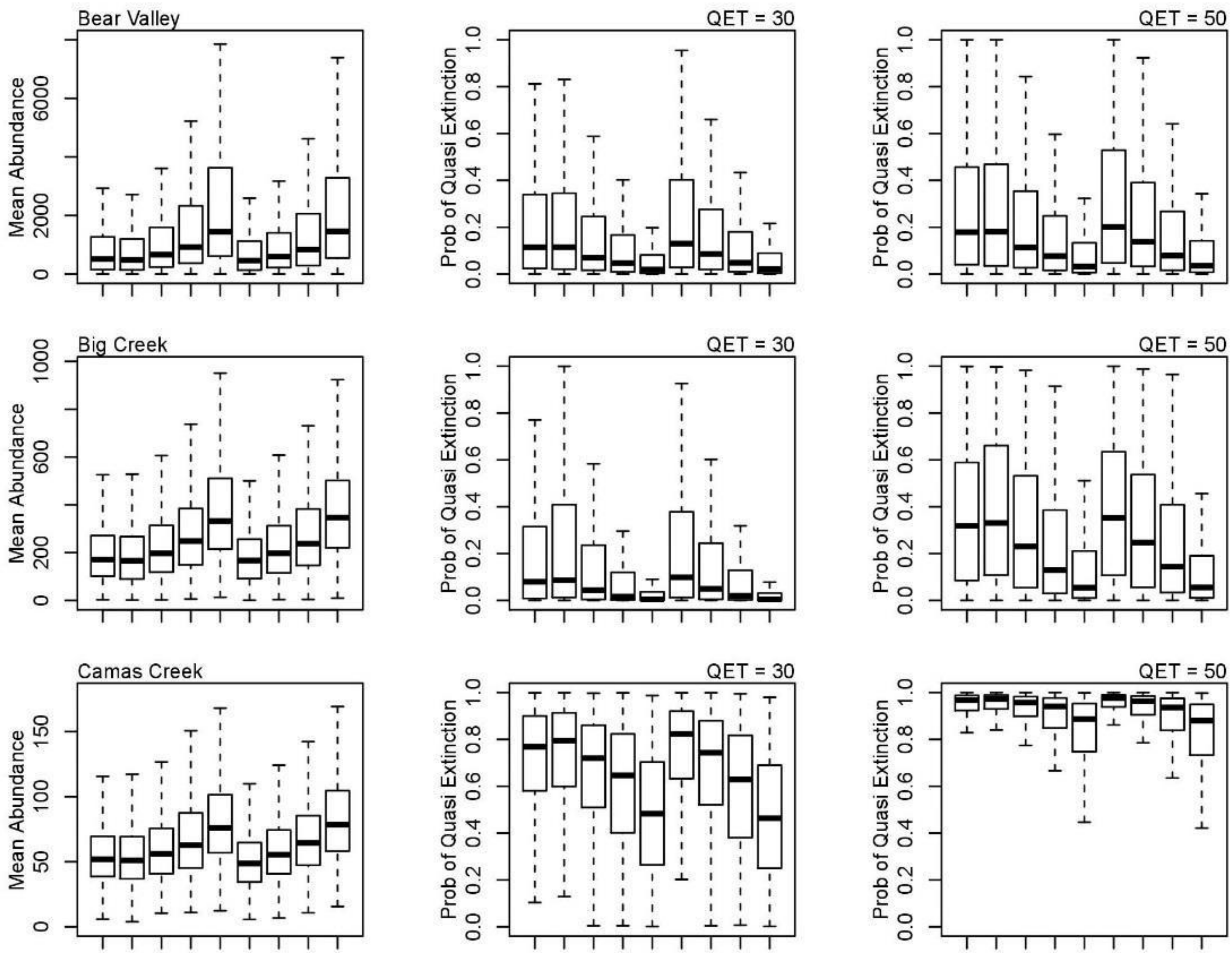
Analysis of the up to 125 percent gas cap flexible spill operation indicated there is little difference between this operation and the estimates for the up to 120 percent gas cap flexible spill operation assuming direct survival improvements only, or 10, 25, and 50 percent improvements in productivity that could result from increased spill (Figure 2.15-10). Simply put, Life Cycle Modeling indicates that assumptions about improved productivity (from potential latent mortality reductions) dominates projected estimates of abundance or probabilities of falling below QETs of 30 or 50 adults.

Table 2.15-20. Life-cycle model projections of median abundance and Quasi-Extinction Risk thresholds of 30 and 50 (5th and 95th percentiles) for populations of naturally produced fish in 24 years under the projected baseline (italicized text), proposed action (up to 120% flexible spill operations and tributary enhancement actions, if applicable), and assuming a 10%, 25%, or 50% increase in survival resulting from hypothesized reductions in latent mortality.

Middle Fork Salmon MPG	Abundance			QET = 30			QET = 50		
Population	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**
Big Creek									
Env. Baseline	***171***	*3*	*526*	***0.080***	*0*	*0.770*	***0.319***	*0*	*0.999*
Prop. Action 120% Flex Gas Cap	**167**	2	528	**0.086**	0	0.999	**0.331**	0	0.997
PA + 10%	**197**	2	606	**0.044**	0	0.583	**0.230**	0	0.982
PA + 25%	**248**	6	737	**0.016**	0	0.296	**0.130**	0	0.914
PA + 50%	**332**	13	951	**0.004**	0	0.090	**0.055**	0	0.511
Bear Valley Creek									
Env. Baseline	***516***	*0*	*2,928*	***0.114***	*0*	*0.812*	***0.179***	*0*	*1.000*
Prop. Action 120% Flex Gas Cap	**482**	0	2,716	**0.115**	0	0.831	**0.181**	0	1.000
PA + 10%	**663**	0	3,610	**0.070**	0	0.588	**0.113**	0	0.843
PA + 25%	**922**	0	5,223	**0.047**	0	0.402	**0.077**	0	0.597
PA + 50%	**1,447**	0	7,853	**0.019**	0	0.197	**0.032**	0	0.323
Marsh Creek									
Env. Baseline	***211***	*9*	*568*	***0.018***	*0*	*0.271*	***0.127***	*0*	*0.842*
Prop. Action 120% Flex Gas Cap	**210**	10	554	**0.022**	0	0.307	**0.143**	0	0.877
PA + 10%	**241**	8	606	**0.009**	0	0.195	**0.082**	0	0.724
PA + 25%	**284**	17	723	**0.004**	0	0.073	**0.049**	0	0.416
PA + 50%	**357**	45	835	**0.001**	0	0.026	**0.021**	0	0.217
Sulphur Creek									
Env. Baseline	***60***	*2*	*179*	***0.681***	*0.002*	*1.000*	***0.897***	*0.480*	*1.000*
Prop. Action 120% Flex Gas Cap	**61**	1	183	**0.689**	0	0.999	**0.899**	0.532	0.999
PA + 10%	**70**	4	205	**0.598**	0	1.000	**0.866**	0.408	0.999
PA + 25%	**90**	4	246	**0.427**	0	0.992	**0.798**	0.086	0.995
PA + 50%	**116**	7	303	**0.221**	0	0.972	**0.653**	0	0.986

Middle Fork Salmon MPG	**Abundance**			**QET = 30**			**QET = 50**		
Population	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**
Camas Creek									
Env. Baseline	***52***	*6*	*116*	***0.768***	*0.104*	*0.999*	***0.967***	*0.829*	*1.000*
Prop. Action 120% Flex Gas Cap	**51**	4	117	**0.794**	0.129	0.999	**0.972**	0.840	1.000
PA + 10%	**56**	11	127	**0.720**	0.004	0.997	**0.957**	0.774	1.000
PA + 25%	**63**	11	151	**0.646**	0.005	0.999	**0.941**	0.666	1.000
PA + 50%	**76**	12	168	**0.483**	0.001	0.987	**0.887**	0.446	0.999
Loon Creek									
Env. Baseline	***70***	*3*	*204*	***0.604***	*0.001*	*1.000*	***0.869***	*0.345*	*1.000*
Prop. Action 120% Flex Gas Cap	**68**	1	213	**0.638**	0.001	0.999	**0.881**	0.332	0.999
PA + 10%	**77**	2	225	**0.542**	0.002	0.999	**0.841**	0.271	0.999
PA + 25%	**93**	6	256	**0.387**	0	0.992	**0.761**	0.003	0.996

Middle Fork Salmon MPG	**Abundance**			**QET = 30**			**QET = 50**		
Population	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**
PA + 50%	**123**	4	320	**0.202**	0	0.989	**0.604**	0.001	0.995


Bear Valley
Mean Abundance
0
2000
4000
6000
QET = 30
Prob of Quasi Extinction
0.0
0.2
0.4
0.6
0.8
1.0
QET = 50
Big Creek
0
200
400
600
800
1000
Camas Creek
0
50
100
150

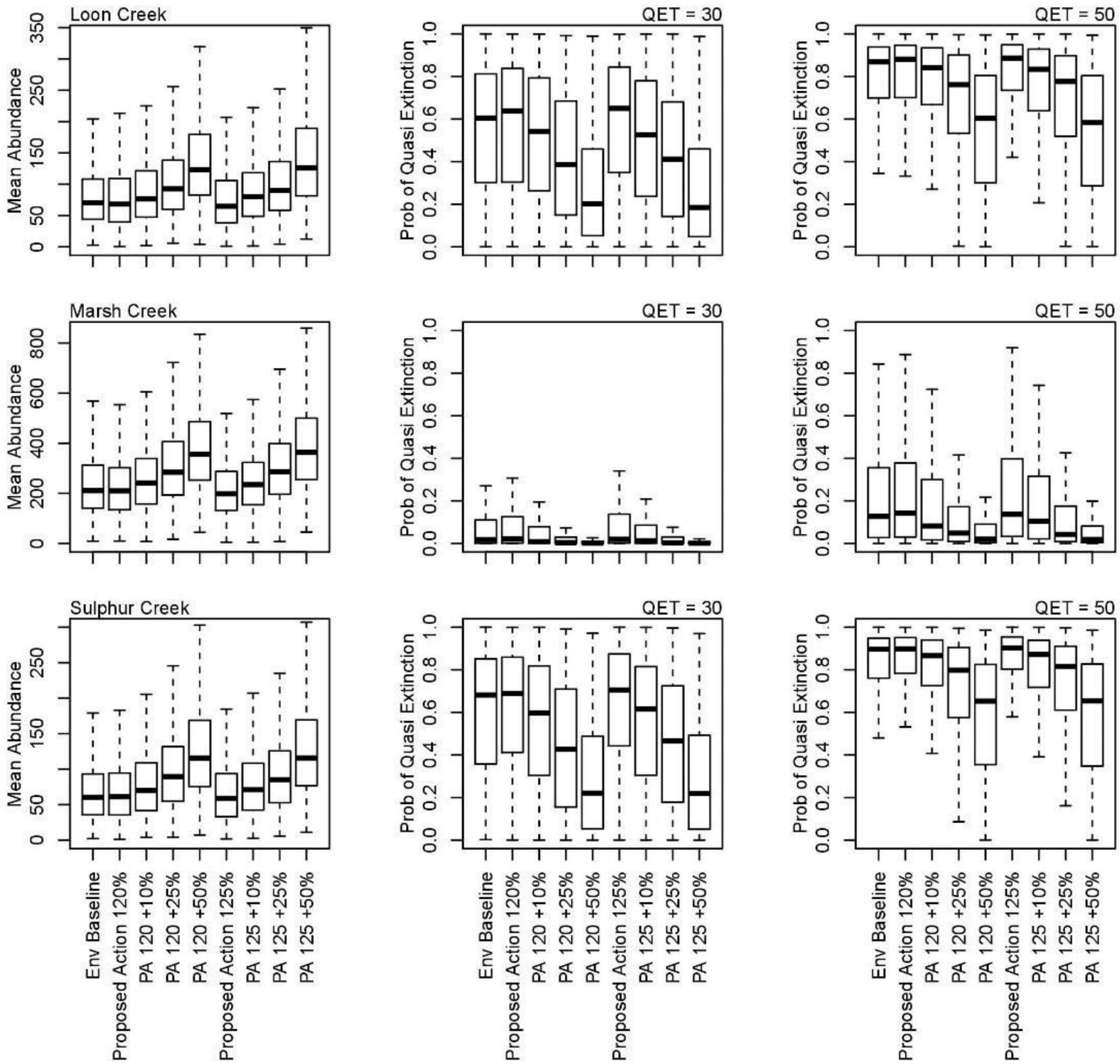


Figure 2.15-10. Life-cycle model projections of median abundance and Quasi-Extinction Risk thresholds of 30 and 50 for Grande Ronde River MPG populations of naturally produced fish in 24 years under (from left to right) the Environmental Baseline, proposed action (up to 120% flexible spill hydro operation and tributary enhancement actions, if applicable), and assuming a 10, 25, or 50 percent increase in productivity as a result of hypothesized reductions in latent mortality stemming from increased spill operations; and the proposed action (up to 125% flexible spill hydro operation and tributary enhancement actions, if applicable), and assuming a 10, 25, or 50 percent increase in productivity as a result of hypothesized reductions in latent mortality stemming from increased spill operations Boxes display 25th, 50th, and 75th percentiles; whiskers display 5th and 95th percentiles.

Upper Salmon River MPG

As previously noted, within the Upper Salmon River MPG, seven populations have sufficient information available to support Life-cycle modeling. Model results are displayed in Figure 2.15-11 and in Table 2.15-20. In general, the proposed action (making no assumptions about reductions in latent mortality) and proposed habitat restoration work, where applicable, generally results in similar (to those projected for conditions representing the environmental baseline median abundance projections for these populations: Lemhi (128), Valley Creek (84 or 41 depending upon the specific model), Yankee Fork (9), Upper Salmon Mainstem (416), North Fork (5), East Fork (51), and Pahsimeroi (311). Habitat restoration actions are expected to occur in the Lemhi, North Fork, Pahsimeroi, and Yankee Fork systems, which tend to somewhat improve projected median abundance relative to the other populations.

The projected median probability of falling below a QET of 30 or 50 adults for four consecutive years within the next 24 years is relatively low for the Upper Salmon Mainstem and Pahsimeroi populations (less than two percent and 4 to 13 percent, respectively). The projected median probability of falling below a QET of 30 adults remains high (75 to 100 percent) for the Yankee Fork, Valley Creek (one model), East Fork, and North Fork populations. The projected median probability of falling below a QET of 30 or 50 adults is intermediate for the Lemhi and Valley Creek (alternative model) populations (roughly 30 to 65 percent for the Lemhi, and 50 to 75 percent for Valley Creek, respectively).

As a sensitivity analysis, Figure 2.15-11 and Table 2.15-21 also display the projected results of increasing productivity an additional 10, 25, or 50 percent, which roughly bounds the benefits hypothesized by the CSS (2017 and 2018) to result from increasing spill to the 120 tailrace TDG limits. In general, a projected increase in productivity of 10 percent does little to substantively improve median abundance or decrease the probability of falling below QETs of 30 or 50 adults. Increasing productivity by 50 percent would result in substantially increased projected median abundance estimates (in 24 years) for all populations: Lemhi (524), Valley Creek (195 to 202), Yankee Fork (101), Upper Mainstem (996), North Fork (67), East Fork (266), and Pahsimeroi (700). The projected median probability of dropping below a QET of 50 adults would decrease to 0 to 2 percent for the Lemhi, Upper Salmon mainstem, and Pahsimeroi populations. The projected mean probability of dropping below a QET of 30 would be substantially reduced for Valley Creed (about 7 percent) and East Fork (about 2 percent) populations and remain somewhat high for Yankee Fork (37 percent) and North Fork (66 percent). Increasing productivity by 25 percent results in intermediate increases in projected abundance and reduced probabilities of dropping below QETs of 30 or 50 adults, as would be expected.

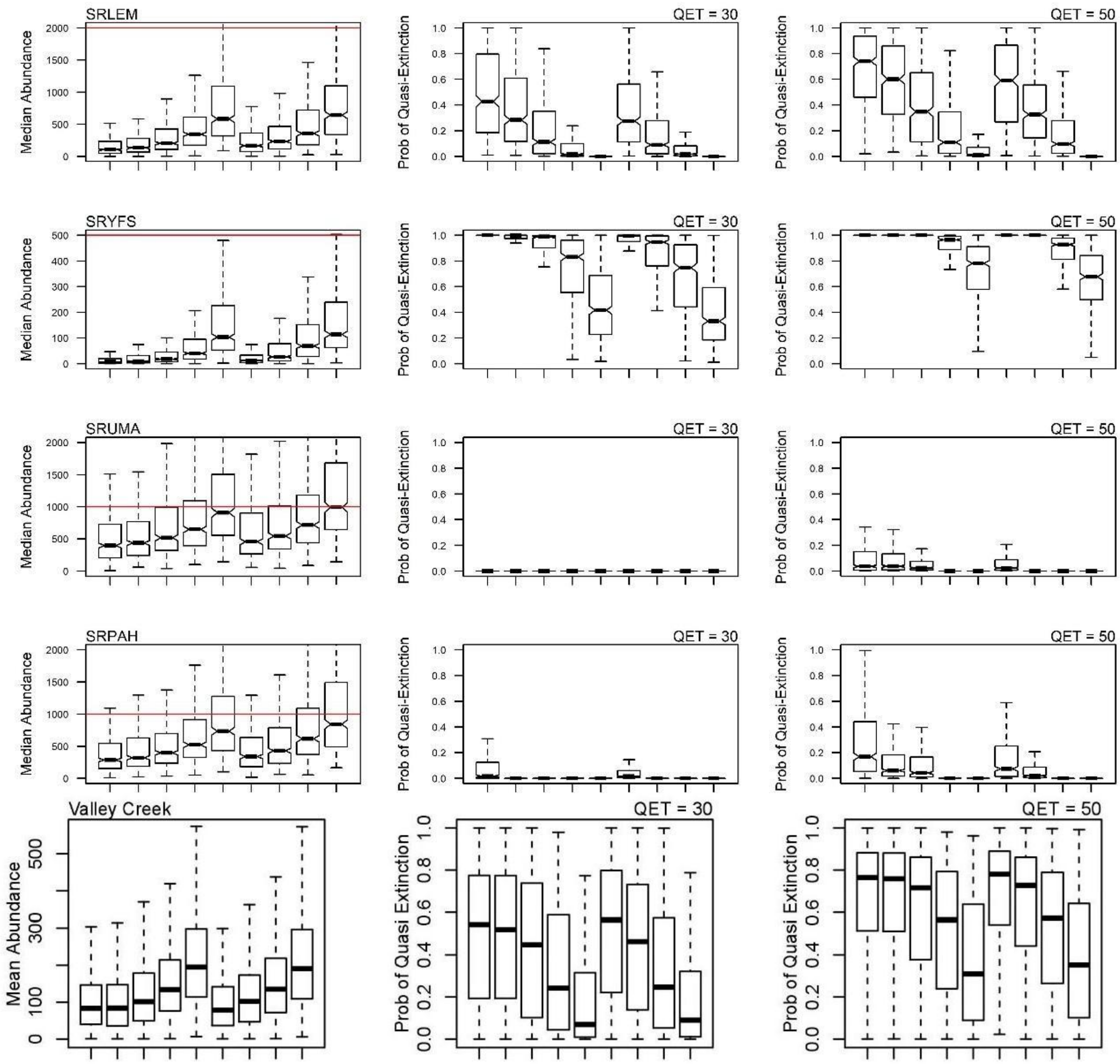
Analysis of the up to 125 percent gas cap flexible spill operation indicated there is little difference between this operation and the estimates for the up to 120 percent gas cap flexible spill operation assuming direct survival improvements only, or 10, 25, and 50 percent improvements in productivity that could result from increased spill (Figure 2.15-11). Simply put, Life Cycle Modeling indicates that assumptions about improved productivity (from potential latent mortality reductions) dominates projected estimates of abundance or probabilities of falling below QETs of 30 or 50 adults.

Table 2.15-21. Life-cycle model projections of median abundance and Quasi-Extinction Risk thresholds of 30 and 50 (5th and 95th percentiles) for populations of naturally produced fish in 24 years under the projected baseline (italicized text), proposed action (up to 120% flexible spill operations and tributary enhancement actions, if applicable), and assuming a 10%, 25%, or 50% increase in survival resulting from hypothesized reductions in latent mortality.

Upper Salmon MPG	**Abundance**			**QET = 30**			**QET = 50**		
Population	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**
Lemhi									
Env. Baseline	***107***	*12*	*588*	***0.428***	*0.061*	*0.985*	***0.740***	*0.192*	*0.996*
Prop. Action 120% Flex Gas Cap	**128**	20	780	**0.304**	0.018	0.950	**0.649**	0.121	0.976
PA + 10%	**214**	37	1,098	**0.115**	0.003	0.941	**0.368**	0.036	0.964
PA + 25%	**309**	76	1,298	**0.021**	0	0.629	**0.158**	0.005	0.828
PA + 50%	**524**	120	2,177	**0**	0	0	**0.018**	0	0.418
Valley Creek (Crozier Model)									
Env. Baseline	***83***	*1*	*304*	***0.543***	*0*	*1.000*	***0.765***	*0*	*0.999*
Prop. Action 120% Flex Gas Cap	**84**	1	315	**0.520**	0	1.000	**0.759**	0.001	1.000
PA + 10%	**101**	1	370	**0.448**	0	1.000	**0.716**	0	1.000
PA +25%	**134**	1	419	**0.242**	0	0.979	**0.565**	0.001	0.981
PA + 50%	**195**	7	574	**0.069**	0	0.774	**0.310**	0	0.963
Valley Creek									
Env. Baseline	**44**	3	220	**0.872**	0173	1.000	**0.960**	0.964	1.000
Prop. Action 120% Flex Gas Cap	**41**	5	220	**0.787**	0.168	0.999	**0.977**	0.483	1.000
PA + 10%	**74**	12	438	**0.611**	0.188	0.972	**0.884**	0.415	0.997
PA + 25%	**117**	26	527	**0.336**	0.042	0.866	**0.673**	0.247	0.948

Upper Salmon MPG	Abundance			QET = 30			QET = 50		
Population	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**
PA + 50%	**202**	54	850	**0.070**	0.002	0.617	**0.372**	0.059	0.808
Yankee Fork									
Env. Baseline	**7**	0	93	**1.000**	1.000	1.000	**1.000**	1.000	1.000
Prop. Action 120% Flex Gas Cap	**9**	0	93	**1.000**	1.000	1.000	**1.000**	1.000	1.000
PA + 10%	**23**	1	127	**0.983**	0.427	1.000	**1.000**	1.000	1.000
PA +25%	**42**	5	214	**0.878**	170	0.999	**0.977**	0.642	1.000
PA + 50%	**101**	21	458	**0.366**	0.072	0.878	**0.799**	0.330	0.985
Upper Salmon Mainstem									
Env. Baseline	**397**	102	1,736	**0**	0	0	**0.038**	0.001	0.663
Prop. Action 120% Flex Gas Cap	**416**	115	1,735	**0**	0	0	**0.040**	0.001	0.557
PA + 10%	**497**	148	1,759	**0**	0	0	**0.016**	0	0.341
PA + 25%	**637**	186	2,106	**0**	0	0	**0**	0	0
PA + 50%	**996**	318	3,635	**0**	0	0	**0**	0	0
North Fork									
Env. Baseline	**4**	0	42	**1.000**	1.000	1.000	**1.000**	1.000	1.000
Prop. Action 120% Flex Gas Cap	**5**	0	52	**1.000**	1.000	1.000	**1.000**	1.000	1.000
PA + 10%	**11**	0	99	**0.997**	0.661	1.000	**1.000**	1.000	1.000
PA + 25%	**28**	2	176	**0.976**	0.350	1.000	**1.000**	1.000	1.000
Upper Salmon MPG	**Abundance**			**QET = 30**			**QET = 50**		

Upper Salmon MPG	Abundance			QET = 30			QET = 50		
Population	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**
Population	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**	**Median**	**5th**	**95th**
PA + 50%	**67**	12	343	**0.663**	0.208	0.982	**0.945**	0.627	0.999
East Fork									
Env. Baseline	**39**	3	288	**0.845**	0.226	1.000	**0.981**	0.630	1.000
Prop. Action 120% Flex Gas Cap	**51**	3	301	**0.756**	0.144	0.999	**0.955**	0.493	1.000
PA + 10%	**91**	9	441	**0.502**	0.065	0.991	**0.808**	0.236	0.997
PA + 25%	**151**	23	716	**0.274**	0.030	0.922	**0.564**	0.115	0.969
PA + 50%	**266**	56	1,175	**0.022**	0	0.487	**0.229**	0.027	0.844
Pahsimeroi									
Env. Baseline	**288**	67	1,142	**0.017**	0	0.711	**0.169**	0.008	0.848
Prop. Action 120% Flex Gas Cap	**311**	89	1,310	**0.015**	0	0.530	**0.128**	0.003	0.797
PA + 10%	**363**	116	1,443	**0**	0	0	**0.037**	0	0.604
PA + 25%	**573**	157	2,007	**0**	0	0	**0**	0	0
PA + 50%	**700**	228	2,615	**0**	0	0	**0**	0	0


SRLEM
Median Abundance
QET = 30
Prob of Quasi-Extinction
QET = 50
SRYFS
SRUMA
SRPAH
Valley Creek
Mean Abundance
Prob of Quasi Extinction

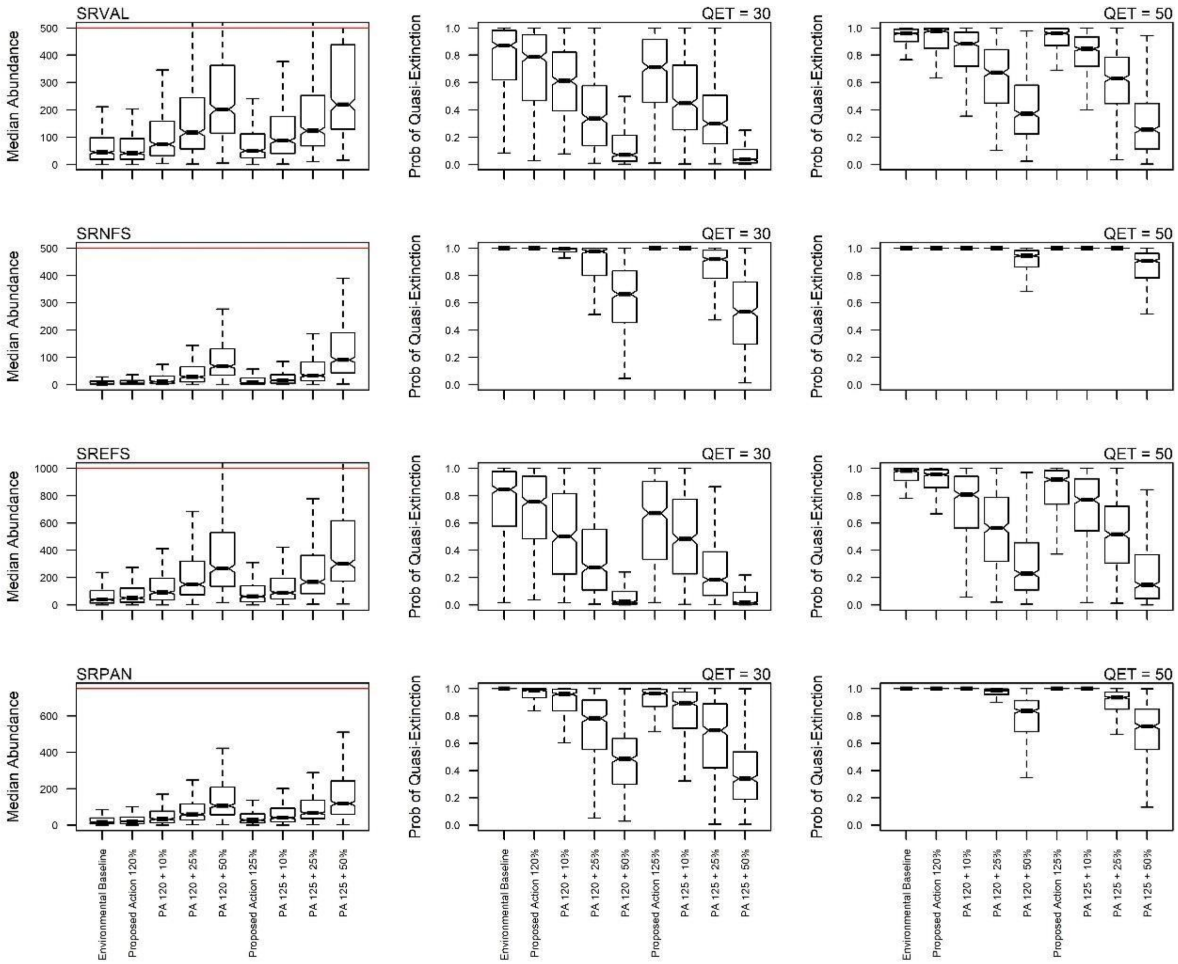


Figure 2.15-11. Life-cycle model projections of median abundance and Quasi-Extinction Risk thresholds of 30 and 50 for Grande Ronde River MPG populations of naturally produced fish in 24 years under (from left to right) the Environmental Baseline, proposed action (up to 120% flexible spill hydro operation and tributary enhancement actions, if applicable), and assuming a 10, 25, or 50 percent increase in productivity as a result of hypothesized reductions in latent mortality stemming from increased spill operations; and the proposed action (up to 125% flexible spill hydro operation and tributary enhancement actions, if applicable), and assuming a 10, 25, or 50 percent increase in productivity as a result of hypothesized reductions in latent mortality stemming from increased spill operations Boxes display 25th, 50th, and 75th percentiles; whiskers display 5th and 95th percentiles.

Summary

Life-cycle models are limited by the amount and quality of the available data that can be used to estimate, or infer, relationships to factors that influence the survival and productivity of individuals within a population throughout their life cycle. The life-cycle models presently do not incorporate interactions between populations (straying, source-sink dynamics etc.) or between MPGs, though these dynamics are generally known to occur. That said, they provide useful frameworks for assessing how populations are likely to respond to factors that are correlated with survival or abundance.

The Life-cycle model results generally indicate that the productivity and abundance of populations in each of the four MPGs, for which modeling was possible, will change little as a result of the proposed action (assuming no productivity improvements from hypothesized reductions in latent mortality) compared to a scenario where the previous operation continued (as projected under the environmental baseline), and will likely remain substantially below the abundance and productivity objectives established in the recovery plan at the end of 24 years.

Habitat restoration actions are expected to slightly improve the productivity in the targeted tributaries (e.g., Catherine Creek and Upper Grande Ronde).

The Life-cycle model indicates that each of the MPGs would continue to have at least one populations that is projected to be relatively abundant (i.e., a median of greater than 300 adults) and have a relatively high likelihood of persistence (low projected probabilities of dropping below the QET of 30 or 50 adults for four consecutive years) through 24 years. As noted previously in the environmental baseline, these larger, more productive populations are very important to the persistence and integrity of each MPG. Adults from these populations undoubtedly stray into, and spawn with, adults in nearby, less productive and abundant populations, supporting their persistence and increasing the overall demographic and genetic resiliency of each MPG.

Life-cycle model projections also indicate that each modeled MPG, excepting the South Fork Salmon River MPG, also has examples of populations that would be expected to have very low median abundance (< 50 adults) and high (90 percent or greater) probabilities of falling below the QET or 50 or even 30 adults for four consecutive years. These populations tend to inhabit areas that have suffered from severe habitat degradation (e.g., Catherine Creek, Upper Grande Ronde, and Yankee Fork populations; unrelated to the CRS operations), or that inhabit higher elevation, relatively unproductive habitat (e.g., Sulphur Creek, Camas Creek, Loon Creek, North Fork Upper Salmon, and East Fork Upper Salmon). There are also examples of populations that would be expected to be intermediate, between these two groups of populations.

The CSS (2017 and 2018) has hypothesized that increasing spill will reduce the number of powerhouse passage events, increase survival rates for in-river migrating smolts, reduce latent mortality, and increase adult returns (increasing productivity). Life-cycle model results assessing an additional 10, 25, or 50 percent projected improvement in the SARs of in-river migrating fish (which roughly correspond to productivity improvements hypothesized for increasing spill to the 120 tailrace TDG limits) indicate that a 10 percent increase (1.10 multiplier) has little overall effect for most populations on projected median abundance or the projected probability of falling below a QET of 30 or 50 adults for four consecutive years within the next 24 years. Increasing productivity by 50 percent (1.50 multiplier) would, if it were to occur, result in substantial projected improvements in median abundance and substantially lower projected probabilities of falling below a QET of 30 or 50 adults for four consecutive years, excepting the larger, more robust populations that were already very unlikely to fall below these levels, and the smaller, least productive populations constrained by juvenile production (capacity).

Model projections, as expected, for increases in productivity of 25 percent (1.25 multiplier) were intermediate between the results of the 10 percent and 50 percent increase scenarios.

Analysis of the up to 125 percent gas cap flexible spill operation indicated there is little difference between this operation and the estimates for the up to 120 percent gas cap flexible spill operation assuming direct survival improvements only, or 10, 25, and 50 percent improvements in productivity that could result from increased spill. Simply put, Life Cycle Modeling indicates that assumptions about improved productivity (from potential latent mortality reductions) dominates projected estimates of abundance or probabilities of falling below QETs of 30 or 50 adults.

2.15.3.1.10 Research and Monitoring Activities

The Action Agencies' RM&E program will be similar to the current program, or will be implemented at a reduced scale. Thus, the level of injury and mortality discussed in the environmental baseline, primarily from the capture and handling of fish, is likely to continue at a similar or reduced level. We estimate that, on average, the following number of SR spring/summer Chinook salmon will be affected each year during the interim period:

- Projected estimates of SR spring/summer Chinook salmon handling and mortality during activities associated with the Smolt Monitoring Program and CSS: (1) five hatchery and five wild adult handled; (2) zero hatchery or wild adults killed; (3) 91,187 hatchery and 52,039 wild juveniles handled; and (4) 2,447 hatchery and 2,090 wild juveniles killed;
- Projected estimates of SR spring/summer Chinook salmon handling and mortality during activities associated with Fish Status Monitoring:[224]39 (1) 14,304 hatchery and 4,600 wild adults handled; (2) 143 hatchery and 46 wild adults killed; (3) 63,761 hatchery and 50,319 wild juveniles handled; and (4) 638 hatchery and 503 wild juveniles killed;
- Projected estimates of SR spring/summer Chinook salmon handling and mortality for all other RM&E programs: (1) 447 hatchery and 144 wild adults handled; (2) four hatchery and one wild adult killed; (3) 361,831 hatchery and 124,801 wild juveniles handled; (4) 3,618 hatchery and 1,248 wild juveniles killed.

The combined observed mortality associated with these elements of the RM&E program will, on average, affect less than 1 percent of the wild (i.e., natural origin) adult returns or juvenile production for the SR spring/summer Chinook salmon ESU. Although we estimate that 19.57 percent of the wild adults and 16.42 percent of the wild juvenile production will be handled each year, on average, we expect that only up to 1 percent of these will die after release (in this case, 0.20 percent of adults and 0.16 percent of juveniles handled). This relatively small effect is deemed worthwhile because it will allow the Action Agencies and NMFS to continue to evaluate the effects of CRS operations including modifications to facilities, operations, and mitigation actions.

Electrofishing operations for the NPMP during the interim period are expected to continue at the same level of effort as in recent years (four 15-minute sampling events per 0.6-mile reach

[224] Fish Status Monitoring is intended to include individuals handled/killed during status and trend, "fish-in/fish out," and habitat effectiveness monitoring projects.

between RM 47 near Clatskanie, Oregon, and RM 394 on the Columbia River and to RM 156 on the lower Snake River during April-July; a total of 550 hours system-wide). Some adult and juvenile SR spring/summer Chinook salmon are likely to be present in shallow shoreline areas during electrofishing activities and may be stunned and even killed. However, because the operator releases the electrical field as soon as salmonids are observed and most of these fish quickly recover and swim away, we are unable to use observations from past operations to estimate the number of fish from this ESU that will be affected. Information obtained through electrofishing supports management of the NPMP, which is reported to have reduced salmonid predation by about 30 percent (Williams et al. 2017). This level of take is anticipated to occur for the duration of this proposed action, pending completion of the NEPA process.

Table 2.15-22. Effects of the proposed action on the physical and biological features essential for the conservation of the SR spring/summer Chinook salmon ESU.

Physical and Biological Feature (PBF)	Effects of the Proposed Action
Freshwater spawning sites	● The principal effect of habitat improvements in spawning areas will be that over 4,800 acre-feet of flow will be enhanced and 179 acres of riparian habit will be improved across subbasins used by SR spring/summer Chinook salmon (Grande Ronde/Imnaha, Upper Salmon River, and Lower Snake MPGs) for spawning and rearing. This will improve water quality, floodplain connectivity, and natural cover at the local scale in HUC5 watersheds used for spawning and rearing.
Freshwater migration corridors	● Continuation of altered seasonal flows (decreased spring and early summer flows and increased winter flows) due to system-wide storage operations, including those at CRS reservoirs (reduced water quantity in the juvenile migration corridor) ● Continuation of delayed spring warming, delayed fall cooling, and reduced daily temperature variability due to the thermal inertia of the CRS reservoirs (reduced water quality in juvenile and adult migration corridors) ● Continuation of decreased survival through the CRS dams (safe passage) ● The proposed flexible spring spill operation will slightly increase the incidence of adult fallback and will have small effects on juvenile travel time (reduced) and survival (increased) (safe passage) ● Increasing the operating range by 6 inches at lower Snake River dams (MOP 1.5-foot range) and at John Day Dam (MIP 2-foot range) and increasing spill as a result of the flexible spill operation (up to 120 or 125 percent TDG levels) will decrease travel times and exposure to predators (obstructions and excessive predation in juvenile migration corridors) ● Sediment will continue to accumulate behind CRS dams, reducing turbidity in the migration corridor during the spring smolt outmigration, which could

Physical and Biological Feature (PBF)	Effects of the Proposed Action
	affect the safe passage PBF by increasing the risk of predation ● Continuation of current levels of predation with ongoing implementation of the avian and pikeminnow management programs (safe passage) ● Increase in TDG levels up to the state-approved limits at the CRS run-of-river projects will result in only a slight increase in the incidence and severity of GBT symptoms (water quality in the juvenile and adult migration corridor) ● The proposed August spill reduction should have no substantive effect on juvenile or adult passage or survival (safe passage). ● The proposed cessation of transport (June 21 to August 4) starting in 2020 would have no effect on juvenile survival or adult returns.
Estuarine areas	● This PBF will continue to improve with the proposed reconnection of an average of 300 acres of floodplain habitat per year during implementation of this proposed action (increased access to forage) ● Because estuary bird colonies and predation rates are in flux, it is not clear whether tern and cormorant colony management has reduced predation rates. Any existing survival benefits will continue under the proposed action. Thus we expect the predation risk to remain unchanged.

2.15.3.1.11 Research and Monitoring Activities

The Action Agencies' RM&E program will be similar to the current program, or will be implemented at a reduced scale. Thus, the level of injury and mortality discussed in the environmental baseline, primarily from the capture and handling of fish, is likely to continue at a similar or reduced level. We estimate that, on average, the following number of SR spring/summer Chinook salmon will be affected each year during the interim period:

- Projected estimates of SR spring/summer Chinook salmon handling and mortality during activities associated with the Smolt Monitoring Program and CSS: (1) five hatchery and five wild adult handled; (2) zero hatchery or wild adults killed; (3) 91,187 hatchery and 52,039 wild juveniles handled; and (4) 2,447 hatchery and 2,090 wild juveniles killed;
- Projected estimates of SR spring/summer Chinook salmon handling and mortality during activities associated with Fish Status Monitoring:[225] (1) 14,304 hatchery and 4,600 wild adults handled; (2) 143 hatchery and 46 wild adults killed; (3) 63,761 hatchery and 50,319 wild juveniles handled; and (4) 638 hatchery and 503 wild juveniles killed;
- Projected estimates of SR spring/summer Chinook salmon handling and mortality for all other RM&E programs: (1) 447 hatchery and 144 wild adults handled; (2) four hatchery

[225] Fish Status Monitoring is intended to include individuals handled/killed during status and trend, "fish-in/fish out," and habitat effectiveness monitoring projects.

and one wild adult killed; (3) 361,831 hatchery and 124,801 wild juveniles handled; (4) 3,618 hatchery and 1,248 wild juveniles killed.

The combined observed mortality associated with these elements of the RM&E program will, on average, affect less than 1 percent of the wild (i.e., natural origin) adult returns or juvenile production for the SR spring/summer Chinook salmon ESU (Bellerud 2018). Although we estimate that 19.57 percent of the wild adults and 16.42 percent of the wild juvenile production will be handled each year, on average, we expect that only up to 1 percent of these will die after release (in this case, 0.20 percent of adults and 0.16 percent of juveniles handled). This relatively small effect is deemed worthwhile because it will allow the Action Agencies and NMFS to continue to evaluate the effects of CRS operations including modifications to facilities, operations, and mitigation actions.

Electrofishing operations for the NPMP during the interim period are expected to continue at the same level of effort as in recent years (four 15-minute sampling events per 0.6-mile reach between RM 47 near Clatskanie, Oregon, and RM 394 on the Columbia River and to RM 156 on the lower Snake River during April-July; a total of 550 hours system-wide). Some adult and juvenile SR spring/summer Chinook salmon are likely to be present in shallow shoreline areas during electrofishing activities and may be stunned and even killed. However, because the operator releases the electrical field as soon as salmonids are observed and most of these fish quickly recover and swim away, we are unable to use observations from past operations to estimate the number of fish from this ESU that will be affected. Information obtained through electrofishing supports management of the NPMP, which is reported to have reduced salmonid predation by about 30 percent (Williams et al. 2017). This level of take is anticipated to occur for the duration of this proposed action, pending completion of the NEPA process.

2.15.3.2 Effects to Critical habitat

Implementation of the Gas Cap portion of the flexible spring spill operation will affect the freshwater migration corridor for all juvenile and adult SR spring/summer Chinook. Implementation of the proposed action will also affect the volume and timing of flow in the Columbia and Snake Rivers, which has the potential to alter habitat in the mainstem of both rivers and the lower Columbia River estuary. The PBFs that will be affected by the proposed action are described in Table 2.15-22.

2.15.4 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation (50 CFR 402.02). Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing nonfederal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult, if not impossible, to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in Section 2.15.2.

Nonfederal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat, and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. These projects also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth-management programs (planning and regulation); a variety of stream and riparian habitat projects; watershed planning and implementation; acquisition of water rights for instream purposes and sensitive areas; instream flow rules; stormwater and discharge regulation; TMDL implementation to achieve water-quality standards; hydraulic project permitting; and increased spill and bypass operations at hydropower facilities and increased flow through storage projects. NMFS determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. These activities are likely to have beneficial cumulative effects that will significantly improve conditions for the salmon and steelhead, including SR spring/summer Chinook salmon.

NMFS also noted that some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects are activities that occurred in the recent past and were included in the environmental baseline. Some of these activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the action area, nonfederal actions are likely to include activities associated with human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations.

Overall, we anticipate that projects to restore and protect habitat, restore access and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will have beneficial effects on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area.

2.15.5 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.15.3) to the environmental baseline (Section 2.15.2) and the cumulative effects (Section 2.15.4), taking into account the status of the species and critical habitat (Section 2.15.1), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat for the conservation of the species.

2.15.5.1 Species

The SR spring/summer-run Chinook salmon ESU includes all naturally spawned populations of spring/summer-run Chinook salmon in the mainstem Snake River and the Tucannon River, Grande Ronde River, Imnaha River, and Salmon River subbasins, as well as 10 artificial propagation programs. The ESU is comprised of 28 extant populations within five MPGs. NMFS' recent status review affirmed SR spring/summer Chinook salmon as threatened (NMFS 2016e). While there have been improvements in the abundance/productivity for multiple populations relative to prior reviews (Ford 2011), those changes were not sufficient to warrant a change in status. All extant populations face a high risk of extinction, except Chamberlain Creek in the Middle Fork MPG, which has improved to a maintained status due to increases in abundance (NWFSC 2015). Natural-origin abundance has increased since the 2011 status review for most populations (Ford 2011), although the increases are not substantial enough to change viability ratings. Since the last status review in 2015, observations of coastal ocean conditions suggested that the 2015–17 outmigrant year classes experienced below average survival during a marine heatwave and its lingering effects, which led researchers to predict a corresponding drop in adult returns through 2019 (Werner et al. 2017). The negative impacts on juvenile salmonids associated with the marine heatwave had subsided by spring 2018, but other aspects of the ecosystem (e.g., temperatures below the 50-m surface layer) had not yet returned to normal (Harvey et al. 2019).

The proposed action will continue to affect the survival of juvenile and adult SR spring/summer Chinook salmon as they move between the Snake River basin and the ocean. Passage through the eight dams will be improved, but survival rates will continue to average about 84 percent for adults (Bonneville to Lower Granite Dams) and 58.2 percent (which includes both natural and dam related losses) for juveniles based on COMPASS modeling (flexible spill up to 120 percent TDG). We expect the proposed flexible spill operation to reduce juvenile travel time by almost one day from Lower Granite to Bonneville Dam. The proportion of juvenile outmigrants that are expected to be transported is 8.1 percent lower, but if higher spill levels reduce latent mortality as hypothesized by CSS, the abundance and productivity of SR spring/summer Chinook populations will also improve. If the hypothesized CSS benefits do not prove true, a slight decrease in adult returns for some populations, most likely resulting from reduced transport rates at the three Snake River collector projects, could result.

We used life-cycle models as a tool to predict abundance and quasi-extinction risk compared to a hypothetical continuation of the 2017 FOP, and included hypothetical improvements in productivity based on reduced levels of latent mortality. However, the effects of the action include the effects of the continued implementation of the overall proposed operations, , not just the incremental differences from the 2017 FOP .

With respect to potential reductions in latent mortality and associated improvements in productivity, the life-cycle modeling indicates that for the Grande Ronde MPG, the biggest concern is with the Upper Grande Ronde population which, despite positive effects from the implementation of habitat actions, is expected to have a very high QET risk, even with a hypothetical productivity increase from reduced latent mortality. For the South Fork Salmon MPG (no habitat restoration actions proposed), the modeling projects a low QET risk, and improved median abundance from a hypothetical 50 percent productivity improvement from reduced latent mortality, but no improvement with a 10 percent productivity increase. The results are similar for the large populations in the Middle Fork Salmon MPG; however, the small populations are projected to have relatively high QETs, even with hypothetical productivity increases projected from reduced latent mortality. The life-cycle model results indicate that the productivity and abundance of populations in each of the four MPGs for which modeling was possible, will not be greatly affected as a result of the proposed action (unless hypothesized latent mortality reductions occur), and will likely remain substantially below the abundance and productivity objectives established in the recovery plan at the end of 24 years. The life-cycle models do, however, support the proposition that we are unlikely to see reductions in numbers, distribution, or reproduction compared that would be meaningful over the short-term for the ESU. Nevertheless, the ongoing adverse effects of operating the CRS as proposed for a longer duration could be significant in light of the high probability of falling below QETs for some populations as projected over the long term.

The other proposed changes to CRS operations are not anticipated to negatively affect SR spring/summer Chinook salmon survival. In particular, the changes in usable forebay ranges (MOP 1.5-foot range) at the lower Snake River reservoirs and the change in operating range at the John Day forebay (MIP 2-foot range) will, collectively, result in small variations in the timing and amount of flow in the lower Columbia River. These changes in operating range will have little effect on velocity, and thus are not expected to affect adult migration timing or survival rates. The proposed action will decrease juvenile travel time through the CRS by 0.94 days. The Action Agencies propose continued implementation of the avian, pinniped, and fish predation management programs in the estuary and mainstem hydrosystem reach. Predators consume large numbers of SR spring/summer Chinook salmon as they migrate between the Snake River basin and the ocean. Any reduced predation rates achieved under the 2008 biological opinion and associated RPA will continue during the interim period.

Hatchery production goals for SR spring/summer Chinook salmon included in the proposed action include hatchery releases in Yankee Fork and Panther Creek (Upper Salmon MPG), as well as Johnson Creek (South Fork Salmon MPG). If the new Yankee Fork and Panther Creek programs can successfully achieve the ultimate goal of establishing naturally spawning populations, while also limiting stray rates, keeping PNI high, and making sure that broodstock collection goals for the Sawtooth and Pahsimeroi programs continue to be met, this action would help reduce risk to the Upper Salmon MPG. The Johnson Creek Artificial Propagation Enhancement (East Fork, South Fork Salmon River) Program will continue to use 100 percent natural-origin fish in its broodstock. In the interim period of this biological opinion, the Action Agencies will continue their production-level commitment at the safety net and conservation hatcheries.

The Action Agencies will continue to operate the Columbia River projects and the four lower Snake River dams with the annual Water Management Plan and Fish Passage Plan, in accordance with the multiple objectives described above. Flow management has reduced flows in the springs and increased flows in late summer/early fall. Reduced flows in the spring have increased travel times for outmigrating juvenile Chinook salmon and resulted in reduced access to high-quality estuarine habitats from May through July during low tides. The continued action will also continue water-quality effects, and mortality associated with the RM&E program.

As a general matter, the effects of the proposed action are very similar to a short-term continuation of the same effects caused by the current operations and maintenance of the CRS, as well as the associated measures implemented to avoid, minimize, or offset adverse effects. Therefore, we do not anticipate large changes in mortality caused by the CRS, or substantial new risks to SR spring/summer Chinook salmon or their habitat, and we do not expect considerable changes in the effects on reproduction, numbers, or distribution. However, we do anticipate additional improvements in habitat conditions in the estuary and some of the tributaries that will accrue over time.

The tributary habitat program will benefit three of the five MPGs (Upper Salmon River, Grande Ronde/Imnaha, and Lower Snake River) if implemented as anticipated (i.e., achieving at least the minimum commitments included in the proposed action in a manner consistent with scientifically sound identification and prioritization of limiting factors and geographic locations, and principles of watershed restoration). Because the proposed action covers a limited time frame, and because a large scope and scale of actions is required to achieve significant change at the population level, specific improvements resulting from two–three years of implementation would be small, compared to the potential changes resulting from continued targeted implementation over a longer time frame. While it is possible that effects of some actions, such as actions to improve stream flow or remove barriers to passage, could be immediate, for other actions, benefits will take several years to fully accrue (and will take 50 years or more for actions such as restoring riparian areas). Therefore, it is unlikely that the benefits of these actions will be fully realized in the interim pending completion of the Action Agencies' NEPA process.

However, the, proposed tributary habitat improvement program is consistent with recommendations in the recovery plan and will support the improving status of the ESU.

The habitat improvement actions will be strategically identified, prioritized, and implemented to ameliorate specific limiting factors in specific populations in these three MPGs for the interim period pending completion of the NEPA process.

- Upper Salmon River MPG. In this MPG, the Action Agencies have committed to continue to implement actions in flow protection, flow enhancement, entrainment, habitat access, stream complexity, and riparian habitat improvement. Limiting factors in this MPG include reduced flows, loss of habitat complexity, reduced riparian function, passage barriers, and entrainment, so these actions would be targeted at addressing identified limiting factors. As described above, the magnitude of the improvements is anticipated to be small. NMFS' life-cycle modeling for populations in this MPG indicates that continued implementation of habitat actions during the term of this biological opinion, and assuming a focus on similar populations and priorities, will generally continue to increase habitat capacity.
- Grande Ronde/Imnaha River MPG. In this MPG, the Action Agencies have committed to implement actions in flow protection, flow enhancement, habitat access, stream complexity, and riparian habitat improvement. Limiting factors in this MPG include reduced flows, loss of habitat complexity, reduced riparian function, and passage barriers, so these actions would be targeted at addressing identified limiting factors. As described above, the magnitude of the improvements is anticipated to be small. NMFS' life-cycle modeling indicates that continued implementation of habitat actions during the term of this biological opinion at the rate they have been implemented to date, and assuming a focus on similar populations and priorities, will generally continue to increase habitat capacity.
- Lower Snake River MPG. The Action Agencies have committed to continue to implement actions to improve access, stream complexity, and riparian habitat for the single extant in this MPG population. No life-cycle model data are available for this MPG. The recovery plan (NMFS 2017e) proposed target requires the Tucannon to be highly viable, and to evaluate the potential for reintroducing production in Asotin Creek.

Two MPGs are not targeted for habitat restoration actions for the interim period of this consultation: Middle Fork Salmon MPG and South Fork Salmon MPG.

All MPGs migrate downstream through the estuary; according to the status review and the recovery plan, degraded habitat is a key factor limiting survival and recovery, including floodplain connectivity and function. The Action Agencies' proposed commitment to reconnect an average of 300 acres of floodplain per year in the estuary will be a continuation of the implementation of the ongoing estuary program. Further, this work will continue the trend of increasing connected area during the interim period, providing increased prey availability to yearling SR spring/summer Chinook salmon in the mainstem migration corridor.

The environmental baseline includes the past and present impacts of hydropower including the existence of the CRS dams, changes in tributary and mainstem habitat (both beneficial and adverse), harvest, and hatcheries on SR spring/summer Chinook. The baseline provides important context for assessing the effects of the action described above.

The largest harvest-related effects on SR spring/summer Chinook salmon result from the tribal and nontribal mainstem Columbia River fisheries. The recent *U.S. v. Oregon* consultation addressed this fishery, and that the harvest rate in tribal fall season fisheries may range from 5.5 to 17 percent, and the average annual harvest rate on these fish from 2008–17 under *U.S. v. Oregon* jurisdiction averaged 12.1 percent. Additional harvest occurs in the Snake River mainstem and its tributaries. For fisheries operating in Idaho above *U.S. v. Oregon* jurisdiction, fisheries are operated under Fishery Implementation Plans based on sliding scales that tie to forecast returns of natural-origin adults.

The status of SR spring/summer Chinook salmon is also likely to be affected by climate change. Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycle. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater and changes to food webs in freshwater, estuarine, and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty. As we continue to deal with a changing climate, management actions may help alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations, increased riparian vegetation to minimize or offset generally increasing water temperatures, etc.).

Improvements, including tributary hydrosystem modification and habitat restoration (e.g., in the estuary), coupled with significant harvest reductions from historic levels, have allowed for progress in improving SR spring/summer Chinook salmon abundance, productivity, spatial structure, and diversity for some populations. However, these improvements also occur in the context of natural fluctuations in environmental conditions, such as cyclical changes in ocean circulation and the unusually warm ocean conditions seen predominating during 2015, which can temporarily adversely affect survival and adult returns of all salmonid species even if freshwater habitat conditions are improving.

Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life-history types that will be successful in the future are neither static nor predictable. Therefore, maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish, and prioritizing populations that have the greatest potential to conserve this diversity and support MPGs (i.e., focal populations), is the wisest strategy for continued existence of populations, including those in the SR spring summer Chinook salmon ESU. The

ESU is likely to be affected by climate-related effects in the estuary, and in tributary streams (altered seasonal flows and temperatures) that support spawning and early rearing. Emerging research using complex life-cycle modeling indicates a potentially strong link between SST and survival of SR spring/summer Chinook salmon populations. However, the apparent link between SST and survival is presumably caused by food web interactions; relationships which could be disrupted by major transformations of community dynamics, as well as ocean acidification and other factors under a changing climate. How that relationship interacts with other variables throughout the SR spring/summer Chinook salmon life cycle will likely be an important area of future research. We do not think we will see dramatic climate change beyond what we see now over the next few years pending completion of the NEPA process. Climate change could continue to pose a threat to species survival/recovery, but the type of actions proposed should, at a minimum, not make the problem any worse and should continue to provide some benefit compared to if they did not occur in the action area.

When evaluating the effects of the action, those effects must be taken together with the effects on SR spring/summer Chinook salmon of future state or private activities, not involving federal activities that are reasonably certain to occur within the action area. NMFS anticipates that human development activities will continue to have adverse effects on SR spring/summer Chinook salmon in the action area. Many of these activities and their effects occurred in the recent past and were included in the environmental baseline, but are also reasonably certain to occur in the future. Within the action area, nonfederal actions are likely to include human development activities, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Habitat restoration efforts lead by state and local agencies, tribes, environmental organizations, and local communities are likely to continue. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives that, in some cases, are identified through ESA recovery plans. Larger, more region-wide, restoration and conservation efforts are either underway or planned throughout the Columbia River basin. These state and private actions have helped restore habitat, improve fish passage, and reduce pollution. While these efforts are reasonably certain to continue to occur, funding levels may vary on an annual basis. We also considered the future anticipated impacts of previously consulted upon federal actions such as the Mitchell Act consultation and BOR's consultation on the Upper Snake projects, and BPA's Habitat Improvement Programmatic. Some of these actions focus on improving habitat PBFs with the goal of improving population viability, or reducing the risk of hatchery programs on natural populations. All of these actions have undergone section 7 consultation, and the actions or the RPA were found to meet the ESA standards for avoiding jeopardy.

NMFS has finalized recovery planning for the Snake River drainage, organized around a subset of management unit plans corresponding to state boundaries. The recovery plans developed by NMFS incorporated viability criteria recommended by the ICTRT and are hierarchical in nature, with ESU-level criteria being based on the status of natural-origin Chinook salmon assessed at the population level. The three plans were developed in coordination with respective state, federal, and local agencies; tribes; and others. They envision actions being implemented generally over a 25-year period. The proposed action does not impair the ability to carry out the specified recovery actions in the time frames considered in the recovery plan, and in some cases (e.g., tributary habitat actions, hydrosystem improvements, etc.) the proposed action is consistent with actions called for in the recovery plan.

After reviewing and analyzing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, and considering the interim nature of this proposed action pending the decision to implement a new action as a result of the NEPA process, it is NMFS' biological opinion that the proposed action is not likely to reduce appreciably the likelihood of both survival and recovery of SR spring/summer Chinook salmon.

2.15.5.2 Critical Habitat

The designated critical habitat for SR spring/summer Chinook salmon consists of river reaches of the Columbia, Snake, and Salmon Rivers, and all the tributaries of the Snake and Salmon Rivers (except the Clearwater River) presently or historically accessible to SR spring/summer Chinook salmon (except above natural falls and the Hells Canyon Dam). Watersheds with PBFs for SR spring/summer Chinook in the Interior Columbia recovery domain vary from excellent in wilderness and roadless areas, to poor in areas subject to heavy agricultural and urban development. Critical habitat throughout much of the Interior Columbia recovery domain has been degraded by intense agriculture, alteration of stream morphology, riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining and urbanization. Reduced summer stream flows, impaired water quality, and reduced habitat complexity are common problems in developed areas.

The environmental baseline includes a broad range of past and present actions and activities that have affected the conservation value of critical habitat for SR spring/summer Chinook salmon. These include the effects of hydropower, changes in tributary and mainstem habitat (both positive and negative), and hatcheries on freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine areas and nearshore marine areas. Across the designated area, widespread development and other land use activities have disrupted watershed processes, reduced water quality, and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and/or current land use or water management activities have adversely affected the quality and quantity of stream and side channel areas, riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for salmon and steelhead production have been weakened. Despite a long-term trend in degradation of these habitats, there have been localized improvements in their conservation value through the combined efforts of federal, state, and local agencies; tribes; and other stakeholders. Tributary dams and other barriers have been removed, estuarine habitats restored and reconnected to the floodplain, and water quality has improved. Despite significant losses to predators in the migration corridor, the combined efforts of multiple parties have reduced the effect of predation (compared to predation rates without the programs), and the Action Agencies propose to continue predator management activities.

Continued operation of the CRS will continue to affect the function of critical habitat in the migration corridor (obstructions in the adult migration corridor). Despite improvements[226] to the dams and their operations, the CRS will continue to increase passage times, and reduce survival of juvenile and adult SR spring/summer Chinook salmon (affecting the safe passage PBF). The proposed flexible spring spill operation is likely to result in small improvements in-river travel times (i.e., decrease traveltimes) and survival rates from the lower Snake River to below Bonneville Dam. Seasonal flows and temperatures will continue to be altered with negative or positive effects on water quantity and quality depending upon the season. Increased numbers of predators, including birds and native and non-native fishes that prey on yearling Chinook salmon are present in the hydrosystem reach (excessive predation in the juvenile migration corridor). Reduced levels of predation by Caspian terns and double-crested cormorants in the estuary and terns nesting on Goose and Crescent Islands on the interior Columbia plateau and by northern pikeminnows in project tailraces and reservoirs that were achieved under the 2008 RPA will be maintained by the continued implementation of the respective predator management plans (reduction in the level of excessive predation).

In the lower Columbia River estuary, the proposed habitat restoration program will continue to reconnect the historical floodplain, increasing the availability of wetland-derived prey to yearling Chinook salmon migrating to the ocean (improved forage in estuarine areas and the juvenile migration corridor). With respect to predator management, the states will have the option to continue to reduce the number of CSLs in the lower Columbia River (NMFS's Letter of Authorization under the MMPA extends through 2021). Ongoing management of the tern and cormorant colonies at East Sand Island is expected to reduce smolt predation rates, but monitoring results from 2018 and the interim period and the data compilation expected in the avian predation synthesis report will be needed for confirmation. In addition, the elements of the NPMP will continue to reduce levels of predation in the lower Columbia River and estuary. On the negative side, toxic contaminants, an effect of land use practices, will continue to be present, especially near urban and industrial areas (reduced water quality in the juvenile and adult migration corridors).

Degraded PBFs in tributary habitat include the loss of substrate, side channels, natural cover, vegetation, and forage; degraded water quality; and the presence of obstructions in areas used for spawning and rearing. The Action Agencies will protect a total of 44 cfs and provide an additional total of about 4,500 acre-feet of instream flow, screen nine flow diversions, provide access to 41 miles of habitat, improve 20 miles of stream complexity, and improve a total of about 180 acres of riparian habitat in subbasins used by SR spring/summer Chinook salmon for spawning and rearing. Habitat improvement actions will strategically target current habitat-

[226] Improvements include juvenile fish passage systems and enhanced operations at each dam including spillway improvements, improvements to the juvenile transport system, screened juvenile bypass systems, surface passage routes, etc.). These improvements will continue under the proposed action.

related threats to SR spring/summer Chinook salmon viability during the interim period pending the decision to implement a new action as a result of the NEPA process. This will improve the functioning of critical habitat at the local scale in some HUC_5 watersheds (improvements in spawning gravel, water quality, water quantity, cover/shelter, food, riparian vegetation, and space in spawning and rearing areas).

Considering the ongoing and future effects of the environmental baseline and cumulative effects, and in light of the status of critical habitat and the interim nature of the proposed action, the proposed action will not appreciably reduce the value of designated critical habitat for the conservation of SR spring/summer Chinook salmon.

2.15.6 Conclusion

After reviewing and analyzing the current status of SR spring/summer Chinook salmon and its critical habitat, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, and considering the interim nature of this proposed action pending the decision to implement a new action as a result of the NEPA process, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of SR spring/summer Chinook salmon or destroy or adversely modify its designated critical habitat.

2.16 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. “Take” is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. “Harm” is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). “Incidental take” is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this ITS.

The measures described in this section are nondiscretionary and must be undertaken by the CRS Action Agencies: Corps, BPA, and Reclamation. The CRS Action Agencies have a continuing duty to regulate the activities covered by this Incidental Take Statement. If the CRS Action Agencies fail to assume and implement the terms and conditions of this Incidental Take Statement, the protective coverage of Section 7(o)(2) may lapse. To monitor the effect of incidental take, the CRS Action Agencies must report the progress of the action and its effect on each listed species to NMFS, as specified in this Incidental Take Statement [50 C.F.R § 402.14(i)(3)].

2.16.1 Amount or Extent of Take

Incidental take will occur as a result of the continued operation of the CRS and the implementation of the proposed action. Categories of incidental take are: CRS operations, habitat improvement, hatchery, predator management actions, and RM&E activities. The following sections specify the amount or extent of take that NMFS anticipates will occur as a result of these actions. If actual mortality rates exceed the mortalities estimated in these sections, it is likely that the incidental take allowed under this opinion has been exceeded by some indeterminate amount. It is challenging to determine if losses are a result of project existence, hydro operations, environmental conditions, or changes in predator abundance, etc.. However, NMFS will evaluate the best science available and determine whether take has, in fact, been exceeded and if reinitiation of consultation is required.

2.16.1.1 Amount of Take from CRS Operations, Maintenance, and Hydropower Actions

NMFS has estimated the expected adult and juvenile survival rates attributable to proposed operation of the CRS (including the mainstem flow effects of Hungry Horse, Columbia Basin Project [Grand Coulee], Chief Joseph Dam, The Dalles, Yakima, Deschutes, and Umatilla irrigation projects) in Sections 2.5-2.15. In this section, NMFS summarizes the expected incidental take of 13 ESA-listed salmon and steelhead resulting from the continued operation of the CRS and implementation of the proposed action.

2.16.1.1.1 Take of Adult Salmon & Steelhead

Adult Migrants

NMFS expects that the current estimated annual average mortalities for upstream migrating adults measured within the appropriate mainstem reaches will continue through the term of this opinion (Table 2.16-1). These estimates remove any reported harvest and account for estimated adult stray rates that would occur in an unmanaged migration corridor of similar size. The estimated adult mortality rates include all other sources that are likely to take place within the identified reaches: mortality resulting from the existence and operation of the CRS, unreported or delayed mortality caused by fisheries and marine mammal predator attacks, and natural mortality (i.e., that would have occurred during upstream migration without human influence).

There is evidence (PIT tag detections in adult fishways) that small numbers of adult UWR Chinook salmon and UWR steelhead pass upstream of Bonneville Dam. Some losses are likely to occur as a result of these fish moving back downstream through the project to reach their natal streams. Otherwise, all take experienced by UWR Chinook salmon and UWR steelhead is in the form of harm or reduced fitness from the biophysical changes in the lower Columbia River as these fish leave the Willamette River and migrate through the Columbia River on their way to the ocean.

Mainstem Spawning

Quantitative estimates of take are not possible for the mainstem spawning and incubation life stages of SR fall Chinook, LCR Chinook, and CR chum salmon. Reliable estimates of the numbers of fry or juveniles reaching the first project (e.g., SR fall Chinook at Lower Granite Dam, LCR Chinook at Bonneville Dam) are not available, or are extremely complicated because of multiple life history strategies. Reliable estimates of CR chum emerging from mainstem redds below Bonneville Dam are similarly not available. Flow operations are intended to provide relatively stable, beneficial conditions for emerging and/or migrating fry. Thus, implementing proposed flow operations - using regional fora for adaptive management - is the most useful indicator for whether or not conditions to minimize take are occuring. Thus, the incidental take of these species will not be prohibited if flow operations are implemented as described in the proposed action and are in compliance with the terms and conditions of the ITS.

Table 2.16-1. Estimates of annual average adult salmonid mortality (wild and hatchery origin fish combined) based on PIT tag detections at Bonneville Dam and at the uppermost federal dam likely to be passed by fish from each ESU/DPS. Data are based on adult return years 2013-17. Estimates were adjusted to remove any reported harvest and to account for the straying rates of adults, but include all other sources of mortality within the identified reaches. That is, these estimates include mortality resulting from the existence and operation of the CRS, unquantifiable levels of mortality from other potential sources such as unreported or delayed mortality caused by fisheries, marine mammal predator attacks, etc., and unquantifiable levels of "natural" mortality (i.e., that would have occurred within a migration corridor of similar size without human influence). Shaded cells denote ESUs/DPS that required using data for other species as surrogates.

ESU	Estimated Mortality of Adults if Migrated In-river as Juveniles[1]		Estimated Mortality of Adults if Transported as Juveniles[1]		Reach	Notes
	Average	Range	Average	Range		
UCR spring Chinook salmon	7.8%	0-15%	NA	NA	BON to MCN (3 dams)	
UCR steelhead	8.0%	3.2 - 12.4%	NA	NA	BON to MCN (3 dams)	
SR fall Chinook salmon	11.2%	0.2-19.8%	19.6%	6.2 - 32.3%	BON to LGR (7 dams)	
SR sockeye salmon[2]	50.3%	28.3 – 95.8%	NA	NA	BON to LGR (7 dams)	
SRB steelhead	10.4%	2.9 – 14.5%	20.7%	13.8 - 25.7%	BON to LGR (7 dams)	
SR spr/sum Chinook salmon	15.0%	6.5 – 22.0%	21.7%	16.5 – 24.1%	BON to LGR (7 dams)	
MCR steelhead[3] 1 dam 2 dams 3 dams	 1.9% 3.7% 5.5%	 0.0 – 4.0% 0.0 – 7.8% 0.0 – 11.5%	NA	NA	BON to TDA, JDA, MCN, or tributaries above MCN	Populations enter the Columbia in different mainstem reservoirs

ESU	Estimated Mortality of Adults if Migrated In-river as Juveniles[1]		Estimated Mortality of Adults if Transported as Juveniles[1]		Reach	Notes
	Average	Range	Average	Range		
UWR Chinook salmon	10 individuals	NA	NA	NA		A few adults from this ESU migrate upstream of BON in some years and some of these fish may die migrating downstream past the project.
UWR steelhead	10 individuals	NA	NA	NA		
LCR Chinook salmon – spring runs[4]	2.3%	2.2 - 3.5%	NA	NA	BON to tributaries entering BON pool	Applies only to populations that migrate to natal streams within BON pool
LCR Chinook salmon – fall runs[5]	3.5%	0 - 6.1%	NA	NA	BON to tributaries entering BON pool	Applies only to populations that migrate to natal streams within BON pool
LCR steelhead[6]	1.9%	0.5-3.3%	NA	NA	BON to tributaries entering BON pool	Applies only to populations that migrate to natal streams within BON pool
LCR coho salmon[5]	2.4%	0-5.5%	NA	NA	BON to tributaries entering BON pool	Applies only to populations that migrate to natal streams within BON pool
CR chum salmon[5]	2.4%	0-5.5%	NA	NA	BON to tributaries entering BON pool	Applies only to populations that migrate to natal streams within BON pool

[1] Generally calculated as 1 – Adjusted Survival Estimates (estimates of harvest and "natural" stray rates are removed) for the pertinent reach.

[2] There are no available estimates of adult passage survival for transported sockeye salmon, however, it is reasonable that transported SR sockeye might exhibit mortalities similar to those differentials observed for SR spring/summer Chinook (6.7%) and SRB steelhead (10.3%).

[3] Uses SRB steelhead as a surrogate estimate of survival (average per-project survival ^ Nth power, where N corresponds to the number of dams upstream of Bonneville passed during the migration) from Bonneville Dam to the natal tributaries of these fish that enter within a lower Columbia River reservoir.

[4] Uses SR spring-run Chinook salmon estimates as a surrogate estimate (i.e., the average per project survival estimate is used as a conservative estimate of survival from Bonneville Dam to the natal tributaries of these fish entering within the Bonneville reservoir).

[5] Uses SR fall-run Chinook salmon as a surrogate estimate (i.e., the average per project survival estimate is used as a conservative estimate of survival from Bonneville Dam to the natal tributaries of these fish entering within the Bonneville reservoir).

[6] Uses SRB steelhead as a surrogate estimate (i.e., the average per project survival estimate is used as a conservative estimate of survival from Bonneville Dam to the natal tributaries of these fish entering within the Bonneville reservoir).

Steelhead Kelts

CRS related mortality of downstream migrating kelts (SR, UCR, MCR and LCR steelhead) is not well known at this time. Colotelo et al. (2013) estimated that in 2012 only 40.2 and 44.8 percent of Snake River steelhead kelts survived from the Lower Granite forebay to the Lower Columbia River (RM156) and the Bonneville dam face (RM 234), respectively, and only 60.4 and 67.3 percent survived from the McNary forebay to the Lower Columbia River (RM156) and Bonneville dam face, respectively. It is important to note that in this study, only fair and good condition kelts were selected for tagging, and these survival rates cannot be applied to poor condition kelts. In a similar study conducted by Harnish et al. 2014, the survival of steelhead kelt through the four Snake River dams averaged 77 percent in 2012 and 49 percent in 2013.

Based on this limited information, the best estimate for incidental take of downstream migrating kelts is up to 60 percent of migrating kelts arriving at Lower Granite dam and up to 40 percent of UCR and MCR kelts arriving at McNary Dam (less for MCR and LCR kelts entering the mainstem Columbia River in the John Day, The Dalles, or Bonneville Reservoirs). Assuming roughly equal losses between the three projects in this reach, about 10-15 percent of LCR kelts from populations upstream of Bonneville Dam might be lost prior to passing the dam. These data represents total mortality to outmigrating SR steelhead kelts and does not distinguish between mortality caused by factors in the environmental baseline or the effects of the CRS. It is not technically possible to provide separate estimates of these components. Estimates of “natural” mortality rates for these fish are not available, but are thought to be high; the fish have typically gone many months without feeding while expending considerable energy migrating and spawning.

Few steelhead kelts from interior Columbia River basin DPSs return from the ocean to spawn. For example, Trammel et al. (2016) estimated that only 2.7 percent of the kelts migrating out of the Yakima River (Prosser Dam) returned to spawn. The Action Agencies therefore fund kelt reconditioning programs, which capture outmigrating kelts (mostly females), recondition them, and release them to spawn a second time. The Action Agencies can capture and hold of up to 1,400 MCR steelhead adults for the Yakima River Program at Chandler Juvenile Monitoring Facility/Prosser Hatchery and an additional 1,500 fish (2,900 total) are reasonably certain to be exposed to some level of take. Program operations at Winthrop NFH (as well as Rock Island Dam, Methow Hatchery and several Methow and Twisp tributary weirs) are not expected to exceed 500 UCR steelhead adults for all associated activities. Several recent studies have demonstrated how valuable these kelt reconditioning programs can be (Hatch et al. 2018).

Sockeye Transport

Consistent with the recommendations presented in NOAA Fisheries’ 2015 Adult Sockeye Salmon Passage Report (2016), trapping and transporting adult sockeye salmon from Lower Granite Dam when elevated water temperatures (greater than 70°F) exist in the Columbia, Snake, or Salmon Rivers will reduce adult sockeye mortalities and increase the number of spawning fish. Up to 50 percent of the fish estimated to pass Lower Granite Dam under these conditions may be removed and transported with an associated mortality rate of up to 10 percent of the transported fish.

Adult listed Chinook salmon and steelhead are also likely to be handled incidentally in the process of capturing sockeye for transport and their incidental take will exceed that of sockeye salmon. Up to 7 percent of SR summer Chinook salmon and 1 percent of SR steelhead pass Lower Granite Dam when sockeye are passing. However, effects on these fish (handling and delayed passage) are expected to be minimal. Mortalities for these non-targeted species, collectively, are not anticipated to exceed 20 SR summer Chinook salmon and ten SR steelhead as a result of this action.

2.16.1.1.2 Take of Juvenile Salmon & Steelhead

Based on COMPASS modeling for SR spring/summer Chinook, SR steelhead, UCR spring Chinook, and MCR steelhead (flexible spill operation up to 120 percent TDG), NMFS expects the average mortalities of in-river migrating juveniles to decrease slightly throughout the interim period due to implementation of the flexible spill operation. NMFS has used these modeling results, and other pertinent information (either recent direct estimates of survival for specific river reaches, or surrogate information from other species) to estimate the expected mortality rates (average and range) associated with the proposed action during the interim period (Table 2.16-2). These estimates capture all sources of mortality manifested within the migration corridor including those resulting from the existence and operation of the CRS including maintenance activities, unquantifiable mortalities from other potential sources (e.g., delayed and/or indirect effects of the CRS that occur upstream of Bonneville Dam, mortalities resulting from avian or piscivorous predators, mortalities associated with the condition of hatchery fish or exposure to toxic chemicals or pathogens, etc.) and unquantifiable levels of "natural" mortality (i.e., levels of mortality in the migration corridor that would have occurred without human influence).

Based on COMPASS modeling and recent transport estimates, no more than 57 percent of juveniles approaching Lower Granite Dam are likely to be transported under the proposed operation. Estimated annual mortalities of juvenile SR spring/summer Chinook, SR fall Chinook, and SR sockeye salmon and SR steelhead collected and transported from the Snake River collector dams should average about 2 percent.

Reliable estimates of the numbers of fry or juveniles SR fall Chinook reaching the first project (e.g., Lower Granite Dam) are not available; multiple life history strategies make it very challenging to generate reasonable estimates when fish pass the dam at different points and at different times in their life cycle. Flow operations are intended to provide relatively stable, beneficial conditions for emerging and/or migrating fry and smolts. Thus, implementing proposed flow operations - using regional fora for adaptive management - is the most useful indicator for whether or not conditions to minimize take are occuring. Thus, due to the inherent uncertainties in estimating survival created by the expression of the multiple life history strategies, the incidental take of juvenile SR fall Chinook salmon is not prohibited if flow and dam operations are implemented as described in the proposed action and in compliance with the terms and conditions of the ITS.

Table 2.16-2. Estimates of juvenile salmon and steelhead mortality for transported (presumed 2% mortality) or in-river (1-[inriver survival of migrants to Bonneville Dam tailrace based on COMPASS model results]. The COMPASS model has been calibrated using recent empirically derived survival estimates for the passage years 2013-18. The reported estimates therefore capture all sources of mortality exhibited within the migration corridor including those resulting from the existence and operation of the CRS, unquantifiable mortalities from other potential sources (e.g., indirect effects of the CRS that occur upstream of Bonneville Dam, mortalities resulting from avian or piscivorous predators, mortalities associated with the condition of hatchery fish or exposure to chemicals or pathogens, etc.) and unquantifiable levels of "natural" mortality (i.e., levels of mortality in the migratory corridor that would have occurred without human influence). Shaded cells denote ESUs that required estimates be made using other ESUs/DPSs as surrogates.

	Transported Juveniles[1]		**In-river Migrating Juveniles**	
ESU/DPS	**Percent of Juveniles Collected for Transport Average Range**	**Percent Juvenile Mortality[2] Average Range**	**Mortality Average[3] Range**	**Notes**
UCR spring Chinook salmon	NA	NA	48.1% 42.5-53.6%	Rock Island to Bonneville Dam
UCR steelhead	NA	NA	49.9% 41.9-59.2%	Rock Island to Bonneville Dam
SR fall Chinook salmon	24.3% 3.6 - 59.1%	0.58% 0.11 - 1.10%	41.8% 32.9 - 58.3%	Survival and transport % estimates use SR spr/sum Chinook salmon as surrogates
SR sockeye salmon[4]	24.3% 3.6 - 59.1%	0.58% 0.11 - 1.10%	41.8% 32.9 - 58.3%	Survival and transport % estimates use SR spr/sum Chinook salmon as surrogates
SRB steelhead	30.7% 10.5-57.0%	0.73% 0.3 - 1.2%	51.6% 38.2-72.9%	
SR spr/sum Chinook salmon	24.3% 3.6 - 59.1%	0.58% 0.11 - 1.10%	41.8% 32.9 - 58.3%	

	Transported Juveniles[1]		In-river Migrating Juveniles	
ESU/DPS	Percent of Juveniles Collected for Transport Average Range	Percent Juvenile Mortality[2] Average Range	Mortality Average[3] Range	Notes
MCR steelhead[5] Passing MCN Passing JDA Passing TDA Passing BON	NA	N/A	36.7% 26.0 – 50.7% 30.5% 21.4 - 43.2% 16.1% 11.6 - 23.2% 11.2% 8.0 - 16.4%	
UWR Chinook salmon	10 individuals	N/A	None	There is evidence that, in some years, a few adults pass upstream of Bonneville Dam.
UWR steelhead	10 individuals	N/A	None	There is evidence that, in some years, a few adults pass upstream of Bonneville Dam.
LCR Chinook salmon	N/A	N/A	8.2% 5.8-11.8%	Uses SR spr/sum Chinook salmon est. of BON survival as a surrogate

	Transported Juveniles[1]		In-river Migrating Juveniles	
ESU/DPS	Percent of Juveniles Collected for Transport Average Range	Percent Juvenile Mortality[2] Average Range	Mortality Average[3] Range	Notes
LCR steelhead	NA	N/A	11.2% 8.0 - 16.4%	Uses SRB steelhead est. of BON survival as a surrogate
LCR coho salmon	N/A	N/A	8.2% 5.8-11.8%	Uses SR spr/sum Chinook salmon est. of BON survival as a surrogate
CR chum salmon	N/A	N/A	8.2% 5.8-11.8%	Uses SR spr/sum Chinook salmon est. of BON survival as a surrogate

1The estimated proportion of fish arriving at LGR that will be collected and transported.

2 Based on the information available, NMFS continues to use 2% as a reasonable estimate of direct mortality for transported juvenile salmonids.

3 Expected mortalities of in-river migrating juvenile salmon and steelhead (1 - Inriver Survival) based on COMPASS modeling.

4Data for SR spring/summer Chinook salmon were used as surrogates for survival and transport estimates for SR sockeye salmon. The two species migrate during the same period over the same reaches of river and empirical estimates of reach survival for the two species are very similar: the 2008-2018 average LGR to BON survival (from PIT tag studies) for spring/summer Chinook salmon was 52.3%; the estimate for sockeye salmon was 53.2% (Zabel 2018). Data for 2016 and 2017 were excluded from these calculations because of the very low survival of SR sockeye salmon smolts released from the Springfield Hatchery in those years.

5 Populations of MCR steelhead enter the Columbia River from upstream of McNary Dam (Yakima and Walla Walla), John Day Dam (Umatilla and John Day), The Dalles Dam (Deschutes), and Bonneville Dam (tributaries to Bonneville pool).

2.16.1.1.3 Take of Adult Eulachon

Direct effects of the proposed action on eulachon can be estimated by looking at the available eulachon data from the downstream migrant trap at Bonneville Dam (a predecessor to the juvenile bypass system) representing a substantial fraction of the total numbers of eulachon migrating upstream of the dam. Based on a single incident in 1988, up to 95,500 adults were harmed or killed at Bonneville Dam, having passed downstream through the trap that year (NMFS 2008a). Even though no eulachon are observed at Bonneville Dam in most years there is the potential that a large return of eulachon passing upstream of Bonneville Dam could occur within the expected duration of this biological opinion. Therefore, incidental take (the number of fish passing downstream through the juvenile bypass system) shall not exceed 95,500 adult eulachon.

In addition to take at Bonneville Dam, incidental take of adult eulachon from CRS research activities will capture and handle up to 13,000 adults annually, with the potential for up to 260 fish to be killed per year during the interim period.

2.16.1.2 Amount of Incidental Take from Habitat Improvement Actions

Completion of the proposed habitat improvement activities will take place beside and within streams used for spawning and rearing and in estuarine areas used for rearing and migration by the listed ESUs/DPSs. Due to the short term adverse effects of implementing restoration activities, incidental take is reasonably certain to occur.

Take of listed salmonids resulting from habitat projects developed to implement the proposed action and authorized, funded, or carried out by BPA, that are consistent in type, design, and methods of implementation to those covered by the ESA Section 7 Formal Programmatic Biological and Conference Opinion, Letter of Concurrence, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for Bonneville Power Administration’s Habitat Improvement Program III (HIP III) (NMFS 2013b), falls within the take provisions of that biological opinion. Take resulting from projects that fall outside the explicit criteria in the HIP III Biological Opinion will require separate and subsequent consultation. NMFS authorizes no additional take of ESA-listed species in this biological opinion (beyond that previously authorized by the HIP III Biological Opinion) for the proposed habitat restoration activities.

2.16.1.3 Amount of Incidental Take from Hatchery Actions

Incidental take from hatchery actions funded as part of the proposed action is assessed in separate biological opinions for each hatchery operation plan and is included in the HGMP for the program. NMFS assumes that any HGMPs that will be submitted for ESA consultation during the interim period will include any incidental take associated with implementation of the hatchery program. Thus, no additional take of ESA-listed salmon and steelhead is authorized for hatchery projects in this opinion. The exception is the take of MCR steelhead kelts at Prosser Dam and the take of UCR steelhead kelts primarily at Winthrop NFH, Methow Hatchery and Rock Island Dam discussed in Section 2.16.1.1.1 (Take of Adult Salmon & Steelhead) because take associated with the capture, handling, and transport of these fish are not covered under any associated HGMPs.

2.16.1.4 Amount of Incidental Take from Predator Control Measures

No take (lethal or non-lethal) of salmonids is expected to result from the avian predator control measures.

Some unquantifiable, but very small, amount of take of adult SR spring/summer Chinook, UCR spring Chinook, and LCR Chinook salmon and LCR steelhead is likely to occur as a result of marine mammal deterrent measures (cracker shells and "bombs"[227]) occurring downstream of Bonneville Dam, and, if necessary, downstream of The Dalles Dam. Some individuals are likely to be harassed and a few (on the scale of individual fish) could be killed as a result implementing measures to deter marine mammal predation. In addition, some individual juveniles from ESUs/DPSs with spring migrating juveniles could be harassed or even killed as a result of implementing measures to deter marine mammal predation. It is not possible to quantify the amount of take per species because the effects cannot be observed (fish are underwater). Thus, we need to use a surrogate for the extent of take.The appropriate surrogate is implementation of the planned operation within the specific time period; there is a direct link between the intensity of the deterrent measures in the plan and the number of fish that are harmed or killed. Incidental take will not be exceeded if these deterrence operations take place within the August 1st to May 31st time period each year.

Listed salmonids will also be taken during implementation of the Sport Reward Fishery and Dam Angling portions of the NPMP. Based on numbers of fish handled and/or killed during 2013-17, the Sport Reward Fishery will handle up to 100 each of adult Chinook salmon (including jacks), steelhead, and coho salmon and up to ten each of adult chum and sockeye salmon from all ESUs/DPSs combined.The Sport Reward Fishery will also handle and/or kill up to 200 juvenile Chinook salmon, 600 steelhead, and 100 each of juvenile coho, chum, and sockeye salmon. These fish cannot be identified to the ESU or DPS level. The Dam Angling Program will handle and/or kill up to ten each of adult Chinook salmon and steelhead, up to five adult sockeye salmon, and zero adult coho or chum salmon. Dam anglers will also handle and/or kill up to 20 each of juvenile Chinook and sockeye salmon and steelhead and zero juvenile coho or chum salmon.

[227] "Bombs" are small explosive charges that are detonated underwater.

2.16.1.5 Amount or Extent of Incidental Take from RM&E Actions

This section identifies the amount or extent of incidental take anticipated under this opinion for RM&E actions.

The CRS Action Agencies, or their contractors, propose to implement the following RM&E actions:

1. Monitor the status of selected fish populations related to CRS actions;
2. Monitor performance and adaptive management related to Hydropower Operations;
3. Monitor performance and adaptive management related to Tributary Habitat Improvement Actions;
4. Monitor performance and adaptive management related to Estuary Habitat Improvement Actions;
5. Monitor performance and adaptive management related to Hatchery Actions;
6. Monitor performance and adaptive management related to Predation Management Actions;
7. Track Project compliance, implementation and effectiveness through monitoring programs and projects.

Many of these RM&E actions will result in short-term adverse impacts on listed salmonids. The primary adverse effects the proposed monitoring activities will have on listed species will be in the form of incidental take caused by observing, capturing, and handling fish, which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to breeding, feeding, or sheltering.

Tables 2.16-3 through 2.16-6 specify, by type of RM&E activity, the amount of take of adult and juvenile salmon and steelhead and eulachon anticipated. Sublethal take includes observation, capture, handling, measurement, collection of samples, tagging, and other activities which have some negative effect on the fish without causing death. Incidental mortalities are unintentional fish deaths which occur during the normal course of the study.

For the electrofishing component (biological monitoring) of the NPMP, incidental take will not be exceeded if operations total up to 550 hours per year at a rate of 15 minutes per km on each side of the river between RM 47 and Priest Rapids Dam in the Columbia River and up to RM 159 in the Snake River and 15 min per 0.31-mile transect in the lower Columbia River. Because the operator releases the electrical field as soon as salmonids are observed and most of these fish quickly move out of the field of view, we are unable to use observations from past operations to estimate the number of fish that will be affected. The area and rate of electrofishing are measures of the intensity of the exposure of adult and juvenile salmonids to the electrical field and are quantifiable surrogates that may be monitored.

Table 2.16-3. Average annual estimates of non-lethal take (i.e., handling, including injury) and incidental mortality associated with implementation of the Smolt Monitoring Program (including Corps monitoring at Ice Harbor Dam) and the Comparative Survival Study as a percent of recent run size estimates (2013-17; Bellerud 2018). Incidental mortality is added to (not a subset of) non-lethal take.

	Smolt Monitoring Program and Comparative Survival Study									
	ESU/DPS		Adult				Juvenile			
			Hatchery		Wild		Hatchery		Wild	
			Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality
Upper Columbia	UCR spring Chinook	Number	0	1	1	1	177,985	5,866	11,904	169
		% of run	0.00%	0.01%	0.02%	0.00%	17.86%	0.59%	2.51%	0.04%
	UCR steelhead	Number	0	1	1	1	13,888	842	35,396	985
		% of run	0.00%	0.01%	0.01%	0.01%	1.73%	0.10%	20.09%	0.56%
Snake River	SR fall Chinook	Number	5	0	0	0	356,087	6,051	125,167	4,147
		% of run	0.01%	0.00%	0.00%	0.00%	6.82%	0.12%	18.35%	0.61%
	SR sockeye	Number	5	0	0	0	8,381	293	3,768	133
		% of run	0.19%	0.00%	0.00%	0.00%	4.38%	0.15%	19.09%	0.67%
	SRB steelhead	Number	5	0	5	0	37,883	611	28,279	855
		% of run	0.00%	0.00%	0.01%	0.00%	0.93%	0.01%	4.15%	0.13%

	Smolt Monitoring Program and Comparative Survival Study									
	ESU/DPS		Adult				Juvenile			
			Hatchery		Wild		Hatchery		Wild	
			Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality
	SR spr/sum Chinook	Number	5	0	5	0	91,187	2,447	52,039	2,090
		% of run	0.01%	0.00%	0.02%	0.00%	1.67%	0.04%	3.76%	0.15%
Mid-Columbia	MCR steelhead	Number	0	0	0	0	1,000	10	23,495	266
		% of run	0.00%	0.00%	0.00%	0.00%	0.22%	0.00%	5.63%	0.06%
Lower Columbia	LCR Chinook	Number	0	0	0	0	0	0	9,093	896
		% of run	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.07%	0.01%
	LCR steelhead	Number	0	0	0	0	0	0	0	0
		% of run	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	LCR coho	Number	0	0	0	0	0	0	2000	107
		% of run	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.31%	0.02%
	CR chum	Number	0	0	0	0	0	0	500	10
		% of run	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%

	Smolt Monitoring Program and Comparative Survival Study									
	ESU/DPS		Adult				Juvenile			
			Hatchery		Wild		Hatchery		Wild	
			Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality
Other	Eulachon	Number	NA		1,000	0	NA			
		% of run			< 0.001%	NA				

Table 2.16-4. Average estimates of non-lethal take (i.e., handling, including injury) and incidental mortality associated with implementation of Fish Status Monitoring as a percent of recent run size estimates (2013-17; Bellerud 2018). Fish status monitoring is intended to include individuals handled/killed during status and trend, “fish-in”/”fish-out,” and habitat effectiveness monitoring projects. Incidental mortality is added to (not a subset of) non-lethal take.

	Fish Status Monitoring									
			Adult				Juvenile			
			Hatchery		Wild		Hatchery		Wild	
	ESU/DPS		Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality
Upper Columbia	UCR spring Chinook	Number	0	0	0	0	26,787	268	16,144	161
		% of run	0.00%	0.00%	0.00%	0.00%	2.69%	0.03%	3.40%	0.03%
	UCR steelhead	Number	0	0	0	0	9,002	90	12,692	127
		% of run	0.00%	0.00%	0.00%	0.00%	1.12%	0.01%	7.20%	0.07%
Snake River	SR fall Chinook	Number	4588	46	1,297	13	0	0	0	0
		% of run	7.10%	0.07%	9.50%	0.10%	0.00%	0.00%	0.00%	0.00%
	SR sockeye	Number	210	2	0	0	0	0	0	0
		% of run	7.85%	0.07%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	SRB steelhead	Number	23,371	234	11,479	115	22,103	221	45,762	458
		% of run	20.57%	0.21%	22.14%	0.22%	0.54%	0.01%	6.71%	0.07%
		Number	14,304	143	4600	46	63,761	638	50,319	503

	Fish Status Monitoring									
	ESU/DPS		Adult				Juvenile			
			Hatchery		Wild		Hatchery		Wild	
			Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality
	SR spr/sum Chinook	% of run	14.44%	0.14%	18.96%	0.19%	1.17%	0.01%	3.64%	0.04%
Mid-Columbia	MCR steelhead	Number	100	1	1200	12	8,613	86	43,642	436
		% of run	0.43%	0.00%	4.66%	0.05%	1.90%	0.02%	10.46%	0.10%
Lower Columbia	LCR Chinook	Number	0	0	0	0	0	0	0	0
		% of run	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	LCR steelhead	Number	0	0	0	0	0	0	0	0
		% of run	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	LCR coho	Number	0	0	0	0	0	0	0	0
		% of run	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	CR chum	Number	0	0	0	0	0	0	0	0
		% of run	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table 2.16-5. Average annual estimates of non-lethal take (i.e., handling, including injury) and incidental mortality associated with implementation of other RM&E activities [other than the Smolt Monitoring Program/Comparative Survival Study and Fish Status Monitoring] as a percent of recent run size estimates (2013-17; Bellerud 2018). Incidental mortality is added to (not a subset of) non-lethal take.

	Other Research, Monitoring and Evaluation									
	ESU/DPS		Adult				Juvenile			
			Hatchery		Wild		Hatchery		Wild	
			Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality
Upper Columbia	UCR spring Chinook	Number	95	1	1,754	18	38,901	389	13,822	138
		% of run	0.50%	0.01%	37.00%	0.00%	3.90%	0.04%	2.91%	0.03%
	UCR steelhead	Number	210	2	78	1	3,703	37	10,207	102
		% of run	2.23%	0.02%	0.97%	0.01%	0.46%	0.00%	5.79%	0.06%
Snake River	SR fall Chinook	Number	143	1	307	3	1,412,639	14,126	389,947	3,899
		% of run	0.22%	0.00%	2.25%	0.02%	27.04%	0.27%	57.16%	0.57%
	SR sockeye	Number	337	3	0	1	55,294	553	5,698	57
		% of run	12.60%	0.11%	0.00%	0.09%	28.91%	0.29%	28.87%	0.29%
	SRB steelhead	Number	1,519	15	387	4	303,326	3,033	64,356	644
		% of run	1.34%	0.01%	0.75%	0.01%	7.41%	0.07%	9.43%	0.09%

	ESU/DPS		Other Research, Monitoring and Evaluation							
			Adult				Juvenile			
			Hatchery		Wild		Hatchery		Wild	
			Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality
	SR spr/sum Chinook	Number	447	4	144	1	361,831	3,618	124,801	1,248
		% of run	0.45%	0.00%	0.59%	0.00%	6.63%	0.07%	9.02%	0.09%
Mid-Columbia	MCR steelhead	Number	720	7	200	2	1,001	10	15,308	153
		% of run	3.10%	0.03%	0.78%	0.01%	0.22%	0.00%	3.67%	0.04%
Lower Columbia	LCR Chinook	Number	868	9	47	1	99,937	999	114,575	1,146
		% of run	2.48%	0.03%	0.04%	0.00%	0.29%	0.00%	0.94%	0.01%
	LCR steelhead	Number	80	1	128	1	4,558	46	277	3
		% of run	0.34%	0.00%	0.78%	0.01%	0.37%	0.00%	0.09%	0.00%
	LCR coho	Number	998	10	626	6	111,169	1,112	15,795	158
		% of run	5.25%	0.05%	1.77%	0.00%	1.46%	0.01%	2.47%	0.02%
	CR chum	Number	17	1	398	4	43,532	871	856,468	17,129
		% of run	2.96%	0.17%	2.26%	0.02%	6.65%	0.13%	15.97%	0.32%

	Other Research, Monitoring and Evaluation									
	ESU/DPS		Adult				Juvenile			
			Hatchery		Wild		Hatchery		Wild	
			Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality
Willamette	UWR Chinook	Number	174	2	149	1	29,910	299	14,213	142
		% of run	0.55%	0.01%	2.35%	0.02%	2.34%	0.02%	0.26%	0.00%
	UWR steelhead	Number	73	1	62	1	923	9	1,323	13
		% of run	3.05%	0.04%	3.29%	0.05%	0.51%	0.00%	0.92%	0.01%
Other	Eualchon	Number	NA		1,000	0	NA			
		% of run			< 0.001%	NA				

Table 2.16-6. Average annual estimates of all non-lethal take (i.e., handling, including injury) and incidental mortality associated with implementation of the Smolt Monitoring Program/Comparative Survival Study, Fish Status Monitoring, and other types of RM&E considered in this opinion as a percent of recent run size estimates (2013-17; Bellerud 2018). Incidental mortality is added to (not a subset of) non-lethal take.

	Grand Total									
	ESU/DPS		Adult				Juvenile			
			Hatchery		Wild		Hatchery		Wild	
			Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality
Upper Columbia	UCR spring Chinook	Number	95	2	1,755	19	243,673	6,523	41,870	468
		% of run	0.50%	0.01%	37.03%	0.40%	24.45%	0.65%	8.83%	0.10%
	UCR steelhead	Number	210	3	79	2	26,593	969	58,295	1,214
		% of run	2.23%	0.03%	0.98%	0.02%	3.32%	0.12%	33.08%	0.69%
Snake River	SR fall Chinook	Number	4,736	47	1,604	16	1,768,726	20,177	515,114	8,046
		% of run	7.32%	0.07%	11.75%	0.12%	33.86%	0.39%	75.50%	1.18%
	SR sockeye	Number	552	5	0	1	63,675	846	9,466	190
		% of run	20.64%	0.19%	0.00%	0.09%	33.29%	0.44%	47.97%	0.96%
	SRB steelhead	Number	24,895	249	11,871	119	363,312	3,865	138,397	1,957
		% of run	21.91%	0.22%	22.90%	0.23%	8.87%	0.09%	20.29%	0.24%
		Number	14,756	147	4,749	47	516,779	6,703	227,159	3,841

	Grand Total									
	ESU/DPS		Adult				Juvenile			
			Hatchery		Wild		Hatchery		Wild	
			Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality
	SR spr/sum Chinook	% of run	14.90%	0.15%	19.57%	0.19%	9.46%	0.12%	16.42%	0.28%
Mid-Columbia	MCR steelhead	Number	820	8	1,400	14	10,614	106	82,445	855
		% of run	3.53%	0.03%	5.44%	0.05%	2.34%	0.02%	19.76%	0.20%
Lower Columbia	LCR Chinook	Number	868	9	47	1	99,937	999	123,668	2,042
		% of run	2.48%	0.03%	0.04%	0.00%	0.29%	0.00%	1.02%	0.02%
	LCR steelhead	Number	80	1	128	1	4,558	46	277	3
		% of run	0.34%	0.00%	0.78%	0.01%	0.37%	0.00%	0.09%	0.00%
	LCR coho	Number	998	10	626	6	111,169	1,112	17,795	265
		% of run	5.25%	0.05%	1.77%	0.00%	1.46%	0.01%	2.78%	0.04%
	CR chum	Number	17	1	398	4	43,532	871	856,968	17,139
		% of run	2.96%	0.17%	2.26%	0.02%	6.65%	0.13%	15.98%	0.32%

	Grand Total									
	ESU/DPS		Adult				Juvenile			
			Hatchery		Wild		Hatchery		Wild	
			Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality	Non-lethal Take	Incidental Mortality
Willamette	UWR Chinook	Number	174	2	149	1	29,910	299	14,213	142
		% of run	0.55%	0.01%	2.35%	0.02%	0.54%	0.01%	1.11%	0.01%
	UWR steelhead	Number	73	1	62	1	923	9	1,323	13
		% of run	3.05%	0.04%	3.29%	0.05%	0.51%	0.00%	0.92%	0.01%
Other	Eualchon	Number	NA		2,000	0	NA		NA	
		% of run			< 0.001%	NA				

2.16.2 Effect of the Take

In this biological opinion, NMFS has determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to jeopardize the continued existence of the affected species or result in the destruction or adverse modification of critical habitat.

2.16.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" are non-discretionary measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR 402.02).

The following reasonable and prudent measures and terms and conditions are necessary and appropriate to: (1) minimize the impacts of incidental take associated with the proposed CRS operation and maintenance and (2) minimize the impacts of take associated with monitoring and evaluation activities.

1. **CRS operations and maintenance.** The CRS Action Agencies shall reduce the level of take from proposed CRS operation and maintenance of the CRS by implementing the measures specified in Section 2.16.4 to reduce take of juveniles and adults.
    a) The CRS shall ensure that the incidental take of adult and juvenile migrants and mainstem spawning is minimized through the implementation of measures specified in Section 2.16.4.
2. **Tributary and Estuary Habitat Improvement.** The CRS Action Agencies shall ensure that take is minimized by demonstrating that proposed habitat improvement actions are being implemented as expected and that the effects of the actions are occurring as expected by reporting on implementation as outlined below in Section 2.16.4 and by completing and implementing a habitat RM&E strategy for the geographic scope encompassed in the proposed action.
3. **Predator Management.** The Corps and BPA shall continue to implement the proposed management of the Caspian tern colony on East Sand Island (reduce smolt predation rates).
4. **RM&E.** The CRS Action Agencies (or their designated contractors conducting the research) shall monitor the level of take of ESA listed species (salmonids and eulachon) associated with specific RM&E actions and will report the observed take to NMFS's designated CRS take determination coordinator no later than six months after the completion of the RM&E action (i.e., when fieldwork has been completed).
    a) The CRS Action Agencies shall minimize the level of take resulting from the proposed hydrosystem RM&E actions.
    b) The CRS Action Agencies shall minimize the level of take resulting from proposed habitat and hatchery RM&E actions.

c) The CRS Action Agencies shall reduce take by coordinating research and monitoring activities with other funding and implementing agencies to ensure that necessary data is being collected in a manner that minimizes impacts on listed species. Coordination includes following standardized collection protocols and data sharing. This will reduce take by reducing the potential numbers of fish needed to perform similar research activities.

5. **Monitoring and Implementation Reports.** To better understand how to minimize take from activities associated with hydrosystem operations and improve effectiveness of take minimization activities on fish, the CRS Action Agencies will maintain and report information related to implementation of the proposed action. This information supports adaptive management and revision of operations based on information learned. The required information includes take monitoring reports, implementation plans, and implementation progress reports, as outlined in more detail below. This information will help NMFS determine if the proposed action is being implemented as identified in this opinion or, conversely, if re-initiation triggers defined in 50 CFR 402.16 have been exceeded.

2.16.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and the Action Agencies or any applicant must comply with them in order to implement the RPMs (50 CFR 402.14). The Action Agencies or any applicant have a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this ITS (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse.

1. **CRS Operations and Maintenance Actions**. To implement reasonable and prudent measure #1, the CRS Action Agencies shall implement the measures below to minimize take from proposed CRS operation and maintenance:

a) Evaluate Adult Reach Survivals

- The CRS Action Agencies shall annually estimate adult survival through key reaches of the migration corridor (Bonneville to Lower Granite dam for Snake River species and Bonneville to McNary Dam for Upper Columbia and Middle Columbia River species) in accordance with the PIT-tag conversion rate methodology used in this Opinion, compare averages of the resulting annual mortality estimates (1-survival) to the values reported in Table 2.16-1, and inform NMFS of the results of this comparison. This will minimize take by identifying potential problem areas within the adult migration corridor and allow for potential changes to configurations or operations to benefit the species.

b) Evaluate Juvenile Reach Survivals

- The CRS Action Agencies will annually estimate juvenile migrant survival through key reaches of the migration corridor in accordance with the methods used in this opinion.

- The CRS Action Agencies, in coordination with NMFS through the annual planning process, will also continue to support and fund the monitoring of wild juvenile Snake River fall Chinook salmon survival, growth, and life history attributes and will investigate the feasibility of estimating the survival of transported and in-river migrating juvenile SR sockeye salmon and capitalize on opportunities to conduct these survival studies if feasible. These items will reduce take by identifying configuration and operation measures that may benefit the species on their migration through the CRS or by improving the survival of transported juveniles (or ESUs / DPSs as a whole).

c) Monitor Smolt-to-Adult Returns of Transported and Inriver Migrating Fish

- The Corps and BPA shall continue ongoing transport survival studies for juvenile migrants passing Lower Granite, Little Goose, and Lower Monumental dams. Updated annual SAR estimates (and daily or weekly estimates if the data allow) for each transported species and their inriver counterparts shall be included in the annual progress reports or by other mutually agreed upon means. This will reduce take by providing the CRS Action Agencies with information to further refine transport operations to optimize operations for Snake River spring and summer migrating fish to improve the survival of transported juveniles (or ESUs / DPSs as a whole).

d) Monitor Effects of Dissolved Gas Supersaturation

- The CRS Action Agencies shall contribute to regional efforts to monitor the levels of TDG and associated biological impacts in the lower Snake and Columbia Rivers. This annual program will include water quality monitoring and will be developed and implemented in coordination with the Water Quality Team (WQT) and the mid-Columbia PUDs. The TDG pressure and percent saturation, water temperature, and barometric pressure will be sampled on an hourly basis and shared with resource agencies on a real-time basis. This will reduce take by ensuring that juvenile and adult fish have sufficient levels of both spill and water quality for migrating through the CRS.
- The water quality sampling methodology should include monitoring TDG levels throughout the Columbia River basin in river reaches. A comprehensive monitoring plan includes monitoring TDG levels in locations in coordination with the WQT for each project in critical reaches. This program will also include a QA/QC component conforming to the Data Quality Criteria developed by the Corps in coordination with the WQT. This data quality control system will involve frequent calibration and maintenance of water quality equipment, daily screening of real time data, and archival storage in a Corps' online database. The QA/QC components will be reviewed annually and modified as improved information and techniques become

available. The CRS Action Agencies will conduct an annual QA/QC conference in coordination with the WQT. The biological monitoring components will include smolt monitoring at selected smolt monitoring locations and hourly/daily TDG data collection and reporting.

e) Reduce Take Associated with Elevated Pinniped Predation Near Bonneville Dam Fish Ladder Entrances

- The available information indicates that the exposure of adult salmon and steelhead to sea lion predation is exacerbated by dams. At Bonneville Dam, many adult salmonids experience delay as they attempt to navigate through fishway entrances increasing pinniped predation exposure. Past dam hazing efforts were primarily limited to the spring period when California sea lions were present. In recent years, increasing numbers of Steller sea lions have been hauling out at Bonneville Dam in the fall and winter and are feeding unabated near fish ladder entrances on steelhead, coho, and fall Chinook ESU's. While hazing has had limited effectiveness compared to removals, the available information indicates dam hazing does temporarily push pinnipeds away from entrances where they are most effective at consuming and delaying adult salmon and steelhead. Steller sea lions are more responsive to hazing efforts than California sea lions, and effective hazing could reduce removals of the recently delisted Steller sea lions. To reduce salmonid take associated with sea lion predators taking advantage of the dam and ladder entrance configuration, the Action Agencies shall implement the following measures:
    - The Corps shall fund and support dam hazing and dissuasion efforts to effectively reduce take of adult salmon and steelhead at Bonneville Dam. Dam hazing shall be focused on minimizing the amount of time that individual sea lions spend near ladder entrances. Hazing and dissuasion shall be supportive of pinniped removal efforts and cover the period from August 1 to May 31 or whenever California and Steller sea lions are effectively consuming ESA-listed salmonids at Bonneville Dam. The Action Agencies may reduce dam-based hazing effort from August 1 to March 1 as necessary to implement a study in coordination with NOAA that evaluates the effectiveness of Steller sea lion hazing and dissuasion.
    - The Corps shall opportunistically haze pinnipeds observed in the vicinity of fishladder entrances at The Dalles Dam.

f) Offseason Surface Spill for Downstream Passage of Adult MCR Steelhead at McNary Dam

- The proposed evaluation of offseason surface spill (24 hours per week) as a means of providing safe and effective downstream passage for adult steelhead at McNary Dam should also reduce incidental take associated with MCR steelhead that overshoot and then migrate back downstream through McNary Dam (primarily steelhead populations from the John Day and Umatilla Rivers) during months when there is no scheduled spill (e.g., September-October and February-March as proposed).

g) Implement and Report On Adult Kelt Passage and Reconditioning Efforts

- The CRS Action Agencies will, in coordination with NMFS and regional processes, implement the necessary measures (collection, transport, or reconditioning of kelts, or a combination thereof) consistent with existing kelt management plans to enhance selected UCR and MCR steelhead. This will reduce take by reducing high kelt mortality rates (from both mainstem passage and natural causes) and increase the survival and productivity of the targeted populations/MPGs.
  - The CRS Action Agencies will coordinate annually with NMFS and co-managers to report the number of kelts collected, transported to reconditioning facilities, and surviving at the reconditioning facilities.
  - The CRS Action Agencies will coordinate with NMFS and co-managers to provide estimates of the number of reconditioned kelts released into targeted tributaries (populations) or basins (MPGs) to spawn.

h) Reduce take associated with the implementation of the Northern Pikeminnow Management Program

- Available information indicates that relatively high numbers of ESA listed salmonids are incidentally encountered and recorded as take while electrofishing during implementation of the NPMP. To further reduce take associated with the NPMP, the Action Agencies shall implement the following measures:
  - Evaluate the feasibility of using improved electrofishing methods, reduced electrofishing duration, or other changes to the program to meet the biological monitoring and pikeminnow exploitation goals while substantially reducing take of ESA listed salmonids.
  - Fund update of northern pikeminnow exploitation and consumption models using best available information including a range of estimated inter and intra-specific compensation, as needed, to more accurately estimate the predation-reduction benefits of the NPMP.

i) Fish Status and Trend Monitoring

- To better understand how to minimize take from activities associated with hydrosystem operations and improve effectiveness of take minimization activities on fish, the Action Agencies shall continue monitoring the status of listed salmonids that are affected by the operation of the CRS:
  - The CRS Action Agencies shall support continued fish population status and trend monitoring where ongoing status and trend programs are located and linked to overall population viability assessments. Support assessing adult abundance

monitoring in tributaries as a component of fish population status and trend monitoring in as many populations as possible.

- The CRS Action Agencies shall continue to advance the deployment, development and testing of new and emerging tools, techniques and methods that assist with status and trend monitoring such as GSI and PBT.
- The CRS Action Agencies shall improve the distribution and quantity of steelhead monitoring throughout the basin.

2. **Tributary Habitat Activities**. To implement reasonable and prudent measure #2, the CRS Action Agencies shall demonstrate that proposed tributary habitat improvement actions are being implemented as expected and that the effects of the actions are occurring as expected by reporting on implementation as outlined below and by completing and implementing a habitat RM&E strategy for the geographic scope encompassed in the proposed action:
   - Compliance and Implementation. The CRS Action Agencies shall conduct and support tributary habitat action compliance and implementation monitoring in priority tributaries where actions are implemented during the period of this biological opinion to assist in measuring and evaluating the benefits of off-site actions.
   - Effectiveness. The CRS Action Agencies shall support effectiveness monitoring at both the site and watershed scales in priority tributaries where habitat actions are implemented during the period of this biological opinion and in tributaries where previous actions have been undertaken to assist in measuring and evaluating the benefits of off-site actions.
   - Coordination. The CRS Action Agencies shall work with NMFS and the region's fish and wildlife managers, through the Columbia Basin RM&E steering committee, to develop the Columbia Basin Tributary Habitat Research Monitoring and Evaluation Strategy including prioritizing the watersheds for continued and new Intensively Monitored Watersheds and paired fish population status and trend monitoring and 'fish in/out" monitoring to assist in measuring and evaluating the benefits of off-site actions.
   - Reporting. The CRS Action Agencies shall report on the results of the compliance, implementation, effectiveness monitoring, and paired habitat with "fish in/fish out" and fish population status and trend monitoring.

3. **Predator Management.** To implement reasonable and prudent measure #3, the Corps and BPA shall continue to evaluate the effectiveness of the proposed management of the Caspian tern colony on East Sand Island in reducing smolt predation rates by implementing the following measure:

   a) The Corps and BPA shall continue to fund PIT-tag recoveries, PIT-tag detection probabilities, and other activities needed to estimate per capita predation rates for terns nesting at this colony during the interim period, unless a predictive per capita predation rate analysis can predict future predation rates with the same precision and potential bias as empirically derived rates.

4. **RM&E.** To implement reasonable and prudent measure #4, the CRS Action Agencies (or their designated contractors conducting the research) shall implement the following to minimize the level of take associated with RM&E activities:

   a) The Action Agencies shall minimize take by coordinating research and monitoring activities with other funding and implementing agencies to ensure that necessary data is being collected in a manner that minimizes impacts on listed species.

      - The CRS Action Agencies shall continue to support efforts pertaining to the coordination of monitoring efforts including standardization of collection protocols and data sharing.
      - The CRS Action Agencies shall continue to support monitoring and coordination forums and other efforts that the region's tribes, state, other federal agencies, NGOs and other entities participate in to coordinate monitoring actions.

   b) The CRS Action Agencies shall implement "fish in/fish out" monitoring for focal populations where it is important to link habitat actions and their effectiveness with fish productivity and survival.

   c) The Action Agencies minimize the level of take resulting from the proposed hydrosystem RM&E actions by implementing the following measures:

      Fish listed under the ESA must be handled with extreme care and kept in water to the maximum extent possible during sampling and processing. Adequate circulation and replenishment of water in holding units is required. When using gear that captures a mix of species, ESA-listed fish must be processed first, to the extent possible, to minimize the duration of handling stress. ESA-listed fish must be transferred using a sanctuary net (which holds water during transfer) whenever practical to prevent the added stress of being out of water. Should NMFS determine that a researcher's procedure is no longer acceptable; the researcher must immediately cease such activity until an acceptable alternative procedure can be developed with NMFS.

      - Researchers must not intentionally kill or cause to be killed any listed species unless a specific monitoring or evaluation proposal, approved by NMFS, specifically allows intentional lethal take.
      - Each researcher must ensure that the ESA-listed species are taken only by the means, in the areas, and for the purposes set forth in the research proposal, as limited by the terms and conditions.
      - Each ESA-listed fish handled out of water must be anesthetized to prevent injury.
      - Anesthetized fish must be allowed to recover (e.g., in a recovery tank) before being released. Fish that are simply counted but not handled must remain in water, but do

not have to be anesthetized. Whenever possible, unintentional mortalities of ESA-listed fish that occur during scientific research and monitoring activities shall be used in place of intentional lethal take.

- Workers must use a sterilized needle for each individual injection when PIT tags are inserted into listed fish.
- Each researcher, in effecting the take authorized by this incidental take statement and through NMFS's Take Determination letters, is considered to have accepted the terms and conditions of this incidental take statement and any additional terms or conditions required by NMFS's Take Determination letters.
- Each researcher is responsible for the actions of any individual operating under the authority of the researcher's designated take authorization.
- Each researcher, staff member, or designated agent acting on the researcher's behalf must possess a copy of the incidental take statement in this opinion and the NMFS authorizing take determination letter.
- Researchers may not transfer or assign incidental take included within this determination to any other person(s), as person is defined in Section 3(12) of the ESA. The take authorization ceases to be in force or effective if transferred or assigned to any other person without prior authorization from NMFS.
- Each researcher must obtain any other federal, state, and local permits or authorizations necessary to conduct the activities provided for in this incidental take statement.
- Each researcher must coordinate with other applicable co-managers and researchers to avoid unnecessarily duplicating effort and increasing the adverse cumulative effects that may result from the researcher's activities.
- NMFS reserves the right to inspect research activities as they occur. This may include observation or review of research activities, facilities, records, etc. pertaining to ESA-listed species covered by this determination, the incidental take statement or the biological opinion.
- Any researcher violating any applicable condition of this incidental take statement will be subject to any and all penalties as provided by the ESA. NMFS may revoke a researcher's authorization for any activities not conducted in compliance with the requirements of the ESA.
- Each researcher is responsible for biological samples collected from ESA-listed species as long as they are useful for research purposes. The terms and conditions concerning any samples collected remain in effect as long as the researcher maintains authority over and responsibility for the material taken. A researcher may not transfer biological samples to anyone not listed in the research proposal without obtaining prior written approval from NMFS. Any such transfer will be subject to such

conditions as NMFS deems appropriate.

- NMFS may amend a take authorization identified in this incidental take statement or adjust specific take levels after reasonable notice to the applicable researcher.
- If the activities authorized in this incidental take statement are not carried out in accordance with its terms and conditions and the purposes and requirements of the ESA, or if NMFS otherwise determines that the continuation of activities would operate to the disadvantage of ESA-listed species, NMFS may revoke a take authorization identified in this incidental take statement.

d) The Action Agencies shall minimize the level of take resulting from proposed habitat, hatchery, and status RM&E actions by implementing, in addition to those applicable measures in 4.b., the following measures:

- The CRS Action Agencies must obtain NMFS's review and approval of any monitoring and evaluation plans before initiating any research-related activities. These plans must identify annual anticipated take levels.
- Workers must stop handling listed juvenile fish if the water temperature exceeds 70° F at the capture site. Under these conditions, listed fish may only be visually identified and counted. Additionally, electrofishing is not permitted if the instantaneous water temperature exceeds 64° F.
- If workers incidentally capture any listed adult fish while sampling for juveniles, the adult fish must be released without further handling and such take must be reported.
- If backpack electrofishing methods are used, workers must comply with NMFS' Guidelines for Electrofishing (NMFS 2000) available at http://www.westcoast.fisheries. noaa.gov/publications/reference_documents/esa_refs/section4d/electro2000.pdf.
- Electrofishing is not permitted if listed adult salmon or steelhead are known to be present. Any listed adult salmon or steelhead encountered while electrofishing are considered take, even if it is allowed to swim away without any further interaction or handling, and must be reported as such in the annual report.
- The CRS Action Agencies must obtain approval from NMFS before changing sampling locations or research protocols.
- Implement the following measures when implementing escapement / redd surveys:
    - Except for escapement (redd) surveys, no in-water work will occur within 300 feet of spawning areas during anadromous fish spawning and incubation times.
    - Persons conducting redd surveys will be trained in redd identification, likely redd locations, and methods to minimize the likelihood of stepping on redds or delivering fine sediment to redds.

    - Workers will avoid redds and listed spawning fish while walking within or near stream channels to the extent possible. Researchers will examine pool tail outs and low-gradient riffles for clean gravel and characteristic shapes and flows before walking or snorkeling through these areas.
    - If redds or listed spawning fish are observed at any time, workers will step out of the channel and walk around the habitat unit on the bank at a distance from the active channel.
  - Snorkel surveys will follow a statistically valid sampling design.
  - Researchers will minimize effects on any given stream or riparian buffer area by avoiding numerous repeat visits to sampled sites to the degree practicable.

5. **Monitoring Reports, Implementation Plans and Reports, and Monitoring Plans**. To implement reasonable and prudent measure #5, the CRS Action Agencies shall submit monitoring reports, implementation plans and implementation progress reports.

   Incidental take monitoring reports:

   a) It is not possible to monitor the incidental take of eulachon exposed to the hydrosystem operations. The Action Agencies will report numbers of adult eulachon observed in samples from the juvenile bypass system at Bonneville Dam, and will provide this number to NMFS on an annual basis (within the calendar year).

   b) Annual monitoring reports for all RM&E programs identified in this incidental take statement shall be submitted using the Authorization and Permits for Protected Species (APPS) online reporting system (https//apps.nmfs.noaa.gov) or other reporting system as designated by NMFS. This is to be completed within six months from when fieldwork has been completed.

   c) The Corps and BPA shall continue to evaluate the effectiveness of the proposed management of the Caspian tern colony on East Sand Island in reducing smolt predation rates.

   d) For the NPMP, reported take of listed salmon, steelhead, and eulachon shall include, to the extent practicable for each element of the program (e.g., Sport Reward Fishery, Dam Angling Program, and biological monitoring including electrofishing):

      - Numbers of each species (Chinook, coho, chum, or sockeye salmon, steelhead, eulachon, green sturgeon) encountered, handled, or killed
      - Status of adipose fin for salmonids (clipped or unclipped)
      - Life stage (adult, jack, or juvenile)
      - Method of take (e.g., hook and line, electrofishing)
      - Location (e.g., dam, reservoir; or "Lower Columbia below Bonneville Dam," "Middle Columbia River above McNary Reservoir," or "Snake River above Lower

Granite Reservoir")

- o Week, if practicable, or month and year
- o For electrofishing, hours and miles by reach and week/year
- o Reports for each field season shall be submitted by February 1st of the following year, or NMFS may suspend this take coverage

Implementation Plans:

a) The Action Agencies shall submit to NMFS implementation plans that detail commitments for hydrosystem, tributary and estuary habitat improvements, hatchery actions, predator management, and RM&E. These can be formal plans, a report, or in the form of other materials, including email, that describe expected activities in adequate detail:

- Annual Fish Passage (including Fish Operations) and Water Management Plans for hydrosystem structures and operations (no later than March 31 for spring migrants or June 15 for summer migrants)
- Annual Total Dissolved Gas Report (no later than January 31 of the year following implementation).
- A Tributary Habitat Implementation Plan, including actions to be implemented and monitoring to be implemented during 2019 and, to the extent possible, in 2020 (no later than May 15, 2019). (Information on 2020 and any future years under this biological opinion may be supplemented as additional detail becomes available.)
- The CEERP's Restoration and Monitoring Plan (no later than May 15th each year)
- Avian Predation Management and Monitoring Plan (provide lists of actions including monitoring by bird species and location no later than January 31, 2020)
- Northern Pikeminnow Management and Monitoring Plan (provide lists of actions including monitoring no later than January 31, 2020)
- Pinniped Management and Monitoring Plan (no later than April 15, 2019, and March 1, 2020)
- Fish Status RM&E Plan (identify populations / water bodies that will be sampled no later than May 15 each year)

The implementation plans or alternative materials will take into account pertinent new information from past years' monitoring as well as new information on the effects of climate change on limiting factors with the potential to affect project priorities.

Implementation Progress Reporting (These can be formal plans, a report, or in the form of other materials, including email, that describe expected activities in adequate detail):

a) The Action Agencies shall report to NMFS by February 2020, on the progress of action implementation, beginning with 2019 spring operations. Implementation progress reporting shall include standard information on the progress of hydrosystem operations, predator management programs, estuary habitat actions, and tributary habitat actions. Progress reports can be formal reports, or in the form of other materials, including email, that describe expected activities in adequate detail, and can also be submitted as part of the biological assessment for the next CRS biological opinion.

b) The Action Agencies should monitor TDG levels in representative raceways and barges to assess the effect of increased TDG levels resulting from proposed flexible spill operations to ensure that transported juveniles are being safely collected and transported.

c) Reporting on tributary habitat improvement actions shall provide adequate information to evaluate the tributary habitat program, including adequate inputs for future life-cycle modeling and for qualitative evaluation of the program's implementation and effectiveness. Reporting shall include the following information for each action implemented, unless these requirements are modified through discussion with and concurrence by NMFS:

- Location and extent of action: Provide GPS coordinates for midpoint, start, and endpoint of action. For barrier remediation, provide point of barrier and extent of benefits from the action; for flow actions, provide location of input and extent of the stream benefits from the action.
- Action category: Provide action category using the standard categories used in the 2008 FCRPS biological opinion and its 2010 and 2014 supplements: flow enhancement/protection; habitat complexity; riparian area restoration; access; screening. (A single action may address more than one category.)
- Action description: Provide a brief narrative description of the action, including a more detailed description of project type – for example: access (barrier removal); complexity (direct channel modification, passive restoration, dike removal/setback, large wood placement, etc.)
- Action rationale and objectives: Describe the objectives and rationale for the action, including the following: What was the basis for choosing the action type and location? What protocol was used to design/implement the action? What were the objectives in terms of changing habitat (these will differ by action type – see examples below):
    - Example habitat change objectives (in terms of relevant habitat conditions):
        - Estimated change from non-pool to pool habitat (e.g., in m^2)
        - Increased sinuosity from current (altered) toward natural (e.g., 1.0 to 1.5)
        - Flow (CFS) restored to reach (upper river km to lower km; for what time period; seasonal or annual)
        - LWD/boulder/rock weir placement (amount, placement protocol, stream

structure change objective)

- Riparian restoration: if active – species used, restoration buffer width description, density
- Dike removal/setback: general description (or a simple map) of extent of intended removal/setback in the target reach. Preliminary estimate of the amount of floodplain habitat that would be reconnected. Description of expected side channel/alcove access versus current
- Special case effects: actions aimed at reducing specific sources of mortality (e.g., predator or predator exposure reductions)

- Implementation timing: (e.g., 1-year design, 2 years to implement)
- Target reach current habitat condition: Provide or cite a reference document/database if available. Ideally should describe current habitat conditions relative to some optimum level of function.
- Target reach post-implementation habitat conditions: How did the habitat change as a result of action implementation? Metrics will differ by project type but, e.g., CFS restored, in what season and for what length of time; how many large wood jams; how many pools created; etc.
- For tributary habitat RM&E, report on activities, including stream mileage surveyed and inventoried, categorized by method and by WRIA, USGS 6th field HUC, and UTM or other appropriate spatial point information.

Research and Monitoring Annual Reporting & Authorization Requirements

a) The conduct of scientific research and monitoring activities each year is contingent on submission and approval of a report on each proceeding year's research and monitoring activities. Researchers are providing annual reports summarizing the take of ESA-listed salmon and steelhead associated with their activity. These annual reports are to be provided to NMFS's designated Take Determination Coordinator by December 1 of each year unless this date is otherwise modified by NMFS's authorizing Take Determination letter. The report must include the following:

- A detailed description of scientific research and monitoring activities, including the total number of fish taken at each location, an estimate of the number of ESA-listed fish taken at each location, the manner of take, and the dates and locations of the take.
- Measures taken to minimize disturbances to ESA-listed fish and the effectiveness of these measures, the condition of ESA-listed fish taken and used for research and monitoring, a description of the effects of research and monitoring activities on the subject species, the disposition of ESA-listed fish in the event of mortality, and a brief narrative of the circumstances surrounding fish injuries or mortalities to ESA-listed fish.

- Any problems that arose during research and monitoring activities, and a statement as to whether the activities had any unforeseen effects.
- Descriptions of how all take estimates were derived.
- Steps that have been and will be taken to coordinate research and monitoring activities with those of other researchers.

Operational Reporting & Notification Requirements

- The Corps shall report progress in implementing the Fish Passage Plan in a timely manner; providing 7-day Corps project adult/juvenile facility reports and 7-day fish transportation summaries to NMFS and FPOM via electronic mail once a week. In addition, the Corps shall provide facility reports and transportation summaries to NMFS and FPOM once a year in electronic format.
- Researchers must obtain NMFS's approval prior to implementing research protocols (e.g., changes in sampling locations or fish handling protocols) that differ from those considered in the Take Determination letters, unless immediate deviation from these same protocols are necessary to reduce impacts to fish in hand. In this case, researchers must contact NMFS' designated Take Coordinator or other designated staff as soon as possible to report on the situation (including reporting any resultant unexpected take), the actions taken by the research to minimize impacts to research fish, and coordination of additional actions that are necessary before the research can continue.
- Each researcher must alert NMFS whenever the authorized level of take is exceeded, or if circumstances indicate that such an event is imminent. Notification should be made as soon as possible, but no later than two days after the authorized level of take is exceeded. The researcher must then submit a detailed written report to NMFS. Pending a review of the circumstances, NMFS may suspend the research and monitoring activities or implement reasonable measures and/or alternatives to allow research and monitoring activities to continue.
- Each researcher must alert NMFS when a take of any ESA-listed species not included in the research proposal is killed, injured, or collected during the course of research and monitoring activities. Notification should be made as soon as possible, but no later than two days after the unauthorized take. The researcher must then submit a detailed written report to NMFS. Pending a review of the circumstances, NMFS may suspend research and monitoring activities or implement reasonable measures and/or alternatives to allow research and monitoring activities to continue.
- In the case of ongoing studies, a report of actual take will be submitted to NMFS no less than 30 days before the request for take for the next year is submitted. For studies which only last one year, or upon termination of a multi-year study, a report of actual take will be submitted no less than 30 days after the activities described in the take

determination letter cease. Take reports will include the numbers, life stage, species, and ESU of fish taken; the type of take (harass, handle, kill); and levels of incidental mortality. The reports will also include the location of the take (geographical names and HUC), and summarize take into blocks no larger than one month (i.e., take for April, May, etc.). Any of the incidents described in items 2 and 3 above (exceeded take limits, or incidental morality not covered by the take determination) will also be described in this report. The report will also include an evaluation if methodology can be improved to reduce take (especially incidental mortality).

2.17 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02). The conservation measures provided here are intended, in part, to inform the ongoing CRSO NEPA process.

1. **Evaluate the feasibility, and implement if feasible and effective, surface passage structures and operations to effectively pass overshooting adult salmon and steelhead at mainstem dams.**

   Relatively large numbers of adult steelhead (e.g., Umatilla, John Day, and Deschutes River, Tucannon River populations) overshoot lower Columbia and Snake River mainstem dams and then volitionally migrate downstream through the dams to reach their natal streams in the fall and winter after juvenile spill operations have ended. This behavior has been repeatedly documented and is identified as a threat in the Snake River and Middle Columbia River steelhead recovery plans.

   The Action Agencies, in coordination with NMFS and other regional co-managers, should assess the results of the proposed McNary Dam surface spill operation study as a means of increasing adult survival rates at other CRS dams where substantial overshoot and downstream migration of adult steelhead has been documented. Where feasible and effective, the Action Agencies should implement similar, or improved, structural and operational measures to increase adult survival rates of downstream migrating adult steelhead overshoots, and study the effectiveness of these measures.

   a. The study should consider whether the existing structure or a modified structure (limiting flow through the surface weir below that used to attract juveniles) should be used in the study.

   b. The study should consider the behavior (seasonal, weekly, and daily use) of adult steelhead using of the surface weir.

   c. The study should examine the effectiveness of the weir (proportion of adults passing the dam that use the surface passage route).

   d. The study should examine the efficiency of the weir (at what times and over how many days did fish use the weir when provided as a downstream passage route).

2. **Evaluate Relatively Low Juvenile Survival Rates at the Bonneville Dam Spillway**

   Available information indicates that estimated survival rates of juvenile salmon and steelhead passing through the spillway at Bonneville Dam are consistently lower than at other mainstem projects. Increasing spill levels at this project, as proposed, increases the proportion of juvenile salmon and steelhead passing the project via the spillway. To reduce mortality associated with spillway passage at Bonneville Dam, the Action Agencies should implement the following measures:

   - Investigate and identify, to the extent practicable, potential, likely cause(s) of relatively low survival of spillway passed juveniles. Potential issues that might contribute to relatively low survival through the spillway may include sheer associated with spillgate design, physical injury due to relatively small gate openings, predation, or adverse physical conditions in the tailrace.
   - Following completion of the study, the Action Agencies, in cooperation with NMFS and co-managers, should implement, structural or operational measures, if deemed feasible and effective, to increase survival through this route of passage.
   - The Action Agencies, using established regional processes, should develop a study to assess the efficacy of structural or operational measures, including passage times and survival rates of juvenile yearling Chinook salmon and steelhead migrating through the Bonneville Dam spillway.

3. **Investigate and potentially reduce northern pikeminnow predation at mainstem CRS dams.**

   Available information indicates that northern pikeminnow congregate near the mainstem CRS dams to prey on juvenile salmonids. At some projects, dam angling programs have not been implemented for many years, possibly allowing northern pikeminnow to increase in numbers in these areas (increasing take). To enhance the effectiveness of the dam angling, and thereby further reduce predation associated with northern pikeminnow predators at the mainstem dams, the Action Agencies should implement the following measures:

   - Evaluate the effectiveness of focused removals of northern pikeminnow at Columbia and Snake River Dams to investigate the cost and benefits of dam angling in increasing juvenile salmonid survival.
   - Using the existing dam angling program, rotate dam angling crews to mainstem CRS dams to identify if predation hotspots have developed and investigate northern pikeminnow presence and size.
   - Develop a standardized metric such as catch per unit effort (CPUE) indices and compare to existing presence data at The Dalles and John Day Dams. Compare and report metrics including CPUE, total catch, and the size range of northern pikeminnow.

- Report metrics of any incidentally caught non-native piscivorous species and any resulting incidental take of ESA-listed species. Coordinate with NMFS and to determine if future adjustments to the current dam angling program are necessary to reduce mortality of ESA listed salmonids.

4. **Evaluate alternatives to reduce mortality associated with Dworshak Dam turbine maintenance and testing**

   - Each turbine unit at Dworshak Dam (DWR) requires annual preventative maintenance to maintain operational condition. The annual maintenance period is September 15 through the end of February to coincide with the refill period after summer flow augmentation and before flood control operations begin. Annual maintenance is typically performed one unit at a time and requires the unit to be out of service for 2–6 weeks. During the annual maintenance period, Snake River steelhead adults are present in the tailrace at DWR, and mortalities associated with maintenance operations have been documented. It is currently believed that the steelhead are attracted to the flow conditions and are swimming up the draft tube during starts and stops or speed no-load operations and can experience strike and decapitation by making contact with the Francis blades spinning at high velocity (Renholds et al. 2019). To reduce mortality of SRB steelhead, the Action Agencies should implement the following measures:
     - Operate within the guidance provided in the Fish Passage Plan. Continue to use the available information and modify the protocol as necessary to avoid further mortalities.
     - A biologist or trained observer should estimate and record the number of adult salmonids killed or injured during starts and stops and speed no-load maintenance operations. Record time, date, and duration of speed no-load operation along with mortality and injury observations. Identify or estimate the species and origin of mortalities as possible, and report information to NOAA and FPOM.
     - Begin the selection and design process of cost effective physical barriers similar in concept to the alternative selected in Renholds et al. (2019) to prevent future adult SRB steelhead take during testing and maintenance operations.

5. **Continue to Support regional efforts to reduce sea lion predation at fishway entrances.**

   - In recent years, increasing numbers of Steller sea lions have been hauling out at Bonneville Dam in the fall and winter and are feeding unabated near fish ladder entrances on steelhead, coho, and fall Chinook ESUs. While hazing has had limited effectiveness compared to removals, the available information indicates dam hazing does temporarily push pinnipeds away from entrances where they are most effective at consuming and delaying adult salmon and steelhead. Steller sea lions are more responsive to hazing efforts than California sea lions, and effective hazing could reduce predation and delay of adult salmonids by Stellar sea lions. Accordingly, the Corps should coordinate with the Bonneville Dam Pinniped - Fishery Interaction Task Force, the states of Oregon, Washington and Idaho, the Nez Perce Tribe, the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes of the Warm Springs Reservation of Oregon, the Confederated Tribes and Bands of the Yakama Nation, and NMFS to design and implement a study that evaluates the effectiveness of Steller sea lion hazing and dissuasion methods and timing. The results of this study can be used to develop more effective long-term strategies for managing sea lion predation at Bonneville Dam.

6. **Evaluate alternative transport operations to increase adult returns of Snake River salmon and steelhead.**

   The available information clearly indicates that; (1) straying of adults that were transported as juveniles is elevated compared to those that migrated inriver as juveniles and tends to occur most frequently in the lower Columbia River (downstream of McNary Dam); and (2) there is substantial seasonal variability in the patterns of the relative benefit of transportation for Snake River spring-summer Chinook salmon, SR fall Chinook salmon, and SRB steelhead. Straying has been identified as an issue for both donor and recipient populations in multiple recovery plans. Alternative transport operations have the potential to increase the productivity of transported fish (and thereby, Chinook salmon and steelhead populations throughout the Snake River basin) if they could effectively reduce stray rates or better tailor transport operations to when the benefit specific.

   1. The Action Agencies should work with NMFS and regional partners to develop and implement a study evaluating "transport pauses" (slowing the barges at the mouths of rivers as juvenile salmon and steelhead are transported downstream) as a means of increasing homing fidelity of transported SR spring-summer Chinook, steelhead, and sockeye salmon.
      a. The study should specifically consider the potential influence of important stream junctures (Columbia and Snake, Columbia and Deschutes, etc.) in the design.
      b. This study should specifically consider available information to determine the number of hours of delay (and the number of locations where pauses would occur) that would be needed to reasonably assure improved juvenile imprinting would be likely.
      c. This study should consider monitoring requirements needed to determine if implemented measures are effective (i.e., straying rates are reduced).
   2. The Action Agencies should work with NMFS and regional partners to implement a study evaluating the elimination of transport in June and July (when few spring/summer Chinook salmon are present and juvenile fall Chinook salmon typically do not benefit from transport).

   a. This study should specifically consider potential negative effects on yearling spring/summer Chinook salmon, sockeye salmon, or steelhead smolts; and avoid potentially substantial effects to the extent practicable.
   b. This study should consider monitoring requirements needed to determine if implemented measures are effective (i.e., straying rates are reduced; returns of adults migrating as subyearling smolts are generally improved).

7. **Adult Sockeye Salmon Passage and Survival Recommendations**

   NMFS, following the extremely high losses of adult sockeye in 2015, recommended several actions to improve the survival of adult sockeye salmon in the event that similar conditions reoccur. In reviewing these actions, NMFS notes that many of these recommendations have already been adopted and implemented and additional information has been collected with respect to differential temperatures within the adult fishways. To continue this work and further improve fish passage for adult sockeye salmon under high temperature conditions, the Action Agencies should:

   a. Continue monitoring and reporting of all mainstem fish ladder temperatures and identify ladders with substantial temperature differentials (>1.0°C).
   b. Continue to investigate methods to reduce maximum temperatures and temperature differentials in adult fish ladders at mainstem lower Snake and Columbia dams identified as having these problems, and implement if feasible.
   c. Continue to develop water temperature models, or similar tools, to assess the effect of alternative project operations at Lower Granite and Little Goose dams on ladder and tailrace temperatures or implement a study to empirically assess the effect of proposed operations.
   d. Continue to cooperate with NMFS, co-managers, to develop and prioritize locations where additional PIT tag detections could substantially improve our understanding of adult behavior and survival during high temperature events, and cooperate in the development and installation of these detection systems, if practicable.
   e. Continue to evaluate the Dworshak cold water release program to maintain temperatures in the lower Snake River below 18°C during June and most of July to reduce adult sockeye salmon mortality in the lower Snake River.

8. **Evaluate losses of juvenile salmon and steelhead between their natal tributaries and the mainstem lower Snake and Columbia River dams and reservoirs.**

   Large proportions of juvenile salmon and steelhead are lost between PIT tag detectors in tributary streams and those at mainstem lower Snake and Columbia dams. In some cases, these losses far exceed those observed for juvenile migrating through the mainstem reaches

(Widener et al. 2018). Understanding the mechanisms causing these losses could lead to the development of effective actions that would substantially improve the survival and productivity (and the conservation value of designated critical habitat) for a substantial number of salmon and steelhead populations.

a. The Action Agencies should cooperate with NMFS and regional co-managers to develop and implement studies that would identify where, within tributary streams, large numbers of juveniles are being lost, and the mechanism causing these losses.

b. The Action Agencies should cooperate with NMFS and regional co-managers by sharing information, expertise, or funding to enhance our collective understanding of this issue and the means by which it might be addressed.

9. Evaluate alternative means of detecting PIT tags at Bonneville Dam, or in the lower Columbia River and estuary.

Increasing spill levels at Bonneville Dam, on average, reduces both the number of PIT tag detections and the proportion of juveniles detected, which increases the standard error of juvenile survival estimates to Bonneville Dam. In addition, the “estuary trawl,” used to obtain PIT tag detections critical for assessing survival to Bonneville Dam is expensive, time consuming, and not without human safety risks. The Action Agencies should cooperate with NMFS and regional co-managers to assess the potential to utilize expanding PIT tag detector platform capabilities to enhance PIT tag detections near Bonneville Dam and, if feasible and effective, replace the estuary trawl with an alternative PIT tag detection array.

a. Investigate, and implement if feasible and effective, PIT detectors in select Bonneville Dam spillway bays or in the tailrace (flat plate detectors, flexible loop detectors, etc.).

b. Investigate, and implement if feasible and effective, PIT tag detectors in the lower Columbia River and estuary (flat plate detectors, flexible loop detectors, etc.) that could, over time, replace the estuary trawl as the primary means of obtaining PIT detections necessary to make survival estimate sot Bonneville Dam.

10. Evaluate system operations, in consideration of potential climate change effects, to maintain or enhance mainstem migration and passage conditions for adult and juvenile salmon and steelhead.

System operations have evolved over time to enhance conditions for migrating adult and juvenile salmon and steelhead in the mainstem migration corridor. These operations include minimizing drafts to those necessary for flood risk management, augmenting flows through releases of stored water, and the development of the “Dry Year” strategy.

The Action Agencies should use available processes, in coordination with regional co-managers (including NMFS) to explore the potential of enhancing system-wide operations to further improve conditions (flows, temperatures, etc.) in the mainstem migration corridor for salmon and steelhead. Potential operations to buffer projected climate change effects should be a special focus.

a. Explore potential operations through the Action Agencies participation in US – Canada Treaty discussions.

b. Explore potential operations through other, future, climate related forums.

11. Evaluate issues and potential actions to improve the reliability or performance of fish passage structures and operations

There are many potential actions or uncertainties that, once evaluated and implemented, could improve the reliability or performance (increase fish survival, reduce travel times or stress, etc.) of fish passage systems. The Action Agencies should evaluate actions that could achieve this outcome. The actions should consider, but not be limited to, the following:

a. The effect of alternative spill treatments on the survival of yearling Chinook salmon and steelhead on survival, travel times, and route of passage.

b. B2 orifices – need to maintain a cohesive jet (using compressed or atmospheric air) to ensure there are no debris issues and fish are not being impinged.

c. Continue monitoring for PIT tags at avian colonies near the mainstem Columbia River dams

d. Investigate potential actions to reduce delay of adults (target and non-target) at the Lower Granite adult trap.

12. Identify, evaluate and prioritize fish passage related maintenance issues that could negatively affect fish passage structures or operations.

When operating properly, fish passage structures generally provide safe and effective passage of both juvenile and adult salmon and steelhead at the mainstem CRS dams. Maintenance of these structures and systems is critical for their long term reliability and the provision of safe and effective passage.

The Action Agencies should develop, in coordination with NMFS and regional co-managers, a prioritized list of maintenance issues critical for the reliability of fish passage systems at the mainstem dams; and use this list to better guide the use of Operations and Maintenance funds. This list may also be of value when: (1) opportunities arise for additional funding of federal projects or (2) to identify issues that might require specific requests for funding.

13. Work through Tributary Habitat Program Steering Committee to help maximize the effectiveness of tributary habitat improvement actions.

The effectiveness of tributary habitat improvement actions can be enhanced when actions are implemented consistent with best available science and within a within a strategic framework that places near-term actions within a long-term strategic objective and plan.

The Action Agencies should work through the Tributary Habitat Program Steering Committee to help maximize the effectiveness of tributary habitat improvement actions in terms of their benefits to targeted populations and to ensure implementation of the program in a manner consistent with long-term recovery goals. Efforts should include (a) ensuring that actions are prioritized, sequenced, and implemented actions consistent with approaches recommended in best available science on watershed restoration (see, e.g., Beechie et al. 2008, 2010; Hillman et al. 2016) and (b) working with NMFS, through the tributary habitat steering committee and the Columbia Basin RM&E steering committee, to improve alignment between tributary habitat improvement actions prioritized for implementation and NMFS focal populations (Cooney, in press).

14. Ensure that the CRS NEPA process considers, long-term, strategic habitat improvement efforts.

Benefits to habitat and populations as a result of tributary habitat improvement actions implemented during this biological opinion are likely to be small. In almost all cases, we would not expect implementation of habitat actions for only a few years to yield significant improvements, because it is not feasible to implement actions of sufficient scope and scale in that timeframe to yield substantial effects. It is important, however, to put results of the habitat actions to be implemented in the relatively short time-frame of this biological opinion into the context of the effects of longer-term implementation of habitat actions. Under a strategic approach to addressing key limiting factors, implementation over a three-year time period should be viewed as part of a long-term implementation strategy designed to more fully address limiting factors for particular populations over a time period that reasonably considers limitations on annual implementation capacity and other factors. Life-cycle modeling results for spring Chinook salmon in the Grande Ronde and Catherine Creek populations, for example, demonstrate that long-term, strategic implementation of habitat improvement actions can have marked effects (see Pess and Jordan et al., in press). The Action Agencies should ensure that their NEPA analysis includes consideration of long-term, strategic implementation of habitat improvement actions.

15. Develop and implement a Columbia Basin Research, Monitoring and Evaluation Framework consisting of strategies for each of all the major categories of RM&E work including: Tributary Habitat, Fish Status and Trends, Hatcheries, Harvest, Estuary and Ocean, Mainstem River, and Hydropower systems.

Research, monitoring and evaluation is the primary means by which data is gathered, analyzed and formulated into useable information about the performance of and magnitude of impact that actions designed to benefit listed fish species attain that are undertaken by the Action Agencies.   A robust program of RM&E has been carefully developed and implemented over the past 10 years) throughout the geographic scope of the proposed action. Because it is a fundamental principle of an adaptive management approach to make adjustments, many adjustments have been made to these RM&E programs over this time span. However, consistency and durability of programs, robust protocols, methods and analyses and regularity of repeatability are all critically important to generating reliable information for key management decisions and to objectively evaluate the level of success of actions undertaken.

Over the life of this opinion, the CRS Action Agencies should demonstrate that proposed tributary habitat improvement actions are being implemented as expected and that the effects of the actions are occurring as expected by reporting on implementation. The primary mechanism to attain this information and to generate an understanding of the level of confidence is by-way-of continuing to support monitoring the status of listed salmonids and the effectiveness of the proposed action. In order to advance and improve the Action Agencies knowledge base in an adaptive management framework, priority regionally agreed upon adjustments to that monitoring should occur following the development of an RM&E framework and individual thematic strategies (e.g. tributary habitat, estuary and ocean, hatcheries, etc.). As such, the Action Agencies should work with NMFS and regional partners to:

- Establish an implementation plan for the Columbia Basin Research Monitoring and Evaluation Framework and schedules for development of the associated strategies during the term of this biological opinion.
- Work with NMFS, the tributary habitat steering committee, and the Columbia Basin RM&E steering committee to refine the focal population and tributary habitat action areas over the term of this opinion and ensure alignment between priority monitoring with priority actions.
- Refine the fish population status and "fish in/fish out" monitoring approach and prioritize needs for fish in/fish out and status and trend monitoring that is representative of populations and habitats throughout the Columbia River basin.
- Make any adjustments that are contemplated to the existing fish population status and trends monitoring network following completion and through the roll-out of the Fish Population strategy within the Columbia Basin Research Monitoring and Evaluation

Framework developed during the term of this biological opinion.

16. **To promote eulachon conservation and address uncertainties regarding changes in the hydrograph of the Columbia River and adverse effects on eulachon productivity and abundance, the Action Agencies should:**
    - Monitor eulachon abundance in the Columbia River via annual spawning stock biomass surveys.

17. **To promote eulachon conservation and address uncertainties regarding changes in the hydrograph of the Columbia River and adverse effects to eulachon larval and juvenile survival in the estuary, plume, and ocean, the Action Agencies should:**
    - Monitor and evaluate temporal and spatial species composition, abundance, and foraging rates of juvenile eulachon predators at representative locations in the estuary and plume.
    - Monitor, and evaluate the causal mechanisms, e.g., shifts in the timing, magnitude, and duration of the hydrograph of the Columbia River, and migration/behavior characteristics affecting survival of larval eulachon during their first weeks in the plume-ocean environment.
    - Monitor and evaluate the ecological importance of the tidal freshwater, estuary, plume, and nearshore ocean environments to the viability and recovery of the Columbia River subpopulation of eulachon.

18. **Evaluate potential for improving tributary habitat productivity in populations in the Middle Fork Salmon River spring Chinook MPG.**
    - Habitat in the Middle Fork Salmon spring Chinook MPG is generally of high quality due to the preponderance of wilderness areas and other federal lands, and there appears to be relatively low potential for improving habitat productivity in most populations in this MPG. However, as noted in the ESA recovery plan (NMFS 2017e), further exploration of ways to improve habitat is warranted. The potential of the following actions to improve freshwater productivity in the populations in this MPG should be evaluated:
        - Continued efforts to address localized impacts of past land uses
        - Reintroduction of beaver in populations with significant marsh habitat
        - Nutrient supplementation
        - Management of non-native brook trout improve the function of spawning and rearing habitat and provide population benefits.

2.18 Reinitiation of Consultation

This concludes formal consultation for ongoing operation and maintenance of the Columbia River System (CRS) and associated non-operational measures to offset adverse effects to listed species.

As 50 CFR 402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and if: (1) The amount or extent of incidental taking specified in the ITS is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

2.19 “Not Likely to Adversely Affect” Determination

On November 2, 2018, NMFS received the Action Agencies’ request for a written concurrence that the ongoing operation and maintenance of the CRS, and associated non-operational measures to offset adverse effects to listed species, are not likely to adversely affect (NLAA) the Southern DPS of North American green sturgeon (*Acipenser medirostris*) and critical habitat designated under the Endangered Species Act (ESA), and the Southern Resident killer whales (SRKW) (*Orcinus orca*) and their designated critical habitat. This response to that request was prepared by NMFS pursuant to section 7(a)(2) of the ESA, implementing regulations at 50 CFR 402, and agency guidance for preparation of letters of concurrence.

2.19.1 Southern DPS of Green Sturgeon

On April 7, 2006, NMFS listed the Southern DPS of North American green sturgeon as a threatened species under the ESA (71 FR 17757, April 7, 2006). This determination was based on the fact that the Sacramento River basin contains the only known Southern DPS spawning population, information suggesting population decline, and habitat loss and degradation in the Sacramento River basin. Since the listing of the DPS, a number of habitat restoration actions within the Sacramento River basin have occurred, and spawning has been documented in the Feather and Yuba Rivers (Seesholtz et al. 2015; Beccio 2018), but many significant threats have not been addressed. Currently, the majority of Southern DPS green sturgeon spawning occurs within a single reach of the mainstem Sacramento River, placing the species at increased risk of extinction due to stochastic events. NMFS completed a five-year review in 2015 (NMFS 2015c), and recently published a final recovery plan for this DPS[228] (NMFS 2018b).

Green sturgeon are broadly distributed in nearshore marine areas from Mexico to the Bering Sea. Green sturgeon are commonly observed in bays, estuaries, and sometimes the deep riverine mainstem in lower elevation reaches of non-natal rivers along the west coast of North America, including the lower Columbia River estuary; however, the distribution and timing of estuarine use are poorly understood (NMFS 2015c). Green sturgeon consist of two DPSs that co-occur throughout much of their range, but use different river systems for spawning. All naturally spawned populations of green sturgeon originating from coastal watersheds south of the Eel River in Humboldt County, California (known spawning populations are in the Sacramento River system) are considered part of the Southern DPS. The Northern DPS consists of populations originating from coastal watersheds north of, and including, the Eel River (known spawning populations in the Eel, Klamath, and Rogue Rivers). The Northern DPS is not listed as threatened or endangered, but is a NMFS Species of Concern.

[228] The final recovery plan is available at https://www.westcoast.fisheries.noaa.gov/publications/protected_species/other/green_sturgeon/noaa-sdps-green-sturgeon-recovery-plan-8-8-2018.pdf

No hatchery programs exist for the green sturgeon. Southern DPS green sturgeon are confirmed to occur in the Willamette/Lower Columbia, Oregon Coast, and Southern Oregon/Northern California Coasts recovery domains. In many Oregon coastal systems, inadequate data exists to confirm their presence, but presence has been established in Coos Bay, Winchester Bay (Umpqua River), Yaquina Bay, Nehalem Bay, and the Columbia River estuary (NMFS 2010).

Research conducted and published since 2006 confirms and enhances our understanding of the biology and life history of Southern DPS green sturgeon, including reproductive characteristics. North American green sturgeon are thought to reach sexual maturity at about 15 years of age (Van Eenennaam et al. 2006), or a total length of 150–155 cm for Southern DPS individuals. They can live to be 70 years old. Unlike salmon, they can spawn several times during their long lives, returning to their natal rivers every three to four years (range two to six years; Brown 2007; Poytress et al. 2013). They are long-lived, late maturing, and spend substantial portions of their lives in marine and estuarine waters (NMFS 2010).

During spawning runs, adult Southern DPS green sturgeon enter the San Francisco Bay between mid-February and early May before rapidly migrating up the Sacramento River to spawn. In fall, these post-spawn adults move back down the river and re-enter the ocean. After hatching, larvae and juveniles rear in their natal river or estuary before migrating to the ocean. As subadults and adults, Southern DPS green sturgeon migrate seasonally along the West Coast, congregating in bays and estuaries in Washington, Oregon, and California during the summer and fall months. During winter and spring months, they congregate off of northern Vancouver Island, B.C., Canada.

Green sturgeon likely inhabit estuarine waters to feed and optimize growth (Moser and Lindley 2007), and these habitats appear to be important to subadult and adult green sturgeon. Individual green sturgeon exhibit diel movements, using deeper water during the day and moving to shallower water during the night to feed. The movements of green sturgeon are likely influenced by feeding behavior, tidal stage, and possibly light conditions (NMFS 2010). Little is known about green sturgeon diet in estuaries. Stomach sampling is challenging and most studies have depended on samples collected from specimens at the dock or processing plants where stomachs have been partially or completely empty. The best results are samples collected on the boat immediately after landing. Green sturgeon in Willapa Bay were found to feed primarily on benthic prey (e.g., Dungeness crab, crangonid shrimp, and thalassinid shrimp) and fish (Dumbauld et al. 2008). A very limited sample of green sturgeon stomachs in the Columbia River found mostly crangonid shrimp and some thalassinid shrimp (Dumbauld et al. 2008).The presence of these prey species suggests the sampled green sturgeon fed in the saline and brackish water reaches lower in the Columbia River estuary (downstream of approximately Columbia River mile 30) (NMFS 2010, 2015c).

2.19.1.1 Proposed Action and Action Area

The proposed action is described in Section 1.3. The distribution of Southern DPS green sturgeon overlaps with the action area in the lower Columbia River below Bonneville Dam and in the plume.

2.19.1.1.1 Action Agencies' Effects Determinations

The Action Agencies determined that the proposed action is not likely to adversely affect Southern DPS green sturgeon or their designated critical habitat.

2.19.1.1.2 Effects of the Proposed Action

The effects of the proposed action are similar to those discussed in NMFS (2014). NMFS reviewed the scientific and technical information that has become available since that time, and found two papers relevant to the effects of the proposed action: Schreier et al. (2016) and Hansel et al. (2017). Schreier et al. (2016) describe preliminary evidence of green sturgeon spawning in the Columbia River based on the collection of an age-0 individual near Rooster Rock (RM 130). Genetic analyses assigned this individual to the unlisted Northern DPS rather than the listed Southern DPS, which is known to spawn only in the Sacramento River basin. Thus, the best available information indicates the action area is used only for feeding by adult Southern DPS green sturgeon.

Hansel et al. (2017) describe areas in the lower Columbia River occupied by green sturgeon (they were not able to discern whether the fish were from the Northern or the listed Southern DPS) during 2010 and 2011 based on acoustic-tag detections between the mouth and RM 23.5. The purpose of the study was to identify habitat use, arrival and departure timing, and the extent of upstream migration to help design dredging operations to minimize harm to green sturgeon. A total of nine green sturgeon were detected in 2010, and 10 in 2011. These fish entered the Columbia River during May through October in both years, with the highest numbers present in August and September. Only one green sturgeon was detected at the uppermost receiver station (RM 23.5) and, overall, the number of fish detected decreased rapidly with distance from the estuary mouth. The residence times of fish that were only detected in the lower three miles of the river were generally were less than 24 hours; fish detected farther upriver had a median residence time greater than ten days. Green sturgeon were widely dispersed among channel and non-channel habitats in 2010; fish were more concentrated near the estuary mouth in 2011. Sensor tag data indicated that green sturgeon used a mix of habitats — the deep water south and north channel habitats (bottom depths ≥10 m), sandy shoals, shorelines, and bays (bottom depths <10 m). Sensors also showed that water temperatures ranged from 48.4 to 71.6°F (late May through mid-October).

These two reports provide information on habitat use by green sturgeon in the action area for this consultation beyond that discussed in 2014 supplemental FCRPS biological opinion (NMFS 2014). The effects of the proposed action described in the 2014 biological opinion include:

- The potential interaction of green sturgeon during boat-based electrofishing as a monitoring activity for the NPMP in sampling areas below Bonneville Dam. However, no green sturgeon of either DPS have been identified during the monitoring program since the inception of the program in 1990. Thus, we find that this pathway of effect is discountable.

CRS-related changes in flow, sediment transport, and characteristics of the Columbia River estuary that may affect Southern DPS green sturgeon. However, the 2014 opinion found this pathway of effect to be insignificant because the effects are slight to negligible, and because adult southern DPS green sturgeon (the only life stage found within the action area) generally prefer deep water habitats that are generally unaffected by the FCRPS (NMFS 2014).

Since that 2014 supplemental opinion was signed, we have learned that green sturgeon (unknown DPS) use both deep and shallow-margin areas (Hansel et al. 2017), and that average residence time in the lower Columbia River ranged from 0.001 to 3.160 days over the 2010 and 2011 study period (median, 0.009 days in 2010 and 0.107 days in 2011) for fish detected closer to the mouth of the Columbia River; whereas, the residence times of fish detected farther upriver generally were longer, ranging from 1.703 day to 139.756 days (median, 7.849 days) in 2010 (Hansel et al 2017). In 2011, only two fish were detected farther upriver and their residence times were 10.334 and 77.308 days (Hansel et al. 2017). The furthest upstream extent of green sturgeon (unknown DPS) detections was at the receiver station at RM 23.5; no tagged green sturgeon were detected at the receiver located at RM 54.7. These stations are far downstream of Bonneville Dam, at RM 146.1. Our understanding of how the implementation of the CRS affects the Southern DPS of green sturgeon (changing flow, sediment transport, and estuary habitat) has not changed, and we still consider the effects for these pathways to be insignificant.

Climate change has the potential to impact Southern DPS green sturgeon in the future, but it is unclear how changing oceanic, nearshore and river conditions will affect the Southern DPS overall. In freshwater environments (e.g., Sacramento River system), water flow and temperature are important factors influencing green sturgeon spawning and recruitment success (NMFS 2015c). Changing ocean conditions could also impact Southern DPS green sturgeon since subadults and adults use ocean habitats for migration and potentially for feeding. Based on their use of coastal bay and estuarine habitats, subadults and adults can occupy habitats with a wide range of temperature, salinity, and dissolved oxygen levels, so predicting the impact of climate change in these environments is difficult (Kelly et al. 2007; Moser and Lindley 2007). The proposed action will not exacerbate the potential negative effects caused by climate change, and during the duration of the proposed action, the effects are anticipated to remain insignificant.

Other threats include barriers and spawning habitat quality in the Sacramento River (California), bycatch in recreational and ocean fisheries, development and operation of offshore and nearshore energy projects, and application of chemicals and pesticides to control burrowing shrimp. None of these threats are factors in the lower Columbia River.

2.19.1.1.3 Critical Habitat

Designated critical habitat for Southern DPS green sturgeon includes the lower Columbia River estuary from the river mouth to RM 74 (74 Fed. Reg. 52300, October 9, 2009) that support aggregations of Southern DPS green sturgeon during summer. The PBFs essential for species conservation are: (a) food resources, including benthic invertebrates (crangonid and callianasid shrimp, Dungeness crab, mollusks, amphipods) and small fish such as sand lances (*Ammodytes* spp.) and anchovies (*Engraulidae*) (Moyle 2002; Dumbauld et al. 2008); (b) suitable water quality (e.g., temperature, salinity, oxygen levels necessary for normal behavior, growth, and viability); (c) migratory corridors necessary for safe and timely passage; (d) a diversity of depths necessary for shelter, foraging, and migration; and (e) sediment quality necessary for normal behavior, growth, and viability.

The effects of the proposed action will overlap with designated critical habitat for green sturgeon in the lower Columbia River below RM 74, an estuarine area, and the plume, a coastal marine area, within the action area for this consultation. The designated critical habitat in the lower Columbia River estuary contains important summer habitats that support aggregations of green sturgeon, including those from both the unlisted Northern DPS and the listed Southern DPS. In 2014, we stated that it was difficult to assess the effects of any activities on the status of green sturgeon habitat because we know very little about how green sturgeon use coastal marine habitats, and how changes in water quality or levels of available prey resources affect their use of these habitats (NMFS 2014).

In the 2014 supplemental biological opinion, we described the effects of the RPA on green sturgeon critical habitat and on the PBFs. These include:

- Food resources. The PBF includes abundant prey items within estuarine habitats. Prey species for green sturgeon within bays and estuaries primarily consist of benthic invertebrates and fishes, including crangonid shrimp, burrowing thalassinidean shrimp (particularly the burrowing ghost shrimp), amphipods, isopods, clams, annelid worms, crabs, sand lances, and anchovies (NMFS 2009b). In 2014, we concluded that any adverse effects of implementing the RPA on the primary constituent element of food resources were likely to be insignificant (NMFS 2014). This conclusion was based on the following considerations: (1) the availability of invertebrate and fish prey favored by green sturgeon in other estuaries appeared to be high in the lower Columbia River and there was no information to indicate that flow or sediment changes due to the CRS decrease the availability of these species in any measurable way; and (2) the abundances of marine forage fishes in the Columbia River plume increases and decreases based on a number of variables, including oceanic and climate conditions.
- Water quality. The PBFs of critical habitat in estuarine areas include water quality, including temperature, salinity, oxygen content, and other chemical characteristics necessary for normal behavior, growth, and viability of all life stages (NMFS 2009b).

Water temperature is affected by operation of the CRS hydroelectric dams and storage reservoirs. However, effects of the CRS on temperatures in the reach below RM 46 are greatly diminished because that area is also affected by tidal exchange with the ocean and by tributaries to the estuary (e.g., the Cowlitz, Elochoman, and Grays Rivers in Washington and the Clatskanie River and several smaller streams in Oregon). Water temperature monitoring in marine sites near the mouth of the estuary, in zones where marine and freshwater mix with the tides, and at tidal freshwater sites in the lower Columbia River did not show temperatures exceeding 75°F during 2003 through 2006 (Bottom et al. 2008). Therefore, any negative effects of the CRS on the functioning of this aspect of the water quality PBF are likely to be insignificant. Green sturgeon can tolerate a wide range of salinities, thus the CRS is unlikely to have a negative effect on this PBF. Suitable water quality requires low levels of contaminants (e.g., pesticides, PAHs, heavy metals) that otherwise may disrupt growth and survival of subadult and adult life stages (NMFS 2009b). Implementation of the RPA is not likely to concentrate or mobilize these contaminants or otherwise affect this aspect of the water quality PBF, thus we consider the effect of this pathway to be insignificant.

- Migratory Corridor. Migratory pathways that allow safe and timely passage in the estuary and in coastal marine areas. In 2014, we found that implementation of the RPA would have no effect on this PBF (NMFS 2014).
- Water Depth. Subadult and adult green sturgeon require a diversity of depths in estuarine areas for shelter, foraging, and migration. In 2014, we concluded that there is no evidence that implementation of the RPA negatively affects access to either shallow-bottom or near-surface waters that might be used by subadults or adults (NMFS 2014), thus the effects are discountable.
- Sediment Quality. Sediment quality necessary for normal behavior, growth, and viability of all green sturgeon life stages includes sediments free of elevated levels of contaminants, such as polyaromatic hydrocarbons and pesticides (NMFS 2009b). In 2014, we concluded that there is no likely pathway for implementation of the RPA to affect sediment quality in the estuary, and the effects to sediment quality are discountable.

As described above, we have reviewed the new information published since NMFS’ 2014 supplemental opinion was signed. None of that information has changed our understanding of how the CRS affects critical habitat of green sturgeon (changing flow, sediment transport, and estuary habitat) in the action area, and we still consider the effects for these pathways to be insignificant or discountable. In addition, the Action Agencies will continue the estuary habitat mitigation work for the duration of this interim biological opinion. This habitat work will continue to improve ecosystem functions in the estuary, and may contribute to the prey base for feeding adult Southern DPS green sturgeon.

2.19.1.1.4 Conclusion

Based on the above analysis, NMFS concurs with the Action Agencies that the proposed action is not likely to adversely affect Southern DPS green sturgeon and its designated critical habitat because all the effects of the proposed action are either discountable or insignificant.

2.19.2 Southern Resident Killer Whales

The Southern Resident killer whale DPS was listed as endangered on February 16, 2006 (70 FR 69903); the listing was updated in 2014 (79 FR 20802). Critical habitat in inland waters of Washington for the DPS was designated on November 29, 2006 (71 FR 69054) and a recovery plan was completed in 2008 (NMFS 2008c). More recently, a five-year status review completed in 2016 concluded that Southern Resident killer whales (Southern Residents) should remain listed as endangered, and included recent information on the population, threats, and new research results and publications (NMFS 2016f). Based on this information and further analysis, the Action Agencies determined the proposed action is not likely to adversely affect Southern Resident killer whales or their designated critical habitat.

Several factors identified in the final recovery plan for Southern Resident killer whales may be limiting recovery, including quantity and quality of prey, toxic chemicals that accumulate in top predators, and disturbance from sound and vessels. Oil spills are also a risk factor. It is likely that multiple threats are acting together to impact the whales. Although it is not clear which threat or threats are most significant to the survival and recovery of Southern Residents, all of the threats identified are potential limiting factors in their population dynamics (NMFS 2008c).

Southern Resident killer whales consist of three pods (J, K, and L) which inhabit coastal waters off Washington, Oregon, and Vancouver Island and are known to travel as far south as central California and as far north as Southeast Alaska (NMFS 2008c; Hanson et al. 2013; Carretta et al. 2017). During the spring, summer, and fall months, the whales spend a substantial amount of time in the inland waterways of the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound (Bigg 1982; Ford et al. 2000; Krahn et al. 2002; Hauser et al. 2007; Hanson et al.2010a, Whale Museum unpubl. data). All three pods generally remain in the Georgia Basin through October, make frequent trips to the outer coasts of Washington and southern Vancouver Island, and are occasionally sighted as far west as Tofino and Barkley Sound (Ford et al. 2000; Hanson et al. 2010a, Whale Museum unpubl. data).

By late fall, all three pods are seen less frequently in inland waters. Several sightings and acoustic detections of Southern Residents have been obtained off the Washington and Oregon coasts in the winter and spring (Hanson et al. 2010b; Hanson et al. 2013, NMFS 2018c). Satellite-linked tag deployments have also provided more data on the Southern Resident killer whale movements in the winter, indicating that the K and L pods use the coastal waters along Washington, Oregon, and California during non-summer months. Detection rates of K and L pods on the passive acoustic recorders indicate Southern Residents occur with greater frequency off the Columbia River and Westport, and are most common in March (Hanson et al. 2013). The

J pod has only been detected on one of seven passive acoustic recorders positioned along the outer coast (Hanson et al. 2013). The limited range of the sightings/ acoustic detections of J pod whales in coastal waters, the lack of coincident occurrence during the K and L pod sightings, and the results from satellite tagging in 2012–16 (NMFS 2018c) indicate the J pod’s limited occurrence along the outer coast and extensive occurrence in inland waters, particularly in the northern Georgia Strait.

Southern Resident killer whales consume a variety of fish species (22 species) and one species of squid (Ford et al. 1998; Ford et al. 2000; Ford and Ellis 2006; Hanson et al. 2010b; Ford et al. 2016), but salmon are identified as their primary prey. Southern Residents are the subject of ongoing research, including direct observation, scale and tissue sampling of prey remains, and fecal sampling. Scale and tissue sampling from May to September indicate that their diet consists of a high percentage of Chinook salmon (monthly proportions as high as >90 percent) (Hanson et al. 2010b; Ford et al. 2016). The diet data also indicate that the whales are consuming mostly larger (i.e., older) Chinook salmon. DNA quantification methods are also used to estimate the proportion of different prey species in the diet from fecal samples (Deagle et al. 2005). Recently, Ford et al. (2016) confirmed the importance of Chinook salmon to the Southern Residents in the summer months using DNA sequencing from whale feces. Salmon and steelhead made up to 98 percent of the inferred diet, of which almost 80 percent were Chinook salmon. Coho salmon and steelhead are also found in the diet in spring and fall months when Chinook salmon are less abundant. Specifically, coho salmon contribute to over 40 percent of the diet in late summer, which is evidence of prey shifting at the end of summer towards coho salmon (Ford et al. 1998; Ford and Ellis 2006; Hanson et al. 2010b; Ford et al. 2016). Less than 3 percent each of chum salmon, sockeye salmon, and steelhead were observed in fecal DNA samples collected in the summer months (May through September). Prey remains and fecal samples collected in inland waters during October through December indicate that Chinook and chum salmon are primarily contributors to the whales’ diet (NWFSC unpubl. data). Observations of whales overlapping with salmon runs (Wiles 2004; Zamon et al. 2007; Krahn et al. 2009), and collections of prey and fecal samples have also occurred in the winter months. Preliminary analysis of prey remains and fecal samples sampled during the winter and spring in coastal waters indicated that the majority of prey samples were Chinook salmon (80 percent of prey remains and 67 percent of fecal samples were Chinook salmon), with a smaller number of steelhead, chum salmon, and halibut (NWFSC unpubl. data). The occurrence of K and L pods off the Columbia River in March suggests the importance of Columbia River spring-run stocks of Chinook salmon in their diet (Hanson et al. 2013) at that time of year. Chinook salmon genetic stock identification from samples collected in winter and spring in coastal waters included 12 U.S. west coast stocks, and over half of the Chinook salmon consumed originated in the Columbia River (NWFSC unpubl. data) for the K and L pods (primarily fall-run stocks). Based on genetic analysis of feces and scale samples, Chinook salmon from Fraser River stocks dominate the diet of Southern Residents in the summer (Hanson 2011).

NMFS has continued to fund the Center for Whale Research to conduct an annual census of the Southern Resident population. As of July 2018, Southern Residents totaled 74 individuals (22 in J pod, 18 in K pod, and 34 in L pod; Center for Whale Research upubl. data).[229] The NWFSC continues to evaluate changes in fecundity and mortality rates, and has updated the work on population viability analyses conducted for the 2004 status review for Southern Resident killer whales and a science-panel review of the effects of salmon fisheries (Krahn et al. 2004; Hilborn et al. 2012; Ward et al. 2013). As a result of that work, the data now suggest a downward trend in population growth projected over the next 50 years. As the model projects out over a longer time frame (50 years) there is increased uncertainty around the estimates; however, if all of the parameters in the model remain the same the overall trend shows a decline in later years. This downward trend is in part due to the changing age and sex structure of the population, but is also related to the relatively low fecundity rate observed over the period from 2011 to 2016 (Figure 2.19-1, NMFS 2016f). Recent evidence indicates pregnancy hormones (progesterone and testosterone) can be detected in Southern Resident killer whale feces and have indicated several miscarriages, particularly in late pregnancy (Wasser et al. 2017); the authors suggest this reduced fecundity is largely due to nutritional limitation.

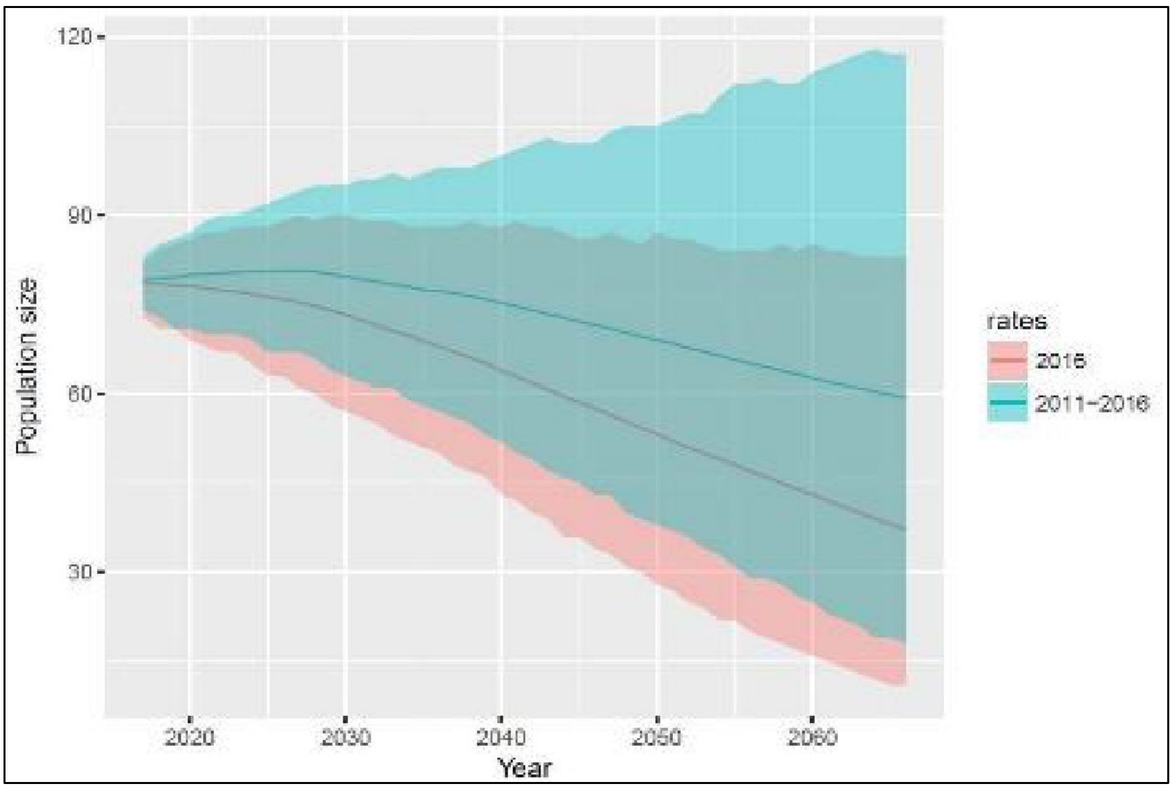


Figure 2.19-1. Southern Resident killer whale population size projections from 2016 to 2066 using two scenarios: (1) projections using demographic rates held at 2016 levels, and (2) projections using demographic rates from 2011 to 2016. The pink line represents the projection assuming future rates are similar to those in 2016, whereas the blue represents the scenario with future rates being similar to 2011 to 2016 (NMFS 2016f).

[229] This is a decline from 81 whales reported in the 2014 FCRPS biological opinion.

To explore potential demographic projections, Lacy et al. (2017) constructed a population viability assessment that considered sublethal effects and the cumulative impacts of threats (contaminants, acoustic disturbance, and prey abundance). They found that over the range of scenarios tested, the effects of prey abundance on fecundity and survival had the largest impact on the population growth rate.

Recent concerns have been raised that the DPS’ small size and insularity has resulted in inbreeding depression, which could affect fitness (Ford et al. 2018). This study sheds new light on both inbreeding within the Southern Resident DPS and the mating patterns of killer whales. They found that only two adult males sired 52 percent of the sampled progeny born since 1990. Based on the pedigree, four sampled offspring were the result of inbred mating; two between a parent and offspring, one between paternal half-siblings, and one between uncle and half-niece. There is no evidence to date that the survival or fecundity of these individuals is lower than normal. There was some evidence for inbreeding depression in the form of a weakly supported relationship between multi-locus heterozygosity and annual survival probability, but the power of their data to quantify this effect was low. They found no evidence of inbreeding avoidance in the population, but a late age of breeding success for males may indirectly limit the frequency of parent/offspring mating. This information shows that the role of various factors in the status of Southern Resident killer whales is likely a complex interaction of various factors.

In June 2018, NMFS and the WDFW published The Southern Resident Killer Whale Priority Stocks Report.[230] NMFS and WDFW developed a framework to identify Chinook salmon stocks that are important to Southern Resident killer whales to assist in prioritizing actions to increase critical prey for the whales. The framework considers three evaluation factors: whether the potential prey item is an observed part of the whale diet, whether the prey item is consumed during reduced body condition or increased diet diversity, and the degree of spatial and temporal overlap of the prey item and whales. The highest-priority Chinook salmon stocks, based on this framework, are fall runs from the Northern Puget Sound and the Southern Puget Sound. Next on the list are the fall runs from the lower Columbia and the Strait of Georgia. Next are the fall runs from the Upper Columbia and Snake Rivers, spring runs from the Fraser River, and spring runs from the lower Columbia River. The complete list of 31 combined runs is presented in the 2018 report. The information presented in this report confirms the importance of a diversity of Chinook salmon runs to the prey base of Southern Resident killer whales. Further, for K and L pods, fall Chinook salmon populations from the Columbia River are an important part of their diet during the winter months.

[230] The report can be found at: https://www.westcoast.fisheries.noaa.gov/publications/protected_species/marine_mammals/killer_whales/recovery/srkw_priority_chinook_stocks_conceptual_model_report___list_22june2018.pdf Last accessed November 5, 2018.

2.19.2.1 Proposed Action and Action Area

The proposed action is described in Section 1.3 and includes a commitment to funding conservation and safety net hatcheries. The Action Agencies have also committed to fund hatchery programs with Chinook salmon production levels equal to, or greater than, those previously analyzed by NMFS in the 2008/2014 biological opinion. The action area for Southern Resident killer whales is inclusive of all areas off the Pacific Coast where salmonid species from the Columbia River, which are affected by the projects or programs of the CRS, are available as prey for listed Southern Resident killer whales. This area encompasses the whales’ entire coastal range from the Columbia River’s mouth and plume south to southern Oregon and north to the Queen Charlotte Islands.

2.19.2.1.1 Action Agencies’ Effects Determinations

The Action Agencies determined that the effects of the CRS program are not likely to adversely affect Southern Resident killer whales or their designated critical habitat.

2.19.2.1.2 Effects of the Proposed Action

The proposed action may affect Southern Resident killer whales through indirect effects to their primary prey. This analysis focuses on effects to Chinook salmon availability in the ocean because the best available information indicates that salmon are the preferred prey of Southern Resident killer whales year round, including in coastal waters, and that Chinook salmon are the preferred salmon prey species. To assess the indirect effects of the proposed action on the Southern Resident killer whale DPS, we considered the geographic area of overlap in the marine distribution of Chinook salmon affected by the action, and the range of Southern Resident killer whales.

In the 2008 FCRPS biological opinion and the 2010 and 2014 supplemental biological opinions, we stated that the operation and configuration of the FCRPS causes mortality of migrating wild (i.e., natural-origin) juvenile Chinook, which in turn results in fewer adult Chinook salmon in the ocean and reduced prey availability for killer whales (NMFS 2008a, 2010, 2014). However, we determined that the hatchery production contained in the RPA more than offsets losses to the killer whale prey base. Some of the assumptions used in that analysis (killer whale biomass and energetic requirements, the amount of time spent in coastal versus inland waters, and ocean harvest rates) have changed in the last decade, but a recent qualitative analysis (NMFS and WDFW 2018) affirmed our conclusion that hatchery Chinook salmon more than compensate for fish lost to the dams in terms of total numbers of Chinook salmon available to the killer whales. West Coast Chinook salmon production, including wild and hatchery production from the Columbia and Snake River basins, has increased over the last 50 years while survival of Chinook salmon through the hydrosystem has improved. The Action Agencies will continue to fund the Chinook salmon hatcheries with Chinook salmon production levels equal to, or greater than, those previously analyzed by NMFS in the 2008/2014 biological opinion and the hatchery production will continue to offset losses caused by CRS operations, maintenance, and management. Thus, the effects to the prey base of Southern Resident killer whales are anticipated to remain insignificant.

In addition, the Action Agencies will continue to fund or implement other activities to minimize or mitigation for the loss of salmon in the hydrosystem. These include the estuary and tributary habitat mitigation programs, and various predator-control programs. The estuary habitat mitigation program will continue the trend of increasing connected area in the estuary and is expected to continue to provide benefits to juvenile salmon, including Chinook. The tributary habitat actions (consistent with scientifically sound identification and prioritization of limiting factors and geographic locations, and principles of watershed restoration) will accrue benefits for the targeted MPGs. These activities will continue to help offset losses caused by CRS operations, maintenance, and management. Therefore, the effects of the proposed action on the prey base for Southern Resident killer whales are insignificant.

2.19.2.1.3 Critical Habitat

The final designation of critical habitat for the Southern Resident killer whale DPS was published on November 29, 2006 (71 Fed. Reg. 69054). Critical habitat consists of three specific areas: (1) the Summer Core Area in Haro Strait and waters around the San Juan Islands; (2) Puget Sound; and (3) the Strait of Juan de Fuca. These areas comprise approximately 2,560 square miles of marine habitat. Based on the natural history of the Southern Residents and their habitat needs, NMFS identified the following PBFs essential to conservation: (1) Water quality to support growth and development; (2) Prey species of sufficient quantity, quality and availability to support individual growth, reproduction, and development, as well as overall population growth; and (3) Passage conditions to allow for migration, resting, and foraging.

On January 21, 2014, NMFS received a petition requesting that we revise critical habitat, citing recent information on the whales’ habitat use along the West Coast of the United States. The Center for Biological Diversity proposes that the critical habitat designation be revised and expanded to include areas of the Pacific Ocean between Cape Flattery, Washington and Point Reyes, California, and extending approximately 47 miles offshore. NMFS published a 90-day finding on April 25, 2014 (79 FR 22933) that the petition contained substantial information to support the proposed measure and that NMFS would further consider the action. We also solicited information from the public. Based upon our review of public comments and the available information, NMFS issued a 12-month finding on February 24, 2015 (80 FR 9682) describing how we intended to proceed with the requested revision, which is still in development.

The proposed action occurs outside of the designated critical habitat. However, a small amount of Columbia River Chinook salmon are recovered in Puget Sound, especially relative to the proportion of Puget Sound Chinook salmon present (Weitkamp 2010). Because so few Columbia River fish from any one of the Chinook salmon ESUs would be encountered, and because the hatchery program compensates for the loss of Chinook salmon in the CRS, the effect to the prey base PBF is insignificant.

2.19.2.1.4 Conclusion

Based on this analysis, NMFS concurs with the Action Agencies that the proposed action is not likely to adversely affect Southern Resident killer whales or designated critical habitat.

3. Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response

Section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. The MSA (section 3) defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH.

This analysis is based on an EFH assessment conducted by NMFS and descriptions of EFH for Pacific Coast groundfish (Pacific Fishery Management Council [PFMC] 2005), coastal pelagic species (CPS) (PFMC 1998), Pacific Coast salmon (PFMC 2014); and highly migratory species (PFMC 2007) contained in the fishery management plans developed by the PFMC and approved by the Secretary of Commerce. In this case, NMFS concluded the proposed action would not adversely affect EFH for Pacific Coast groundfish, coastal pelagic species, and highly migratory species. Thus, consultation under the MSA is not required for these habitats.

3.1 Essential Fish Habitat Affected by the Project

The proposed action and action area for this consultation are described in the Introduction section to this document. The action area includes areas designated EFH for various life-history stages of two Pacific Coast salmon species Chinook salmon and coho salmon (PFMC 2014). Habitat areas of particular concern (HAPC) within the action area include estuaries, complex channel and floodplain habitat, spawning habitat, and thermal refugia (PFMC 2005, 2014).

Freshwater EFH for Pacific Coast salmon (Chinook and coho) consists of four major components: (1) spawning and incubation; (2) juvenile rearing; (3) juvenile migration corridors; and (4) adult migration corridors and holding habitat, and overall, can include any habitat currently or historically occupied within Washington, Oregon, and Idaho. The important elements of Pacific salmon marine EFH are (1) estuarine rearing; (2) ocean rearing; and (3) juvenile and adult migration; the only marine EFH habitat found within the action area for this consultation is the estuarine rearing habitat in the lower Columbia River, and marine habitat where Southern Resident killer whales feed on Columbia River Chinook salmon. Detailed descriptions and identifications of EFH for salmon are found in Appendix A of Amendment 18 of the Pacific Coast Salmon Plan (PFMC 2014).

3.2 Adverse Effects on Essential Fish Habitat

We conclude that the proposed action will have the following adverse effects on EFH designated for Chinook and coho salmon:

1. Reduction in habitat quality in the juvenile and adult migration corridors because of the operation of the dams and reservoirs and increased predation.
2. Reduced access to mainstem spawning habitat (operation of the reservoirs).
3. Reduced quantity and quality of rearing habitat because of lost connectivity to the riverine and estuarine floodplain, reduced water quality, reduced thermal refugia habitat.

3.3 Essential Fish Habitat Conservation Recommendations

For each of the potential adverse effects by the proposed action on EFH for Chinook and coho salmon, NMFS believes that the proposed action, as described in Section 1.3 and the ITS in the CRS Biological Opinion and EFH Consultation 2018 409 (Section 2.17, above) includes the best approaches to avoid or minimize those adverse effects. Reasonable and Prudent Measures 1 through 5 and their associated Terms and Conditions included in the ITS that address minimizing or monitoring effects to Chinook and coho salmon constitute NMFS recommendations to address potential EFH effects. The Action Agencies shall ensure that the ITS, including Reasonable and Prudent Measures and implementing Terms and Conditions, are carried out.

3.4 Statutory Response Requirement

Pursuant to the MSA (§ 305(b)(4)(B)) and 50 C.F.R. § 600.920(j), the Action Agencies are required to provide a detailed written response to NMFS within 30 days of receiving an EFH Conservation Recommendation. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS' EFH Conservation Recommendations unless NMFS and the Action Agencies have agreed to use alternative time frames for the federal agency response. The response must include a description of measures proposed by the agency for avoiding, minimizing, mitigating, or otherwise offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the Conservation Recommendations, the Action Agencies must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects (50 CFR 600.920(k)(1)).

In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget (OMB), NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the Action Agencies. Therefore, we ask that in your statutory reply to the EFH portion of this consultation, you clearly identify the number of conservation recommendations accepted.

3.5 Supplemental Consultation

The Action Agencies must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH Conservation Recommendations (50 CFR 600.920(l)).

4. Data Quality Act Documentation and Pre-Dissemination Review

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion are Bonneville Power Administration, U.S. Army Corps of Engineers, and U.S. Bureau of Reclamation. Other interested users could include the states of Oregon, Washington and Oregon, tribes, and others interested in the conservation of the affected ESUs/DPS. Individual copies of this opinion were provided to the Bonneville Power Administration, U.S. Army Corps of Engineers, and U.S. Bureau of Reclamation. The document will be available through the NOAA Institutional Repository (https://repository.library.noaa.gov/), after approximately two weeks. The format and naming adheres to conventional standards for style.

4.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

4.3 Objectivity

Information Product Category: Natural Resource Plan

4.3.1 Standards

This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA regulations, 50 CFR 402.01 et seq., and the MSA implementing regulations regarding EFH, 50 CFR 600.

4.3.2 Best Available Information

This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this opinion and EFH consultation contain more background on information sources and quality.

4.3.3 Referencing

All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

4.3.4 Review Process

This consultation was drafted by NMFS staff with training in ESA and MSA implementation and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

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Appendix A – Tributary Habitat Technical Foundation and Analytical Methods

Appendix B – Pinniped Predation

Appendix C – Avian Predation Management

Appendix A – Tributary Habitat Technical Foundation and Analytical Methods

A.1 Introduction

This appendix summarizes updated information on the scientific basis for how tributary habitat actions can improve salmonid abundance, productivity, spatial structure, and diversity within the Columbia and Snake River basins. It also describes the methods we used to inform our analysis of the effects of tributary habitat improvement actions in the baseline and the proposed action for this biological opinion. Finally, it discusses important considerations in implementation of tributary habitat improvement actions.

A.2 Scientific Basis for Tributary Habitat Improvement Actions

NMFS has determined, based on best available science, that by identifying the factors limiting habitat function, and by strategically implementing actions to alleviate those limiting factors, habitat function will improve and, ultimately, the abundance, productivity, spatial structure, and diversity of salmon and steelhead will improve as well.[1] This fundamental relationship between fish, freshwater habitat, and population response provides the basis for implementation of tributary habitat improvement actions. This fundamental relationship was articulated in Appendix C of the 2007 Comprehensive Analysis (USACE et al. 2007, Appendix C, Attachment C-1 and Annexes 1-3) and reiterated in NMFS' previous federal Columbia River System (CRS) biological opinions, including the 2008 Federal Columbia River Power System (FCRPS) biological opinion and its 2010 and 2014 supplements (NMFS 2008, 2010, 2014).[2] Below we summarize and update the findings and discussion in those documents.

A.2.1 2014 Supplemental Biological Opinion

In the 2014 supplemental biological opinion, we described our knowledge of the basic relationships between fish and their tributary habitat, and the findings in the scientific literature about how changes in fish habitat affect fish populations. We evaluated multiple lines of

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[1] In most cases, near-term benefits would be expected in abundance and productivity. Depending on the population and the scale and type of action, benefits to spatial structure and diversity might also accrue, either in the near term or over time. In addition, while we expect abundance, productivity, spatial structure, and diversity to respond positively to strategically implemented tributary habitat improvement actions, other factors also influence these viability parameters (e.g., ocean conditions) and any resulting trends. Throughout this tributary habitat discussion, when we discuss improvements in abundance and productivity, it is implied that spatial structure and diversity might also respond positively, and that other factors, as noted here, might influence any resulting trends.

[2] In earlier biological opinions, the federal Columbia River System (CRS) was referred to as the Federal Columbia River Power System or FCRPS.

evidence, including literature on the physical and biological effectiveness of improvement actions, correlation analyses, and preliminary results from monitoring in the Columbia River basin designed to evaluate the effects of various actions on tributary habitat limiting factors and on salmon and steelhead population response. We noted that the outcomes of habitat improvement are well documented and support our determination that the strategic implementation of actions to alleviate habitat limiting factors will improve habitat function and, ultimately, the freshwater survival of salmon and steelhead.[3] We also noted that long-term studies were underway in the Columbia Basin to further validate and contribute to adaptive management and implementation of tributary habitat improvement actions (NMFS 2014).

We determined in the 2014 supplemental biological opinion that tributary habitat improvement actions have been well documented to provide benefits to fish at the stream-reach scale. We also noted that studies examining changes in salmon and steelhead survival at the population scale were less numerous, in part because directly measuring survival in response to habitat improvement at the watershed scale is complex, costly, and generally requires lengthy periods of action implementation and habitat and fish response monitoring. We found that available studies at the population or watershed scale supported our determination that tributary habitat improvements would lead to improved freshwater survival, as did correlation analyses that examined relationships between habitat improvement actions and fish abundance. We also determined that preliminary results from research, monitoring, and evaluation (RM&E) implemented under the 2008 biological opinion appeared to support our determination (NMFS 2014).

In the 2014 supplemental biological opinion, we concluded that the best available scientific literature on habitat improvement indicated that many habitat improvement actions (such as increasing instream flow, improving access to blocked habitat, reducing mortality from

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[3] In the 2008 FCRPS biological opinion and its 2010 and 2014 supplements, we characterized the benefits of tributary habitat improvement actions at the population level primarily in terms of their effect on freshwater survival, either stage-specific or total egg-to-smolt survival. We also assumed based on best available information that these improvements would carry on to direct improvements in recruits per spawner (R/S) and therefore contribute to achieving metrics, such as R/S > 1, that were used as one part of the analysis in those biological opinions. In this current biological opinion, we characterize the effects of tributary habitat improvement actions at the population level primarily in terms of changes in population abundance, productivity, spatial structure, and diversity. We then qualitatively relate these population-level changes to effects to the species or designated critical habitat. This approach is consistent with our section 7 regulations, which direct NMFS to formulate the agency's biological opinion as to whether a proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat for the conservation of the species (50 CFR 402.02). The approach is also consistent with our longstanding use of "viable salmonid population" (VSP) parameters (McElhany et al. 2000) to evaluate Pacific salmon and steelhead population viability. The four VSP parameters (abundance, productivity, spatial structure, and diversity) encompass the species' "reproduction, numbers, or distribution," and are commonly used to evaluate long-term risk of extinction and population status relative to ESA recovery goals. All of these population parameters could affect survival and also mitigate extinction risk by making populations more resilient, and this is why we use these factors to assess the status of populations, which in turn informs the evaluation of species status.

entrainment at water diversion screens, placing of logs and other structures to improve stream structure, and restoring off-channel and floodplain habitat) can improve tributary habitat quantity and quality over relatively short time periods. We also concluded that other habitat improvements, such as actions that address the source of fine sediment in spawning areas (e.g., road decommissioning) and the restoration of riparian vegetation, may take decades to realize their full benefit (NMFS 2014).

In addition, we concluded that the best available scientific literature supports the approach of improving tributary habitat to increase survival of salmon and steelhead at the population scale, and we noted that preliminary results from tributary habitat RM&E conducted under the 2008 biological opinion provided evidence that the Action Agencies' habitat improvements were correctly targeting and improving degraded conditions and providing benefits to fish (NMFS 2014).

A.2.2 Updated Findings on Scientific Basis for Tributary Habitat Improvement Actions

Literature on fish habitat restoration is extensive and has been summarized recently in the context of salmon and steelhead recovery in the Columbia River basin (see Roni et al. 2002, 2008, 2014). More recently, Hillman et al. (2016) conducted a review of published and unpublished literature on the effectiveness of habitat improvements that built upon those earlier reviews. Pess and Jordan at al. (in press) also summarized findings on habitat restorative actions at the site and reach scale, and Roni (2018) reviewed studies that specifically examined fish movement in relation to river or floodplain habitat restoration or improvement. Haskell et al. (2018) and Bennett et al. (2016) summarized key findings from 16 Intensively Monitored Watersheds (IMWs) and evaluated IMWs as a method for evaluating the effects of tributary habitat improvement actions. In addition, the Independent Scientific Advisory Board (ISAB 2015) evaluated density dependence (the relationship between population density and population growth rate) in the Columbia River basin, including density dependence in tributary habitats. Below we briefly describe results from recently published literature and monitoring and evaluation conducted in conjunction with CRS tributary habitat actions, and our conclusions regarding how that information supports the basis of the CRS tributary habitat improvement actions.[4]

[4] Under the 2008 biological opinion and the Adaptive Management Implementation Plan (adopted as part of the 2008 biological opinion and its 2010 supplement), the Action Agencies implemented an extensive tributary habitat monitoring program (under RPA Actions 56 and 57), paired with fish population status monitoring (under RPA Action 50), to define the benefits of habitat improvements (NMFS 2008, 2010, 2014). This RM&E program was part of an adaptive management approach designed to inform and shape future habitat actions so they deliver increasingly meaningful and cost-effective results (BPA and USBR 2013). The program was described briefly in the 2014 supplemental biological opinion (and in more detail in the BPA et al. 2013, BPA 2013, and BPA and USBR 2013). Hillman et al. 2016, Bennett et al. 2016, and Haskell et al. 2018 incorporate recent results from that RM&E program.

A.2.2.1 Response at the Stream-Reach Scale

Hillman et al. (2016) searched for literature not reviewed in the earlier efforts by Roni et al. (2002, 2008, 2014) and identified papers that provided quantitative information on physical and biological response to habitat improvement. They provided an annotated bibliography for each paper they reviewed, summarizing key findings and reporting quantitative changes in physical and biological parameters, including changes in fish habitat and fish abundance where available. They summarized the results for major categories and sub-categories of improvement actions. Below we summarize these findings with extreme brevity and provide a few anecdotal examples from recent monitoring for illustrative purposes; readers are referred to Hillman et al. (2016), Pess and Jordan et al. (in press), Roni et al. (2002, 2008, 2014, 2018), and specific monitoring reports and publications for more detail.

Barrier removal: Habitat conditions have been shown to respond quickly to barrier removal, and positive effects are usually long term or even permanent. Reviews of the effectiveness of habitat improvements have consistently reported removal of barriers or installation of fish passage as one of the most effective methods for increasing fish numbers (Roni et al. 2014; Hillman et al. 2016; Pess and Jordan et al. in press). Examples abound, and we include just a few here for illustration:

- In many years, low flows and obstructions blocked Loup Loup Creek, the southernmost tributary of the Okanogan River, making it impassable to fish trying to reach habitat in the creek's upper reaches. Agreements on water use, removal of culverts, and replacement of another barrier known for stranding fish reopened the creek in 2010. Increasing numbers of juvenile steelhead have been documented by annual snorkel surveys in the creek, and adult steelhead are also returning, with an average of 22 adult steelhead returning to the creek each year from 2012 to 2016 (OBMEP 2018).
- Evaluations of culvert removal projects in Washington State, including two sites in the Columbia River basin, have indicated increases in juvenile coho salmon numbers within two years of culvert removal or replacement (O'Neal et al. 2016).
- In an evaluation of fish numbers above and below former impassable culverts at 32 sites in the interior Columbia River basin, no differences were detected in numbers of steelhead or other salmonids above and below the formerly impassable barriers (Hillman et al. 2016). This suggests culvert replacement has been effective in allowing juvenile salmonids access to formerly blocked habitat.

Instream structures: Actions carried out to improve stream complexity include the placement of structures such as logs, logjams, cover structures, and boulders, and the addition of gravel. Most published literature on placement of instream structures is related to placement of large woody debris (LWD), and the vast majority of these studies show a positive response for habitat and salmonid fishes (Hillman et al. 2016; Pess and Jordan et al. in press). The increase in abundance in improved habitats was typically related to an increase in habitat capacity, and not due to a redistribution of fish from other habitats of the same stream reach (Polivka et al. 2015; Roni 2018). The lack of response or small decrease in abundance reported in some studies appears to be largely because watershed processes (e.g., sediment, water quality, etc.) were not addressed, because monitoring had not occurred long enough to show results, or because treatments had resulted in little change in physical habitat. Although more research specific to these action types for Chinook salmon and steelhead in the Columbia River basin is needed, available studies show that the effects of instream structures are generally rapid (1-3 years), often occurring during the first high flow event (Hillman et al. 2016).

One study (Clark et al. 2017) evaluated 16 projects throughout the Columbia Basin that involved adding large woody debris to streams. The evaluation included snorkel surveys to examine fish numbers in sites where debris had been added as part of restoration, compared to numbers from surveys at control sites where no improvements had been made. The evaluation found nearly double the density of juvenile steelhead in streams with wood structures compared to those without. The improvement in fish numbers was consistent among various sites and watersheds. In addition, the restored reaches included more pools and larger pools, signaling that the woody debris helps add needed complexity to rivers and streams by altering river flows that shape and scour the streambeds. The surveys did not find significant differences in numbers of Chinook and coho salmon between restored and unimproved reaches, but the documented improvements in habitat have often been found to be correlated with a response by fish populations.

In three tributaries of Asotin Creek, a tributary of the Snake River in southeast Washington, scientists from 2012 to 2016 installed more than 650 log structures made of wood debris held in place by log piles driven into the stream bottom in an effort to add complexity to the stream and provide habitat for fish. Early monitoring has documented a 28.8 percent increase in juvenile steelhead abundance in areas with the wood debris compared to those without, and modeling suggests the carrying capacity of the streams has increased by 50 percent following addition of the debris. Initial results also suggest the productivity of fish populations may be increasing, as reflected by the number of surviving smolts per female spawning in the research stretches of streams. Researchers will continue tracking the number of smolts per female to determine whether the increases continue in the long term (Griswold and Phillips 2018).

One relatively new type of instream habitat improvement with promising results is the addition of structures to mimic the hydro-geomorphic effects of beaver dams. The importance of beaver dams for creating habitat is well documented. “Beaver support structures” or “beaver dam analogs” can have similar effects on stream velocity, surface water level and routes, ground water level, sediment sorting, water table, and riparian vegetation. Recently published results from one such project in Bridge Creek, in the John Day River basin, have shown that beaver dam analogs can lead to aggradation of incised channels, increased side channels, increased floodplain area, and increased groundwater levels, as well as to construction of actual beaver dams (Pollock et al. 2012; DeVries et al. 2012; Bouwes et al. 2016b). Results from this study in Bridge Creek also show significant increases in the density, survival, and production of steelhead following construction of beaver dam analogs (Bouwes et al. 2016b). More recent studies outside the Columbia River basin suggest that instream structures can help to restore human-impacted river ecosystems, primarily through altering the abundance and biomass of consumers and resources in the food web (Thompson et al. 2018).

Floodplain habitat reconnection: Studies on effectiveness of floodplain habitat reconnection have consistently shown rapid recolonization of newly accessible habitat by salmonids and other fishes, and fish rearing in such habitats can have higher growth rates than those rearing in the mainstem. Success of these projects depends on their connection with the main channel and their morphology and depth, as well as on addressing water quality and other upstream problems, although more monitoring of such projects in the Columbia River basin is needed (Hillman et al. 2016). Recent examples with positive results include remediation and reconnection of former mining dredge ponds to the Yankee Fork of the Salmon River in central Idaho, where the reconnected habitats quickly became home to juvenile salmon and spawning steelhead (Bellmore et al. 2012). Also, improvements coordinated by the Confederated Tribes of the Umatilla Indian Reservation on Catherine Creek in northeast Oregon increased the habitat capacity for juvenile salmon by roughly two to eight times in terms of usable area for fish, depending on the time of year. Biologists recorded immediate improvements in favorable habitat measures, such as the frequency of slow-water pools, and the amount of large woody debris (CTUIR 2017).

Recent modeling efforts in the Columbia River basin suggest that there has been an estimated 26 percent decrease basinwide in floodplain channel area from historical conditions, and that reconnecting historical floodplains currently used for agriculture could increase side-channel habitat by 25 percent and spring Chinook salmon parr rearing capacity by 9 percent over current estimates (Bond et al. 2018). While individual watersheds throughout the Columbia River basin vary greatly in habitat factors that limit salmon recovery, large-scale estimates of restoration potential like this one are useful in making decisions about long-term restoration goals (Bond et al. 2018).

One of the best examples of floodplain reconnection and its effectiveness is just north of the Columbia River on the Fraser River, in British Columbia. To mitigate damage from past logging activities, the floodplain of the upper Chilliwack River watershed, a tributary to the Fraser River, was extensively restored from 1996 to 2000 through off-channel habitat restoration (Ogston et al. 2014). Researchers estimated that 27 to 34 percent of the total production of out-migrating coho salmon smolts in the watershed could be attributed to the newly created habitat (Ogston et al. 2014).

Riparian planting: Riparian habitat improvement through riparian planting and silvicultural treatment, invasive species control, and riparian fencing and grazing management can lead to increased shade, bank stability, reduction of fine sediment, reduced temperatures, and improvement of water quality (Roni et al. 2014; Hillman et al. 2016; NMFS 2017b). While some benefits of riparian planting begin to accrue after ten to fifteen years (Justice et al. 2017; Pess and Jordan et al. in press), the full effects of riparian plantings on habitat conditions can take more than 50 years to accrue, in part because of the long lag time between tree growth and any change in channel conditions, delivery of large wood, and shading effects on temperature. As a result, few studies have examined the response of instream habitat or fish to riparian planting or thinning. One retrospective study (Lennox et al. 2011) found that project age was positively correlated with both riparian vegetation and fish habitat at enhanced sites. Riparian enhancement actions are also often critical for success of other enhancement actions (e.g., floodplain, instream) (Hillman et al. 2016). Justice et al. (2017) found through modeling that a combination of riparian restoration and channel narrowing could both reduce stream temperatures and increase the abundance of Chinook salmon parr in the Upper Grande Ronde River and Catherine Creek in northeast Oregon. They utilized a stream temperature model to explore potential benefits of channel and riparian restoration on stream temperatures in the Upper Grande Ronde River and Catherine Creek basins, and concluded that restoration of such streams could more than make up for an expected increase in summer stream temperature through 2080.

Livestock exclusions: Monitoring of livestock exclusions to improve riparian areas shows that habitat response can occur relatively rapidly (<5 years), but studies of fish response have been variable. Lack of fish response has been attributed to short duration of monitoring, small size of exclosures, and the influence of upstream processes (Hillman et al. 2016). In one example, researchers are tracking the condition of seven livestock exclusion projects across the Columbia Basin, although only two of the sites include observations from before the livestock exclusion projects for comparison. Where data are available, comparisons show a reduction in erosion and a slight increase in canopy cover, which matches broader findings on the relationship between grazing and riparian health. In a study of 261 grazed and ungrazed watersheds, those without grazing impacts demonstrated more stable banks, deeper pools, and reduced amounts of fine sediment. Researchers expect to see continued improvements in riparian conditions in areas where grazing impacts have been controlled, although the full response may take several years (O'Neal et al. 2017).

Reduction of excess fine sediment: Reduction of excess fine sediment is usually accomplished through road enhancement, agricultural treatments, and riparian enhancement. Actions such as road decommissioning, removal, and upgrading are successful in decreasing fine sediment delivery to streams. Little monitoring and evaluation has been done to examine the response of fish or other biota to road treatments (Hillman et al. 2016).

Flow augmentation: Reduced flows can affect adult and juvenile salmonids by blocking fish migration, stranding fish, reducing rearing habitat availability, and increasing summer water temperatures (NMFS 2017b). Flow protection or enhancement reduces these impacts, and the literature shows an obvious and clear relationship between increased flows and increases in fish and macroinvertebrate production (Hillman et al. 2016). The response is most dramatic in stream reaches that were previously dewatered or too warm to support fish because of water withdrawals, and the most successful projects are those in which acquired flows are held in trust long term or in perpetuity (Hillman et al. 2016). Studies of fish movements following increases in instream flows show rapid fish colonization of newly accessible habitats and illustrate the success of these projects (Roni et al. 2008) For example, ongoing studies in the Lemhi River basin show increased spawner and juvenile fish numbers following enhancement of instream flows in tributaries (Uthe et al. 2017; Appendix A of Griswold and Phillips 2018). Similarly, re-watering a previously dewatered reach of the Bridge River in British Columbia led to increases in juvenile Pacific salmon and riparian plant growth following enhancement of instream flows (Hall et al. 2011; Bradford et al. 2011, cited in Hillman 2016). The effects of flow augmentation on habitat conditions depend on the amount of flow within the channel, how much water is added, and how long it remains in the stream (e.g., is the water removed downstream? is the augmentation perpetual or for a limited time of year or number of years?). Augmented flow in dewatered channels or in streams too warm to support fish will have the greatest effects on habitat condition. In addition, augmenting flood flows can improve floodplain connectivity and off-channel conditions (Hillman et al. 2016).

Nutrient enhancement: Hillman et al. (2016) did a comprehensive review of literature on the topic of nutrient enhancement. They concluded that while additional study is needed, available studies suggest that nutrient enrichment through the addition of inorganic nutrients, salmon carcasses, or an increase in spawning fish can increase primary and secondary production and fish growth and possibly survival of salmonids in oligotrophic streams.

Acquisition and protection: Protection of high-quality riparian/floodplain habitat (e.g., through conservation easements and acquisitions) helps to maintain riparian vegetation, reduce delivery of sediments and pollutants to streams, and maintain bank stability and water quality. The most favorable responses come from protecting large areas of streamside habitat in perpetuity, addressing upstream processes that negatively affect downstream habitat conditions, and regulating/managing activities within the protected areas (Hillman et al. 2016).

A.2.2.1.1 Summary: Response at the Stream-Reach Scale

Extensive literature continues to document benefits to habitat and fish at the stream-reach scale as a result of habitat improvements. Barrier removal and the placement of large woody debris and other types of instream structures are known to improve instream habitat and increase numbers of trout and juvenile coho salmon and steelhead. Various floodplain habitat improvement and enhancement techniques also show positive responses.

Relatively little work has examined the physical and biological response in streams from riparian planting, flow augmentation, sediment reduction (road removal), and acquisition and protection. Additional monitoring or focused studies examining the effects of these methods, and of their cost-effectiveness, would be beneficial. Additional studies of instream structures and floodplain reconnection specific to Chinook salmon in the Columbia River basin may also be warranted; many studies of those techniques have been done in coastal coho streams, but the existing body of literature provides a level of confidence in the effects of those actions.

Addition of inorganic or organic nutrients or salmon carcasses has been shown to increase primary and secondary production and fish growth, although few studies have documented increased fish numbers. Moreover, studies to date in the Columbia River basin have not shown an increase in fish numbers. Thus, these techniques should still be considered experimental and in need of additional evaluation.

In studies where no response has been shown to habitat improvement actions, it appears to be largely because watershed processes (e.g., sediment, water quality, etc.) were not also addressed, because monitoring had not occurred long enough to show results, or because treatments had resulted in little change in physical habitat (Hillman et al. 2016). These findings highlight factors important to the success of habitat improvement actions: ensuring that upstream and watershed processes (such as sediment and water quality) have been addressed, understanding what factors are limiting fish production, and ensuring that the total amount or extent of treatment is adequate.

Roni (2018) reviewed literature that informed a key uncertainty about the effects of tributary habitat improvement: whether fish concentrate around restoration projects (i.e., whether fish move into restored habitat but there is not actually an increase in total fish abundance) or whether restoration actually increases total abundance. Based on his review, he concluded that existing literature provides little evidence to support the view that river restoration leads to concentration of fish at restoration sites. Rather, he found that instead the literature does suggest that restoration may lead to either increased survival, increased abundance, or both. Roni (2018) notes that the scientific literature suggests that fish response to restoration varies greatly depending on the watershed template, location and characteristics of the habitat restoration, and the life history and limiting factors for the species being addressed.

A.2.2.2 Response at the Population/Watershed Scale

As noted in the 2014 supplemental biological opinion (NMFS 2014), population- or watershed-scale monitoring projects are rare compared to reach-scale monitoring, because population-scale monitoring is challenging and costly, requiring robust large-scale monitoring and implementation designs; long-term monitoring, coordination, and funding commitments; and large and extensive treatments. However, as we noted in 2014, a number of IMWs have been underway throughout the Columbia Basin and the Pacific Northwest.

IMWs are large-scale experiments with well-developed, long-term monitoring designed to determine population/watershed-scale fish and habitat responses to enhancement actions. Although most IMWs are in the early stages of development and would not be expected to show full results yet, a few have demonstrated fish responses at the watershed scale.[5] Some IMWs

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[5] Ten IMWs have detected improvements in juvenile fish metrics and four have already documented significant increases in adult salmon. Adult salmon increases were limited primarily to IMWs that included removals of dams or barriers that opened new areas for colonization, again indicating that those actions are the most expedient ways of increasing numbers of adult salmon and steelhead.

have shown little or no response even after intense treatment and monitoring (e.g., Tenmile and Fish Creeks). This is believed to be because broader watershed-scale factors, such as floods and road failures, limited the success of the restoration actions implemented, or, in some cases, because design and procedural issues during monitoring limited the ability of the IMW to detect responses to enhancement.

Below we highlight notable results from some of the longer-running IMWs in the Columbia River basin. Because enhancement actions have generally not been implemented for a long enough period for habitat and fish populations to respond and to allow full evaluation, most IMWs are several years away from definitive conclusions regarding enhancement effectiveness. Several summaries of results to date have recently been completed (Roni et al. 2014; Hillman et al. 2016; Bennett et al. 2016; Griswold and Phillips 2018; Haskell et al. 2018), and readers are referred to those summaries as well as to publications cited therein and below regarding specific IMWs for additional detail.

Asotin Creek IMW: The goal of the Asotin Creek IMW is to test the effectiveness of adding LWD to increase habitat complexity and steelhead production. Researchers added LWD to treatment sections and compared the treated sections to control sections. Although monitoring is still in the early stages, initial results show significant improvements in habitat complexity. The frequency of LWD has increased by 185 percent in treated sections compared to control sections, and the structures are creating hydraulic and geomorphic responses. It is too early to evaluate changes in steelhead production, but researchers have documented a significant (250 percent) increase in juvenile abundance in treatment reaches compared to control reaches. Practitioners also report increases in juvenile growth, survival, and productivity, as well as in numbers of adults and redds (Haskell et al. 2018). The remainder of the study will focus on estimating changes in productivity and other life-history characteristics of steelhead, and identifying the causal mechanisms of changes (Bouwes et al. 2016a).

Bridge Creek IMW: The Bridge Creek IMW is designed to test whether constructing beaver dam analogs to encourage natural beaver dam development can improve habitat in Bridge Creek, a deeply incised stream in the John Day River basin that has limited riparian vegetation and poor habitat complexity and quality. The hypothesis is that the analogs and beavers will aggrade the channel and thereby alter hydrology, temperature, geomorphology, and vegetation to improve habitat conditions for steelhead. Researchers saturated four reaches on Bridge Creek with beaver dam analogs and identified control reaches. Monitoring occurred three years before treatment (2007–09) and four years after treatment (2010–13). In 2013, researchers counted 236 beaver dams in Bridge Creek. About half of these were made by beavers; the others were functioning beaver dam analogs (overall an eight-fold increase over the pre-treatment conditions). Treated reaches had higher water levels and deeper pools, lower water temperatures, large upstream dam pools and downstream plunge pools, and large increases in inundation area, thermal refugia, and side channels. The beaver complexes also created greater variability in water depths, channel widths, and temperatures, indicating an increase in habitat complexity. These changes translated into changes in fish density, density-dependent decreases in growth, and increases in juvenile survival. Four years following treatment, juvenile production had increased in Bridge Creek by 175 percent relative to the control. The treatments had no negative effects on upstream or downstream migration of juvenile or adult steelhead (ISEMP/CHaMP 2015, 2016; Bouwes et al. 2016b).

Entiat River IMW: Researchers and stakeholders determined that reduced instream complexity was the primary concern limiting Chinook salmon and steelhead production in the lower 26 miles of the Entiat River. Current land uses (primarily agriculture, roads, and residential development) restrict habitat improvement options in this portion of the river, so an engineered approach is being used to increase complexity, including adding rocks and large wood to the river, and reconnecting the floodplain by breaching levees where possible. So far, two of four planned rounds of habitat actions have been completed, affecting about 14 percent of the targeted stretch of river. To date, habitat monitoring has shown a significant increase in the volume of wood in the Entiat River (ISEMP/CHaMP 2015, 2016). No other habitat or geomorphic metrics have yet responded to the treatments, and researchers have not yet found significant fish population responses. However, fish are using treated areas on a seasonal basis at a fine scale (RD Nelle, USFWS, personal communication, cited in Hillman et al. 2016). Polivka et al. (2015) also found that both Chinook salmon and steelhead were more abundant in improved pools than in untreated pools in early summer, but this difference was mostly absent by September. They concluded that the increase in juvenile Chinook salmon abundance in improved pools was related to an increase in habitat capacity and not because of a redistribution of fish from natural habitat in the same segment.

Importantly, the Entiat River has not yet experienced the high post-treatment flows needed to affect channel morphology as hypothesized. Furthermore, the enhancement plan is only 50 percent complete. Whether the enhancement plan can be implemented as originally designed is questionable because landowner constraints currently limit the completion of the implementation plan. The Entiat IMW showcases many of the challenges of implementing enhancement actions under a structured monitoring design (Hillman et al. 2016).

Lemhi River IMW: In the Lemhi River, stakeholders and researchers determined that insufficient instream flow, loss of access to historically important habitat, and simplification of mainstem habitat were the primary ecological concerns for Chinook salmon and steelhead productivity (ISEMP/CHaMP 2015, 2016). Researchers developed a plan to remove or reduce migration barriers, maintain or enhance riparian conditions, decrease fine sediment and temperatures, increase tributary connections, and improve habitat quality. Twenty-two types of habitat improvement actions were planned in high-priority watersheds. To date, tributary water diversions have been replaced with mainstem diversions, allowing tributaries to be reconnected to the mainstem, reducing total water withdrawals, and allowing cooler tributary water to enter the mainstem Lemhi River. In addition, tributary passage conditions have been improved, providing access to relatively intact public lands. Fish and habitat monitoring are underway to detect life-stage specific responses to individual habitat actions and the accumulated effects of multiple actions at the population scale.

The reconnection of tributaries to the Lemhi River has nearly doubled the length of stream available to Chinook salmon and steelhead (ISEMP/CHaMP 2016). Minimum instream flow agreements have addressed passage impediments and reduced temperatures in the upper mainstem Lemhi River. Overall, restoration has resulted in a 22 percent increase in wetted stream area and a 19 percent increase in pool habitat compared to pre-treatment conditions. Adult steelhead have moved into each of the five reconnected tributaries, and these tributaries are producing anadromous juveniles. Researchers have also documented the presence of adult Chinook salmon in two of the five reconnected tributaries, and juvenile Chinook salmon in all reconnected tributaries (Hillman et al. 2016; Haskell et al. 2018). This is the first occurrence of juvenile salmon in four of the five tributaries since the mid-2000s. The IMW team has reported an increase in juvenile Chinook salmon productivity (Uthe et al. 2017; Haskell et al. 2018). Overall, work in the Lemhi River basin has increased the summer rearing capacity for parr by 62 percent. Monitoring information and modeling results now indicate that juvenile Chinook salmon rearing habitat, particularly winter habitat, is currently limiting in the lower Lemhi River. As a result, habitat improvement efforts have shifted to improve habitat in the lower Lemhi River (Hillman et al. 2016).

Fish Creek IMW: Fish Creek, a tributary to the Clackamas River in Oregon, was one of the earliest IMWs. The goals of enhancement were to increase the amount of pool habitat for summer and winter rearing and the amount of habitat for anadromous salmonids (Chinook and coho salmon and steelhead). Intensive monitoring of enhancement activities began in 1982 and continued through 1995. Some preliminary enhancement activities occurred in 1983, but most work (LWD placement, off-channel pond construction) occurred from 1986 to 1988. This included placement of 500 LWD structures covering much of the anadromous zone of Fish Creek. Despite intensive monitoring of habitat and numbers of parr, smolts, and adults, significant changes in fish numbers were not detected after enhancement. There were rapid increases in pool habitat following placement of instream structures, but no significant increases in coho salmon or steelhead parr or smolts were detected. Chinook salmon were present only during the initial years of the study and their response to enhancement could not be examined. Floods in the winter of 1995–96 damaged or destroyed many of the instream structures, and road failures and other broader watershed-scale factors and processes following enhancement appear to have limited the success of the habitat actions. These results highlighted the need for (1) addressing watershed-scale processes, (2) having a control watershed, and (3) not relying solely on statistical significance to determine fish response to enhancement (Reeves et al. 1997, cited in Hillman et al. 2016).

Methow River IMW: In the Methow Basin, analysis indicated that insufficient instream flows, floodplain connectivity, and off-channel habitat; fish passage barriers; high levels of fine sediments; and degraded riparian conditions limited salmonid productivity. As a result, more than 120 improvement and protection projects have been implemented within the basin since 1999. Actions include augmenting flow, screening of water withdrawals, improving fish passage, reconnecting floodplains and side channels, improving riparian habitat, and placing of instream structures. A collection of studies designed to look at different reach-scale enhancement measures and limiting factors is being carried out. Results to date indicate that Chinook salmon and steelhead carrying capacity of reconnected side channels is 251 percent higher, on average, than in the main channel (based on food availability) (Bellmore et al. 2013), and that densities (but not survival) increased for both Chinook salmon and steelhead following habitat action implementation. The side channels also provide escape cover for juvenile Chinook salmon and steelhead from predatory fish species (Haskell et al. 2018).

This work also led to the development of an Aquatic Trophic Production model (food-web model), which can be used to estimate the effects of habitat improvement projects (floodplain connection, riparian habitat enhancement, nutrient enhancement, and instream structures) on freshwater carrying capacity for Chinook salmon and steelhead (Benjamin and Bellmore 2016). The model was also used to compare the relative response of various restoration actions (side-channel addition, carcass additions, and riparian restoration) on changes to the food-web biomass. Bellmore et al. (2017) found that adding side channels adjacent to the main channel had the greatest effect on fish (and all other trophic levels), indicating that efforts to enhance river-floodplain connectivity may be beneficial (Bellmore et al. 2013; Martens and Connolly 2014).

Potlatch Creek IMW: In the Potlatch Creek basin, research indicated that low flows and dewatering were the primary factors affecting steelhead production in the lower basin, while a lack of habitat complexity was limiting steelhead production in the upper basin (Bowersox and Biggs 2012; Heekin 2013). In the lower basin (Big Bear Creek), low flows and dewatering are being addressed by removing fish passage barriers to open inaccessible habitat and developing water-release strategies from headwater reservoirs. In the upper basin (East Fork Potlatch River), habitat enhancement actions, including woody debris treatments and meadow rehabilitation, are being implemented to improve habitat complexity. Currently, about 25 percent of planned treatments have been completed. Preliminary results suggest that juvenile steelhead densities are greater within treatment reaches than in control reaches in the upper basin, and steelhead redds have been found above the site of the Dutch Flat Dam removal in the lower watershed. Thus, while the treatments have not yet elicited a population response relative to pre-treatment baseline conditions in index watersheds, researchers have documented these and other fish and habitat responses that indicate the potential for future population-level responses (Uthe et al. 2017; Haskell et al. 2018).

Wind River IMW: In the Wind River basin, researchers and stakeholders identified impaired fish passage, reduced abundance of instream woody debris, increased sedimentation and scour, and reduced channel stability and habitat complexity as the primary concerns limiting Chinook salmon and steelhead production (Coffin 2014; Buehrens and Cochran 2015). A collaborative enhancement and monitoring program initiated in the 1990s included the removal of Hemlock

Dam on Trout Creek in 2009 and Martha Creek Dam in 2012, as well as the decommissioning of roads, addition of woody debris, removal of invasive plant species, enhancement of riparian areas, and improvement of fish passage at road crossings. Increases in steelhead adults and smolt density have been documented in Trout Creek (treated watershed) relative to the Wind River (untreated, reference watershed). For example, adult returns increased from 77 spawners in Trout Creek (pre-treatment) to 208 spawners in 2017 (after treatment), and smolt density increased 29 percent in Trout Creek (treatment site), while in the Wind River (reference site) it decreased 7.4 percent (Haskell et al. 2018).

A.2.2.2.1 Summary: Response at Population/Watershed Scale

Although the population/watershed-scale effectiveness monitoring projects are in varying stages of completeness, some are demonstrating habitat and fish responses. The most immediate responses have occurred where barriers were removed, resulting in increased spawning distributions of salmon and steelhead and increased juvenile life-history diversity. Projects that improved floodplain and side-channel connectivity have also shown significant benefits. For example, the use of beaver dam analogs and beavers to reconnect floodplain habitat and reduce channel incision have shown large improvements in juvenile steelhead abundance, survival, and production. Reconnecting side channels in the Methow River basin increased habitat area and fish capacity within treated reaches. Instream placement of large wood has, in general, increased habitat diversity by increasing pools and side channels, which has resulted in an increase in juvenile fish density and survival, and in some cases reduced fish growth. At this time, nutrient enhancement has not been fully evaluated.

Researchers have noted both the utility and limitations of IMWs for evaluating population and watershed-scale responses (Bennett et al. 2016; Griswold and Phillips 2018; Haskell et al. 2018), and have concluded that successful IMWs appear to have the following characteristics: (1) implementers conduct watershed assessments and/or use modeling to identify problems and limiting factors (ecological concerns) within the watersheds before developing an enhancement plan; (2) implementers work with stakeholders and landowners to prioritize and sequence appropriate enhancement actions; (3) implementers use robust experimental designs and implement enhancement and monitoring plans within an adaptive management framework; (4) a large percentage of the watershed is improved; (5) projects are set up to identify causal mechanisms; (6) there is a commitment to long-term monitoring and funding (>10 years); and (7) enhancement, monitoring, funding, and implementation entities are well coordinated (Hillman et al. 2016). Factors that continue to make implementing IMWs a challenge include: lack of ability to control other management activities, coordination of enhancement activities and monitoring across multiple organizations, and funding (Roni et al. 2015). Excellent coordination among the various entities and stakeholders is needed to help maintain suitable control streams. Several authors of recent retrospective reports have highlighted the importance of coordination and communication between restoration action implementation programs and monitoring programs to ensure the proper placement and design of actions, as well as the potential of detecting results (Hillman et al. 2016; Bennett et al. 2016; Haskell et al. 2018). The majority of the region's

IMWs have documented positive results from habitat implementation actions to either habitat parameters, fish parameters, or both. Some IMWs have not documented conclusive results, but this is due in large part to the long time periods necessary to affect habitat change and subsequent fish response (Haskell et al. 2018)

Finally, as noted by Chapman (1996), Reeves et al. (1997), and others (cited in Hillman et al. 2016), maintaining control streams is an important element of IMWs. Finding control streams is difficult and there is no guarantee that control streams will remain suitable throughout the life of the project (i.e., Johnson et al. 2005).

A.2.2.3 Density Dependence

The productivity of fish populations is density dependent, meaning that the productivity of a population declines as the density of fish in a habitat increases.[6] The productivity of a population will be lowest when a particular habitat is at capacity. At this point, further increases in abundance will not result in higher productivity (i.e., in more fish surviving to the next life stage), and in some cases increased abundance at this point could result in declines in productivity. For example, in freshwater habitats, as the density of smolts increases, increased competition for limited resources (e.g., food and shelter) drives survival down (or drives movement of fish to different habitats if available). In addition to a population being limited by the quantity or quality of a particular type of habitat (e.g., juvenile rearing habitat), the spatial patterns of habitat may also be limiting. Spawning and rearing habitat need to be in close enough proximity to each other for the fish to utilize them (Falke et al 2013).

The ISAB examined the question of density dependence in a 2015 report, and determined that "density effects on smolt production are now strongly evident at spawning abundances that are low relative to historical levels, implying that existing freshwater habitat is constraining the maximum sustainable size of the population." The ISAB noted that dams and other development had limited fish to two-thirds of their historical habitat, and much of the habitat they could reach was degraded and could not support as many fish as it once did. The evidence of density dependence "suggests that habitat capacity has been greatly diminished," the ISAB concluded. The loss of habitat, "continuing changes to environmental conditions stemming from climate change, chemicals, and intensified land use appear to have further diminished the capacity of habitat that remains accessible." The ISAB found that "the overall implication is that total adult returns of naturally spawning and hatchery fish may now be exceeding the carrying capacity of some areas of the Columbia Basin and its estuary." In this case, improvements in tributary habitat capacity or productivity, if targeted at limiting life stage and limiting factors, would be

[6] Productivity is used as an indicator of a population's ability to sustain itself or its ability to rebound from low numbers. The terms "population growth rate" and "population productivity" are interchangeable when referring to measures of population productivity over an entire life cycle. The indicator for productivity is the average number of surviving offspring per parent, which can be expressed as the number of recruits (adults) per spawner or the number of smolts per spawner.

likely to improve overall population abundance and productivity by removing a bottleneck on population growth.

A.2.3 Conclusion Regarding Scientific Basis for Tributary Habitat Improvement Actions

The results in published literature and recent RM&E confirm and build upon our findings in the 2008 biological opinion and the 2010 and 2014 supplemental biological opinions regarding habitat and fish response at the stream-reach scale. Overall, the scientific literature continues to support the basis for implementing tributary habitat improvement actions, and our previous conclusion that many habitat restoration actions can improve salmon abundance and survival over relatively short periods. Examples of such actions include increasing instream flow, improving access to blocked habitat, reducing mortality from entrainment at water diversion screens, placing of logs and other structures to improve stream structure, and restoring off-channel and floodplain habitat. Other habitat improvements, such as reduction of excess fine sediment in spawning areas and restoration of riparian vegetation, may take decades to realize their full benefit.

The best available science and information also support the approach of improving tributary habitat to increase abundance, productivity, spatial structure, diversity (and survival) of salmon and steelhead at the population scale. Results from tributary habitat monitoring and evaluation provide evidence that the Action Agencies' habitat improvements are correctly targeting and improving degraded conditions and providing benefits to fish. Life-cycle modeling conducted for this biological opinion also supports this view (see below; also see Pess and Jordan et al. in press and Zabel and Jordan in press).

The literature also continues to confirm and inform the need to incorporate proper planning, sequencing, and prioritization into decision frameworks to best achieve habitat objectives (see below).

A.3 Analysis of Effects of Tributary Habitat Actions

A.3.1 Methods Used in 2008 Biological Opinion and its Supplements

The approach used in the 2008 biological opinion for analyzing the effects of tributary habitat actions relied on using expert judgment to estimate the change in habitat function as a result of implementing habitat improvement actions, and then using an empirically based model to estimate the overall change in habitat function and a corresponding change in egg-to-smolt survival that would result from that change in habitat function. A monitoring and evaluation program was in place to track the effects of tributary habitat actions and to provide input for the adaptive management framework within which the Action Agencies implemented habitat improvement actions.

This method was developed by the Remand Collaboration Habitat Workgroup (CHW), which was convened in 2006 at the request of the Policy Work Group formed as part of the court-ordered remand of NMFS' 2004 biological opinion for the CRS. Members of this workgroup represented the states, tribes, and federal agencies (including NMFS) involved in the remand collaboration process and were selected for their technical expertise. The workgroup developed methods based upon both expert opinion and review of scientific information (such as known egg-to-smolt survival relationships for Chinook salmon and steelhead) that could be applied consistently to all populations. Given the lack of adequate quantitative data for many populations across the basin, it was not feasible to apply more formal models and quantitative approaches across all populations at that time.[7]

In the 2008 and 2014 biological opinions, NMFS found that the approach used to estimate changes in habitat as a result of implementing tributary habitat actions and the corresponding changes in survival was based on the best available scientific information from fish and habitat experts, and on general empirical relationships between habitat quality and salmonid survival. NMFS also found that the approach represented the best available scientific information that could be consistently applied over the larger Columbia Basin to estimate the survival response of salmonids to habitat mitigation actions.

The 2008 biological opinion noted that as new data and tools became available to inform estimates of habitat benefits of actions and resulting changes in survival, the Action Agencies would continue to incorporate that information into their action implementation and evaluation of benefits (NMFS 2008, RPA Action 35a).

A.3.2 Methods Used in 2019 Biological Opinion

We noted in the 2014 supplemental biological opinion that life-cycle models (actually, a suite of models within a common framework) were under development and should be available for future CRS analyses (NMFS 2014). These models were developed through the Adaptive Management Implementation Plan (AMIP) process and have been peer-reviewed by the ISAB (ISAB 2013, 2017).

Life-cycle models are increasingly being used in an effort to better predict the outcome of various management scenarios on Pacific Northwest salmonids. By modeling multiple stages and transitions, life-cycle models can determine where bottlenecks in survival or capacity limit recovery, or make projections about population abundance and extinction risk under various scenarios of potential future conditions. Life-cycle models are well-suited to management of salmonid populations because the salmonid life cycle encompasses vast geographic ranges and multiple opportunities to address human impacts. Developing effective management strategies

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[7] For additional detail on the methods used in the 2008 biological opinion, see NMFS 2014, Section 3.1.1.6; Appendix C of the 2007 Comprehensive Analysis (Appendix C, Attachment C-1 and Annexes 1–3, USACE); and Appendix C of Milstein et al. (2013).

involves balancing a range of potential actions across life stages, habitat types, and anthropogenic impacts. The full life-cycle modeling framework used in this biological opinion is documented in Zabel and Jordan (in press), with additional detail on modeling of tributary habitat improvement actions provided in Pess and Jordan et al. (in press).

The life-cycle modeling effort includes the development of several tributary habitat models in collaboration with key state and tribal scientists. These models represent an evolving method to estimate salmonid population response to habitat improvement actions. They allow detailed estimation of juvenile habitat capacity and survival, making it possible to evaluate changes in capacity and survival under various management or restoration scenarios. All the models are framed in the matrix life-cycle modeling format originally described by the Interior Columbia Technical Recovery Team and Zabel (ICTRT and Zabel 2007), although each is adapted to use the different levels of information available to populate its freshwater life stages (Zabel et al. 2017; Pess and Jordan et al. in press).

In this biological opinion, we considered results of these tributary habitat models for some spring Chinook salmon populations in evaluating the baseline and the effects of the proposed action. We expect to continue model development for additional populations (including steelhead) and to expand their use in the next CRS biological opinion (as well as their use for other purposes, such as recovery plan implementation).

In addition to using life-cycle models to evaluate tributary habitat actions for some populations, we also evaluated proposed tributary habitat actions using qualitative considerations. Both the quantitative methods and qualitative considerations are described below.

A.3.2.1 Quantitative Methods: Modeling the Effects of Tributary Habitat Actions

Using life-cycle models to estimate fish population response to a suite of tributary habitat actions involves the following steps:

1. **Estimate life-stage specific habitat capacities:** To estimate how a population will respond to various types and intensities of tributary habitat improvement actions, modelers first need to estimate life-stage specific habitat capacity, or how many fish a system might support at a specific life stage under historical, current, or proposed habitat conditions. This requires a compilation of available data on parameters such as life-stage-specific capacity, survival, and abundance. Models can then be developed at the appropriate level of detail given the available data and understanding of limiting factors (i.e., which key habitat or management variables will be included in the model). If data to parameterize a model are lacking, modelers must choose whether to collect the necessary data or to utilize the parameters and functional relationships from nearby basins or the general literature to inform the model. Zabel et al. (2017) and Zabel and Jordan (in press) describe and compare different methods to estimate juvenile rearing capacity at several spatial scales and extents. Pess and Jordan et al. (in press) provide additional discussion on the approaches used to estimating juvenile rearing capacity.

2. Calibrate life-cycle models to fish data and current conditions: To make models more accurately reflect fish data and current conditions, modelers calibrate them, meaning that they adjust model parameters based on available data. Calibration techniques range from straightforward to complex. For example, a simple approach would be to develop life-cycle model parameters independently based on the literature and reach-scale data, and then adjust the reach-scale parameters to produce population-scale predictions that are in closer agreement with basin-scale fish data. More complex approaches involve the use of statistical model fitting, where statistical techniques, such as state-space models, are used to derive parameters directly from local fish abundance data, where available. This approach allows for uncertainty in the data to be carried through all stages of the model, and reflected in the outputs. Approaches to calibration are discussed in more detail in Pess and Jordan et al. (in press).

3. Evaluate how habitat restoration scenarios would change habitat capacity and survival: If managers develop several restoration scenarios, modelers can then evaluate how each restoration scenario would change habitat capacity and productivity from existing or historical conditions. This evaluation is done by comparing the current or proposed stream condition to experimental or observational work that can inform how habitat capacity, fish growth, or fish survival of the life stage(s) of interest change under different habitat scenarios. Such an analysis can be a powerful approach to evaluating various potential habitat restoration scenarios.

Habitat is typically evaluated by looking at habitat quantity (e.g., stream channel area, pool frequency, floodplain condition), habitat quality (e.g., pool frequency, floodplain condition, wood loading, fine sediment levels, riparian condition), environmental conditions (e.g., stream temperature, streamflow), indicators of habitat quality (e.g., adjacent land use), and causes of habitat degradation (e.g., water diversions and barriers). Each of these variables can have an impact on salmon habitat capacity and survival at a single or multiple life stages.

Habitat changes between restoration scenarios and current or historical conditions are then translated into changes in life-stage capacity or survival at specific life stages. For example, addition of wood structures to a channel may increase both summer and winter rearing capacity, and change life-stage survivals. By contrast, a change in spawning gravel quality by decreasing percent fine sediment would not alter spawning capacity, but would increase egg-to-fry survival. Pess and Jordan et al. (in press) document the methods used for translating habitat actions into life-cycle model inputs. They also contrast methods and results using "data rich" and "data poor" environments in the Upper Grande Ronde, Wenatchee, and Upper Salmon River basins.

In general, changes in habitat quantity translate into changes in habitat capacity, and changes in habitat quality translate into changes in life-stage survival. The functional relationships between a habitat change and the change in capacity or survival are typically developed from literature values or from local empirical relationships. For example, numerous studies of fine sediment effects on egg-to-fry survival show that egg-to-fry survival decreases with increasing fine sediment, and both general and species-specific equations can be developed to translate changes in fine sediment into a change in survival. On the other hand, local data may indicate that smolt production of a species is related to a measured stream parameter such as summer stream flow, and the statistical relationship between stream flow and survival may be used to quantify rearing survival in a life-cycle model. For additional detail on translating habitat quantity into habitat capacity estimates and translating habitat quality in to survival estimates, see Pess and Jordan et al. (in press).

4. Use life-cycle models to evaluate differences in fish production among scenarios: Finally, the changes in capacity and survival from the restoration scenarios are used as inputs to a life-cycle model to assess the overall change in salmon abundance and productivity, and potentially change in spatial structure and diversity as well, that would result from the restoration scenarios. For example, modelers might estimate that reconnecting floodplains will increase parr capacity in a particular stream by 10 percent. That information then becomes an input to a life-cycle model to evaluate whether that increase in parr capacity will result in an increase in adult abundance or, alternatively, in falling below a quasi-extinction threshold. If there is strong density dependence after the parr stage (e.g., in overwinter survival) then the increased parr capacity might not produce many additional adults. In other cases there might be a proportional increase in adult abundance, which would indicate that in that case, tributary habitat is a limiting factor for the population.

Life-cycle models can vary considerably in complexity, particularly in the number and specificity of life stages included in the model. In general, more complex models allow for a greater range of restoration scenario development; however, they require more data. Conversely, less complicated models accommodate a more limited range of restoration scenarios, but do not require the same amount of input data.

For this biological opinion, we considered modeling of the effects of implemented tributary habitat actions on the environmental baseline for Snake River spring/summer Chinook salmon ESU populations in the Grande Ronde/Imnaha major population group (MPG) and Upper Salmon River MPG, and for the Wenatchee River population in the Upper Columbia River spring Chinook salmon ESU. For some populations in the Snake River spring/summer Chinook salmon ESU (Upper Grande Ronde, Catherine Creek, Lemhi, Pahsimeroi, Upper Mainstem, and Yankee Fork) we also considered modeling of the effects of proposed tributary habitat improvement actions. In some cases, modeling of additional habitat action scenarios, such as scenarios involving longer-term strategic implementation of actions, or scenarios involving random implementation of actions, was also available and informed our understanding of the context for the proposed tributary habitat action.

For the Grande Ronde/Imnaha River spring/summer Chinook salmon MPG, modelers evaluated (1) the impacts of tributary habitat actions implemented in 2009–16 (using summaries of the expected change in key habitat parameters estimated by the Upper Grande Ronde/Catherine Creek Expert Panel under the 2008 biological opinion); (2) the impacts of the tributary habitat actions in the proposed action for this biological opinion; (3) several scenarios of the results of long-term implementation, including specific actions called for in the *Snake River*

Spring/Summer Chinook Salmon and Steelhead ESA Recovery Plan, Appendix A (Northeast Oregon) and a scenario that focuses on restoring stream structure and reducing temperatures through the combined effects of riparian shade and achieving natural channel structure and width/depth ratios. (See Pess and Jordan et al. in press and Cooney in press for additional detail.)

For the Wenatchee River spring Chinook salmon population, modelers quantified biological benefits from a subset of freshwater habitat restoration actions completed from 2009 to 2015. They focused on completed actions located in areas that contributed to spring Chinook salmon production. For example, they excluded actions in areas with little or no contemporary occurrence of spring Chinook salmon. They also excluded actions located in the mainstem Wenatchee River, which currently has limited spawning of spring Chinook salmon. Modelers also focused on actions that altered the landscape through physical geomorphic habitat changes. Conservation easements and land purchases, for example, while important for preserving existing functional habitats, were excluded. (See Pess and Jordan et al. in press and Jorgensen in press for additional detail.)

In the Upper Salmon River MPG, modelers evaluated the effects on juvenile rearing capacity and spawning capacity of instream actions (i.e., instream actions to improve stream complexity or floodplain/side-channel connectivity) and actions to improve access for actions implemented from 2009 to 2015 and for proposed actions. For proposed actions, modelers assumed that the Action Agencies' efforts would be focused in the near term on the same populations that received the highest level of effort under the 2008 biological opinion (i.e., the Lemhi, Pahsimeroi, Upper Mainstem, and Yankee Fork populations). Modelers also made other assumptions, documented in Pess and Jordan et al (in press) (e.g., habitat access projects were assumed to open habitat of similar type and quality to that currently available, and complexity actions were applied to improve the quality of habitat currently in moderate or good condition). Because the models do not evaluate the effects of actions such as returning flow to the stream, screening diversions, and restoring riparian areas, benefits of those types of actions are not included in the modeled increases in capacity. (See Pess and Jordan et al. in press and Jordan et al. in press for additional detail.)

The tributary habitat models, the specific methods used, and the scenarios modeled are described in detail in Pess and Jordan et al. (in press). Some results are also summarized briefly for each species as relevant in the tributary habitat environmental baseline and effects analyses of the 2019 biological opinion.

Generally the modeling shows (1) actions implemented in 2009–16 will have small positive effects on abundance and extinction risk for the populations modeled; (2) implementation of actions as outlined in the proposed action for the 2019 biological opinion will have small positive effects on abundance and extinction risk; (3) implementation of actions at similar or enhanced levels of effort for a longer time period (e.g., 20-year time frame), consistent with recovery plan priorities (e.g., see discussion of life-cycle modeling results for the Grande Ronde spring/summer Chinook salmon MPG in Zabel and Jordan [in press]) and best principles of watershed restoration (see, e.g., Roni et al. 2002; Beechie et al. 2008, 2010; Hillman et al. 2016; Pess and Jordan et al. in press) can have larger benefits to abundance and extinction risk, and implementation of appropriate actions in appropriate locations enhances the results.

A.3.2.2 Qualitative Considerations Used in 2019 Biological Opinion

In addition to considering the results of modeling of salmonid population response to habitat improvement actions, we also used a qualitative framework to evaluate tributary habitat actions. The qualitative framework included consideration of tributary habitat baseline conditions and proposed actions in the context of the following factors:

A.3.2.2.1 Extent to Which Actions Address Identified Limiting Factors or Life Stages

A limiting factor is a factor that controls the growth, abundance, or distribution of a population in an ecosystem. Thus tributary habitat improvement actions will be most beneficial if targeted at the factor or life stage that is most limiting. We considered the extent to which tributary habitat actions implemented and proposed for implementation addressed identified limiting factors and life stages. Our qualitative evaluation of this factor for the proposed tributary habitat action is necessarily coarse in scale since the proposed actions are identified at the MPG scale. However, based on the Action Agencies' past record of implementation, their stated commitment to continue to improve strategic implementation, and the types of actions they have identified for implementation, we are confident that in general, actions to be implemented are targeting the limiting factors identified using best available information.

A.3.2.2.2 Potential to Improve Tributary Habitat Conditions

Our qualitative evaluation also considered the potential for improvements in tributary habitat capacity and/or productivity in the targeted populations. This consideration is important because it speaks to the potential to achieve improvements in abundance, productivity, spatial structure, and diversity (and survival) as a result of implementing tributary habitat improvements. Our evaluation of the potential to improve tributary habitat conditions was informed by ESA recovery plans for interior Columbia Basin salmon and steelhead (UCSRB 2007; NMFS 2009, 2015, 2017a, 2017b;), the 2016 ESA 5-year status reviews (NMFS 2016a, 2016b, 2016c), the focal population analysis (Cooney in press; also see additional discussion below), and the ISAB's 2015 examination of density dependence in salmon and steelhead in the Columbia River basin (ISAB 2015). Again, our qualitative evaluation of the limiting factors for the proposed tributary habitat action is necessarily coarse since the proposed actions are identified at the MPG scale. However, based on our evaluation and on the recent past focus of the Action Agencies' implementation, actions to be implemented will target populations where there is potential to improve tributary habitat productivity.[8]

A.3.2.2.3 Role of Populations in ESA Recovery Scenario

NMFS has completed ESA recovery plans for all listed salmon and steelhead in the Columbia River basin (UCSRB 2007; NMFS 2009, 2013a, 2015, 2017a, 2017b). These recovery plans provide: (1) recovery goals, (2) management actions to achieve the goals, and (3) estimates of the time and cost required to carry out the actions. The plans also provide additional information to help frame and prioritize recovery actions, including descriptions of the current status of the species and their component populations; identification of limiting factors and threats; and "scenarios" for recovery of the ESU or DPS. Recovery scenarios are based on the biological viability criteria developed by technical recovery teams (TRTs) to define conditions that, when met, will describe viable populations and species.[9]

The biological viability criteria are consistent with the hierarchical population structure that is critical to the resilience and long-term survival of salmon and steelhead. Each ESU or DPS consists of multiple independent populations that spawn in different watersheds throughout the ESU/DPS range. Additionally, within an ESU or DPS, independent populations are organized into larger groups known as major population groups. MPGs are groups of populations that share similarities within the ESU or DPS (ICTRT 2005). The viability criteria are designed to assess risk for abundance/productivity and spatial structure/diversity at the population level. These population-level assessments are then considered in the context of criteria for how many and which populations within an MPG need to be at what status for the MPG as a whole to have a risk of extinction consistent with de-listing. The viability criteria developed by the Interior Columbia Technical Recovery Team (ICTRT) are summarized briefly below and outlined in detail in Interior Columbia recovery plans (NMFS 2017a, 2017b, 2015, 2009; UCSRB 2007) and the ICTRT's technical report (ICTRT 2007).

ESU/DPS viability criterion: All extant MPGs and any extirpated MPGs critical for proper functioning of the ESU or DPS should be at low risk.

MPG-level viability criteria: The following six criteria should be met for an MPG to be regarded as at low risk:

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[8] Based on our discussions with the Action Agencies and on the fact that it is not feasible in the limited duration of the proposed action for the Action Agencies to make large shifts in emphasis of implementation, it is a reasonable assumption that their focus will remain on the populations that were a focus of tributary habitat efforts in the recent past.

[9] NMFS appointed two TRTS for Columbia Basin: the Willamette/Lower Columbia TRT and the Interior Columbia TRT. This discussion focuses on the ICTRT, but the work of both Columbia Basin TRTs, and of all West Coast TRTs, was based on the same scientific principles (e.g., McElhany et al. 2000) and was generally consistent with each other.

1. At least one-half of the historical populations within the MPG (with a minimum of two populations) should meet viability standards.[10]
2. At least one population should be classified as highly viable.[11]
3. Viable populations within an MPG should include some populations that are classified (based on historical intrinsic potential) as "very large," "large," or "intermediate." In particular, very large and large populations should be at or above their composite historical fraction within each MPG.
4. All major life-history strategies (e.g., spring and summer run timing) that were present historically within the MPG should be represented in populations meeting viability requirements.
5. Remaining MPG populations should be maintained with sufficient abundance, productivity, spatial structure, and diversity to provide for ecological functions and to preserve options for ESU/DPS recovery.
6. For MPGs with only one population, the population must be Highly Viable.

Population-level criteria: The ICTRT also defined population-level criteria for evaluating the status of the individual populations. These criteria describe a viable population based on the four viable salmonid population (VSP) parameters (abundance, productivity, spatial structure, and diversity).

Thus the criteria for determining whether an MPG is at low risk allow some flexibility in which populations will be targeted for a particular recovery level to achieve a low risk MPG. The ESA recovery plans provide some additional guidance on which populations are targeted for viable, highly viable, or maintained status to achieve ESA recovery. This is relevant to the effects analysis because in general efforts focused on populations that need to achieve viable or highly viable status and, where there is potential to improve tributary habitat, will be valuable to near-term recovery efforts. We will work with the Action Agencies during implementation of this proposed action to identify any needs for greater alignment of their tributary habitat improvement actions with these ESA recovery plan priorities.

A.3.2.2.4 NMFS Focal Population Analysis

To provide strategic guidance for implementation of recovery plans, NMFS has developed the concept of focal populations. The intent of this concept is to develop and apply criteria to identify populations where tributary habitat recovery efforts should be focused in the short term

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[10] This means that, based on evaluation of population-level abundance/productivity, spatial structure, and diversity, using methods recommended by the ICTRT, a population should have a low (<5 percent) risk of extinction over a 100-year time frame.

[11] This means that, based on evaluation of population-level abundance/productivity, spatial structure, and diversity, using methods recommended by the ICTRT, a population should have a very low (<1 percent) risk of extinction over a 100-year time frame.

(i.e., a 5- to 10-year time frame) to contribute to both near-term improvements and long-term recovery goals. This concept and the method used to identify focal populations are described in detail in Cooney (in press).

The importance of sequencing or prioritizing restoration and recovery efforts over time to optimize conservation outcomes has gained increased attention in the conservation literature (e.g., see Drechsler and Wissel 1998; Willi et al. 2006; McBride et al. 2010; Wilson et al. 2011; Aitken et al. 2013). Considerations include the importance of explicitly considering how to maximize gains towards long-term objectives in light of starting conditions and inherent limitations on annual resources available for implementation, as well as the time required for restoration actions to achieve desired improvements in habitat conditions and the associated lags in benefits to fish. In many ways, the basic principles for these multi-population-level sequential planning strategies parallel advice regarding within-population protection and restoration (e.g., Beechie et al. 2010).

Using ESA recovery plans and ICTRT work as starting points, supplemented by new information and additional considerations, NMFS developed an approach to identify short-term opportunities to benefit key populations consistent with longer-term goals for ESA and broad-sense recovery. Criteria for identifying focal populations include: (1) VSP characteristics (genetic and life history characteristics, intrinsic potential [population size and complexity], and meta-population characteristics); (2) current population status (quasi-extinction risks, current abundance relative to minimum thresholds, supplementation contributions, recovery gaps); (3) relative habitat improvement potential; and (4) climate change vulnerabilities. For details on these criteria and how they were applied, see Cooney in press.

The focal population concept is intended to complement or help prioritize important ongoing activities in the basin in support of recovery plan implementation, CRS-related actions, and other processes. For example, results from the focal population analysis could contribute to sequencing future efforts to develop more strategic action plans at the population or MPG level. Accordingly, in our qualitative evaluation of the effects of tributary habitat actions under this biological opinion, we considered alignment between the Action Agencies' efforts and the focal populations. Since the focal population concept has only recently been developed, we would not expect the Action Agencies necessarily to align their implementation of habitat improvement actions with it at this time. Instead, we expect to work with the Action Agencies and co-managers over time to more closely align tributary habitat efforts with the focal populations. Nevertheless, the focal population analysis was informative in our consideration of the environmental baseline and effects of the action.

<u>A.3.2.2.5 Action Agencies' Track Record of Implementation</u>

As in the 2014 biological opinion, our qualitative evaluation also considered the Action Agencies' track record of implementation, their relationships with local implementing partners, and their commitment to continuing to improve implementation through adaptive management.

Under the 2008 biological opinion, the Action Agencies implemented substantial tributary habitat improvement actions, increased investments in the tributary habitat, and improved the scope, biological rigor, and collaborative regional effort directed at implementing tributary habitat actions (BPA et al. 2013, 2016; NMFS 2014). The Action Agencies have stated their commitment to continuing to improve strategic implementation of tributary habitat actions, consistent with best available science related to habitat restoration; to convene a tributary habitat program steering committee; to report on implementation using metrics that will allow NMFS to evaluate the success of the actions; and to conduct RM&E to assess tributary habitat conditions, limiting factors, action effectiveness, and to address associated critical uncertainties.

A.3.2.2.6 Short-term Negative Effects of Implementing Tributary Habitat Improvement Actions

We considered short-term negative effects that could result from implementation of tributary habitat improvement actions. Tributary habitat improvement actions will have long-term beneficial effects at the action and subbasin scale. Adverse effects during construction are expected to be minor, occur only at the project scale, and persist for a short time (no more and typically less than a few weeks). Examples of such short-term effects include sediment plumes, localized and brief chemical contamination from machinery, and the destruction or disturbance of some existing riparian vegetation. These impacts will be limited by the use of the practices described in NMFS (2013b). The positive effects of these actions on habitat function and salmon and steelhead populations (e.g., restored access, improved water quality and hydraulic processes, restored riparian vegetation, enhanced channel structure) will be long term.

A.3.2.3 Conclusion Regarding Analysis of Effects

NMFS has determined that the approach used to evaluate the effects of proposed tributary habitat improvement actions is based on best available science. The qualitative considerations used in our analysis are comprehensive and based on best available information. In addition, we considered life-cycle model results that represent an improved method to estimate salmonid population response to a series of habitat improvement actions (Pess and Jordan et al. in press).

The life-cycle models were developed in collaboration with key state and tribal scientists, and have been independently peer-reviewed twice by the ISAB (ISAB 2013, 2017). The models allow detailed estimation of juvenile habitat capacity and survival, making it possible to evaluate changes in capacity and survival under various management or restoration scenarios. They are based to a greater extent on population-specific empirical relationships than methods used in the 2008 biological opinion, and they are based on a more complex and realistic representation of fish-habitat relationships and timing of benefits than the methods used in the 2008 biological opinion. Life-cycle models can be developed as a general framework that can be parameterized with location-specific habitat and life-history data, or structured in a population-specific manner that targets the unique features of a single population. In either case, population-specific models allow researchers to capture unique habitat and life-history attributes and leverage data that may not exist in all locations. Population-specific models can also be used to inform across multiple populations to varying degrees, depending on their underlying structure and the biological and physical relationships captured by the model parameters.

Under the methods used in the 2008 biological opinion, professional judgment by experts provided a large part of the determination of habitat function in all locations given the limited extent of readily available empirical data and information. We expect that expert opinion will continue to provide some role in the process of estimating habitat benefits (e.g., in estimating how specific actions or suites of actions will change habitat), but we also expect reliance on empirically and mathematically derived relationships to continue to evolve.

Benefits to habitat and populations as a result of tributary habitat improvement actions implemented during this biological opinion are likely to be small (see additional discussions in Chapter 2 of this biological opinion). In almost all cases, we would not expect implementation of habitat actions for only a few years to yield significant improvements, because it is not feasible to implement actions of sufficient scope and scale in that timeframe to yield substantial effects. It is important to put the results of the habitat actions to be implemented in the relatively short time-frame of this biological opinion into the context of the effects of longer-term implementation of habitat actions.

Under a strategic approach to addressing key limiting factors, implementation over a relatively short time period should be viewed as part of a long-term implementation strategy designed to more fully address limiting factors for a particular population over a time period that reasonably considers limitations on annual implementation capacity and other factors. Life-cycle modeling results for spring Chinook salmon in the Grande Ronde and Catherine Creek populations, for example, demonstrated that long-term habitat implementation of habitat improvement actions can have marked effects (see Pess and Jordan et al., in press).

A.4 Adaptive Management

The 2008 biological opinion and its 2010 and 2014 supplements (NMFS 2008, 2010, 2014) contained a robust and sizeable RM&E program focused on tributary habitat and fish use of tributaries and actions implemented to benefit them. The collection, assembly, and analysis of data from this RM&E program has enhanced understanding of the effects of tributary habitat improvement actions and provided a means to incorporate new information into decision-making on habitat action prioritization and design. Adaptive management will continue to play an important role in implementation of tributary habitat actions under the 2019 CRS biological opinion. The Action Agencies intend to implement a tributary habitat RM&E program to assess tributary habitat conditions, limiting factors, and habitat improvement action effectiveness, and to address critical uncertainties associated with habitat mitigation actions. The Action Agencies will also develop a newly refined habitat RM&E strategy in collaboration with NMFS and other regional partners that will guide longer term RM&E and adaptive management activities.

The proposed action makes some reductions to existing tributary habitat monitoring and increases uncertainties about the future state of data collection and monitoring programs. If current program areas of habitat and related fish monitoring (such as: IMWs, non-watershed scale key habitat evaluation programs focused on the benefits of habitat actions in measurements of fish performance, and fish status and trend monitoring) are reduced, it could impact the ability to detect habitat action effects and fish population response. The Action Agencies, NMFS, and other stakeholders are working on the development of a Columbia Basin Tributary Habitat Monitoring Strategy (as outlined in the proposed action) that will guide RM&E actions during the term of and following the 2019 biological opinion. The adequacy of the future RM&E program to evaluate the effectiveness of tributary habitat actions will be a key consideration during the development of the strategy.

A.5 Implementation Considerations

In the 2008 biological opinion and its 2010 and 2014 supplements, we described recent findings in the literature regarding approaches to watershed restoration. That literature emphasized the need to incorporate proper planning (including assessing the natural potential of a system and using that information to direct action location, design, and selection), sequencing, and prioritization into decision frameworks to best achieve habitat objectives. We noted the four principles outlined in Beechie et al. (2010) to help ensure that restoration was guided toward sustainable actions: (1) address the root causes of degradation; (2) be consistent with the physical and biological potential of the site; (3) scale actions to be commensurate with the environmental problems; (4) clearly articulate the expected outcomes.

Recent literature, monitoring information, and life-cycle modeling continue to reinforce the principles outlined in Beechie et al. 2010. In fact, new information continues to reinforce that if the wrong action is implemented in the wrong place or at the wrong time, desired habitat conditions will not be observed or sustained over time. Based on their literature review, Hillman et al. (2016) concluded that actions that are most effective at producing desired habitat conditions are those that:

1. Address the life stage and habitat condition limiting fish performance. Salmonid response to habitat enhancement is based on whether or not the enhancement actions address the specific life stage and habitat factors limiting that population’s performance.

2. Consider and are implemented in context with fluvial and geomorphic conditions and are sequenced such that the effects of enhancement actions on habitat conditions are not limited by upstream watershed processes. Habitat improvement actions, including protection projects, are ineffective or the effects are short-lived if unaddressed upstream watershed processes degrade treatment sites.

3. Treat a large percentage of the stream or watershed. The literature indicates that the largest biological benefits are associated with treating more than 20 percent of a

watershed. Treating small portions of degraded habitat has little biological effect at the watershed scale, and the treatments are often overwhelmed by upstream degraded habitat conditions. (Roni [2018] also noted that the total amount of restoration and the connectivity of the restored habitats are important drivers of population- or watershed-level response to restoration.)

4. Derive from detailed watershed assessments to determine disrupted processes and lost habitat. Limiting factors analysis, watershed assessments, reach assessments, and habitat and life-cycle modeling are tools that can be used to identify threats, problems, and limiting factors within a watershed.

5. Are implemented in the context of a watershed implementation plan that prioritizes locations and types of actions. The sequencing of actions needs to consider degraded watershed processes and threats, and limiting life stages and habitats. The literature identified degraded upstream watershed processes as the most common factor affecting the success of enhancement projects.

6. Include adequate coordination among stakeholders, landowners, funding and monitoring entities, and implementers. A lack of landowner support can derail a well-designed implementation plan.

7. Incorporate effectiveness monitoring at a subset of projects. Monitoring data collected under an adaptive management framework provide information needed to determine if enhancement work should continue as planned or be refocused or redirected.

Hillman et al. (2016) also summarize findings regarding specific types of habitat improvement actions, and note the importance of protecting high-quality habitat, and prioritizing reconnecting spawning and rearing areas (particularly areas with high intrinsic potential). They recommend that use of instream structures be implemented in concert with actions that improve watershed processes. Instream structures often provide benefits that are realized more quickly than actions that improve watershed processes, but it is important that they be sized appropriately for the channel and designed to mimic natural accumulations.

The core components of these findings were reinforced by the ISAB in its review of spring Chinook salmon in the upper Columbia River (ISAB 2018). They noted that while further analysis of limiting factors was needed, “simply listing potential limiting factors and eliciting professional opinions will not provide an accurate or even relative basis for designing and ranking restoration actions in a recovery plan.” They further noted that “analysis must include the full life cycle of the population and assess the effects of physical, environmental, ecological, and anthropogenic factors on adult spawners across multiple generations.”

Pess and Jordan et al. (in press) elaborate on some of these themes and demonstrate the utility of life-cycle modeling in both data-rich and data-poor situations for evaluating and choosing among alternative restoration scenarios. They note that it is the combined effect of all restoration actions that will determine the potential magnitude of change in salmon populations, and demonstrate how alternative restoration scenarios at the watershed-scale can be developed and evaluated to determine which suite of actions will likely provide the largest benefit to salmon populations. The purpose of these analyses is to help focus restoration efforts on the types, location, and level of actions that lead to a measurable and significant improvement to salmon populations. Specific methods for these analyses depend on local habitat and fish data availability, and may range from simple analyses based on coarse spatial and/or temporal resolution data to more detailed evaluations with higher resolution data. Therefore, while the richness of the data will determine the analysis type used to evaluate the salmon population response to a suite of potential restoration actions, we do have tools available for both data-rich and data-poor situations. Further, learning from data-rich scenarios will inform and support decision making in data-poor scenarios.

We support the conclusions and evaluation approaches noted above regarding effective implementation of tributary habitat improvement actions, and we expect that the Action Agencies will continue working to implement the tributary habitat improvement actions consistent with the recommendations noted above so that their effectiveness will be enhanced.

A.6 Conclusion

For this biological opinion, we reviewed the literature on habitat restoration and re-affirmed the strong technical foundation for the tributary habitat program. We evaluated RM&E information and found that it also supported the foundation of the program. We determined that the methods we use to evaluate the effects of tributary habitat actions are based on best available science and information. We evaluated the effects of proposed tributary habitat actions quantitatively for some populations and qualitatively for all populations within the context of our understanding of limiting factors, habitat improvement potential, and recovery plan and focus population frameworks. We then qualitatively related these population-level changes to effects to the species or designated critical habitat. We considered short-term negative effects that could result from implementation of habitat improvement actions. We also considered the Action Agencies' track record of implementation, as well as the strategic framework within which the Action Agencies were committing to implement the tributary habitat improvement actions.

In addition, in the past, we considered the adequacy of the RM&E and adaptive management framework that was in place to test and validate the assumptions and effects of the program during the term of the 2008, 2010, and 2014 biological opinions and found it to be adequate. We also considered the adequacy of the RM&E and adaptive management framework proposed to evaluate and support implementation of tributary habitat actions. The proposed action includes reductions from monitoring that had been underway under the 2008 biological opinion and its supplements. The development of a basin-wide habitat monitoring vision and strategy, as outlined in the proposed action, is a laudable and important action. NMFS is committed to participating in the development of the vision, scope, and architecture of the RM&E framework during the term of the 2019 biological opinion in preparation for and, in addition to, long-term plans that will be evaluated in the 2020 Columbia River System Operations EIS.

As noted above, benefits to habitat and populations as a result of tributary habitat improvement actions implemented during this biological opinion are likely to be small. In almost all cases, we would not expect implementation of habitat actions for a limited time period to yield significant improvements, because it is not feasible to implement actions of sufficient scope and scale in that timeframe to yield substantial effects.

It is important to put the results of the habitat actions to be implemented in the relatively short time-frame of this biological opinion into the context of the effects of longer-term implementation of habitat actions. Under a strategic approach to addressing key limiting factors, implementation over a relatively short period should be viewed as part of a long-term implementation strategy designed to more fully address limiting factors for a particular population over a time period that reasonably considers limitations on annual implementation capacity and other factors.

Over time, understanding of habitat limiting factors has improved, along with the tools and processes for identifying, prioritizing, and coordinating the locations and types of actions that will provide the greatest improvements. The completion of ESA recovery plans for all ESA-listed Columbia Basin salmon and steelhead, along with the tools the Action Agencies have developed, and the development of the NMFS focal population concept (Cooney in press) should further enhance the ability to implement actions within a strategic framework. The Action Agencies' continued development and support of the local partnerships and the implementation infrastructure they have developed over the past ten years should also contribute to this effort. Thus, we expect that future habitat restoration actions will target actions strategically to address limiting factors in a manner that contributes to both short-term and long-term benefits to VSP parameters, with a focus on populations that are important in near-term recovery efforts.

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Appendix B – Pinniped Predation

This appendix describes the most recent available information related to pinniped predation on Endangered Species Act (ESA)-listed salmon and steelhead in the Columbia River basin. The information presented in this appendix was considered in the development of the National Marine Fisheries Service's (NMFS') 2019 Columbia River System (CRS) biological opinion. In recent years, increasing pinniped abundance in the Columbia River basin has increased predation rates on most stocks of listed salmonids, with run timing being the most consistent predictor of evolutionarily significant unit (ESU) vulnerability. This appendix discusses the recent rate increases and provides management recommendations for consideration in the development of conservation measures to reduce predation.

B.1 Pinniped Predation in the Columbia River Estuary

Abundance of sea lions and seals has increased considerably along the northwest United States coast since The Marine Mammal Protection Act (MMPA) was enacted in 1972 (Carretta et al. 2014). California sea lions (CSL; *Zalophus californianus*), Steller sea lions (SSL; *Eumetopias jubatus*), and harbor seals (*Phoca vitulina)* consume adult and juvenile salmonids from the mouth of the Columbia River to Bonneville Dam and in some tributaries (e.g. Willamette River, Cowlitz River).

The Oregon Department of Fish and Wildlife (ODFW) has been enumerating individual CSLs hauling out at the East Mooring Basin (EMB) in Astoria, Oregon since 1997 (Wright 2018). The data from this monitoring indicate that CSL abundance within the Columbia River has increased dramatically since 2013 during most months; and the data indicate nearly a tenfold increase in predatory CSL individuals at the mouth of the Columbia River during the spring period in the last five years, compared to the previous five years (Table B-1).

The exposure of different salmon and steelhead ESUs to increasing sea lion abundance varies by migration timing. During March–May, when adult spring Chinook salmon are migrating through the lower Columbia River estuary, CSL counts averaged 154 per month from 2008–12, but increased nearly tenfold from 2013–17 to an average of 1,364 per month. Pinniped counts at EMB during September and October, when fall Chinook and Snake River steelhead are migrating, have also increased notably since 2015, while pinniped counts at EMB during November and December, when chum salmon are migrating, have shown a smaller increase and are still relatively low. Pinniped counts at EMB during June, when sockeye salmon are migrating, have increased substantially since 2015, even though most male CSLs begin migrating to breeding grounds outside of the Columbia Basin in June. Pinniped counts during the Middle Columbia River steelhead migration (July–August) have seen little change and have remained low since the majority of CSLs have moved to breeding grounds outside of the Columbia Basin during the summer months.

Table B-1. Maximum monthly counts of California Sea Lions at Astoria, Oregon East Mooring Basin from 2008–17 (Wright 2018).

Year	Jan.	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
2008	40	56	67	126	162	46	6	191	213	204	273	157
2009	27	42	84	118	173	45	38	346	376	241	89	84
2010	58	93	136	229	216	157	29	316	356	265	98	54
2011	19	42	77	155	242	126	11	302	246	85	159	106
2012	20	27	82	240	201	92	19	212	187	147	91	21
2013	37	149	595	739	722	153	8	368	377	208	182	100
2014	237	586	1,420	1,295	793	90	32	423	492	369	94	126
2015	260	1,564	2,340	2,056	1,234	623	37	394	1,318	459	84	208
2016	788	2,144	3,834	1,212	1,077	620	3	291	1,004	878	235	246
2017	1,498	2,345	808	1,131	1,204	573						

It is unclear at this time how other factors, such as recent Pacific Ocean warming and abundance of non-salmonid feed sources (e.g., Eulachon, shad), influence these counts, but they are likely a major contributing factor (Rub et al. 2018). For example, the eastern Pacific Ocean was warm and had relatively low productivity from 2010–16 (McClatchie et al. 2016), and an oceanic heat wave (i.e. “the Blob”) developed in 2013–15 (Leising et al. 2015). The conditions caused prey fish in the California Current ecosystem to be displaced geographically, and affected prey availability for pinnipeds in coastal California. Many displaced CSL migrated into the Columbia River where they found an abundance of eulachon, which are followed closely in run timing by spring Chinook salmon. It is unclear if the CSL will permanently return to southern habitats closer to their breeding grounds if ocean conditions rebound, or if the increased pinniped presence will persist due to an abundance of animals having “discovered” the eulachon and salmon available to them at in the Columbia River. Regardless, current information clearly indicates that pinnipeds are increasing in abundance in the Columbia River and are currently having an increasing impact on spring, early summer, and fall runs.

Based on pinniped count data and mark-recapture logistic regression modeling, increasing pinniped abundance in the Columbia River estuary has resulted in an increased loss of spring Chinook salmon in recent years (Figure B-1). Rub et al. (2019) conducted a five-year mark-recapture tagging study to examine the behavior and survival of spring Chinook salmon returning to the Columbia River basin (above Bonneville Dam) amid increasing pinniped abundance. Using spring Chinook salmon that were known through genetic testing to have originated above Bonneville Dam, these researchers found that Non-harvest related mortality ranged from .20 and .44 annually over the five-year study, and survival was lowest during the last two years of study amidst the years with the highest pinniped abundance. It is important to note that while mortality due to harvest was accounted for in the estimates, effects from capture, handling, and mortality from natural causes were not accounted for. These researchers found strong evidence that the recent increases in spring Chinook salmon loss estimates were a function of the large increase in pinnipeds counted from 2012–15. This study provides evidence that increasing numbers of pinnipeds within the Columbia River are associated with reductions in the survival of returning adult salmon, most likely due to predation (Rub et al. 2019).

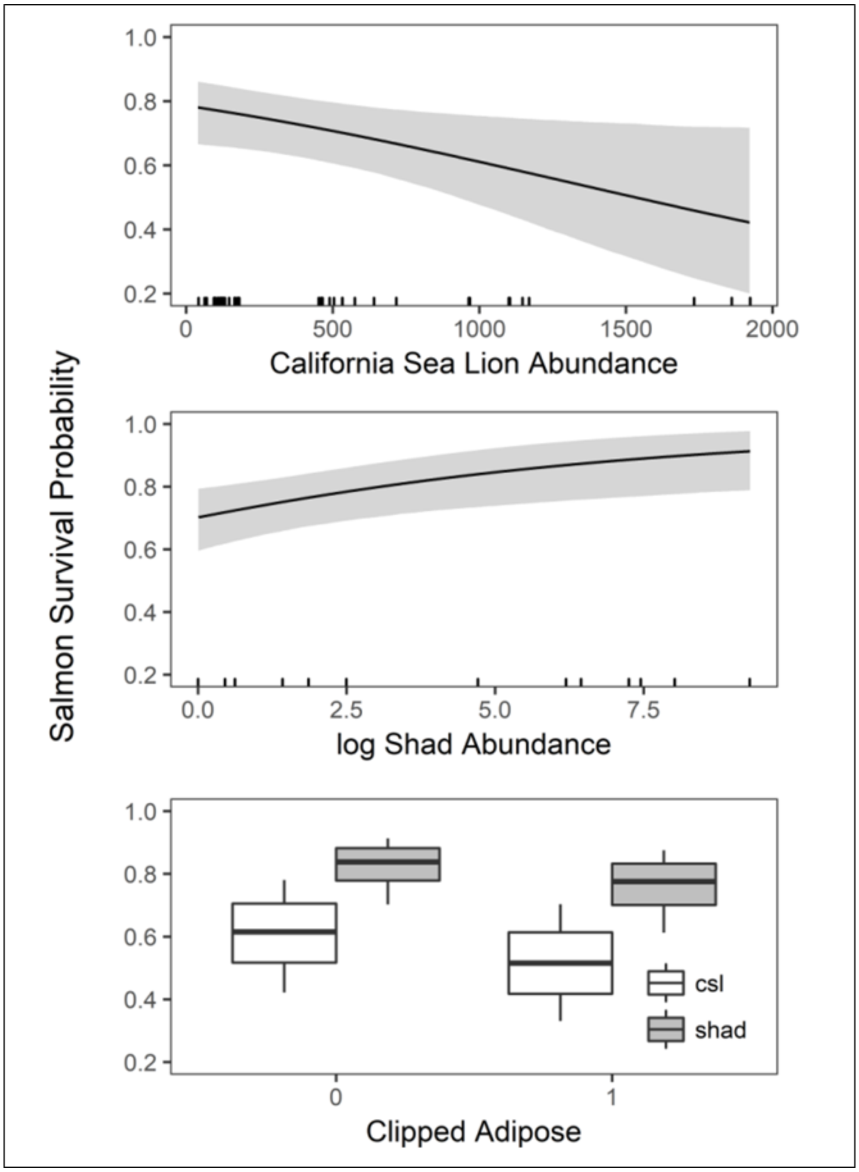

Figure B-1. Model-response curves illustrating the relationship between salmon survival and (a) California Sea Lion (CSL) Abundance, (b) log Shad abundance, and (c) clip status. The y-axis for each graph represents survival probability and the x-axis is the range of observed values for each covariate (Rub et al. 2018).

Chinook salmon populations exhibit a range of migration timings due to their different migration strategies adapted in response to phenology of migration, spawning, and juvenile rearing habitat conditions. For spring/summer Chinook, survival is typically lowest overall for fish migrating earlier in the run. Research has consistently found that the highest proportional impact of predation losses were experienced by fish that returned to Bonneville Dam during late winter and early spring, compared to those that followed (Figure B-2) (Keefer et al. 2012). In 2013–15, survival at Bonneville Dam was especially low for early migrants, corresponding with a period of increased CSL presence in the estuary. Early migrating spring Chinook salmon populations experienced a 22 percent reduction in survival in 2013–15 relative to a baseline period of 1998–2012, while survival of later-migrating populations declined by only 4–16 percent (Figures B-3 and B-4) (Sorel et al. 2017). The current information indicates that salmon populations with relatively early migration timing are more at risk because the relative predator density (number of predators/number of prey) has been highest early in the spring, and pinnipeds appear effective at capturing prey even at relatively low prey density.

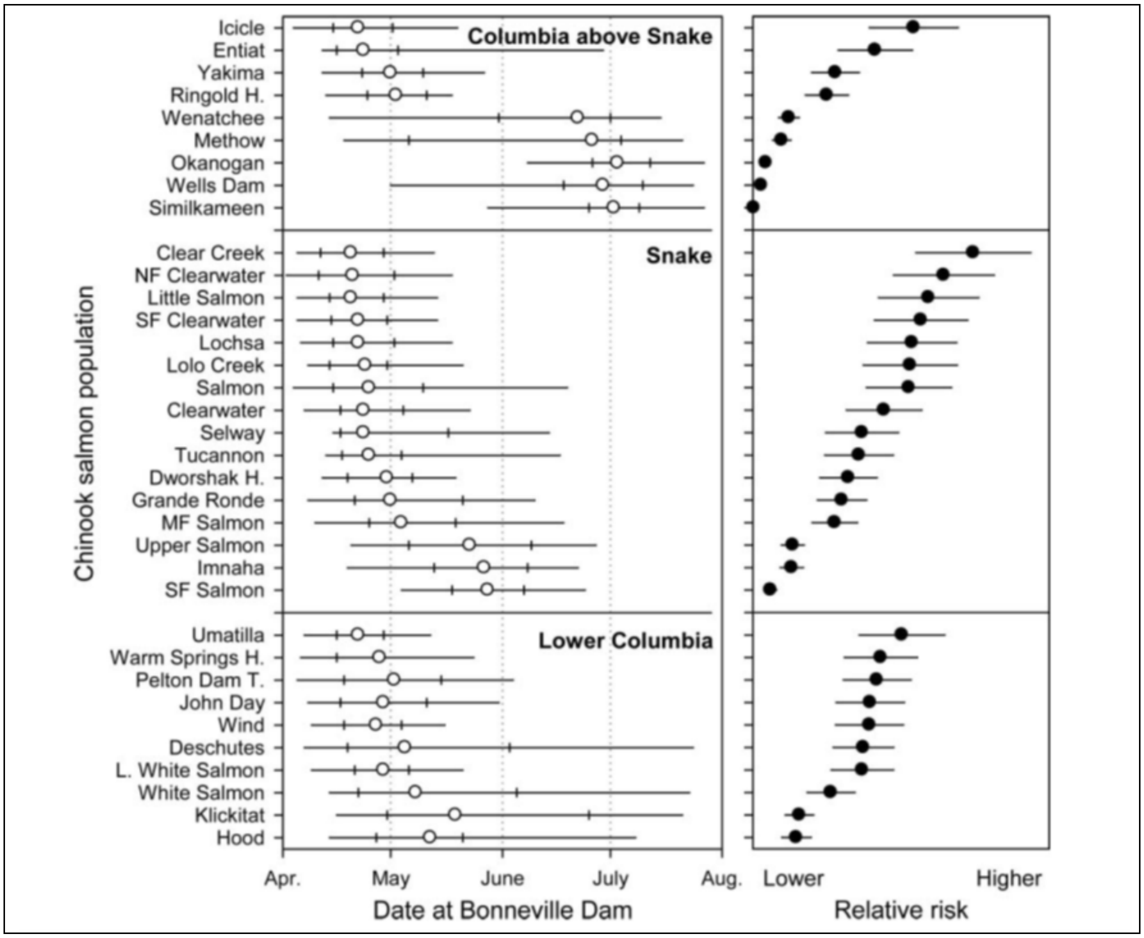

Figure B-2. Left panel: Migration timing distributions calculated using 5,229 radio-tagged spring and summer Chinook salmon from 32 upriver populations in the lower Columbia River, Snake River, and Columbia River upstream from the Snake River confluence, 1996–98 and 2000–04. Distributions show 5th, 25th, 50th, 75th, and 95th percentiles. Right panel: the relative risk (±1 SE) of predation by pinnipeds, estimated by multiplying weekly mean predation-rate estimates from the pinniped observation study by population-specific migration timing distributions (Keefer et al. 2012).

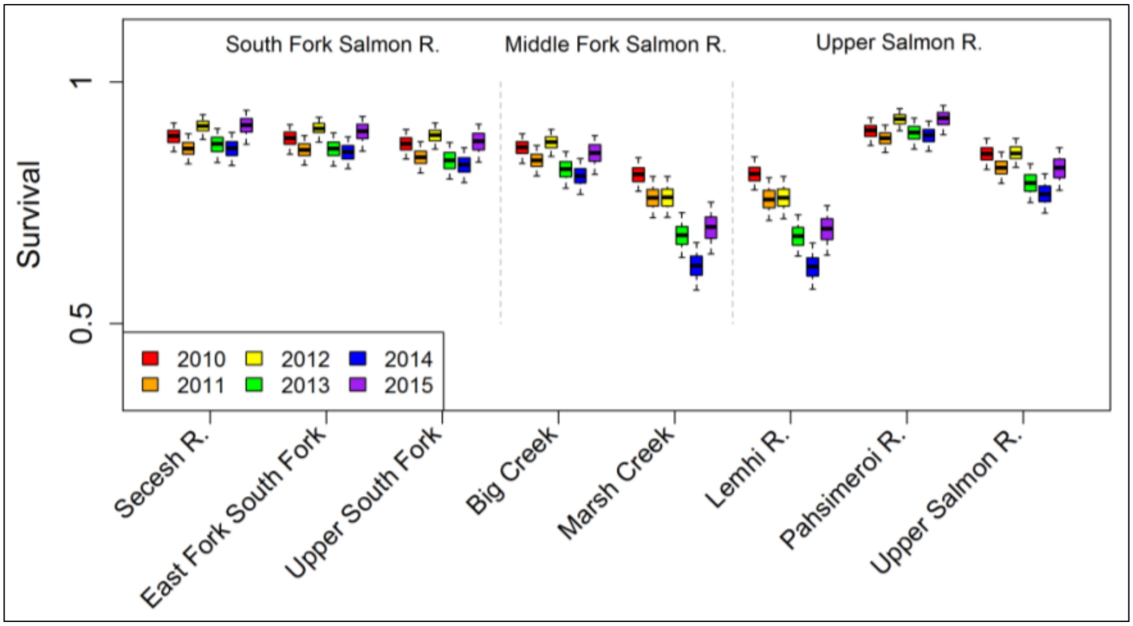

Figure B-3. Modeled population- and year-specific survival rates of adult spring Chinook salmon during their migration from the mouth of the Columbia River (near Astoria, OR) to Bonneville Dam. The horizontal black line in the middle of each box represents the median survival estimate, the range of each box represents the interquartile range, and whiskers reach the 5th and 95th percentiles (Sorel et al. 2017).

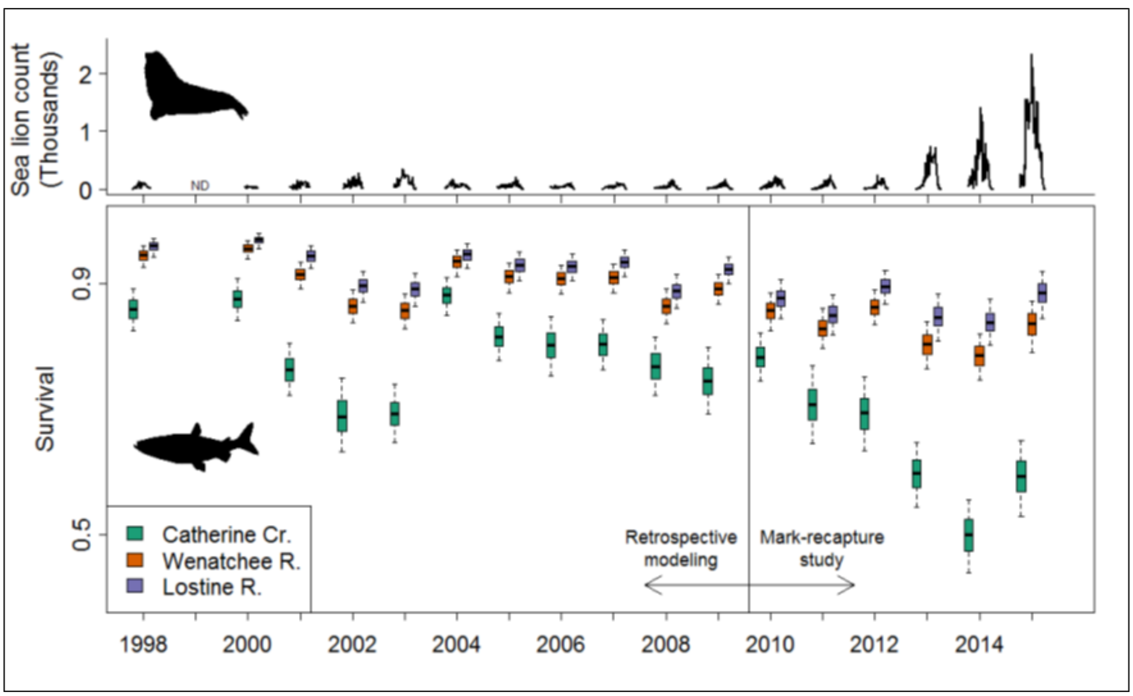

Figure B-4. Top Panel: Daily counts of California sea lions hauled out at the East Mooring Basin in Astoria from 1 January to 30 June 1998–2015. Sea-lion counts were unavailable for 1999. Bottom Panel: Modeled population- and year-specific survival rates of adult spring-summer Chinook salmon during their migration from the mouth of the Columbia River (near Astoria) to Bonneville Dam. The boxplots represent medians, interquartile ranges, and 5th and 95th percentiles of survival-rate estimates. We used the model of survival based on the mark-recapture study conducted in 2010–15 to retrospectively model survival rates as a function of California sea-lion counts (Sorel et al. 2017).

B.2 Pinniped Predation at Bonneville Dam

Based on the proposed action, the U.S. Army Corps of Engineers (Corps') will continue to install, and improve as needed, sea-lion excluder gates at all adult fish ladder entrances at Bonneville Dam annually. In addition, the Corps' and Bonneville Power Administration will continue to support land and water-based harassment efforts by ODFW, Washington Department of Fish and Wildlife (WDFW), and Columbia River Inter-Tribal Fish Commission (CRITFC) to keep sea lions away from the area downstream of Bonneville Dam. The Corps' will continue estimating sea lion abundance, spatial distribution, temporal distribution, predation attempts, and predation rates in the Bonneville Dam tailrace annually from early August through 31 May. Through the Fish Passage Operations and Maintenance Coordination Team (FPOM) and Sea Lion Task Force, the Corps' will continue to use adaptive management to address changing circumstances as they relate to supporting sea lion harassment efforts and monitoring of sea lion predation at Bonneville Dam.

Within the Columbia River, spring Chinook salmon losses due to pinniped predation are greatest directly downstream of Bonneville Dam. The highest adult salmonid-per-kilometer mortality rates within the Columbia Basin have been documented in the tailrace of Bonneville Dam and at Willamette Falls. Rub et al. (2018) found that up to 50 percent of the mortality of adult spring-run Chinook salmon destined for tributaries above Bonneville Dam occurred within the 10-mile reach just below the dam (Figure B-5). Wright et al. (2017) estimated that 25 percent of the winter steelhead run was consumed at Willamette Falls in 2017. In general, hydroelectric dams can delay upstream fish passage and congregate fish searching for ladder entrances. Such delays can make fish vulnerable to predation by pinnipeds (Stansell 2012; Naughton et al. 2011). An extreme example of pinniped-salmonid predation near a man-made impoundment was the functional extirpation of the Ballard Locks winter steelhead run in Washington State in the late 1980's (Jeffries and Scordino 1997). Pinniped predation on Upper Willamette River winter steelhead has recently been hypothesized to be the primary cause of decline and potential extinction risk factor for the species (Falcy 2017). The dam structure provides a predation advantage as fish congregate and delay migration in search of ladder entrances. These delays concentrate fish and predators, making fish more vulnerable to predation (Stansell 2012).

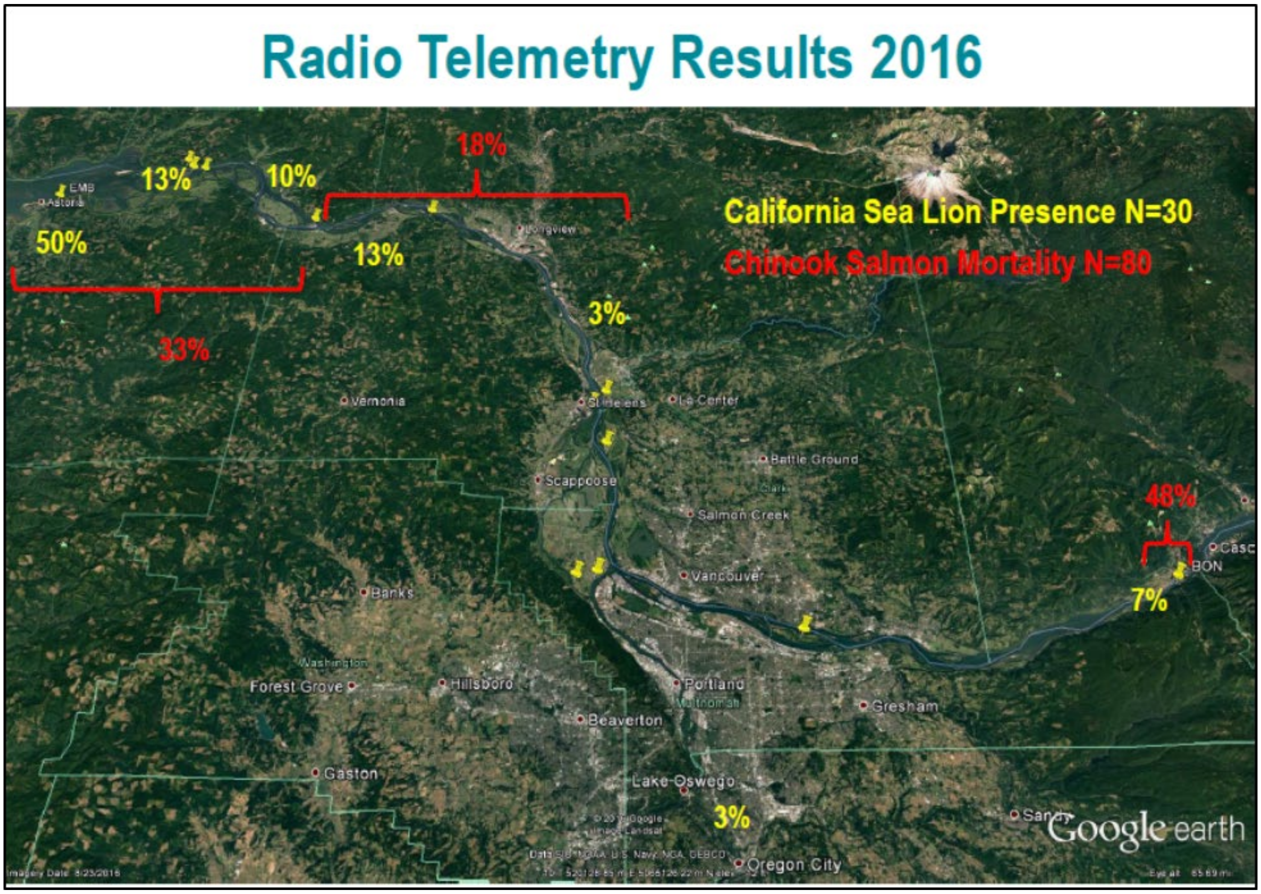

Figure B-5. Telemetry results indicating elevated spring Chinook losses near Bonneville Dam from (Rub et al. 2018).

Biologists have been estimating spring Chinook salmon consumption by pinnipeds directly below (2km) Bonneville Dam since 2002 (Tidwell et al. 2018). Pinniped predation on spring Chinook salmon has been variable during the time, but has generally increased in recent years. Tidwell et al. (2018) reports that an estimated 4,951 adult spring Chinook salmon (all ESU's) were consumed by both pinniped species in 2017, which equates to 4.5 percent of the adult spring Chinook salmon that passed the dam. Consumption rates of spring Chinook salmon in the last three years (2015–17) have ranged from 4.3–5.9 percent and are the highest consumption rates since monitoring began in 2002 (Table B-2). Observed predation at Bonneville Dam is typically highest near the Dam (Figure B-6).

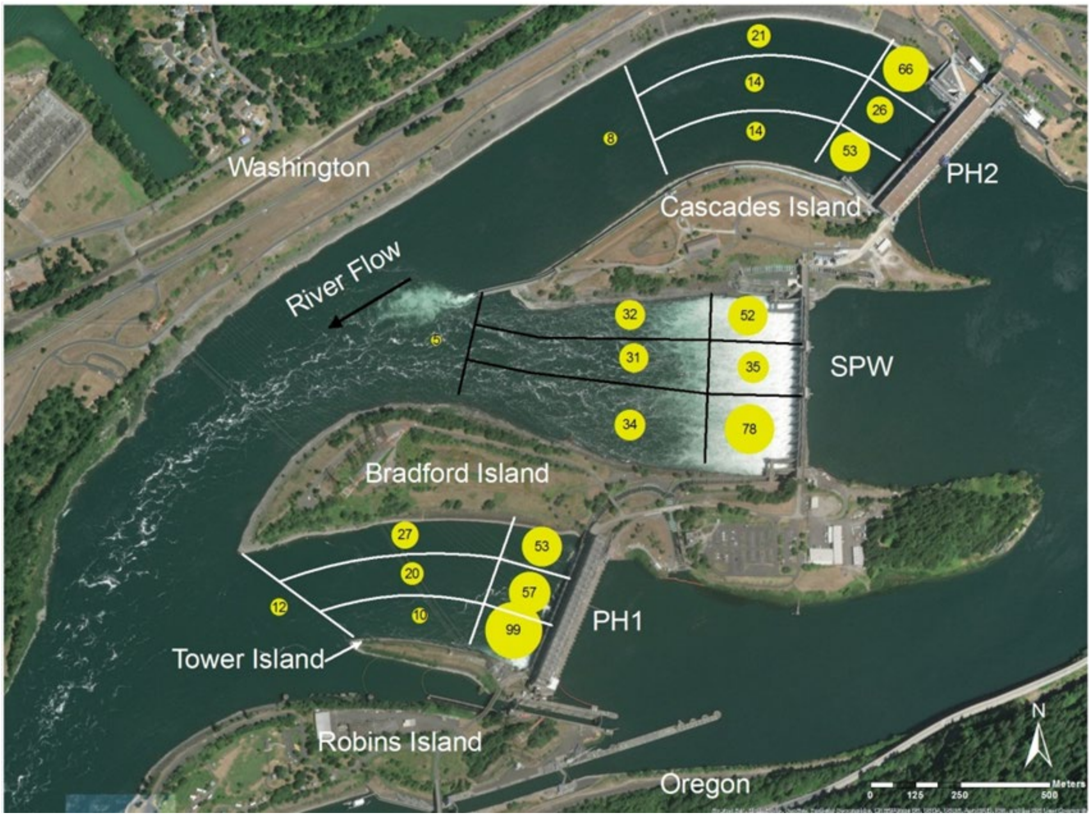

Figure B-6. Spatial distribution of observed salmonid predation by California sea lions at Bonneville Dam from 1 January through 1 June 2018 (Tidwell et al. 2019).

Table B-2. Consumption of spring Chinook salmon by pinnipeds at Bonneville Dam tailrace from 1 January through 15 June 2002–17. Passage counts of Chinook salmon include both adult and jack salmon (Tidwell et al. 2018).

Year	Bonneville Dam Spring Chinook Passage	Chinook Consumption Estimate	% Run
2002[x]	316,468*	880[†]	0.3 %
2003[x]	247,059	2,313	0.9 %
2004[x]	210,569	3,307	1.5 %
2005[x]	102,741	2,742[‡]	2.6 %
2006[x]	130,014	2,580	1.9 %
2007[x]	101,068	3,403	3.3 %
2008	143,139	4,500	3.0 %
2009	181,174	4,360	2.3 %
2010	257,036	5,909	2.2 %
2011	218,092	3,634	1.6 %
2012	165,681	1,960	1.2 %
2013	117,165	2,710	2.3 %
2014	214,177	4,576	2.1 %
2015	233,794	10,622	4.3 %
2016	148,360	9,222	5.9 %
2017	105,583	4,951	4.5 %

The abundance and residency of SSL's during the fall months at Bonneville Dam has also increased appreciably in the last six years (Table B-3). Between 15 August and 31 December 2017, Tidwell et al. (2019) documented 3 individual CSLs and 36 individual SSLs, and an average of 14.5 SSLs per day, at Bonneville Dam. An estimated 892 (737–1,046) adult salmonids were consumed, which equates to 1.20 percent of all the adult salmonids that were counted passing the dam's second power house tailrace between 30 August and 31 December 2017. Of these consumed salmonids, the estimates show that 401 were Chinook, 368 were coho, and 123 were steelhead. Using fish counted passing the Washington shore, where the observations took place, pinnipeds were estimated to consume 0.7 percent of the Chinook, 3.1 percent of the coho, and 1.5 percent of the steelhead (Table B-4).

Table B-3. Average daily combined pinniped presence by month at Bonneville Dam (Tidwell et al. 2019).

Month	2011	2012	2013	2014	2015	2016	2017
Aug.	0.0	0.0	0.0	1.0	1.9	5.2	10.8
Sept.	0.0	0.0	1.5	6.8	16.6	30.7	13.2
Oct.	2.4	2.6	13.3	11.7	22.5	26.6	14.8
Nov.	4.9	2.8	15.9	16.8	22.3	18.9	18.5
Dec.	7.0	4.1	10.2	9.2	16.1	16.4	16.4

Table B-4. Adjusted consumption estimates on adult salmonids (including adults and jacks) and White Sturgeon by California and Steller sea lions at Bonneville Dam between 30 August and 31 December. Observation periods were when predation monitoring was occurring.

	Adjusted Salmonid Consumption Estimates	Range of Estimate	Total Salmonid Passage at Washington Shore	% Total Passage Consumed	Salmonid Passage at Washington Shore during observation period	% Observed Passage Consumed
Chinook	401	281 – 506	204,707	0.19 %	54,371	0.74 %
Coho	368	296 – 432	49,630	0.74 %	11,896	3.09 %
Steelhead	123	63 – 172	26,169	0.47 %	7,967	1.54 %
Sturgeon	238	183 – 281	N/A	N/A	N/A	N/A
All Salmon*	892	737 – 1,046	280,517	0.32 %	74,262	1.20 %

*Sockeye passed Bonneville Dam during the sampling period but no predation was documented (Tidwell et al. 2019).

B.3 Discussion

The information reviewed in this appendix for the 2019 CRS biological opinion indicates that pinniped predation on listed salmonids is a growing issue that continues to raise concern. While some management actions, such as limited hazing and lethal removal, are currently being implemented, and have had some beneficial effects, they appear to be ineffective at reversing the trend of increasing pinniped abundance and predation. The available information indicates that the hydroelectric dams are increasing the effectiveness of the predators, with the highest consumption estimates occurring within a few kilometers of dams (Wright et al. 2017; Rub et al. 2018).

To reduce salmonid mortality associated with pinniped predation at Bonneville and The Dalles Dams, NMFS concludes the information suggests that an increase in dam hazing intensity and duration is warranted. This would reduce the amount of time that pinnipeds spend near fish ladders where the data indicate pinnipeds are most effective at consuming salmonids. While some dam hazing is occurring in the spring at Bonneville Dam, there are no dam hazing efforts to address the increasing predation from steller sea lions occurring in the fall period. Steller sea lions are generally known to be more responsive to hazing than California sea lions, and efforts to haze or dissuade steller sea lions would complement removals outside of the spring period. As a recommendation, NMFS suggests the action agencies take the lead and work with NMFS and regional partners to develop and implement a pinniped management plan with the primary goal of reducing predation rates at Bonneville Dam. This plan should consider and use the best available methods and monitoring alternatives to effectively reduce predation rates, should have the flexibility to adapt to changing conditions, and should be funded as necessary to implement action within practical boundaries.

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B.5 Additional Information

The Corps' pinniped monitoring program provides monitoring data, access to the dam facilities, and collaboration between state, tribal, and federal agencies charged with managing fish and pinniped species. As such, it is pertinent to highlight the collaborative roles of the involved agencies: The states of Oregon, Washington, and Idaho (the States) received permission from NMFS to extend the Letter Of Authorization (LOA) granted on 15 March 2012 under Section 120 of the Marine Mammal Protection Act (MMPA) to permanently remove California Sea Lions (CSLs) at Bonneville Dam that were having significant negative impacts on the recovery of ESA-listed Chinook salmon and steelhead stocks (NMFS 2015). An extension was approved on 7 July 2016 for an additional five years (U.S. Office of the Federal Register 2016). The Columbia River Inter-Tribal Fish Commission (CRITFC) supports the program with personnel and boat-based hazing efforts, and the U.S. Department of Agriculture (USDA) provides dam-based hazing (i.e. deterrence) efforts under contract to the Corps'.

Table 1. Lower Columbia River weighted mean survival estimates for PIT-tagged adult Chinook salmon destined for tributaries above Bonneville Dam.

Year	Adult Chinook salmon (N)	Dates Sampled	Baseline Survival (95% CI)	Adjusted Survival (95% CI)
2010	172	4/14-5/11	.75 (.69-.82)	.91 (.83-.99)
2011	381	4/1-5/16	.73 (.69-.77)	.87 (.82-.92)
2012	372	3/23-5/31	.70 (.65-.75)	.86 (.80-.92)
2013	73	4/19-6/14	.62 (.48-.75)	.74 (.57-.91)
2014	297	3/20-5/13	.47 (.39-.54)	.58 (.49-.67)
2015	205	3/19-5/8	.55 (.45-.65)	.67 (.56-.79)

Note: *Baseline* Survival estimates were adjusted for detection probability at Bonneville Dam if less than 100%. *Adjusted* survival estimates were further adjusted to account for potential mortality due to harvest and impacts from sampling gear. Due to these adjustments, estimates of greater than 100% are possible. This data is an older version and may be superseded by more recent analysis in Rub et al. (2018).

Summary of Pinniped Predation, 7 August 2018, General Council Bonneville Dam Tour

Robert Anderson Email 8/7 to Ritchie Graves with respect to Pinniped Predation 8.7.2018 — General Council Bonneville Dam Tour:

In the Pacific Northwest, pinnipeds have been a substantial source of salmon and steelhead mortalities for the past 30 years.

- Ballard Locks, Washington: Between 1986 and 1992, California sea lions (CSLs) consumed between 42–65 percent of the total Lake Washington winter steelhead run; the Lake Washington winter steelhead run is now considered functionally extinct.

- Bonneville Dam, Washington and Oregon: Estimates of CSLs' consumption of five at-risk salmonid fish stocks at Bonneville Dam has ranged from a low of 0.35 percent in 2002, to a high of 4.17 percent in 2007, and 1.86 percent in 2017. Consumption of at-risk salmonids at Bonneville Dam by all pinnipeds (California sea lions and Steller sea lions) has ranged from a low of 0.35 percent in 2002, to a high of 5.5 percent in 2016, with 4.54 percent in 2017.
- The states of Oregon, Washington, and Idaho have been lethally removing CSLs, under an MMPA Section 120 Letter of Authorization from NMFS, at Bonneville Dam since 2008. Since receiving removal authority in 2008, the states have permanently removed 190 CSLs. The removal program is estimated to have prevented the loss of 24,466 fish (range: 14,329–38,795 fish).
- Willamette Falls, Oregon: Consumption estimates by CSLs of two at-risk salmonid fish stocks at Willamette Falls have ranged from a low of 7 percent in 2014 to a high of 25 percent in 2017.

Table 2. Adjusted consumption estimates on adult salmonids (including adults and jacks) by California and Steller sea lions at Bonneville Dam between 1 January and 2 June 2002–17.

Year		California Sea Lions			Steller Sea Lions			All pinnipeds	
	Bonneville Dam Salmonid Passage	Adjusted Salmonid Consumption Estimates	% Run		Adjusted Salmonid Consumption Estimates	% Run		Adjusted Salmonid Consumption Estimates	% Run
2002	284,732	1,010	0.4%		0	0.0 %		1,010	0.4 %
2003	217,934	2,329	1.1%		0	0.0 %		2,329	1.1 %
2004	186,771	3,516	1.9%		7	0.0 %		3,533	1.9 %
2005	81,252	2,904	3.5%		16	0.0 %		2,920	3.4 %
2006	105,063	3,312	3.1%		85	0.1 %		3,401	3.1 %
2007	88,474	4,340	4.7%		15	0.0 %		4,355	4.7 %
2008	147,558	4,735	3.1%		192	0.1 %		4,927	3.2 %
2009	186,056	4,353	2.3%		607	0.3 %		4,960	2.7 %
2010	267,167	5,296	1.9%		1,025	0.4 %		6,321	2.4 %
2011	223,380	2,689	1.2%		1,282	0.6%		3,970	1.8%
2012	171,665	1,067	0.6%		1,293	0.7%		2,360	1.4%
2013	120,619	1,497	1.2%		1,431	1.2%		2,928	2.4%
2014	219,929	2,747	1.3%		1,874	0.8%		4,621	2.1%
2015	239,326	8,324	3.3%		2,535	1.0%		10,859	4.3%
2016	154,074	6,371	3.9%		2,598	1.6%		8,969	5.5%
2017	109,040	2,024	1.9%		2,925	2.7%		4,949	4.5%

Table 3. Consumption of spring Chinook salmon by pinnipeds at Bonneville Dam tailrace from 1 January through 15 June 2002–17. Passage counts of Chinook salmon includes both adult and jack salmon (Tidwell et al. 2017).

Year	Bonneville Dam Spring Chinook Salmon Passage	Chinook Salmon Consumption Estimate	% Run
2002	316,468	880	0.3 %
2003	247,059	2,313	0.9 %
2004	210,569	3,307	1.5 %
2005	102,741	2,742	2.6 %
2006	130,014	2,580	1.9 %
2007	101,068	3,403	3.3 %
2008	143,139	4,500	3.0 %
2009	181,174	4,360	2.3 %
2010	257,036	5,909	2.2 %
2011	218,092	3,634	1.6 %
2012	165,681	1,960	1.2 %
2013	117,165	2,710	2.3 %
2014	214,177	4,576	2.1 %
2015	233,794	10,622	4.3 %
2016	148,360	9,222	5.9 %
2017	105,583	4,951	4.5 %

2017—An estimated 4,951 (4,276–5,585) spring Chinook were consumed, which equates to 4.5 percent of the run. Of these, Stellar sea lions (SSLs) consumed 2,860 (2,494–3,211), which equates to 2.6 percent of the run, and CSLs consumed 2,091 (1,781–2,374), which was 1.9 percent of the run.

2016—An estimated 9,222 spring-run Chinook salmon were consumed at Bonneville Dam by CSLs and SSLs in 2016. These losses include 6,539 fish consumed by CSLs.

Table 4. Minimum estimated number of individual pinnipeds observed at Bonneville Dam tailrace areas and the hours of observation during the focal sampling period, 2002 to 2017.

Year	Total Hours Observed	California Sea Lions	Steller Sea Lions	Harbor Seals	Total Pinnipeds
2002	662	**30**	**0**	1	31
2003	1,356	**104**	**3**	2	109
2004	516	**99**	**3**	2	104
2005	1,109	**81**	**4**	1	86
2006	3,650	**72**	**11**	3	86
2007	4,433	**71**	**9**	2	82
2008	5,131	**82**	**39**	2	123
2009	3,455	**54**	**26**	2	82
2010	3,609	**89**	**75**	2	166
2011	3,315	**54**	**89**	1	144
2012	3,404	**39**	**73**	0	112
2013	3,247	**56**	**80**	0	136
2014	2,947	**71**	**65**	1	137
2015	2,995	**195**	**69**	0	264
2016	1,974	**149**	**54**	0	203
2017	1,142	**92**	**63**	1	156

Summary of California Sea Lion and Steller Sea Lion Removal Activity at Bonneville Dam since the start of the MMPA Section 120 Removal Program

Impacts on Columbia River Salmonid Fishery Stocks

- Minimum predation estimates of salmonids at Bonneville Dam by CSLs in 2002–17: **53,689** fish.
- Minimum predation estimates of salmonids at Bonneville Dam by all pinnipeds (CSL and SSL) from 2002–17: **68,288** fish.

Estimated Benefits of the Pinniped Removal Program at Bonneville Dam

Based on bioenergetic models that produce estimates of food requirements, not food consumption, the permanent removal of CSL from 2008–17 is estimated to have prevented the loss of approximately 23,000–30,000 salmonid fishes.

ESA-guided recovery plans have been developed and implemented in every watershed that supports these listed salmon and steelhead species. The recovery plans include actions to: restore important habitat; improve dam passage survival; re-tool hatchery programs to assist production in wild populations; and close, reduce or reshape fisheries to limit fishery-related mortality of listed stocks and focus on selectively harvesting healthy stocks. These efforts equate to hundreds of millions of dollars invested annually, and billions over the past decades.

Appendix C – Avian Predation Management

C.1 Introduction

Research shows that, in some years, Caspian terns (*Hydroprogne caspia*) and double-crested cormorants (*Phalacrocorax auritus*) nesting on East Sand Island in the Columbia River estuary have consumed more than 10 to 20 percent of the juvenile Endangered Species Act (ESA)-listed Chinook and steelhead migrating from the interior Columbia Basin (USACE 2015a; Evans et al. 2016). In response to these findings, NMFS provided several management measures in the 2008 FCRPS[12] biological opinion and 2010 and 2014 supplemental biological opinions to reduce the predation rates (NMFS 2008; 2010; 2014):

- RPA Action 45—The FCRPS Action Agencies will implement the Caspian Tern Management Plan. East Sand Island tern habitat will be reduced from 6.5 to 1.5–2 acres.
- RPA Action 46—The FCRPS Action Agencies will develop a cormorant management plan encompassing additional research, development of a conceptual management plan, and implementation of warranted actions in the estuary.
    - This RPA action was modified in 2014 to read: "The FCRPS Action Agencies will develop a cormorant management plan (including necessary monitoring and research) and implement warranted actions to reduce cormorant predation in the estuary to Base Period levels (no more than 5,380 to 5,939 nesting pairs on East Sand Island."
- RPA Action 47—Inland Avian Predation: The FCRPS Action Agencies will develop an avian management plan (for Double-Crested Cormorants, Caspian Terns, and other avian species as determined by RM&E) for Corps-owned lands and associated shallow-water habitat.

In this appendix, we document the Action Agencies' progress with respect to these RPA actions. We also discuss current estimates of smolt predation rates using information developed through the research and monitoring programs in RPA actions 66, 67, and 68.

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[12] In earlier biological opinions, the federal Columbia River System (CRS) was referred to as the Federal Columbia River Power System or FCRPS.

C.2 Effects of Avian Predator Colonies in the Columbia River Estuary

C.2.1 Caspian Terns Nesting on East Sand Island

Terns first nested on East Sand Island in the lower Columbia River estuary in 1984, following the deposition of fresh dredged material at the eastern tip of the island in 1983. By 1985, vegetation covered the nesting site making it unsuitable for terns and by 1986 the colony had shifted to Rice Island, a dredged-material disposal site located 16 miles upriver. In 1999 and 2000, the Corps' used social attraction mechanisms, decoys and pre-recorded callbacks, from Rice Island back to East Sand Island, to decrease the numbers of juvenile salmon and steelhead consumed by the terns (USACE 2015b).

This work to decrease predation rates was challenged under the National Environmental Policy Act (NEPA) by the Seattle Audubon Society, National Audubon Society, American Bird Conservancy, and Defenders of Wildlife. In 2002, the parties involved in the lawsuit reached a settlement agreement, which allowed the Corps' to continue to use social attraction devices to induce the terns to nest on East Sand Island, but also required the Corps', U.S. Fish and Wildlife Service (USFWS), and NMFS to produce an Environmental Impact Statement (EIS) for a plan to manage the terns in the long term with the goal of reducing predation on juvenile salmonids. Subsequently, the federal agencies completed the Caspian Tern Management to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary Final Environmental Impact Statement (USFWS et al. 2005). The USFWS and Corps' each issued their own records of decision (RODs) in 2006 (USFWS 2006; USACE 2006). Collectively, these documents were called the Caspian Tern Management Plan.

The Caspian Tern Management Plan called for the redistribution of 60 percent of the East Sand Island colony to new habitat (islands) to be constructed in Oregon, California, and Washington. Thus, the reduction in habitat area on East Sand Island would be met by the creation of the new islands at a nesting area ratio of 2:1. Because Caspian terns nested on an average of five acres from 2001–04 on East Sand Island, approximately seven to eight acres of new suitable habitat would need to be created to reduce the East Sand Island habitat from 1–1.5 acres (USFWS et al. 2005). Plans to create the habitat in Washington State were unattainable so a modified alternative was selected that involved constructing seven acres of new habitat and reducing East Sand Island habitat to 1.5–2 acres so that a larger number of terns would remain on the island (3,125–4,375 pairs assuming an average nesting density of 0.55 pairs/m^2).

Despite the reduction in nesting habitat on East Sand Island, however, the tern population continued to increase after 2005, with the number of nesting pairs on the island in 2013 (7,000) and 2014 (6,200) at twice that predicted in the 2005 EIS (USFWS et al. 2005) and in the Corps' 2006 Record of Decision (USACE 2015b). The Corps' responded by preparing a smaller habitat area (1 acre) to reduce the size of the tern colony as prescribed in the Caspian Tern Management Plan with the expected outcome of a colony size of 3,125-4,375 breeding pairs. Even with the Corps' efforts, terns further increased their nesting density at East Sand Island to 1.36 nests/m^2 in 2016 (Roby et al. 2018). Thus, numbers of breeding pairs remained above the Caspian Tern Management Plan's objective of 3,125-4,375 pairs.

In 2017 the situation on East Sand Island changed. After increasing for a decade, the Caspian tern nesting density declined, dropping to 0.97 nests/$m^{2,}$ with a peak size of about 3,500 breeding pairs in early June 2017. However, this decline in nesting at East Sand Island was met by an increase in tern interest at Rice Island, 16 miles upriver, where about 1,500 pairs of terns roosted, or tried to nest.[13] The increase in activity at Rice Island indicates that some of the birds displaced from East Sand Island remained within the estuary, but were too far from the mouth of the river to include a larger proportion of marine forage fishes in their diet (i.e., diet was almost entirely salmonids). The Corps increased dissuasion efforts and was able to keep terns from successfully nesting on Rice Island during the 2015-18 nesting seasons.

By mid-June 2017, the size of the tern colony on East Sand Island was declining rapidly and all nesting attempts had failed (Roby et al. 2018). By late June, terns completely abandoned the colony and stayed away for 10 days, an unprecedented event at this location. A smaller wave of nesting activity began in July and continued through early September; researchers reported up to several hundred nests with eggs present on the colony at one time. However, these nests also failed and no Caspian tern young were raised on East Sand Island in 2017.

The lower nesting density of terns on East Sand Island in 2017 could have been related to an increase in the rate of disturbance by bald eagles (*Haliaeetus leucocephalus*) and gulls (*Larus* spp.). Eagles often harass terns to get them to drop fish they are bringing back to the nest (kleptoparasitism); when terns leave their nests during an eagle disturbance, the gulls follow close behind, preying on the exposed eggs and chicks.

C.2.1.1 Smolt Predation Rates by East Sand Island Caspian Terns

Evans et al. (2018a) compared average annual predation rates before and after initiation of the Caspian Tern Management Plan (Table C-1). The findings indicate that predation rates have been, on average, significantly lower during the management period (2011–17) than before management (2000–10). The lowest rates for East Sand Island terns coincided with the colony failure in 2017. For steelhead, predation rates were linearly related to colony size, indicating that management actions to reduce numbers of terns on East Sand Island resulted in lower than average annual predation rates at this colony.

[13] In addition, Caspian tern activity at Rice Island had increased in 2015 following the placement of dredged material. The Corps built a berm on the downstream portion of the island in September 2015 to reduce line-of-sight visibility from areas where terns were prospecting for nests to the river. This reduced Caspian tern interest in this habitat (loafing or roosting in the upland placement area) from about 6,000 individuals in 2015 to about 1,500 in 2017. A small proportion of these birds laid eggs, all of which were collected under annual depredation permits from USFWS.

The presence of approximately 1,000 terns attempting to nest at Rice Island in 2017 offset, to some degree, the lower predation rates at the East Sand Island colony (Evans et al. 2018a). Fortunately, hazing and dissuasion ensured that nesting attempts on Rice Island were not successful. Overall, however, historical (pre-management) per capita predation rates on salmonids by nesting terns were two to three times higher at Rice Island than at East Sand Island where the forage base includes several species of marine fishes (Roby et al. 2002).

Table C-1. Average annual predation rates (with 95 percent credible intervals) on Snake River (SR), Upper Columbia River (UCR), Upper Willamette River (UWR), Mid-Columbia River (MCR), Lower Columbia River (LCR), and Columbia River (CR) salmonids by Caspian terns at East Sand Island. The management time period is defined as the period when management actions significant reduced colony size, not necessarily when first implemented. Comparable estimates are not available (NA) for some time periods. An asterisks (*) indicates statistically credible differences between management periods for a salmonid species. Source: Evans et al. (2018a).

Salmonid ESU/DPS	Pre-management Period	Management Period
	2000-2010	2011-2017
SR sockeye salmon[a]	1.5% (0.9-2.2)	1.4% (1.0-1.8)
SR spring/summer Chinook salmon*	4.8% (4.3-5.4)	1.5% (1.3-1.8)
UCR spring Chinook salmon*	3.9% (3.4-4.6)	1.6% (1.3-2.0)
SR fall Chinook salmon*	2.5% (2.2-3.0)	0.8% (0.6-0.9)
UWR spring Chinook salmon*	2.5% (1.9-3.3)	1.0% (0.6-1.4)
SR steelhead*	22.2% (20.3-24.8)	9.5% (8.4-10.8)
UCR steelhead*[b]	17.2% (15.7-19.3)	9.0% (7.9-10.3)
MCR steelhead*[c]	14.9% (13.1-17.6)	9.3% (7.9-10.8)
LCR Chinook salmon	NA	NA
LCR steelhead	NA	NA
LCR coho salmon	NA	NA
CR chum salmon	NA	NA
UWR Chinook salmon*[d]	2.5% (1.9-3.3)	1.0% (0.6-1.4)
UWR steelhead	NA	NA

[a] Predation rate estimates for SR sockeye salmon were not available in 2000-2008 and in 2016-2017 due to insufficient sample sizes.
[b] Predation rate estimates for UCR steelhead were not available in 2000-2002 due to insufficient sample sizes.
[c] Predation rate estimates for MCR steelhead were not available in 2000-2006 due to insufficient sample sizes.
[d] Predation rate estimates for UWR Chinook salmon were not available in 2000-2006 and in 2017 due to insufficient sample sizes.

C.2.1.1.1 Tern Predation on Lower Columbia River Chinook and Coho Salmon

The predation rate in Evans et al. (2018a) is based on the number of passive integrated transponders (PIT) tags detected on East Sand Island as a function of the number of tagged smolts that pass Bonneville Dam (or Sullivan Dam on the lower Willamette River in the case of Upper Willamette River Chinook salmon). Few PIT-tagged smolts from Lower Columbia River ESUs and DPSs pass Bonneville Dam—which lies upriver from most of the spawning and rearing areas used by these species—so this method does not work for those species. However, Sebring et al. (2013) estimated predation rates on PIT-tagged subyearling hatchery Chinook salmon from the Lower Columbia River (LCR) Chinook salmon ESU during 2002–

10. Findings from this study indicate that, based on PIT-tag recoveries from the East Sand Island colony, minimum predation rates[14] by terns on hatchery smolts originating downstream of Bonneville Dam averaged 4 percent. Although this study was not repeated during the management period (2011–17), predation rates may have been lower based on a comparison for the two periods for Snake River (SR) fall Chinook salmon (0.8 percent during the management period compared to 2.5 percent pre-management; Evans et al. 2018a). Tern predation rates for the yearling life-history type from this ESU may have also declined, based on data for SR spring/summer Chinook salmon (1.5 percent during the management period compared to 4.8 percent pre-management) and Upper Columbia River (UCR) spring Chinook salmon (1.6 percent during the management period compared to 3.9 percent pre-management; Evans et al. 2018a).

Sebring et al. (2010) also estimated a 3 percent minimum predation rate on PIT-tagged hatchery-origin LCR coho salmon by terns nesting at East Sand Island.

C.2.1.2 Summary—Impacts of Caspian Terns in the Columbia River Estuary

The nesting attempts by approximately 1,000 pairs of terns on Rice Island in 2017 indicate that this species' response to habitat reduction on East Sand Island is still in flux. The success of the management plan in reducing smolt predation is likely to depend on whether nesting densities remain low on East Sand Island and, if they do, whether birds move to areas outside the Columbia River basin rather than upstream to sites like Rice Island or the interior Columbia River plateau. Resightings of previously banded Caspian terns during the 2017 nesting season showed that some moved from the estuary to the plateau or to Puget Sound, but that others were still coming to East Sand Island from other colonies in the Pacific Flyway (Roby et al. 2018). One tern that was banded as a fledgling on East Sand Island and resighted there in 2016, was later seen at Corps'-constructed islands at Don Edwards National Wildlife Refuge in San Francisco Bay in 2017. This indicates that it may take more time for the colony on East Sand Island to reach and stabilize at a size of about 3,125 nesting pairs as assumed in the 2008 FCRPS biological opinion, or that additional management actions may need to be evaluated.

C.2.2 Double-crested Cormorants Nesting on East Sand Island

The double-crested cormorant colony on East Sand Island increased nearly threefold during 1997–2013 to about 14,900 breeding pairs (Turecek et al. 2018). The estimated per-capita smolt consumption by cormorants on East Sand Island was about four times higher than that of Caspian terns before management, both due to the larger number of breeding pairs and the higher food requirement of larger individual cormorants (Roby et al. 2013). Under 2008 RPA action 46 (as modified in the 2014 Supplemental FCRPS biological opinion), the Corps'

[14] Sebring et al. (2013) provide minimum predation rates because their estimates were not corrected for PIT-tag detection probabilities on East Sand Island. In addition, the samples were not representative of the Lower Columbia River Chinook salmon ESU at-large because they consisted only of hatchery-origin subyearling fish.

developed the *Double-crested Cormorant Management Plan to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary* (Cormorant Management Plan). The Cormorant Management Plan (USACE 2015a) calls for a two-phased approach:

- Phase I – Reduce East Sand Island colony to 5,380-5,939 breeding pairs by implementing primarily lethal methods to reduce the population (i.e., four years of culling adults and three years of nest loss through egg oiling).
- Phase II – Transition to lower maintenance, primarily non-lethal techniques to ensure colony size does not exceed 5,380-5,939 breeding pairs. This would be accomplished via habitat modifications to reduce the availability of nesting habitat, supported with human hazing and limited egg take (500 eggs on East Sand Island and 250 at dredged placement sites in the upper estuary) to support the objectives of habitat modification and ensure the colony size does not exceed management objectives.

Phase I of the effort was expected to last four years, ending with a colony size of about 5,600 breeding pairs. However, the dispersal and subsequent nesting failure of this colony in 2016 and 2017 (see below) triggered the decision to end culling after April 2017, the third year of the implementation (see Table 5-3 in USACE 2015b). Early implementation of Phase II therefore began in 2018.

C.2.2.1 Double-crested Cormorant Colony Dispersal in 2016 and 2017

In 2016, double-crested cormorants started nesting on East Sand Island in late April, but were absent between the week of 17 May and late June (Anchor QEA 2017). Researchers suspended ground surveys to avoid disrupting the remaining individuals, but reinitiated surveys when larger numbers of birds returned in late June. Peak numbers (19,544 double-crested cormorants; 9,772 nests) were observed during the first week of July (Anchor QEA 2017). During the period when cormorants were absent from East Sand Island, many were observed on the Astoria-Megler Bridge, about 9 miles upriver. Counts of the birds peaked at over 4,000 cormorants and about 550 nests in mid-June 2016 (Anchor QEA 2017).

A second dispersal event occurred during the 2017 breeding season. Cormorants began loafing on the beaches of East Sand Island in mid-April, using the western portion of the island for staging and loafing, but were unable to establish a colony (Turecek et al. 2018). They did have two brief periods of attendance during mid-May and early-June, but frequent disturbances by bald eagles resulted in partial or complete flushes to nearby beaches or to rafts on the water, usually in nearby Baker Bay. After the dispersal event on 5 June 2017, cormorants did not sustain colony attendance except for 544 nests late in the season and did not appear to fledge any chicks. However, they did nest successfully on the Astoria–Megler Bridge with a peak count of about 6,000 individuals and more than 800 nests on 11 July (MacDonald 2017). Smaller numbers nested on the Lewis and Clark Bridge (Longview, WA); aids to navigation between Tongue Point, Oregon and Skamokawa, Washington; and the electrical transmission towers near the Sandy River delta, Oregon.

C.2.2.2 Smolt Predation Rates by East Sand Island Cormorants

Before 2016, most double-crested cormorants in the estuary nested on East Sand Island and researchers were able to base predation rates for cormorants in the estuary as a whole on PIT-tag recoveries at that location. In 2016 and 2017, however, large numbers of cormorants dispersed to the Astoria–Megler Bridge and other locations in the estuary for much of the breeding season (MacDonald 2017). Estimates of smolt consumption calculated by the researchers for 2016 and 2017 must be considered minimum estimates because cormorants spent little time on the island during the peak smolt outmigration (Evans et al. 2018a). Thus, it is not possible to directly compare predation rates by cormorants in the estuary as a whole during 2016–17 (the colony management period) to those from prior years (Table C-2).

Table C-2. Average annual predation rates (with 95 percent credible intervals) by double-crested cormorants nesting on East Sand Island. Average predation rate estimates for 2016–17, following the start of management activities, were not available (NA) because cormorants dispersed from East Sand Island during the peak smolt outmigration. Source: Evans et al. (2018a).

Salmonid ESU/DPS	Pre-management Period 2013-2015	Management Period 2016-2017
SR sockeye salmon	3.6% (2.7-4.5)	NA
SR spr/sum Chinook salmon	5.2% (4.4-6.1)	NA
UCR spr Chinook salmon	3.1% (2.4-3.9)	NA
SR fall Chinook salmon	3.0% (2.6-3.6)	NA
UWR Chinook salmon	1.3% (0.5-1.8)	NA
SR steelhead	9.3% (8.0-11.0)	NA
UCR steelhead	5.1% (4.1-6.1)	NA
MCR steelhead	8.3% (6.8-10.1)	NA
LCR Chinook salmon	NA[1]	NA
LCR steelhead	NA	NA
LCR coho salmon	NA[2]	NA
CR chum salmon	NA	NA
UWR Chinook salmon	1.3% (0.5-1.8)	NA
UWR steelhead	NA	NA

[1] Lyons et al. (2014) estimated predation rates on select groups of LCR hatchery- and natural-origin Chinook salmon tagged during 2007–2010; rates averaged 22 percent and 8 percent, respectively. However, rates were generated with a different modeling framework and therefore are not directly comparable to the other estimates in this table.

[2] Lyons et al. (2014) estimated predation rates on select groups of LCR hatchery- and natural-origin coho salmon tagged during 2007–2010; rates averaged 30 percent and 10 percent, respectively. However, rates were generated with a different modeling framework and therefore are not directly comparable to the other estimates in this table.

Sebring et al. (2013) estimated predation rates on PIT-tagged subyearling hatchery Chinook salmon from the LCR Chinook salmon ESU during 2002–10. Based on PIT-tag recoveries from the East Sand Island colony, minimum predation rates by cormorants on hatchery smolts originating downstream of Bonneville Dam averaged 10 percent. Lyons et al. (2014) estimated an average predation rate of 26 percent on the LCR Chinook salmon ESU during

2007–10. Predation rates differed by rearing type, averaging 29 percent on hatchery-origin Chinook salmon and 11 percent on natural-origin Chinook salmon.

Sebring et al. (2012) estimated a 10 percent minimum predation rate on PIT-tagged hatchery-origin LCR coho salmon by cormorants nesting at East Sand Island in 2010. Lyons et al. (2014) estimated an average predation rate of 28 percent on the LCR coho salmon ESU by this colony during 2007–10, weighting estimates by the relative abundances of hatchery- and natural-origin fish originating upstream and downstream of Bonneville Dam. Predation rates differed by rearing type, averaging 30 percent on hatchery-origin and 10 percent on natural-origin coho salmon.

C.2.2.3 Summary—Impacts of Double-crested Cormorants in the Columbia River Estuary

The dispersal of double-crested cormorants from the East Sand Island colony in 2016–17 indicates that this species' response to natural factors—including frequent disturbances by bald eagles, which was often followed by gulls taking eggs and chicks—and habitat management activities on East Sand Island remains in flux. We expect that implementation of habitat modification in Phase II will ensure that this colony does not exceed the management plan objective of no more than 5,380-5,939 nesting pairs. Furthermore, attempts to reduce smolt predation are complicated by the growing number of birds nesting on the Astoria–Megler Bridge in recent years. The Corps' has no authority to haze cormorants on the bridge and these birds are relatively protected from eagle harassment and subsequent gull predation.

Methods to estimate predation rates based on PIT-tag recoveries cannot be used at sites such as bridges and aids to navigation where tags cannot be recovered below the nests. As a result, currently there is no basis for determining whether activities to manage the size of the nesting cormorant colony on East Sand Island have affected predation rates on salmon and steelhead. Double-crested cormorants (and gulls) nesting on Rice Island in 1997–98 consumed more salmonids than those on East Sand Island because their foraging range does not overlap or overlaps to a lesser degree with marine fishes such as herring, surfperch, and flounder in the lower estuary (Collis et al. 2002). Cormorants nesting on the Astoria-Megler Bridge, about midway between Rice and East Sand Islands, may still be able to take advantage of marine forage fish.

C.2.3 Summary—Effects of Avian Predator Colonies in the Columbia River Estuary

The nesting attempts by approximately 1,000 pairs of terns on Rice Island in 2017 indicate that this species' response to habitat reduction on East Sand Island is still in flux. The success of the management plan in reducing smolt predation is likely to depend on whether nesting densities remain low on East Sand Island and, if they do, whether birds move to areas outside the Columbia River basin rather than upstream to sites like Rice Island or the interior Columbia River plateau. The dispersal of cormorants from East Sand Island to other nesting sites in the estuary in 2016–17 indicates that this species' response to the combination of natural factors (eagle and gull predation) and Corps' management activities on East Sand Island is also in flux.

C.3 Effects of Avian Predator Colonies on the Interior Columbia Plateau

C.3.1 Management Activities at Inland Caspian Tern Colonies

Predation on salmonids by piscivorous waterbirds nesting in the Columbia basin upstream of Bonneville Dam (i.e., interior Columbia plateau) became a concern due to the establishment of colonies at Crescent Island in McNary Reservoir and on Goose Island in Potholes Reservoir. Roby et al. (2011) estimated total predation on salmonids at Crescent Island during 2004-09 of 330,000-500,000 smolts per year. Annual predation rates on UCR steelhead by terns nesting on Goose Island (Potholes Reservoir) averaged 15.7 percent during 2007–13 (Collis et al. 2018). As a result of these impacts, NMFS required the Corps and Reclamation to develop an Inland Avian Predation Management Plan (IAPMP) in RPA action 47.

The objective of the IAPMP is to reduce predation on ESA-listed salmonids by Caspian terns nesting at Goose and Crescent Islands while taking actions to prevent terns from forming new colonies and/or expanding existing colonies where feasible (USACE 2014). In general, the IAPMP aims to reduce predation on interior Columbia basin salmonids to less than 2 percent per listed ESU/DPS per tern colony per year. Actions were structured to occur in two phases. The primary management goal during the first phase was to fully dissuade terns from nesting on Goose Island with a long term goal of reducing the colony to less than approximately 40 breeding pairs (estimated to meet the <2 percent predation rate objective). During 2014, the first year of implementation, The Corps set up passive dissuasion (ropes and flagging) and conducted active hazing, although 156 pairs nested on a nearby islet called Northwest Rocks (Roby et al. 2015). Terns also tried to nest at four other previously used colony sites in 2014 (Crescent Island in McNary Reservoir, the Blalock Islands in John Day Reservoir, Twinning Island in Banks Lake, and Harper Island in Sprague Lake) and one new location, a small island in Lenore Lake. Of these sites, only the tern colonies at Crescent Island and the Blalock Islands succeeded in raising young. The Caspian tern colony on Crescent Island was the largest in the interior Columbia plateau region in 2014 (474 breeding pairs).

The second phase of the IAPMP called for development of suitable alternative Caspian tern nesting habitat in areas where predation on ESA-listed species would be lower and then dissuading terns from Crescent Island. Similar to efforts on Goose Island, the short-term goal was to dissuade terns from nesting with a long-term goal of less than about 40 nesting pairs (to achieve the <2 percent predation rate objective) (USACE 2014). The Corps identified a potential site at Don Edwards San Francisco Bay National Wildlife Refuge during site exploration efforts and modified this area for tern nesting during Phase 2 (winter 2014-15). The Action Agencies therefore were able to begin dissuading terns from nesting on Crescent Island during the 2015 breeding season. Passive dissuasion and hazing successfully prevented any nesting on Crescent Island and most nesting at Goose Island. However, the number of terns at the Blalock Islands was ten times higher in 2015 than the year before and resightings of colored leg-bands indicated that large numbers had moved there from Crescent Island (and many of these same terns nested at the Blalock Islands again in 2016). Terns also came to the interior plateau from East Sand Island in the estuary, and from additional Corps'-constructed colony sites in southeastern Oregon and northeastern California in 2015 when those areas experienced severe drought.

Terns displaced from Crescent Island continued to relocate to the unmanaged colony sites at the Blalock Islands and to a limited degree (i.e., below the approximate 40 pairs per colony threshold) at Badger Island in 2017 (Collis et al. 2018). Overall, the numbers of pairs of Caspian terns at each breeding colony in the interior Columbia plateau region during 2017 represented a 19 percent decline compared to the pre-management period (Figure C-1).

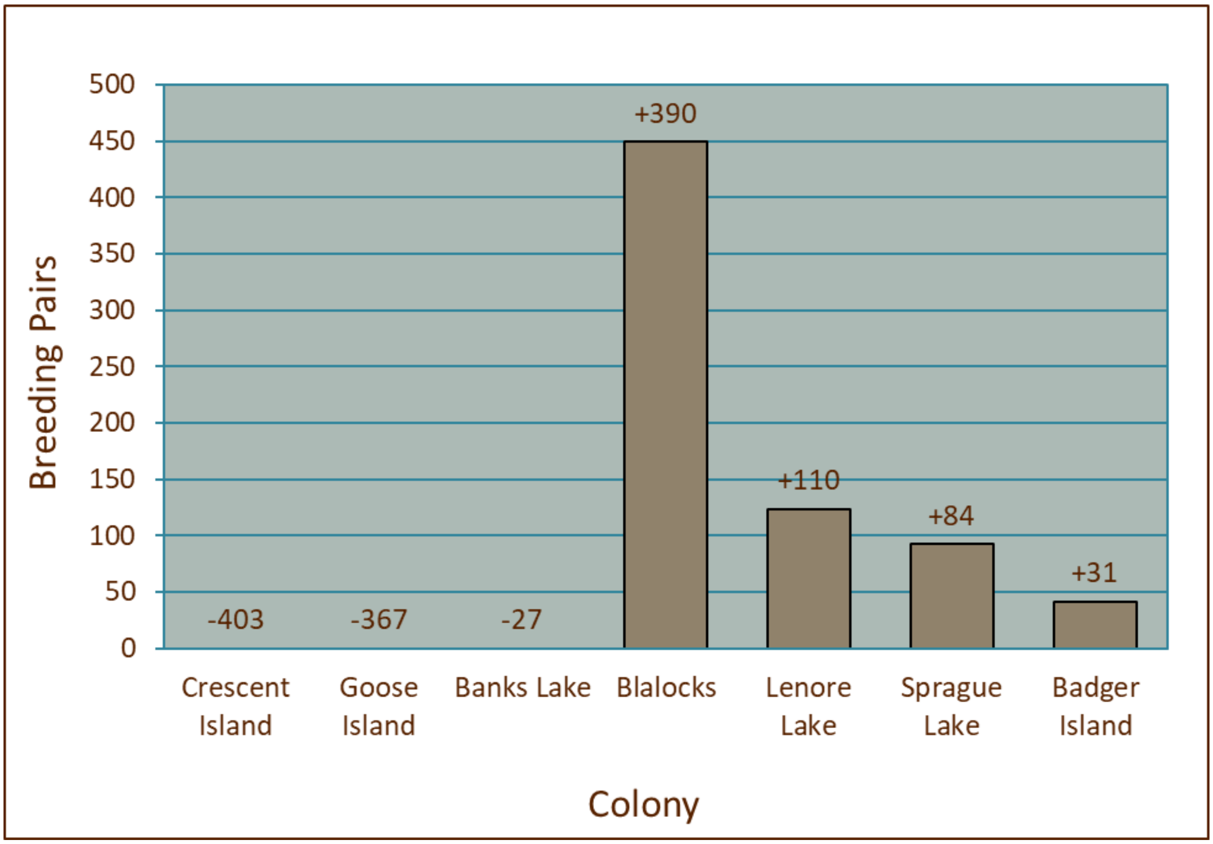

Figure C-1. Sizes of Caspian tern nesting colonies (numbers of breeding pairs) in the interior Columbia plateau region during the 2017 breeding season. The number over each bar indicates the change in colony size in 2017 compared to the average colony size before tern management (2005–13). Source: Collis et al. (2018).

C.3.2 Salmonid Predation Rates at Interior Columbia Plateau Tern Colonies

In 2017, the goal of the IAPMP to reduce ESU/DPS-specific predation rates to less than 2 percent was achieved by dissuading Caspian tern nesting at Goose and Crescent Islands (at Goose Island for the second consecutive year and at Crescent Island for the third year; Collis et al. 2018). As a result, the Caspian tern predation rate on UCR steelhead has declined from <1.0–15.7 percent across the plateau during the pre-management period to <1.0–5.3 percent (Table C-3). However, predation rates on other ESA-listed salmonids (especially SR sockeye salmon and SRB steelhead) by terns on the Blalock Islands have been significantly higher since colony management began at Goose and Crescent Islands.

Table C-3. Average annual predation rates by Caspian terns nesting at colonies in the interior Columbia plateau region on Snake River (SR) and Upper Columbia River (UCR) salmonids. Management actions were implemented on Goose Island in Potholes Reservoir during 2014–17, on an unnamed island in northeastern Pothole Reservoir in 2017, and on Crescent Island during 2015–17. No management actions have been conducted at Caspian tern colonies on Twinning Island (data first available in 2009), Blalock Islands, Lenore Lake (data first available in 2015), and Badger Island (data first available in 2017). The years 2007–13 and 2014–17 represent the pre-management and management periods, respectively. Source: Collis et al. (2018)

ESU/DPS	Goose Is. Potholes Res.		N. Potholes Potholes Res.		Crescent Is. McNary Res.		Twinning Is. Banks L.		Badger Is. McNary Res.	Blalock Is. John Day Res.		Lenore Lake
	’07-‘14	’14-‘17	2016	2017	’07-‘14	’15-‘17	’09-‘14	’15-‘17	2017	’07-‘14	’15-‘17	’15-‘17
SR sockeye	0.1%	< 0.1%	< 0.1%	< 0.1%	1.1%	< 0.1%	< 0.1%	< 0.1%	NA	0.3%	3.9%	< 0.1%
SR sp/su Chinook	< 0.1%	< 0.1%	< 0.1%	< 0.1%	0.7%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	0.1%	0.9%	< 0.1%
UCR spr Chinook	2.5%	0.1%	0.1%	< 0.1%	0.5%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	0.8%	< 0.1%
SR fall Chinook	< 0.1%	< 0.1%	< 0.1%	< 0.1%	0.8%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	0.6%	< 0.1%
SR steelhead	< 0.1%	< 0.1%	< 0.1%	< 0.1%	3.9%	< 0.1%	< 0.1%	< 0.1%	0.4%	0.6%	5.2%	< 0.1%
UCR steelhead	15.7%	0.7%	4.1%	< 0.1%	2.4%	< 0.1%	0.3%	0.9%	0.5%	0.6%	5.3%	0.3%

C.3.3 Gull Colonies on the Interior Columbia Plateau

When the IAPMP was developed, estimates of salmonid predation by gulls nesting in the interior Columbia plateau region did not exceed 2 percent per listed ESU/DPS per colony per year (Table C-4). The largest impact by California and ring-billed gulls (*Larus californicus* and *L. delawarensis*, respectively) was from the colony nesting at Miller Rocks, a group of rock outcroppings and small islands in The Dalles Reservoir. The Corps concluded that, in comparison to Caspian terns nesting at Goose and Crescent Islands, the benefits to ESA-listed salmonids through reductions in predation by avian predators, such as gulls nesting on Miller Rocks, would be substantially lower (Lyons et al. 2011).

Table C-4. Average annual predation rates on ESA-listed Snake River (SR) and Upper Columbia River (UCR) salmonids by California and ring-billed gulls at Miller Rocks, The Dalles Reservoir, 2007–10, adjusted to account for the fraction of each salmonid species transported around the interior Columbia plateau waterbird colonies as part of the Corps' juvenile salmonid transportation program. Sources: Lyons et al. (2011); USACE (2014)

Chinook			Sockeye	Steelhead	
SR spr/sum	SR fall	UCR spr	SR	SR	UCR
0.3%	0.3%	0.4%	0.6%	1.2%	1.6%

While implementing the IAPMP, the Corps' made an effort to prevent nesting by California and ring-billed gulls on Goose and Crescent Islands. This decision was based on the theory that gulls attract prospecting Caspian terns and, thus, could limit the efficacy of efforts to dissuade terns from nesting (USACE 2014; Roby et al. 2016). The effort was partially successful with gulls dispersing from Crescent Island to add to numbers at the colonies on Miller Rocks, Island 20 (McNary Reservoir), and the Blalock Islands in 2015 (The gull colony on Goose Island has remained relatively stable in recent years) (Collis et al. 2018). Gull predation rates, like those of terns, were generally higher for juvenile steelhead than for salmon (Table C-5).[19]

Table C-5. Average annual predation rates on PIT-tagged Snake River (SR) and Upper Columbia River (UCR) salmonids by gulls nesting at Island 20 and Badger Island (McNary Reservoir), the Blalock Islands (John Day Reservoir), and Miller Rocks (The Dalles Reservoir) in 2015–16. Predation rates were adjusted to account for tag loss due to on-colony detection efficiencies and deposition rates. Source: Roby et al. (2016, 2017).

ESU/DPS	Island 20		Badger Island		Blalock Islands[2]		Miller Rocks	
	2015	2016	2015	2016	2015	2016	2015	2016
SR fall Chinook	0.3%	<0.1%	0.3%	<0.1%	0.7%	0.4%	2.6%	1.0%
SR spr/sum Chinook	0.5%	0.2%	0.1%	0.2%	0.2%	0.1%	1.7%	1.2%
SR steelhead	3.6%	1.2%	3.1%	1.1%	2.6%	3.5%	9.7%	6.7%
SR sockeye	NA[1]	0.9%	NA	1.2%	1.3%	3.4%	7.4%	6.4%
UCR spr Chinook	0.6%	0.2%	0.5%	0.9%	0.6%	0.1%	3.5%	2.5%
UCR steelhead	7.9%	5.7%	4.1%	3.8%	6.7%	6.2%	13.2%	10.1%

[19] Due to improvements in estimation methods, the predation rates in Table C-5 are somewhat more accurate than those in Table C-4.

The following predation rates exceeded 2 percent per listed ESU/DPS per gull colony per year:

- Island 20 and Badger Island – SR steelhead and UCR steelhead (2015 and 2016);
- Blalock Islands – SR steelhead and UCR steelhead (2015 and 2016), and SR sockeye salmon (2016); and
- Miller Rocks – SR steelhead and sockeye salmon, UCR steelhead and spring Chinook salmon (2015 and 2016), and SR fall Chinook salmon (2015).

Consumption rates by gulls from colonies in the interior Columbia plateau region during 2015 were significantly higher than those observed at the same colonies in previous years, with a roughly two- to five-fold increase observed in some cases (Roby et al. 2016). Consumption rates for gulls nesting on Miller Rocks were the highest of any bird colony evaluated by Roby et al. (2017) in 2016.

Further research is needed to understand whether gulls disproportionately consume weak or compromised smolts, especially near dams, or prey on fish from the general outmigrant population. In either case, smolt predation rates at certain gull colonies were comparable to, or higher than, those associated with other colonies, for example, the Caspian tern colony on Blalock Islands in 2015–16, and have continued to be some of the highest predation rates associated with any piscivorous waterbird colony in the interior Columbia Plateau region since multi-predator species studies were initiated in 2007. Management of gull predation is not addressed in the current avian predation management plans for the Columbia plateau or the estuary.

C.3.4 Summary—Impacts of Avian Predator Colonies on the Interior Columbia Plateau

As discussed in Collis et al. (2018), management actions to eliminate breeding colonies of Caspian terns on Goose Island in Potholes Reservoir and on Crescent Island in McNary Reservoir—formerly the largest breeding colonies for the species in the interior Columbia plateau region—were successful in 2017. As a result, predation on juvenile salmonids by Caspian terns nesting at these two colony sites was effectively eliminated. Overall, numbers of breeding Caspian terns on the interior Columbia plateau have decreased by 19 percent from pre-management levels due to the management of colonies on Goose and Crescent Islands through 2017. However, based on resightings of banded Caspian terns in previous years, most terns that were displaced from Goose and Crescent Islands have remained in the region and many have tried to nest at unmanaged colony sites. Most notable has been the post-management increase in the size of the formerly small breeding colony in the Blalock Islands. Caspian terns nesting in the Blalock Islands during 2015–17 consumed sufficient numbers of juvenile salmonids to at least partially off-set reductions in smolt consumption due to tern management at Goose and Crescent Islands. Based on results during the first four years of implementation of the IAPMP, the over-all goal of the management plan to reduce predation rates to less than 2 percent per tern colony on ESA-listed ESU/DPS per year will not be fully realized until alternative nesting habitat is further reduced at the currently unmanaged colony sites, especially in the Blalock Islands.

In addition, smolt predation rates by gulls 2015–16 exceeded that at tern colonies on the interior Columbia plateau, at least in the case of SR and UCR steelhead (Table C-5). Reductions in gull predation rates at the colony level were considered not warranted when the IAPMP was developed and there are no regional plans to manage these colonies at this time.

C.4 Is Caspian Tern or Double-crested Cormorant Predation Additive or Compensatory?

An unstated assumption in many predator control programs is that reducing predation during a specific time window increases the survival of prey over a much longer time horizon. In the current context, this would suggest that decreasing predation of smolts not eaten by Caspian terns or double-crested cormorants during outmigration should increase the overall probability of smolts surviving to adulthood. If so, avian predation would be considered an "additive" source of mortality. Alternatively, if decreasing predation by birds did not increase the survival of smolts to adulthood because smolts ultimately succumbed to other sources of mortality such as fish predators, disease, or starvation, then avian predation would be considered a "compensatory" source of mortality.

The completely additive and completely compensatory hypotheses are illustrated in the left and right panels, respectively, of Figure C-2 (adapted by Evans et al. 2018b from Anderson and Burnham 1976 and Sandercock et al. 2011). The first graph shows the idealized slope of an additive relationship between survival and predation rate (slope = -1). If tern and/or cormorant predation is a completely additive source of mortality for Columbia Basin salmonids, smolt survival will decrease linearly as tern or cormorant predation increases. If, however, tern and/or cormorant predation is completely compensatory, then smolt survival would remain constant as predation by terns or cormorants increases up to a critical threshold, above which smolt survival would decline.

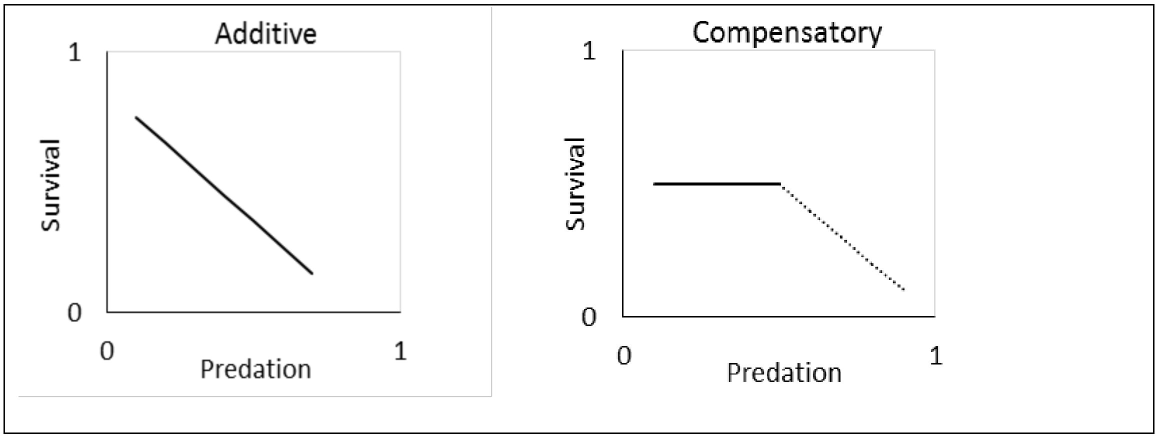

Figure C-2. Graphical representation of the completely additive and compensatory hypotheses for the effects of avian predation on the survival of salmonid populations to adulthood, adapted by Evans et al. (2018b) from Anderson and Burnham (1976) and Sandercock et al. (2011).

In recent years, researchers in the Columbia basin have asked if tern or cormorant predation is additive to natural mortality, or can be compensated for to some degree. If the latter, reducing predation rates by hazing or culling birds or reducing colony sizes may not translate into a corresponding increase in the rate of survival to adulthood. There is evidence that, at least for steelhead, fish condition, size, and rearing history may affect the vulnerability of fish to avian predation (Hostetter et al. 2012) and it is likely that predation losses to avian predators is compensated somewhat due to these vulnerabilities. NMFS could use information on degree of compensation to assess whether the Action Agencies' avian predator control programs are affecting the number of returning adults, but the magnitude of compensation associated with avian predation on juvenile salmonids in the Columbia Basin is not well understood. In the following sections, we review preliminary modeling studies by Haeseker (2015) and Evans et al. (2018b) to describe these relationships.

C.4.1 Discriminant Function Test of Compensation vs. Additivity

Haeseker (2015) postulated that cormorant-induced mortality on steelhead was compensated for through reductions in other sources of mortality later in the life cycle. Haeseker (2015) therefore conducted a discriminant function test of compensation versus additivity by adapting a model by Anderson and Burnham (1976), which was further refined in Burnham and Anderson (1984) and Burnham et al. (1984).

Haeseker (2015) used data for SRB steelhead because Lyons et al. (2014) reported that estimates of predation mortality by double-crested cormorants were highest for this DPS. He identified three groups of PIT-tagged steelhead that were detected over two-week intervals at either Lower Granite or Bonneville Dam during 1998-2009[20]:

- Fish that were tagged or collected at Lower Granite Dam and subsequently transported to below Bonneville Dam,
- Fish that were tagged or collected at Lower Granite Dam and subsequently bypassed to continue their in-river migration, and
- Fish that were detected passing Bonneville Dam.

The number of juveniles in each group or "cohort" was compared to the number of subsequent recoveries of their PIT tags from the double-crested cormorant colony on the East Sand Island. Recoveries included fish that were detected in the year of migration, as well as those detected in subsequent years. Tag-recovery rate was calculated as the cumulative number of PIT tags detected on the cormorant colony divided by the starting number of PIT-tagged juveniles for each cohort and data set. As described above, if cormorant predation is a compensatory source of mortality, there should be no association between smolt-to-adult return rates (SARs) and the smolt consumption rate (i.e., a slope equal to zero).

Haeseker (2015) applied this modeling framework to the smolt and adult return data for SR steelhead described above and found that the hypothesis that cormorants were an additive source of mortality was rejected using all three data sets. After incorporating cormorant consumption rates into a multivariate regression model, described by Hall and Marmorek (2013), Haeseker found that cormorant consumption rates were not a significant factor that explained variability in steelhead SARs. He hypothesized that shifts in predation impacts among different species of predators limited or eliminated the benefits achieved through reducing the population of a single species (e.g., double-crested cormorants). That is, if there were fewer cormorants in the estuary eating fewer smolts, other predators, presumably in the ocean, made up the difference.

[20] The use of Lower Granite Dam as the starting point allowed for higher sample sizes than were available at Bonneville Dam, and separately analyzing transported versus in-river migrants provided the opportunity to evaluate whether there were differences in the level of compensation between the two groups (Haeseker 2015).

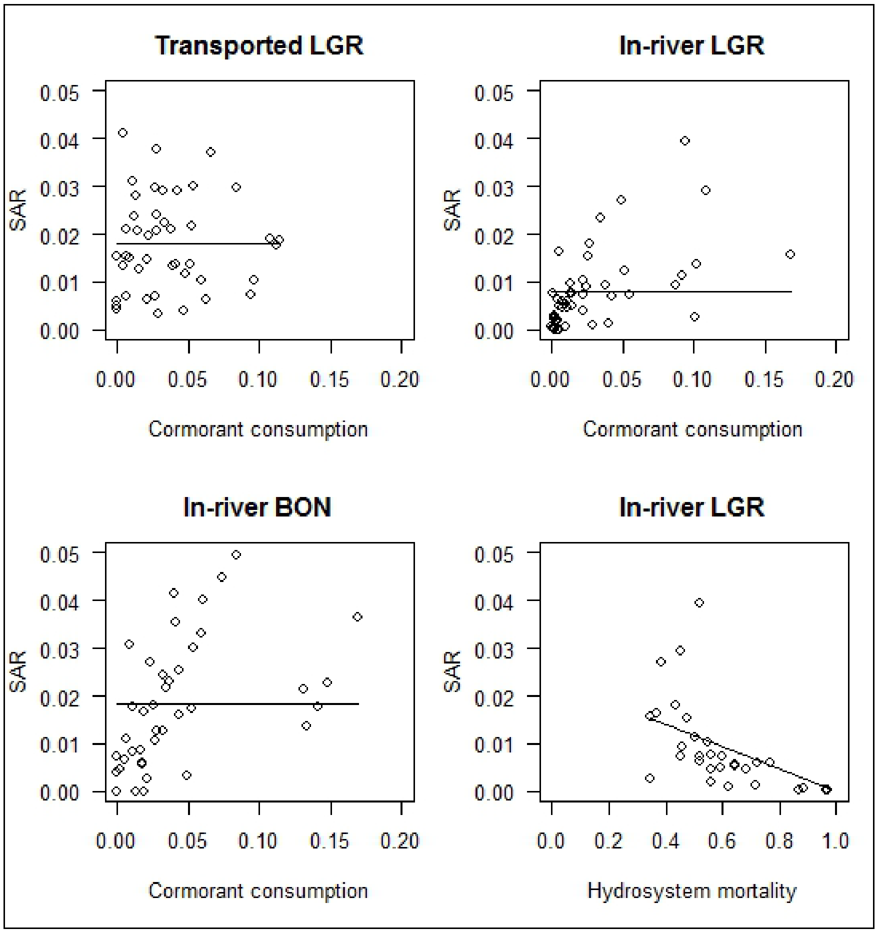

Figure C-3. Associations between the smolt-to-adult return rates (SARs) and cormorant consumption rates along with the association between SARs and hydrosystem mortality rates for hatchery and wild Snake River steelhead that were transported from Lower Granite Dam (LGR) to below Bonneville Dam (BON) versus in-river migrants, 1998–2009. The lines represent the predicted SAR using the structural model and maximum likelihood estimates of S_0 and *b*. Source: Haeseker (2015).

Haeseker's (2015) analysis was reviewed by fisheries biologists and biostatisticians at NMFS' Northwest Fisheries Science Center (Scheuerell et al. 2016). The reviewers stated that the appropriate spatial and temporal scales at which to estimate survival and mortality are key to using the model described by Burnham and Anderson (1984). For mallards, the temporal scale was one year, from the start of a hunting season until the same date the following year. For the cormorant–steelhead situation, the definition is complicated by the substitution of SARs for a given smolt migration year. Smolt-to-adult survival is an integrated measure of survival over several years that includes large spatial and temporal domains (i.e., the ocean) outside the influence of East Sand Island cormorants.[21]

[21] Petrosky and Schaller (2010) and Myers (2018) describe evidence of a strong effect of highly variable ocean conditions on adult returns for steelhead.

Scheuerell et al. (2016) also noted that instead of estimating all the survival and detection probabilities from the three data sets plus the kill rates by cormorants within the same model, as shown by Burnham and Anderson (1984), Haeseker (2015) did it "in a piecemeal fashion." This method did not adequately account for all sources of variance as the analysis progressed through its stages. Thus, due to the nature of the sampling and its associated error, the true correlation between the two sources of mortality (due to cormorants and due to all other factors) was biased toward -1. Scheuerell et al. (2016) cite an example of this bias in a paper by Schaub and Lebreton (2004), where the apparent correlation between juvenile storks killed by power lines and the natural mortality rate appears to be nearly -1, but that rate drops to -0.4 after properly accounting for the variances.

Haeseker (2015) tested a fourth data set that was limited to cohorts of outmigrating steelhead smolts with in-river survival estimates from Lower Granite Dam to Bonneville Dam ($S_{LGR\text{-}BON}$). These data were used to evaluate the degree to which mortality experienced during passage through the hydrosystem ($1 - S_{LGR\text{-}BON}$) was compensatory or additive. In contrast to the effects of variable cormorant consumption rates, Haeseker's analysis of the effects of hydrosystem mortality on SARs found that mortality during hydrosystem passage was additive. As a result, he concluded that reducing mortality in the hydrosystem reach was likely to increase adult abundance and productivity.

In their review of this portion of Haeseker's analysis, Scheuerell et al. (2016) noted a potential inconsistency with the principles stated in Anderson and Burnham (1976) and recognized in Haeseker (2015). Specifically, in the Columbia Basin context, the methods are valid when the smolt mortality rate due to hydrosystem passage is below the level where the steelhead populations are no longer resilient and able to compensate for increased levels of mortality. Beyond this level, increasing hydrosystem mortality is expected to reduce SARs. Because most of the hydrosystem mortality rates in Haeseker's analysis were greater than 50 percent, Scheuerell et al. (2016) thought that his assumption that the smolt consumption rate was less than this critical threshold required some justification. At this point in time, Haeseker has not responded to the critique or questions in the Scheuerell et al. paper.

C.4.2 Joint Mortality and Survival Model

Using a Joint Mortality and Survival Model developed by Hostetter et al. (2018) and Evans et al. (2018b) are investigating the degree to which avian predation limits smolt survival to Bonneville Dam compared to other types of mortality such as hydrosystem passage, predation by piscivorous fish, or disease. They are also studying the relationship between avian predation and SARs. The study has entailed tagging over 71,000 UCR steelhead smolts with PIT tags during 2008–17 and releasing them in the tailrace of Rock Island Dam (RM 453). Mortality due to avian predation was estimated from PIT tags recovered at 14 colonies: Banks Lake Island (Caspian terns); Lenore Lake Island (Caspian terns); Potholes Reservoir (Caspian terns); Island 20 (gulls); Foundation Island (double-crested cormorants); Badger Island (Caspian terns, gulls); Crescent Island (Caspian terns, gulls); Blalock Islands (Caspian terns, gulls); Miller Rocks Island (gulls); and East Sand Island (Caspian terns, double-crested cormorants). Smolt survival was estimated from detections at mainstem dams and adult returns from detections in the Bonneville Dam ladders.

Comparisons of cumulative total mortality and mortality due to avian predation indicated that predation from colonial waterbirds was associated with much of the mortality in UCR steelhead smolts between Rock Island and Bonneville Dams during the 2008–17 period. In Figure C-4, cumulative predation rates accounted for 47–69 percent of all mortality per year; smolt losses from the colonies were greater than those associated with all other types of mortality combined in nine of the ten years of study.

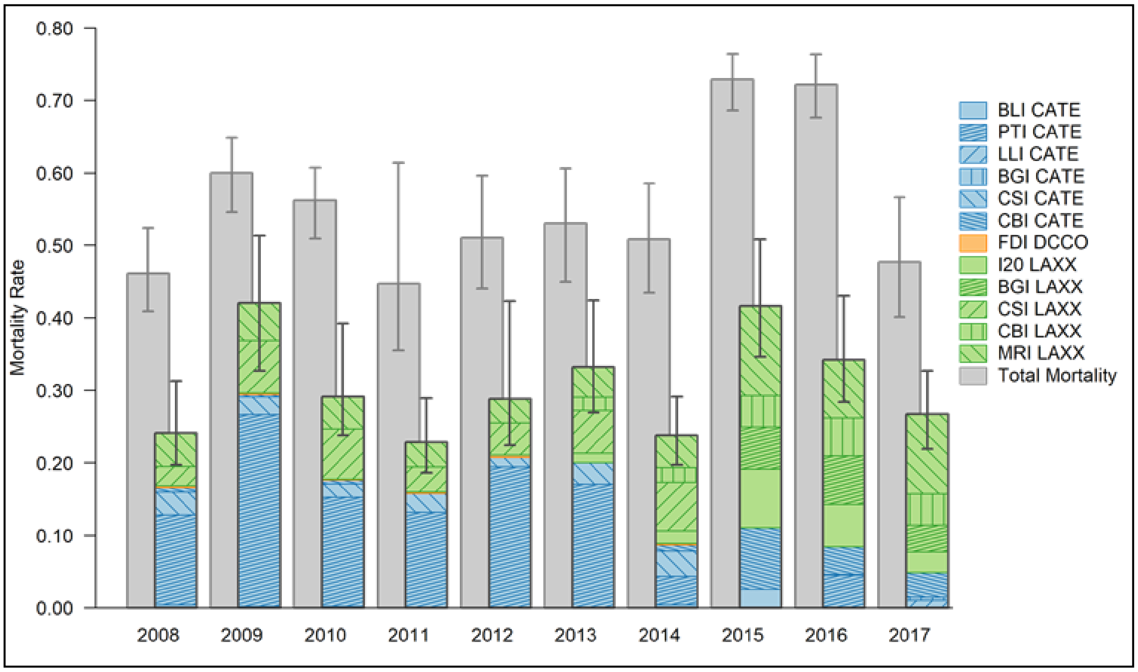

Figure C-4. Estimated cumulative total mortality (1-survival) and mortality due to avian predation by colonial waterbirds on Upper Columbia River (UCR) steelhead smolts during passage from Rock Island Dam to Bonneville Dam. Error bars represent 95% credible intervals. Not all double-crested cormorant (DCCO) and California and ring-billed gull (LAXX) colonies were scanned for UCR steelhead smolt PIT tags in all years, so cumulative predation estimates were minimum estimates in some years. Source: Evans et al. (2018b).

Evans et al. (2018b) report a strong negative relationship between cumulative Caspian tern predation rates on UCR steelhead and steelhead survival rates in the hydrosystem reach from Rock Island to Bonneville Dam in all years of study (Figure C-5). They estimated that in the hypothetical absence of Caspian tern predation, the survival of UCR steelhead smolts would have been 8–32 percentage points higher.

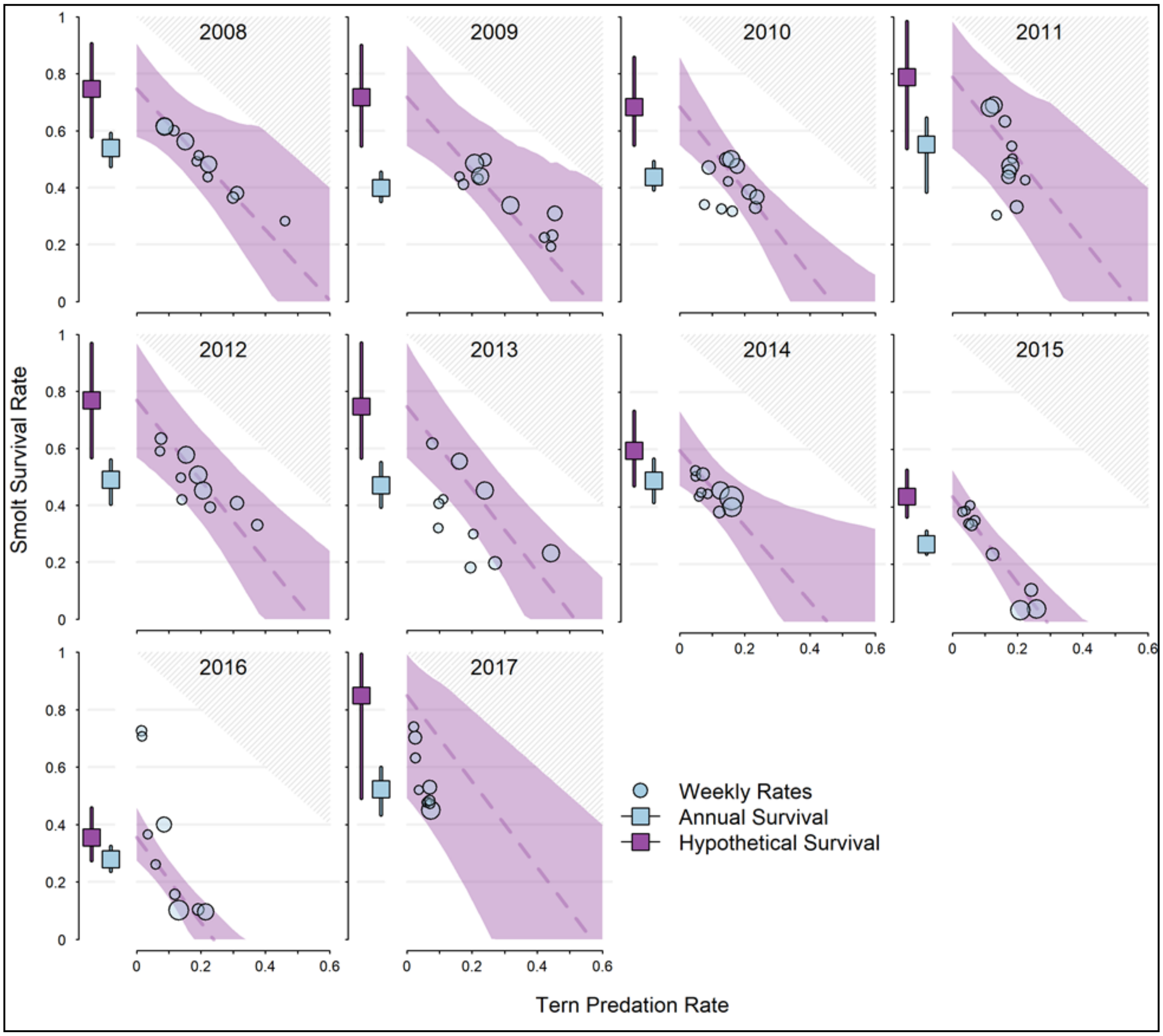

Figure C-5. Estimated relationship between Upper Columbia River (UCR) steelhead smolt survival rates and Caspian tern predation rates during out-migration from Rock Island Dam to Bonneville Dam. The relative size of the blue circles depicts differences in the number of tagged UCR steelhead smolts released each week in the tailrace of Rock Island Dam. Dashed lines represent the best fit estimate and shading denotes 95% credible intervals (CRI) around the best fit. Box-and-whisker plots show annual estimates of smolt survival rate in the presence of tern predation (blue) and in the hypothetical absence of tern predation (purple) (bars show 95% CRIs). Source: Evans et al. (2018b).

In all years with complete adult returns, (2008–14), Evans et al. (2018b) also found a strong negative relationship between cumulative Caspian tern predation rates and SARs to Bonneville Dam, with greater weekly rates of tern predation associated with significantly lower SARs (Figure C-6). In the hypothetical absence of Caspian tern predation on UCR steelhead smolts, annual SARs would have been 1–5 percentage points higher, equivalent to a 100–267 percent increase.

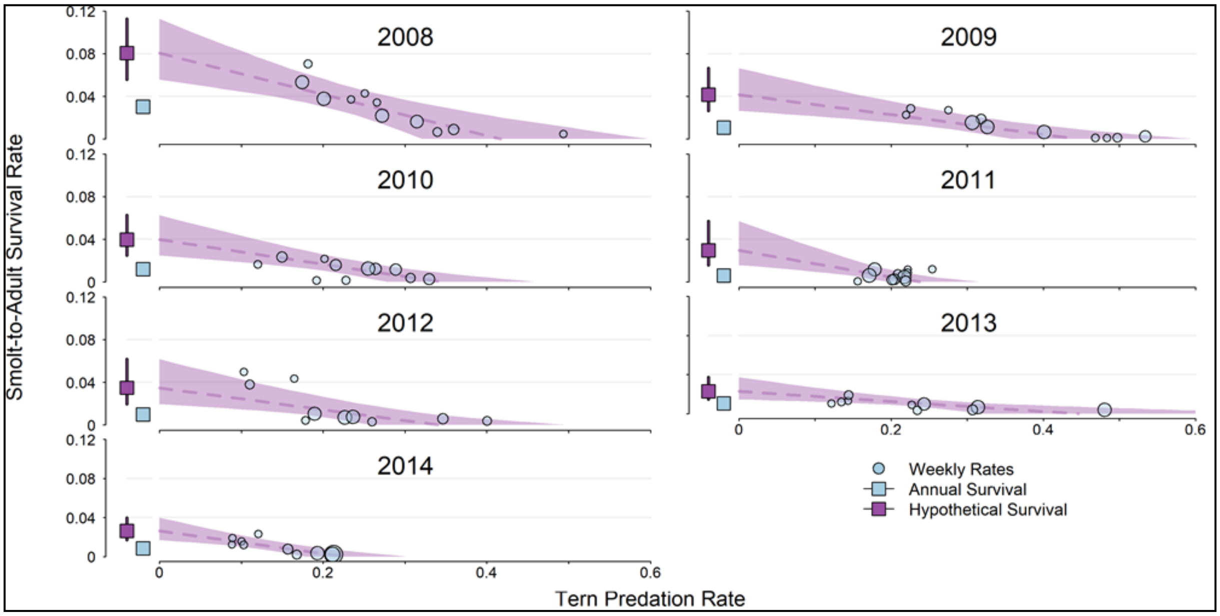

Figure C-6. Estimated relationship between smolt-to-adult survival for Upper Columbia River (UCR) steelhead from Rock Island Dam (as out-migrating smolts) to Bonneville Dam (as returning adults) and Caspian tern predation rates on out-migrating smolts. The relative size of the blue circles depicts differences in the number of tagged UCR steelhead smolts released each week in the tailrace of Rock Island Dam. Dashed lines represent the best fit estimates and shading denotes the 95% credible intervals (CRI) around the best fit. Box-and-whisker plots show annual estimates of SARs in the presence of tern predation (blue) and in the hypothetical absence of tern predation (purple) (bars show 95% CRIs). Source: Evans et al. (2018b).

The slopes of the lines in Figure C-5 indicate that tern predation is likely to be an additive source of mortality within the hydrosystem reach (between Rock Island and Bonneville Dams) because the relationship is strongly negative as predation rate increases. However, although still negative, the lines in Figure C-6 are shallower, indicating that compensatory mechanisms become active in the Bonneville-to-Bonneville portion of the life cycle. This indicates that, in terms of influencing adult steelhead returns, tern predation is partially additive (or compensatory) and efforts to limit predation rates are partially improving adult returns. Evans et al. (2018b) plan to submit a more detailed and comprehensive report to Grant County Public Utility District, the Priest Rapids Coordinating Committee, and other interested parties in the spring of 2019. NMFS expects to review the full report at that time.

C.4.3 Compensatory versus Additive Mortality in the 2008/2010/2014 FCRPS Biological Opinions and 2019 CRS Biological Opinion

The RPA developed for the 2008 FCRPS biological opinion and its 2010 and 2014 supplements employed multiple measures to improve the survival of ESA-listed salmonids. This included efforts to improve hydrosystem structures and operations, tributary and estuary habitat quality, and hatchery practices, and reduce avian, fish, and pinniped predation. NMFS did not quantitatively assume any compensatory mortality in assessing the benefits of predation management as applied to Caspian terns in the 2008 FCRPS biological opinion and stated there was no clear indication that the case would be different, or substantial, for predation by double-crested cormorants in the 2014 FCRPS biological opinion.

As described above, since the 2008 FCRPS biological opinion, researchers have developed preliminary estimates of the degree to which avian predation may be compensatory. Their approaches vary widely and require further refinement and peer review before they can be incorporated into the the life cycle models we use in this 2019 biological opinion for SR spring/summer Chinook and UCR spring Chinook salmon. However, any losses due to terns and cormorants (or other predators), including any compensatory effects, are captured in the historical time series of SARs. The Action Agencies propose to continue implementing the avian predation management plans described in sections C.2 and C.3, maintaining the reduced amounts of nesting habitat achieved for terns and cormorants on East Sand Island and continuing to dissuade terns from nesting on Goose and Crescent Islands on the interior Columbia plateau (BPA et al. 2018). Thus, we expect that any reduced avian predation rates achieved under the 2008 FCRPS biological opinion and associated RPA will continue during the interim period. Although work remains, we expect that at least some of the predation that is occurring is additive and contributes to increased SARs.

C.5 Summary—Avian Predation Management in the Columbia Basin

The success of implementing the current management plans in improving the survival of juvenile salmonids by managing the size of avian predator colonies is uncertain at this time. This is because, although numbers of Caspian terns and double-crested cormorants have been reduced at the targeted colonies, many birds appear to have moved to nearby locations rather than leaving the Columbia Basin. Caspian terns and double-crested cormorants could continue to occupy the remaining colony sites at the same or lower numbers over the next few years, or colony sizes and locations could remain in flux so that even direct effects on smolt survival remain uncertain. If the latter is observed, the interagency Caspian tern and double-crested cormorant adaptive management teams could consider additional management actions. The proposed Avian Predation Synthesis Report will help the adaptive management teams assess whether to recommend that the Action Agencies or other regional parties consider additional measures in the future to further reduce predation pressure. Some types of potential actions by the Corps could require that Congress provide an explicit authority and/or authorization. These types of activities might not be ready for implementation during the interim period, but could be considered as part of a longer-term plan to contribute to the viability of listed salmon and steelhead.

As discussed in Section C.4.3, an important question in evaluating the success of these programs is whether avian predation is an additive or compensatory source of mortality. Most importantly, do reductions in smolt predation rates by Caspian terns or double-crested cormorants result in higher adult returns because avian predation adds to the other sources of smolt mortality, or are the smolts eaten by birds destined to die before returning as adults regardless of the level of predation? The latter case could occur because avian predation could be compensated for by sources of mortality in the ocean phase of the life cycle so that adult returns are unchanged. Haeseker (2015) and Evans et al. (2018b) have begun modeling the degree to which double-crested cormorant and Caspian tern predation, respectively, are additive versus compensatory sources of mortality. Given the magnitude of bird predation on smolts observed in the Columbia Basin, it is likely that some of the smolts consumed by birds could otherwise have survived to adulthood. Therefore, even if avian predation is partially compensatory, we expect that current and potential future efforts to limit the size of these tern and cormorant colonies will contribute to increased SARs for the listed ESUs/DPSs.

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