State of Washington DEPARTMENT OF FISH AND WILDLIFE
Mailing Address: 600 Capitol Way N • Olympia, WA 98501-1091 • (360) 902-2200, TDD (360) 902-2207
Main Office Location: Natural Resources Building • 1111 Washington Street SE • Olympia, WA

Scott Rumsey, Ph.D. 12/1/2022
Acting Regional Administrator, West Coast Region
National Marine Fisheries Service
1201 Northeast Lloyd Boulevard, Suite 1100
Portland, OR 97232

RE: MMPA §120(f) Sea Lion Management Annual Report for the period of July 1, 2021, through June 30, 2022.

Dear Dr. Rumsey:

The following information comprises the 2022 annual report to the National Marine Fisheries Service from the eligible management entities regarding Marine Mammal Protection Act (MMPA) §120(f) management and monitoring activities of sea lions in the Columbia River Basin. This report documents compliance with the Terms and Conditions of our 2020 Authorization for lethal removal of predatory California sea lions (CSLs) and Steller sea lions (SSLs) in the mainstem of the Columbia River between river mile 112 and river mile 292, or in any tributary (below river mile 292) to the Columbia River that includes spawning habitat of threatened or endangered salmon or steelhead. The current Authorization was granted to 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, the Confederated Tribes of the Grand Ronde Community, and the Confederated Tribes of the Siletz Indians of Oregon (with Eligible Entities having the option to delegate authority to the Columbia River Inter-Tribal Fish Commission) on August 14, 2020 and is valid until August 14, 2025 unless renewed or revoked.

The following are the Terms and Conditions from the 2020 Authorization:

1) Authorization

This permit authorizes the Eligible Entities, as defined below, consistent with the terms and conditions set forth herein, to lethally remove sea lions that are located in the mainstem of the Columbia River between river mile 112 and river mile 292, or in any tributary (below river mile 292) to the Columbia River that includes spawning habitat of threatened or endangered salmon or steelhead.

2) Permit Duration

This permit is valid beginning **August 14, 2020, through August 14, 2025,** unless renewed or revoked.

3) Eligible Entities

a) For removal of sea lions located in the mainstem Columbia River, from river mile 112 to river mile 292, and its tributaries in the state of Washington and in the state of Oregon above Bonneville Dam, the Eligible Entities are: the state of Washington; the state of Oregon; the State of Idaho; the Nez Perce Tribe; the Confederated Tribes of the Umatilla Indian Reservation; the Confederated Tribes of the Warm Springs Reservation of Oregon; and the Confederated Tribes and Bands of the Yakima Nation.

b) For removal of sea lions located in the Willamette River and other tributaries of the Columbia River within the state of Oregon below Bonneville Dam, the Eligible Entity is a Committee composed of Oregon Department of Fish and Wildlife, the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes of the Warm Springs Reservation of Oregon, the Confederated Tribes of the Grand Ronde Community, and the Confederated Tribes of the Siletz Indians of Oregon.

4) Delegation of Authority

The Eligible Entities described in paragraph 3(a) above may delegate their removal authority to the Columbia River Inter-Tribal Fish Commission. In order to delegate their authority, the Eligible Entities must submit a request to NMFS in writing, and NMFS will respond in writing either approving or denying the request.

5) Limit on Removals

a) The Eligible Entities shall not remove (i.e., place in permanent captivity or kill) more than **540 California sea lions** and not more than **176 Steller sea lions** over the 5-year period of this permit.

b) The number of sea lions removed under this permit, combined with the number of sea lions removed under any other permits issued by NMFS under MMPA section 120(f), may not exceed 10 percent of the potential biological removal (PBR) levels for either the CSL or SSL stocks. If at any time NMFS determines that removals under this permit may result in cumulative removals in excess of 10 percent of PBR, NMFS shall reduce the allowable number of removals under this permit to ensure that cumulative removals under MMPA section 120(f) do not exceed 10 percent of PBR levels. If NMFS determines that reducing the number of removals identified in paragraph 5(a) above is required, NMFS shall provide the Eligible Entities with 72 hours' notice of the new removal limits.

6) Manner of Removals

a) The Eligible Entities may capture and remove sea lions by trapping or by live capture of free ranging sea lions using established wildlife darting techniques.

b) The Eligible Entities may capture and remove sea lions at any time of year.

c) Under this permit, lethal removal of sea lions is not contingent on nonlethal measures.

d) The use of firearms by the Eligible Entities to kill sea lions is prohibited.

e) The Eligible Entities shall appoint an Institutional Animal Care and Use Committee (IACUC) composed of veterinarians, marine mammal biologists, and a non-affiliated member who shall represent the community, to advise the Eligible Entities on protocols for capture, darting, anesthetizing, holding, transferring, and euthanasia of sea lions.

f) Prior to implementation, the IACUC shall develop, and NMFS shall approve, the methods for chemical euthanasia of sea lions.

g) Prior to implementation, the IACUC shall develop, and NMFS shall approve, the specific methods and protocols for darting and removal of free-ranging sea lions subject to this authorization.

h) Annually, the IACUC shall reevaluate the methods and protocols and determine any needed modifications.

i) Annually, NMFS will review the IACUC methods and protocols for darting and removal of free-ranging sea lions administered by the Eligible Entities and affirm that lethal removals are consistent with the definition of humane within the meaning of section 3(4) of the MMPA.

j) The Eligible Entities will notify and coordinate with local law enforcement/governments and tribes prior to sea lion removal activities as part of a communications strategy to maximize coordination and public awareness.

k) Any intentional taking must be implemented by qualified individuals. Qualified individuals include the Eligible Entities and their employees and other qualified individuals under contract to such entities.

7) Disposition

Sea lions removed under this permit shall be relocated or disposed of as follows:

a) Should NMFS notify the Eligible Entities that a pre-approved permanent holding facility (research, zoo, or aquarium) is willing to accept an animal(s); the Eligible Entities shall maintain the animal in a temporary holding facility approved by the IACUC for up to 48 hours. If the pre-approved research, zoo, or aquarium facility (or their designee) does not collect or make arrangements to collect an animal within 48 hours of its capture, the Eligible Entities may euthanize it.

b) Like other marine mammals, sea lions are susceptible to a variety of environmental contaminants that bioaccumulate upward through marine food webs to high-level predators. These substances include organochlorines (e.g., polychlorinated biphenyls, dioxins, dichloro-diphenyl-trichloroethane and its derivatives, various other pesticides and herbicides), polybrominated diphenyl ethers, heavy metals (e.g., mercury, copper, selenium, zinc), and may have harmful zoonotic organisms, all of which may have negative health consequences if not handled with appropriate protective gear. Thus, to reduce these risks, we recommend that the Eligible Entities use protective gear to reduce the risk of contamination when handling dead marine mammals. The Eligible Entities

shall ensure that the disposal of carcasses, tissues, organs, or parts is in accordance with applicable laws.

c) If a tribe that is party to this permit has interest in a sea lion carcass for educational and cultural uses[1], the Eligible Entities may make sea lion carcasses killed pursuant to this permit available to the requesting tribe(s) for educational and cultural uses. *See* 50 CFR 216.22.

8) Monitoring and Reporting.

a) The Eligible Entities may collect biological samples of sea lions killed pursuant to this permit for scientific research or for educational purposes.

b) The Eligible Entities shall report all removals of sea lions (i.e., placed in permanent captivity or killed) to the Regional Administrator, NMFS, West Coast Region, within 3 days following removal.

c) The Eligible Entities shall provide reports to the Regional Administrator, NMFS, West Coast Region, consistent with the marine mammal regulations at 50 CFR 216.22(b) and 50 CFR 216.22(c) regarding all sea lion carcasses provided to tribes for educational and cultural uses.

d) **Annually, on or before December 1st,** the Eligible Entities shall submit a monitoring report to the Regional Administrator, NMFS, West Coast Region, that includes:

i. The number of sea lions observed in the action area.

ii. The specific locations (e.g., latitude-longitude or river mile) where the Eligible Entities captured individual sea lions.

iii. The number of sea lions killed or transferred by species.

iv. The method of removal.

v. The number of prey observed[2] taken by sea lions throughout the action area.

vi. The impacts of sea lion predation (e.g., percent predation) on affected at-risk fish stocks in the Columbia River Basin.

vii. The preemptive measures, e.g., non-lethal deterrence, taken to reduce sea lion predation on at-risk fish stocks.

viii. The Eligible Entity's compliance with the terms and conditions of this authorization, and plans for future actions in compliance with this authorization.

e) The Eligible Entities shall evaluate the impacts of sea lion predation on at-risk fish species, and the effectiveness (benefits) of permanent removal of predatory sea lions as a method to reduce mortality on at-risk fish species.

[1] As proposed in the June 13, 2019, application.
[2] When predation impacts cannot be observed, an eligible entity shall use a bioenergetics model or equivalent method.

i. The Eligible Entities shall evaluate key population parameters for at-risk fish species by means of a population viability analysis or equivalent method to estimate the effectiveness of permanent removal of predatory sea lions as a method to reduce or eliminate mortality on at-risk fish species and estimate extinction risks to at-risk fish species.
ii. **By December 1, 2023,** the Eligible Entities shall submit a 3-year comprehensive report to NMFS on the above-mentioned requirements so NMFS and the Task Force can evaluate the effectiveness of the authorized lethal removal or alternative actions implemented, as required pursuant to section 120(c)(5) of the MMPA.

9) NMFS may modify, suspend, or revoke this authorization at any time with 72 hours' notice to the Eligible Entities

The Eligible Entities' compliance with the Terms and Conditions is listed below:

1. Authorization

All animals were removed within the designated boundaries of the management area as described above. Specifically, removals occurred at Willamette Falls and Bonneville Dam. In total, 15 CSLs and 33 SSLs were removed during the period covered in this report (Table 1). California sea lions removed during the reporting period that had already been authorized for lethal removal under the existing MMPA §120 Willamette Falls permit were removed and reported under that permit and are not included here.

2. Permit Duration

This report covers management activities between July 1, 2021, and June 30, 2022. The permit under which this work was conducted was granted on August 14, 2020, and expires on August 14, 2025, unless extended or withdrawn before that time.

3. Eligible Entities

All removal efforts were conducted by the Eligible Entities.

a) Staff from the States of Washington, Oregon, Idaho, and the Columbia River Inter-Tribal Fish Commission participated in lethal removal of 14 adult male CSLs and 33 adult male SSLs at Bonneville Dam.

b) Staff from the State of Oregon participated in lethal removal of 1 adult male CSL at Willamette Falls.

4. Delegation of Authority

The Confederated Tribes of the Umatilla Reservation, the Confederated Tribes and Bands of the Yakama Nation, and the Nez Perce Tribe delegated management authority to the Columbia River Inter-Tribal Fish Commission during this reporting period.

5. Limit on Removals

a) The eligible entities did not remove, via permanent placement in captivity or lethal removal, more than 540 CSLs or more than 176 SSLs over the 5-year period of this permit. As of this reporting period (ending June 30, 2022), a cumulative total of 38 CSLs and 53 SSLs have been removed under this authorization.

b) NMFS made no determination that removals under this permit may result in cumulative removals in excess of 10 percent of PBR.

6. Manner of Removals

a) All removals during this reporting period were conducted using live trapping and capture methods (see Methods section).

b) Removals are now permitted at any time of year.

c) Under this permit, lethal removal is not contingent on nonlethal measures.

d) The use of firearms by the Eligible Entities is expressly prohibited and they were not utilized.

e) The Eligible Entities appointed an Institutional Animal Care and Use Committee (IACUC) composed of veterinarians, marine mammal biologists, and a member not affiliated with any of the Eligible Entities who serves to represent the community. Approval by this committee is required for all protocols for capture, darting, anesthetizing, holding, transferring and euthanasia of sea lions used by the Eligible Entities.

f) The IACUC was formed prior to any removal operations and conducted a review and approval of proposed methodologies on August 20, 2021. These protocols were further approved by NMFS before use. The approved Animal Care and Use Protocols operational during this reporting period are included in Appendix 1.

g) The Eligible Entities developed darting protocols, which were considered and approved by the IACUC as part of the protocol review and update on August 20, 2021. To date, no management activities have been conducted using these methods.

h) The IACUC will reevaluate the methods and protocols by December 1, 2023, to determine any needed modifications.

i) NMFS reviewed and approved the IACUC Animal Care and Use Protocols finalized on September 12, 2022, prior to their enactment for management. These methodologies will again be presented to NMFS for annual approval prior to December 1, 2023.

j) The Eligible Entities coordinated with local law enforcement and tribes prior to sea lion removal activities as part of regular communication that maximized coordination and awareness for all parties.

k) All intentional taking was conducted by employees of Eligible Entities.

7) Disposition

a) No requests for permanent placement were made to NMFS for sea lions removed during this management period. Therefore, all captured animals were humanely euthanized.

b) Staff were given safety trainings on handling of wildlife, including possible exposure to zoonoses and transmission of reverse zoonoses. Any staff participating in management or handling of animals utilized the appropriate Personal Protective Equipment, including safety glasses, nitrile gloves, work gloves, cut-proof gloves, aprons and waterproof sleeves, waterproof boots, and additional PPE as related to mitigating risks related to COVID-19.

c) Tribes that are party to this permit requested parts from sea lion carcasses killed pursuant to this permit for educational and cultural purposes. The Eligible Entities provided parts from sea lions EB033 and EB034 to The Confederated Tribes and Bands of the Yakama Nation, and parts from ZB024 to The Confederated Tribes of the Warm Springs Reservation of Oregon.

8. Monitoring and Reporting

a) The Eligible Entities conducted full necropsies of removed animals and collected biological samples for scientific research purposes including food habits, immunology, toxicology, pathogens, biometrics, and general health.

b) The Eligible Entities reported all removals to the Regional Administrator of NMFS within 72 hours of removals. These reports were subsequently forwarded to the Task Force members via NMFS.

c) Sea lion carcasses provided to tribes for educational and cultural purposes under Term 7c) were reported to the NMFS West Coast Regional Administrator.

d) This document fulfills the reporting requirements for the period of management beginning July 1, 2021, until June 30, 2022. Monitoring and predation reports for work previously authorized under the MMPA §120 Willamette Falls permit were provided to NMFS in November 2022 (Wright et al. 2022, Brown et al. 2022).

    i. The number of sea lions observed in the action area are detailed in the Results section of this report.

    ii. The specific locations where the Eligible Entities captured individual sea lions is detailed in Table 1 of this report.

    iii. The number of sea lions killed or transferred by species is detailed in Table 1 of this report.

    iv. The method of removal for all sea lions killed during this reporting period was by chemical euthanasia via overdose of anesthetic. Method details are provided in the attached IACUC (Appendix 1).

    v. The number of prey observed taken by sea lions throughout the action area are detailed in the Results section and Table 2 of this report.

vi. Estimates of predation impacts of removed animals are presented in the Results and Discussion section and Appendix 3 of this report.

vii. Non-lethal deterrence measures taken to reduce sea lion predation on at-risk fish stocks are detailed in the Methods sections of this report.

viii. This letter describing our compliance with the terms and conditions of the 2020 Authorization for monitoring and management activities conducted in 2021-2022 represents our annual monitoring report to NMFS. The Eligible Entities are currently planning to conduct similar work in 2022-2023 under this MMPA §120(f) authority

e) The Eligible Entities continue to evaluate the impacts of sea lion predation on at-risk fish species, and the effectiveness (benefits) of permanent removal of predatory sea lions as a method to reduce mortality on at-risk species. Monitoring and predation reports to date have been summarized in previous Willamette Falls and Bonneville Dam sea lion management reports (e.g., Brown et al. 2022, Clark et al. 2021, Wright et al. 2022). This same information for the current MMPA §120(f) permit is included in this report.

   i. The Eligible Entities continue to evaluate key population parameters for at-risk fish species by means of a population viability analysis to estimate the effectiveness of permanent removal of predatory sea lions as a method to reduce or eliminate mortality on at-risk fish species and estimate extinction risks to at-risk fish species.

   ii. The Eligible Entities will submit a three-year comprehensive report to NMFS by December 1, 2023.

9) The Eligible Entities understand that NMFS may modify, suspend, or revoke this authorization at any time with 72 hours' notice to the Eligible Entities.

This report details MMPA §120(f) activities that occurred between July 1, 2021, and June 30, 2022. We thank you for your assistance and support of our work to monitor and reduce sea lion predation on threatened and endangered fish in the Columbia River Basin.

Sincerely,

John M. Edwards

John Edwards
Columbia River Pinniped Biologist
Washington Department of Fish and Wildlife

ANNUAL REPORT:
2022 COLUMBIA RIVER BASIN RESEARCH AND MANAGEMENT ACTIVITIES

John Edwards[1], Bryan Wright[2], Casey Clark[1], Mike Brown[2], Shay Valentine[2], Doug Hatch[3], and John Powell[4]

December 1, 2022

Submitted on behalf of all MMPA §120(f) Eligible Entities, including:

The State of Oregon
The State of Washington
The State of 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
The Confederated Tribes of the Grand Ronde Community
The Confederated Tribes of the Siletz Indians of Oregon
The Columbia River Inter-Tribal Fish Commission

[1] Washington Department of Fish and Wildlife
[2] Oregon Department of Fish and Wildlife
[3] Columbia River Inter-Tribal Fish Commission
[4] Idaho Department of Fish and Game

TABLE OF CONTENTS

INTRODUCTION 1

METHODS 2

Estimation of sea lion abundance in the action area 2
Trapping 3
Estimation of predation rates and diet analysis 3
Effect of removals 4

RESULTS AND DISCUSSION 4

Estimation of sea lion abundance in the action area 4
Trapping 6
Estimates of predation rates and diet analysis 6
Effect of Removals 8

TASK FORCE RECOMMENDATIONS 9

TABLES AND FIGURES 10

Table 1. Description and relevant data for lethally removed sea lions 10
Table 2. Raw data from USACE sea lion predation monitoring during Fall 2021 and Spring 2022 12
Table 3. prey items recovered from gastro-intestinal tracts of CSLs and SSLs. 13
Figure 1. Weekly sea lion counts on the Columbia River 16
Figure 2. Weekly sea lion counts at Willamette Falls 17
Figure 3. Individual sighting locations and total counts of sea lions in the Willamette River 18

ACKNOWLEDGEMENTS 19

LITERATURE CITED 20

APPENDIX 21

Appendix 1. IACUC 21
Appendix 2. Tissue samples collected from euthanized animals 48
Appendix 3. Agent-based model 50

INTRODUCTION

Bonneville Dam, located approximately 235 km (146 miles) upriver from the Pacific Ocean, is the lowermost hydroelectric project on the Columbia River. During the 1980s and 1990s, one or two California sea lions (CSLs; *Zalophus californianus*) were reported annually at the dam during fishway inspections (Stansell 2004). In 2001, however, there were reports of up to six CSLs observed at one time, and in 2002 the U.S. Army Corps of Engineers (USACE) estimated 30 CSLs were foraging on salmonids (*Oncorhynchus* spp.) at the dam. Many of these salmonid runs are listed under the Endangered Species Act (ESA). Since that time, the minimum number of CSLs seen at Bonneville Dam during a given year has fluctuated between approximately 40-200 individuals, with associated predation estimates of approximately 1,000 to 8,000 salmonids per year (van der Leeuw and Tidwell 2022).

Steller sea lion (SSL; *Eumetopias jubatus*) abundance and residency at the dam has also increased over the last decade, from zero animals before 2003 to a maximum of 89 individuals in 2011 (van der Leeuw and Tidwell 2022). This species is now present at Bonneville Dam for most of the year, in contrast to CSLs which are present primarily in the spring. While SSLs initially foraged primarily on white sturgeon (*Acipenser transmontanus*), in recent years they have consumed more salmonids than sturgeon and have increasingly impacted fall and winter salmonid runs. Most notably, in 2017, SSLs consumed more salmonids than CSLs did in 2006 when authority to lethally remove CSLs at Bonneville Dam was initially requested (van der Leeuw and Tidwell 2022).

In response to increasing pinniped predation at the dam, state, federal, and tribal agencies attempted to deter pinnipeds using a variety of non-lethal methods. Starting in 2005, these methods included aerial and underwater pyrotechnics, acoustic harassment devices, vessel chase, rubber projectiles, and capture-relocation. While hypothetically effective at deterring predation by naïve animals, they have generally been found to be ineffective at deterring predation by habituated individuals (Scordino 2010), and proved ineffective at deterring predation by sea lions at Bonneville Dam.

Increasing predation by CSLs on ESA-listed salmonids, coupled with unsuccessful non-lethal deterrence efforts, led the States of Washington, Oregon, and Idaho in November 2006 to apply under §120 of the Marine Mammal Protection Act (MMPA) for the authority to permanently remove CSLs that were observed preying on salmonids near Bonneville Dam. In March 2008, National Marine Fisheries Service (NMFS) partially approved the States' application and issued a Letter of Authorization (LOA) for the lethal removal of certain CSLs under specific conditions (NMFS 2008). This authority was repeatedly challenged in federal court, which resulted in intermittent removal activity. Litigation ended in September 2013 when the U.S. Court of Appeals for the Ninth Circuit ruled in NMFS's favor, allowing for the removal activity to continue under the States' 2012 LOA. That LOA was to expire on June 30, 2016, but on June 28, 2016, it was renewed until June 30, 2021. On April 17, 2019, the removal criteria in Term & Condition 1 of this authorization were amended, but the duration of the authorization was not changed (NMFS 2016, NMFS 2019).

On August 14, 2020, managing parties were granted a new permit under §120(f) to conduct similar management activities in an extended geographic area (the mainstem of the Columbia River between river mile 112 and river mile 292, or in any tributary (below river mile 292) to the Columbia River that includes spawning habitat of threatened or endangered salmon or steelhead) under a new set of requirements (NMFS 2020). The newest authorization also allows for the lethal removal of Steller sea lions within the geographic area of management.

This report summarizes pinniped research and management activities between July 1, 2021, and June 30, 2022, in the management area encompassed in this MMPA §120(f) permit, though management was only conducted at Bonneville Dam and Willamette Falls during this reporting period. This work was led by the Oregon Department of Fish and Wildlife (ODFW) and the Washington Department of Fish and Wildlife (WDFW), in cooperation with the Columbia River Inter-Tribal Fish Commission (CRITFC) and Idaho Department of Fish and Game (IDFG). This work has been conducted in close coordination and cooperation with USACE and NMFS, as well as numerous other agencies.

METHODS

Activities conducted under and in association with this authorization included pinniped surveys between Bonneville Dam and the mouth of the Columbia River, pinniped surveys and estimates of fish predation by pinnipeds in the area of Willamette Falls, trapping and lethal removal of predatory CSLs and SSLs, diet analysis from contents of stomachs and intestines recovered from euthanized CSLs and SSLs, and estimation of the effect of removals on salmonid runs (i.e., the number of salmon "saved" as a result of lethal removal of predatory CSLs and SSLs). The methods used for these activities are detailed below.

Non-lethal hazing of sea lions at Bonneville Dam was and is currently being conducted by USDA staff in 2021 and 2022. These activities will be included in the forthcoming USACE report of activities at Bonneville Dam. Non-lethal hazing is not a requirement of lethal management at Willamette Falls, and no non-lethal deterrence measures were conducted due to limited animal presence during the reporting period.

Estimation of sea lion abundance in the action area

Sea lion abundance in the action area is monitored using a variety of approaches. At Bonneville Dam, the USACE has taken the lead role in reporting sea lion abundance in the tailraces since 2002 (see van der Leeuw and Tidwell (2022) for methods).

In the mainstem Columbia River, CRITFC conducts periodic river surveys to document and enumerate sea lion abundance and predation activity in the river below Bonneville Dam. Surveys extended from the Bonneville Dam tailrace to the I-205 river crossing in Portland, Oregon. A single boat was crewed by a captain and at least one observer. Sea lion species, observed predation events, and GPS location data were recorded for all sightings. In addition, counts of sea lions hauled out at Phoca Rock were conducted throughout the season.

Lastly, in the lower Willamette River and at Willamette Falls, ODFW staff conduct a variety of observations to monitor abundance including land-based observations, automated camera counts, and boat-based river surveys. See Wright et al. (2022) and Brown et al. (2022) for methods, but briefly, counts at Willamette Falls were conducted hourly during weekday, daytime observation shifts, and the number of sea lions hauled out on ODFW traps in the Willamette River was counted from hourly images taken by remote cameras 24 hrs a day, 7 days a week. Periodic boat-based surveys of the Willamette River were typically conducted in a single 24-ft closed cabin boat travelling downstream at approximately 5 knots with a minimum of two staff per survey. Surveys began in Oregon City below Willamette Falls and proceeded downriver, typically to the confluence with the Columbia River (42 km; 26 mi). Staff recorded the number, behavior, and location of each species of pinnipeds observed, which were also photographed when possible.

Trapping

Sea lions at both Bonneville Dam and Willamette Falls were trapped using haul-out traps placed in areas that the sea lions prefer to haul out. Sea lions use these traps as haul-out sites, entering and exiting traps by way of a vertically sliding door, which was padlocked open when trapping was not actively underway (e.g., weekends and months when fieldwork did not occur). Tailrace traps were monitored by state, federal, and private security staff. In addition, wireless trap monitoring sensors were installed on all trap doors to automatically notify project staff by text in the event of an unplanned trap closure. In spring 2019, real-time trap monitoring was introduced using in-trap cellular cameras. This allowed co-managers to determine whether animals were on the traps, which was particularly important in the event of an unplanned trap closure.

Tailrace trap doors were closed using a remote-controlled magnetic release mechanism. Once sea lions were captured, they were herded into holding cages on a barge built specifically to handle sea lions. If a NMFS-approved zoo or aquarium facility was available to receive candidate sea lions for permanent holding, then captured animals would be given a health screening by field staff and veterinarians, including members of the Eligible Entities' Institutional Animal Care and Use Committee. If an animal passed the health screening, it would be transferred to an approved temporary housing facility prior to shipment to a zoo or aquarium. If an animal failed the health exam, or if there were no approved facilities prepared to accept an animal, then it was chemically euthanized. Euthanized animals were necropsied and various samples (e.g., teeth, tissue, blood, whiskers) were collected and stored for later analysis (Appendix 2).

Estimation of predation rates and diet analysis

As with abundance monitoring, estimation of predation rates varies by location. At Bonneville Dam, the USACE has taken the lead role in estimating sea lion predation in the tailraces since 2002 (see van der Leeuw and Tidwell (2022) for methods). At Willamette Falls, ODFW has estimated sea lion predation since 2014 (see Wright et al. (2022) for methods).

Diet analysis is based on the identification of undigested prey remains from the stomachs and large intestines of euthanized CSLs and SSLs following the procedures in Lance et al. (2001). Briefly, undigested remains were washed through a series of nested sieves (2 mm, 1 mm, and 0.05 mm) and all parts were collected for later identification. Samples were identified to the lowest possible taxonomic level using a dissecting microscope by comparing all identifiable prey remains (e.g., bones, otoliths, cartilaginous parts, eye lenses, teeth, and cephalopod beaks) against a reference collection of fish and invertebrates from the northeastern Pacific Ocean and Oregon estuaries. Prey were enumerated by examining all structures (otoliths, tail structures, cephalopod beaks, etc.) to determine the minimum number of individual prey items in the sample. This enumeration process accounts for paired structures (i.e., left vs. right side structures) and differences in size of recovered prey remains that may indicate they originated from different individual prey items.

Effect of removals

The effect of removals was characterized by estimating how many salmonids would have been required to meet the sea lions' energetic demands over the expected post-removal lifetimes of individual sea lions had they not been removed. This was accomplished using an agent-based modeling (ABM) approach (see Appendix 3 for details).

RESULTS AND DISCUSSION

Estimation of sea lion abundance in the action area

Bonneville Dam

Results of USACE sea lion monitoring efforts at Bonneville Dam will be included in their annual report in early 2023; however, the Corps has shared preliminary data with the Eligible Entities to be reported here. The information included here can be used to infer timing and trends in sea lion abundance in the vicinity of Bonneville Dam, but these numbers should not be treated as final until they are published in the next USACE annual report[3].

Sea lion monitoring efforts at Bonneville Dam are conducted during the period of sea lion presence at the dam, typically extending from August until May. This timeframe is officially broken into two monitoring periods, with fall monitoring extending from August to December, and the spring period from January to May. The Fall 2022 monitoring efforts began on August 3, 2021, and concluded on December 31, 2021, consisting of 96 separate counts. Only SSLs were present at Bonneville Dam during the fall, and animals were observed during the entire reporting period. Peak SSL abundance during Fall 2021 was 68 animals and occurred on September 28, 2021. Average SSL abundance during the entire Fall 2021 monitoring period was 30 individuals (range: 3–68).

[3] When completed, the 2021-2022 USACE annual report will be available here: http://pweb.crohms.org/tmt/documents/FPOM/2010/Task%20Groups/Task%20Group%20Pinnipeds/

Both CSLs and SSLs were present at Bonneville Dam during the Spring 2022 monitoring period, which began on January 1, 2022, and extended until May 28, 2022, consisting of a total of 95 separate counts. Whereas SSLs were present at the dam for much of Spring 2022 (January 1 – May 26), CSLs were not observed until March 15 and were last seen on May 26. Peak SSL abundance during Spring 2022 was 62 animals and occurred on April 30, 2022. Average Spring 2022 SSL abundance was 11 individuals (range: 0–62). Peak CSL abundance during this same period was 10 individuals, which were recorded on both April 23 and April 28, 2022. The average CSL abundance in Spring 2022 was 2 animals (range: 0–10); however, if only the period beginning with the first CSL observation is considered, the average was 3 individuals per count.

Mainstem Columbia River

Weekly boat river surveys between the Bonneville Dam tailrace and the I-205 crossing in Portland, Oregon, peaked with 21 sea lions counted on April 18 and maintained an average 16.0 sea lions per week (range 11 – 21) throughout the spring survey season (Figure 1). Between April 12 and May 9, 2022, a total of 80 sea lions were enumerated in 50 observations. Of those, 8 observations included predation events (1 salmonid, 7 sturgeon). Steller sea lions outnumbered California sea lions in every weekly river survey and were the predominant species found on Phoca Rock with an average haul out count of 5.20 (range 1-10) between April 12 and May 09, 2022.

Willamette River

Pinniped counts based on automated cameras and incidental observations by staff at the Sportcraft haulout area began July 2021 before sea lions migrated into the study area and continued through early June 2022 when all sea lions had migrated out of the study area. Counts based on formal observations at Willamette Falls began in early January 2022 and continued through early June 2022. Boat-based river surveys began late August 2021 and continued through early June 2022.

California sea lions—There were no sightings of California sea lions in the study area during the last half of 2021 (Figure 2). The first individuals to occur at the falls were a pair of animals that were seen on a single day in late February (2/22/22), followed one month later by a single animal on 3/21/22 which marked the return of the “spring cohort” of California sea lions to the falls. Thereafter, numbers gradually increased until reaching a seasonal maximum of six individuals observed on 4/28/2022. The last sighting in the study area occurred on 6/10/2022. Boat surveys of the Willamette River from the falls to the confluence with the Columbia River showed a similar phenology and relative abundance (Figure 3).

Steller sea lions—There were no sightings of Steller sea lions in the study area during the last half of 2021 (Figure 2). The first individual to occur at the falls was in early January (1/11/22), followed by an intermittent increase in number until reaching a seasonal maximum of five individuals on 2/15/22. The “winter cohort” of Steller sea lions departed 2/28/22 and only a single, highly habituated individual occurred at the falls during the spring months (3/25-4/29/22). Boat surveys of the Willamette River from the falls to the confluence with the Columbia River showed a similar phenology but substantially greater abundance and distribution throughout the river (Figure 3).

Trapping

All animals captured during this reporting period (July 1, 2021, until June 30, 2022) were captured using the trap array within the Boat Restricted Zone at Bonneville Dam, Columbia River Mile 146 (45.6392°, -121.9521°), or the trap array at Willamette Falls (45.3511º, -121.6193º) (Table 1).

In total, 15 adult male California sea lions and 33 Steller sea lions were humanely euthanized (Table 1). Trapping activities at Bonneville occurred over approximately 10 weeks in Fall 2021, from September 14th through November 18th, and 7 weeks in Spring 2022, from April 5th through May 19th (Table 1). Trapping activities at Willamette Falls occurred over 2 weeks in May 2022 (Table 1, Figure 2). Sea lion trapping was conducted under the MMPA §120(f) Columbia River Basin permit; however, CSLs previously added to the list of animals authorized for removal under the previous MMPA §120 Willamette Falls authorization were removed under that permit, thus information about those animals was included in the yearly reports for that permit, submitted to NMFS on November 1, 2022 (Brown et al. 2022, Wright et al. 2022). In May 2022, two CSLs on this list were removed under the prior MMPA §120 authority at Willamette Falls and are not included in the present report.

The average weight of euthanized CSLs (n = 15) was approximately 285 kg (629 lbs), with a range of 195–378 kg (429–833 lbs). The average length of euthanized CSLs was approximately 220 cm (7.2 ft), with a range of 203–235 cm (6.6–7.7 ft). For SSLs (n = 33), the average weight was approximately 536 kg (1182 lbs), with a range of 259–873 kg (570–1925 lbs). The average length of euthanized SSLs was approximately 271 cm (8.9 ft), with a range of 232–315 cm (7.6–10.3 ft). Age data based on sectioned teeth are not yet available for the reporting period.

Estimates of predation rates and diet analysis

Bonneville Dam

Predation—As with the sea lion abundance data, the USACE shared preliminary results of their predation monitoring efforts with the Eligible Entities to be included in this report. Statistically expanded estimates for unsampled times and locations will be included in the final USACE report. Predation monitoring was also divided into a Fall 2021 and Spring 2022 period, though these efforts were more discrete than the abundance estimation periods. Fall 2021 predation monitoring extended from August 17, 2021, through December 8, 2021, and was focused on the tailrace below Powerhouse 2 at Bonneville Dam. Only SSLs were present at the dam during the Fall 2021 predation monitoring period. The raw data based on 234 hours of sampling included 393 predation events (Table 2), consisting in order of abundance of Chinook salmon (*Oncorhynchus tshawytscha*), white sturgeon *(Acipenser transmontanus)*, Coho salmon (*Oncorhynchus kisutch*), steelhead (*Oncorhynchus mykiss*), and Chum salmon (*Oncorhynchus keta*), though species could not be assigned to 93 prey items.

Predation monitoring in Spring 2022 began on April 5 and continued until May 18, when abundance of sea lions at the dam declined. Spring predation sampling occurred at all three tailraces of the dam. Both SSLs and CSLs were present at Bonneville Dam during this period and observers collected 132 hours of predation monitoring data consisting of 148 predation events (Table 2). Observed prey consumed by both SSLs and CSLs consisted almost entirely of Chinook salmon. Both species had at least one observation of predation on steelhead, and there was a single observation of a single SSL eating a white sturgeon. Only three of the prey items consumed by SSLs and one prey item consumed by a CSL could not be identified to species.

Diet—GI tract summary
Forty-seven gastro-intestinal (GI) tracts were collected from euthanized CSLs and SSLs during this reporting period, forty-five of which contained undigested prey remains (Table 3). The 33 SSL GI-tracts contained 20 sturgeon, 19 adult spring Chinook salmon, 40 Chum salmon, 31 Pacific lamprey (*Entosphenus tridentatus*), and 27 unidentified salmonids (all adults). Additional prey recovered from SSL GI-tracts were Northern Pikeminnow (*Ptychocheilus oregonensis*), lamprey species, crayfish species, bass/sunfish species, sculpin species, catfish species, unidentified Cyprinidae, and other unidentified fish. The 14 CSL GI-tracts contained 59 adult spring Chinook salmon, 5 unidentified salmonids (three adults, two juvenile), and 1 American shad (*Alosa sapidissima*).

Willamette Falls

Predation—A total of 178 predation events by California sea lions were documented during the 2022 field season (see Wright et al. 2022 for full report). This includes predation events seen at pre-assigned, probability-based sample units, as well as all anecdotal observations. Salmonids were the most frequently observed prey item (85%), followed by lamprey (13%), and other or unknown prey (2%). Based on the subset of these observations that occurred during probability sampling, we estimated that a total of 597 salmonids were consumed by California sea lions across the sampling frame. Partitioning this total to run based on Monte Carlo modeling, we estimated that California sea lions consumed 50 winter steelhead (1.8% of potential escapement), 109 summer steelhead (1.9% of potential escapement), 90 unmarked spring Chinook salmon (1.4% of potential escapement above falls), and 348 marked spring Chinook salmon (1.1% of potential escapement).

Observers documented 68 predation events by Steller sea lions during the 2022 field season (see Wright et al. 2022 for full report). This includes predation events seen at pre-assigned, probability-based sample units, as well as all anecdotal observations. White sturgeon was the most frequently observed prey item (65%), followed by salmonids (16%), other or unknown prey (12%), and lamprey (7%). Based on the subset of these observations that occurred during probability sampling, we estimated that a total of 45 salmonids were consumed by Steller sea lions across the sampling frame. This estimate was highly uncertain, however, due to the low number of observed events in the frame and we therefore did not further partition the total into run-specific estimates.

Diet—One gastro-intestinal (GI) tract was collected from a euthanized CSL under this authority, which contained undigested prey remains (Table 3). The CSL GI-tract contained undigested remains of 1 adult spring Chinook salmon, 2 Pacific lamprey, and 2 Steelhead.

Effect of Removals

A total of 91 sea lion "agents" were initialized for the ABM including 43 from previous reporting periods (August 14, 2020–June 30, 2021) and 48 from the current reporting period (July 1, 2021–June 30, 2022); seven SSLs occurred during two seasons thus resulting in a grand total of 98 agents (see Appendix 3). Of the 91 sea lions, 53 were SSLs (52 from Bonneville Dam and one from Willamette Falls) and 38 were CSLs (31 from Bonneville Dam and seven from Willamette Falls).

The predicted (median) number of salmonids required by these sea lions had they not been removed was approximately 20,086 fish (95% confidence interval was approximately 10,582 to 33,869 fish) (Appendix 3, Fig. 5). The predicted requirements covered the period from 2021–2035.

TASK FORCE RECOMMENDATIONS

In addition to the Terms and Conditions outlined previously, in the 2020 Authorization NMFS determined that a subset of Task Force recommendations warranted consideration by the Eligible Entities as they will help achieve the goal of reducing/eliminating sea lion predation on at-risk fish species in the Columbia River Basin. NMFS requested that the Eligible Entities, to the maximum extent practicable, implement the following recommendations to minimize sea lion predation on at-risk fish species in the Columbia River Basin and-or to help evaluate the effectiveness of the authorized lethal removals or alternative actions:

1. Consistent with the intent of the Endangered Salmon Predation Prevention Act, NMFS requests that the Eligible Entities develop a long-term management strategy to prevent the future recruitment of sea lions into the 120(f) geographic area.

2. As recommended by the Task Force, NMFS requests that the Eligible Entities continue to pursue non-lethal methods to reduce sea lion predation on at-risk fish stocks.

3. As recommended by the Task Force, NMFS requests that the Eligible Entities conduct necropsies on euthanized sea lions to monitor sea lion age, disease, diet, and health trends in sea lion populations.

4. As recommended by the Task Force, NMFS requests that the Eligible Entities explore opportunities to displace and-or minimize the use of manmade haul outs by sea lions in the Columbia River.

5. As recommended by the Task Force, NMFS requests that the Eligible Entities look at the rate of sea lion recruits after habituated animals are removed to understand the effectiveness of the lethal removal program.

6. As recommended by the Task Force, NMFS requests that the Eligible Entities, in coordination with the Alaska Fisheries Science Center, monitor Steller sea lion rookeries in northern California (Saint George Reef and Sugarloaf Island), Oregon (Three Arch Rocks, Orford Reef and Rogue Reef), and Washington (Carroll Island and Sea Lion Rock) to assess the population status of Steller sea lions at these rookeries.

7. As recommended by the Task Force, NMFS requests that the Eligible Entities consider creating a way to collect public input and observations on the problem interactions in areas identified as Categories 2 and Category 3.

8. As recommended by the Task Force, NMFS requests that the Eligible Entities consider setting up a program, in coordination with NMFS, which would support or help secure the funds needed for monitoring to evaluate success of the lethal removal program.

9. As recommended by the Task Force, NMFS requests that the Eligible Entities conduct a management strategy evaluation on the performance of the bioenergetics model used to estimate the expected benefits of the MMPA section 120 program.

The Eligible Entities will provide a report by December 1, 2023, to NMFS on the implementation status of each of these recommendations, as well as any supporting information and data.

TABLES AND FIGURES

Table 1. Description and relevant data for lethally removed sea lions between July 1, 2021, and June 30, 2022, under MMPA §120(f) authority. Bonneville Dam Coordinates = 45.6392º, -121.9521º. Willamette Falls Coordinates = 45.3511º, -121.6193º

Removal Date	Location	Species	Animal ID	Date Branded	Weight (lbs)	Length (cm)
9/14/2021	Bonneville Dam	SSL	EB017	N/A	776	249
9/15/2021	Bonneville Dam	SSL	EB018	N/A	958	270
9/15/2021	Bonneville Dam	SSL	EB019	N/A	570	236
9/16/2021	Bonneville Dam	SSL	EB020	N/A	796	247
9/21/2021	Bonneville Dam	SSL	O49	5/17/2017	1111	266
9/22/2021	Bonneville Dam	SSL	EB021	N/A	1085	273
9/23/2021	Bonneville Dam	SSL	EB022	N/A	1397	309
9/28/2021	Bonneville Dam	SSL	EB023	N/A	860	253
9/29/2021	Bonneville Dam	SSL	EB024	N/A	1563	304
9/30/2021	Bonneville Dam	SSL	EB025	N/A	644	232
10/6/2021	Bonneville Dam	SSL	EB026	N/A	1484	288
10/6/2021	Bonneville Dam	SSL	EB027	N/A	1379	277
10/7/2021	Bonneville Dam	SSL	O48	5/17/2017	1344	276
10/14/2021	Bonneville Dam	SSL	O42	5/11/2017	1192	273
11/2/2021	Bonneville Dam	SSL	EB028	N/A	1008	254
11/3/2021	Bonneville Dam	SSL	EB029	N/A	991	261
11/3/2021	Bonneville Dam	SSL	O47	5/16/2017	1477	272
11/9/2021	Bonneville Dam	SSL	EB030	N/A	832	261
11/9/2021	Bonneville Dam	SSL	EB031	N/A	1167	282
11/10/2021	Bonneville Dam	SSL	EB032	N/A	990	275
11/16/2021	Bonneville Dam	SSL	EB033	N/A	1261	266
11/16/2021	Bonneville Dam	SSL	EB034	N/A	1728	295
11/17/2021	Bonneville Dam	SSL	EB035	N/A	1597	302
11/17/2021	Bonneville Dam	SSL	EB036	N/A	1532	315
4/19/2022	Bonneville Dam	SSL	EB037	N/A	1186	276

4/20/2022	Bonneville Dam	SSL	EB038	N/A	1444	289
4/20/2022	Bonneville Dam	SSL	EB039	N/A	1663	275
4/20/2022	Bonneville Dam	CSL	ZB016	N/A	429	210
4/21/2022	Bonneville Dam	SSL	O37	4/30/2013	1925	295
4/26/2022	Bonneville Dam	CSL	ZB017	N/A	726	226
4/26/2022	Bonneville Dam	CSL	ZB018	N/A	699	223
4/26/2022	Bonneville Dam	CSL	X842	4/3/2017	506	220
4/27/2022	Bonneville Dam	SSL	EB040	N/A	973	254
4/28/2022	Bonneville Dam	CSL	ZB019	N/A	798	234
4/28/2022	Bonneville Dam	SSL	EB041	N/A	1637	290
5/3/2022	Bonneville Dam	SSL	EB042	N/A	827	249
5/3/2022	Bonneville Dam	CSL	ZB020	N/A	493	217
5/3/2022	Bonneville Dam	CSL	ZB021	N/A	443	203
5/3/2022	Bonneville Dam	CSL	C-096	4/22/2015	833	220
5/3/2022	Bonneville Dam	CSL	ZB022	N/A	466	207
5/4/2022	Bonneville Dam	CSL	2n61	5/16/2018	696	219
5/5/2022	Bonneville Dam	CSL	ZB023	N/A	819	235
5/10/2022	Bonneville Dam	CSL	ZB024	N/A	656	226
5/10/2022	Bonneville Dam	SSL	EB043	N/A	871	252
5/10/2022	Bonneville Dam	SSL	EB044	N/A	727	243
5/11/2022	Bonneville Dam	CSL	ZB025	N/A	593	215
5/11/2022	Bonneville Dam	CSL	ZB026	N/A	599	217
5/17/2022	Willamette Falls	CSL	ZW007	N/A	685	225

Table 2. Raw data from USACE sea lion predation monitoring during Fall 2021 and Spring 2022 (statistically expanded estimates for unsampled times and locations will be included in the final report). Only Steller sea lions were present at Bonneville Dam in fall, whereas both California and Steller sea lions were present in spring. Number of observed predation events for each sea lion species are presented, broken down by prey species where possible. Statistically expanded estimates for unsampled times and locations will be included in the final USACE report.

Fall 2021

		Steller sea lions
Prey species	Scientific name	*n* =
Chinook salmon	*Oncorhynchus tshawytscha*	124
Coho salmon	*Oncorhynchus kisutch*	41
Chum salmon	*Oncorhynchus keta*	10
Steelhead	*Oncorhynchus mykiss*	13
White Sturgeon	*Acipenser transmontanus*	82
Unknown species		93
Total		363

Spring 2022

		Steller sea lions	California sea lions	Both species combined
Prey species	Scientific name	*n* =	*n* =	*n* =
Chinook salmon	*Oncorhynchus tshawytscha*	93	47	140
Coho salmon	*Oncorhynchus kisutch*	0	0	0
Chum salmon	*Oncorhynchus keta*	0	0	0
Steelhead	*Oncorhynchus mykiss*	1	2	3
White Sturgeon	*Acipenser transmontanus*	1	0	1
Unknown species		3	1	4
Total		98	50	148

Table 3. Minimum number of individual prey recovered from gastro-intestinal tracts (stomach and large intestines) collected from 15 California sea lions (CSL) and 33 Steller sea lion (SSL) captured and euthanized at Willamette Falls and Bonneville Dam between July 1, 2021, and June 30, 2022, under Columbia River Basin (CRB) MMPA §120(f) (valid 8/14/2020 - 8/14/2025).

Date	Removal Location	Sea lion species	Animal ID	Unidentified salmon		Adult Chinook	Adult Chum	Sturgeon	Pacific Lamprey	Steelhead	Other**
				Adult	Juvenile						
Fall 2021 Removals											
2021-09-14	Bonneville Dam	SSL	EB017	3							
2021-09-15	Bonneville Dam	SSL	EB018				2	2	6		2
2021-09-15	Bonneville Dam	SSL	EB019	1					1		2
2021-09-16	Bonneville Dam	SSL	EB020				2	1			
2021-09-21	Bonneville Dam	SSL	O49					5			1
2021-09-22	Bonneville Dam	SSL	EB021			1			1		2
2021-09-23	Bonneville Dam	SSL	EB022	7							
2021-09-28	Bonneville Dam	SSL	EB023					2			2
2021-09-29	Bonneville Dam	SSL	EB024	1				1			2
2021-09-30	Bonneville Dam	SSL	EB025					1			1
2021-10-06	Bonneville Dam	SSL	EB026					1			1
2021-10-06	Bonneville Dam	SSL	EB027					1			1
2021-10-07	Bonneville Dam	SSL	O48				5				
2021-10-14	Bonneville Dam	SSL	O42					1	2		6
2021-11-02	Bonneville Dam	SSL	EB028				2				4
2021-11-03	Bonneville Dam	SSL	EB029				12				
2021-11-03	Bonneville Dam	SSL	O47	1			2				
2021-11-09	Bonneville Dam	SSL	EB030	4							
2021-11-09	Bonneville Dam	SSL	EB031								

2021-11-10	Bonneville Dam	SSL	EB032				2	1			
2021-11-16	Bonneville Dam	SSL	EB033				7				1
2021-11-16	Bonneville Dam	SSL	EB034	1				1			1
2021-11-17	Bonneville Dam	SSL	EB035	1				1	20		1
2021-11-17	Bonneville Dam	SSL	EB036				6	1			1
Spring 2022 Removals											
2022-04-19	Bonneville Dam	SSL	EB037								
2022-04-20	Bonneville Dam	CSL	ZB016	1							
2022-04-20	Bonneville Dam	SSL	EB038			3					
2022-04-20	Bonneville Dam	SSL	EB039			3					1
2022-04-21	Bonneville Dam	SSL	O37	4		1		1			
2022-04-26	Bonneville Dam	CSL	X842			7					
2022-04-26	Bonneville Dam	CSL	ZB017	1							
2022-04-26	Bonneville Dam	CSL	ZB018			6					
2022-04-27	Bonneville Dam	SSL	EB040			2					
2022-04-28	Bonneville Dam	SSL	EB041	3		2					
2022-04-28	Bonneville Dam	CSL	ZB019			3					
2022-05-03	Bonneville Dam	SSL	EB042	1							
2022-05-03	Bonneville Dam	CSL	ZB020			7					
2022-05-03	Bonneville Dam	CSL	ZB021			11					
2022-05-03	Bonneville Dam	CSL	C096			5					
2022-05-03	Bonneville Dam	CSL	ZB022			3					
2022-05-04	Bonneville Dam	CSL	2-61			3					
2022-05-05	Bonneville Dam	CSL	ZB023			5					1
2022-05-10	Bonneville Dam	SSL	EB043			2			1		1
2022-05-10	Bonneville Dam	SSL	EB044			5					
2022-05-10	Bonneville Dam	CSL	ZB024			7					
2022-05-11	Bonneville Dam	CSL	ZB025	1							
2022-05-11	Bonneville Dam	CSL	ZB026		2	2					

2022-05-16	Willamette Falls	CSL	ZW007			1			2	3	
Fall 2021 Total				**19**		**1**	**40**	**19**	**30**		**28**
Spring 2022 Total				**11**	**2**	**78**		**1**	**3**	**3**	**3**
Cumulative Total				**30**	**2**	**79**	**40**	**20**	**33**	**3**	**31**

**American Shad, Northern Pikeminnow, Lamprey spp., Crayfish, Bass/Sunfish, Sculpin, Catfish, Cyprinidae unid, Fish unid

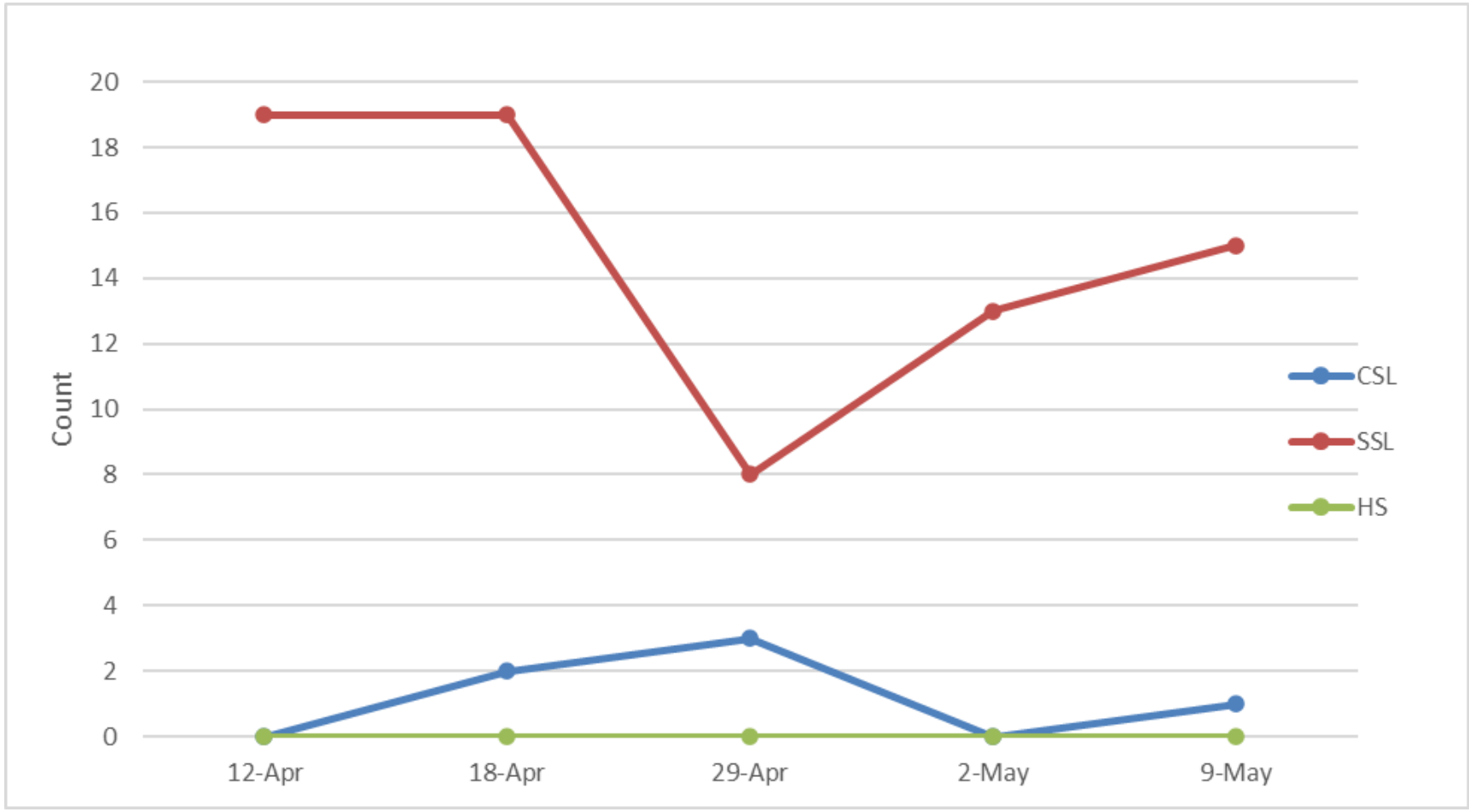


Figure 1. Weekly sea lion counts on the Columbia River between the Bonneville Dam tailrace and I-205 in Portland Oregon.

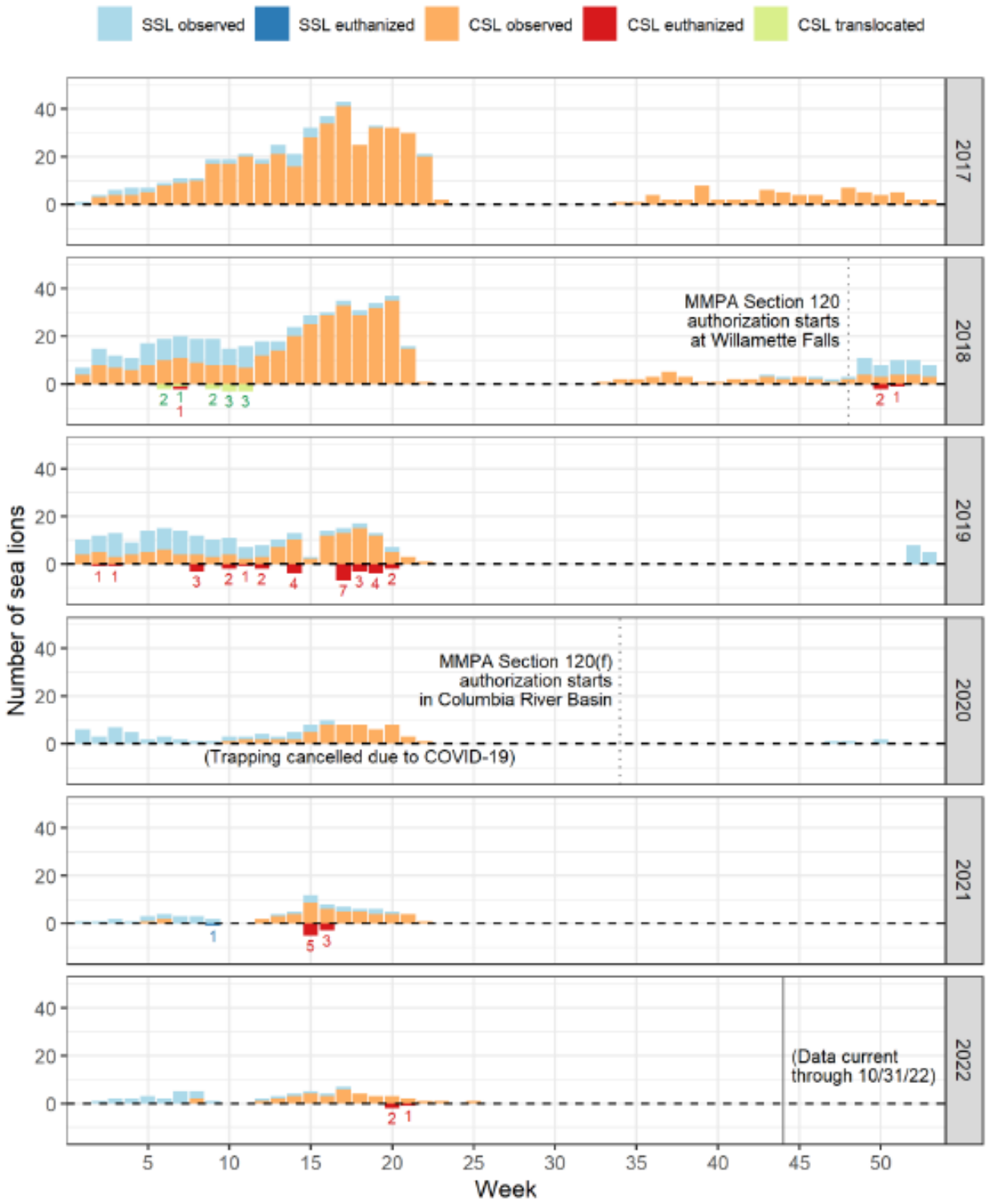
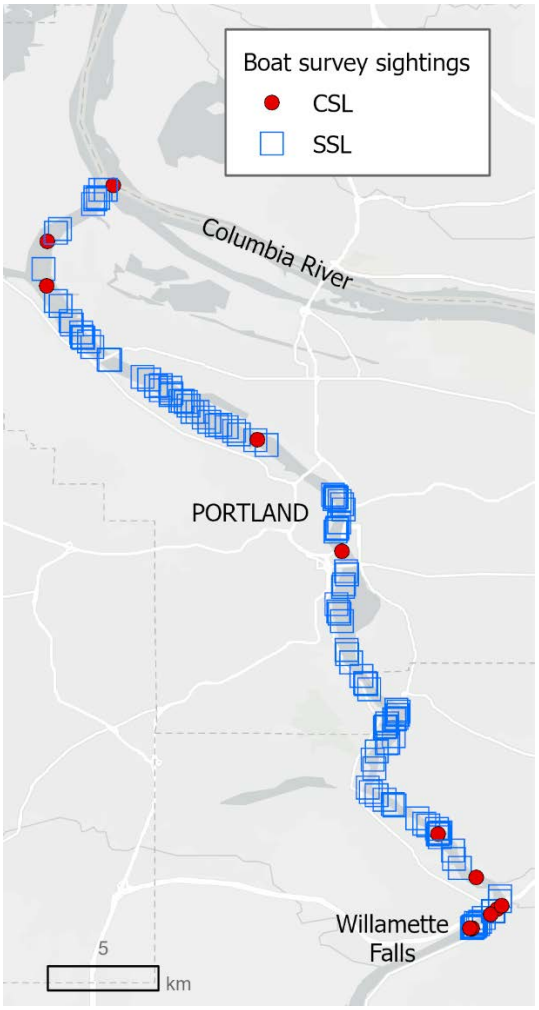


Figure 2. Weekly counts of California sea lions (CSL) and Steller sea lions (SSL) at Willamette Falls, 2017–2022. Non-mutually exclusive count categories include numbers observed, euthanized, or translocated. Observed counts represent the maximum daily count for a given week based on direct observations and/or automated cameras.



Date	Survey end location	CSL	SSL
2021-08-17	Columbia River		
2021-10-01	Columbia River		
2021-11-19	Columbia River		1
2021-12-03	Columbia River		5
2021-12-10	Columbia River		7
2021-12-17	Columbia River		7
2022-01-21	St. Johns Bridge		5
2022-01-28	Columbia River		10
2022-02-11	Columbia River		21
2022-02-14	Columbia River		30
2022-02-18	Multnomah Channel		21
2022-02-23	Columbia River		11
2022-03-01	Columbia River	1	1
2022-03-08	Columbia River		
2022-03-17	Columbia River		
2022-03-25	Columbia River	2	
2022-03-30	Columbia River	4	5
2022-04-08	Columbia River	1	5
2022-04-15	Columbia River	3	4
2022-04-22	Columbia River	3	2
2022-04-29	Columbia River	4	
2022-05-06	Columbia River	4	
2022-05-13	Columbia River		
2022-05-20	Columbia River	1	
2022-06-03	Columbia River		
2022-06-10	Columbia River	1	

Figure 3. Individual sighting locations (map at left) and total counts (table at right) for California sea lions (CSL) and Steller sea lions (SSL) observed during vessel-based surveys of the Willamette River beginning at Willamette Falls in Oregon City and proceeding downriver to the location noted in table.

ACKNOWLEDGEMENTS

We wish to acknowledge and thank all those who have, and continue to, cooperate in the conduct of this work:

- CRITFC: Paul Ward, Bob Lessard, John Whiteaker, Theodore Walsey, and Devayne Lewis.
- NMFS: Robert Anderson, Scott Rumsey.
- ODFW: Sheanna Steingass, Bryan Wright, Colin Gillin DVM, Julia Burco DVM, Shay Valentine, Zane Kroneberger, Eric Nass, Buddy Phibbs, Susan Riemer, Greg Davis and the Bonneville Hatchery staff, Chris Kern, David Fox.
- PSMFC: Dave Colpo, Sarah Kirk.
- USACE: Kyle Tidwell, Bjorn van der Leeuw, Andrew Derugin, Jeanette Wendler, Rebecca Cates, Jerry Carol, Mike Roth, Brian Smith, the Bonneville Rigging Crew, Patricia Madson, Karrie Gibbons, Robert Wertheimer, Nathan Zorich, Brett Carrothers, Kristen Bayley, and Lindsay Magill.
- USDA Wildlife Services staff.
- WDFW: John Edwards, Trever Barker, Coral Pasi, Katherine Haman DVM, Jeanne Ross DVM, Mark Drew DVM, Kessina Lee, Scott Pearson, Meagan West, Nate Pamplin.
- IDFG: Christine Kozfkay, Brian Mitchell DVM, Mike Howell DVM, Alex Stacy
- Safety and Security: Oregon State Police; Jeff Wickersham, Washington Department of Fish and Wildlife; and Jennifer Baker and Greg Webb, USACE.

Funding was provided by ODFW, WDFW, NMFS, and BPA. Activities were authorized under National Marine Fisheries Service (NMFS) Marine Mammal Protection Act §109(h) and §120(f).

LITERATURE CITED

Brown, M., B. Wright, S. Valentine, S. Riemer, Z. Kroneberger, E. Nass, J. Burco, and Colin Gillin. 2021. Annual report: pinniped management at Willamette Falls, 2021–2022. Oregon Department of Fish and Wildlife, Corvallis, Oregon.

Clark, C., M. Brown, D. Hatch, and J. Dupont. 2021. Final field report: 2017–2021 pinniped research and management activities at Bonneville Dam.

Lance, M. M. et al. 2001. Pinniped food habits and prey identification techniques protocol. AFSC (Alaska Fisheries Science Center) Proc. Rep. 2001-04, 36 p. Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, Seattle, WA 98115.

NMFS (National Marine Fisheries Service). 2008. Letter of Authorization. (https://media.fisheries.noaa.gov/dam-migration/sec-120-loa-2008.pdf)

NMFS (National Marine Fisheries Service). 2016. Letter of Authorization. (https://archive.fisheries.noaa.gov/wcr/publications/protected_species/marine_mammals/pinnipeds/June2016/6.28.16_mmpa_section_120_2016_loa_final.doc.pdf)

NMFS (National Marine Fisheries Service). 2019. Letter of Authorization. (https://archive.fisheries.noaa.gov/wcr/publications/protected_species/marine_mammals/pinnipeds/sea_lion_removals/2019/bonnevilledam_mmpa_sec_120_2016_revised_auth__aka_loa__to_states_4-17-19_final_bat_signed.pdf)

NMFS (National Marine Fisheries Service). 2020. Letter of Authorization. (https://media.fisheries.noaa.gov/dam-migration/109544641.pdf)

Schakner ZA, Buhnerkempe MG, Tennis MJ, Stansell RJ, van der Leeuw BK, Lloyd-Smith JO, Blumstein DT. 2016 Epidemiological models to control the spread of information in marine mammals. Proc. R. Soc. B 283: 20162037.

Scordino, J. 2010. West Coast Pinniped Program Investigations on California Sea Lion and Pacific Harbor Seal Impacts on Salmonids and Other Fishery Resources. Pacific States Marine Fisheries Commission, 205 SE Spokane Street, Suite 100, Portland OR 97202.

Stansell, R. 2004. Evaluation of pinniped predation on adult salmonids and other fish in the Bonneville Dam tailrace, 2002-2004. U.S. Army Corps of Engineers, Bonneville Lock and Dam, Cascade Locks, OR 97014.

van der Leeuw B.K. and K.S. Tidwell. 2022. Evaluation of pinniped predation on adult salmonids and other fish in the Bonneville Dam tailrace, 2021. U.S. Army Corps of Engineers, Portland District, Fisheries Field Unit. Cascade Locks, OR. 42 pp.

Wright, B., M. Brown, C. Owen, S. Valentine, Z. Kroneberger, E. Nass, and B. Phibbs. 2022. Annual report: pinniped monitoring at Willamette Falls, 2021-2022. Oregon Department of Fish and Wildlife, Corvallis, Oregon.

APPENDIX

Appendix 1. IACUC

Assurance of Animal Care and Use Form

IACUC Use Only

IACUC Number:
ODFW/WDFW/CRITFC/IDFG 2021-1
(Circle One)

Date Received: 08 20 2021

Initial Review Date: 08 20 2021
Second review:
Third review:

IACUC Training Complete: ☒

IACUC Recommendations: Approved: ☐ Not Approved: ☐

Withhold Approval Pending Modification ☐

Type of Submission: New ☐ Modification ☒
3-Year Renewal

IACUC Chair Signature: Casey Clark **Date:** 09 08 2021

Columbia River Predatory California and Steller Sea Lion Lethal Removal Section 120(f) Authorization Animal Care and Use Form

08 20 2021

A. Administrative Data

Project Title: Columbia River Predatory California and Steller Sea Lion Lethal Removal

Institutions: State of Washington, State of Oregon, State of Idaho, Columbia River Intertribal Fish Commission (representing: Nez Perce Tribe, Confederated Tribes and Bands of the Yakama Nation, Confederated Tribes of the Umatilla), Confederated Tribes of the Grand Ronde Community; Confederated Tribes of the Siletz Indians of Oregon, and the Confederated Tribes of the Warm Springs Reservation of Oregon

Principal Investigators: Casey Clark (WDFW- Acting Lead), Sheanna Steingass (ODFW), Douglas Hatch (CRITFC), Joe Dupont (IDFG), Robin Brown (Community Member At-Large)

Mailing Address: 7801 Phillips Rd SW, Lakewood, WA 98498

Telephone: 541-757-5245 **Fax:** 541-757-4252 **Email:** casey.clark@dfw.wa.gov

Initial Submission ☐ **Renewal** ☐ **or Modification** ▣

Project Title: Columbia River Predatory California and Steller Sea Lion Removal

Anticipated Start Date: September 1, 2021 **Anticipated End Date:** Ongoing

Duration of Approved Protocol: September 1, 2021 through May 16, 2024

Study Site(s) Location (or Where Animals Will Be Housed): Bonneville Lock and Dam, Willamette Falls (Willamette River), Columbia River main stem River Miles 112-292, Columbia River Tributaries

Other approved IACUC Animal Care and Use Assurance relating to this project:

Permits: Identify all relevant permits (Federal, State and other) necessary to conduct this project. Provide permit type(s), permit number(s), and expiration date(s). Please indicate if a permit application is pending a decision.

Permit Type	Permit Number	Expiration Date
NMFS Permit & Letter of Authorization		August 14, 2025
Oregon Fish & Wildlife Statutes	OARs	
Washington F&W Statutes	RCWs	

*The NMFS policy intends to comply with the **Animal Welfare Act** (AWA) - Title 7 of U.S. Code §2131 et. seq. and implementing regulations and adhere to the principles of the **U.S. Government Principles** for the Utilization and Care of Vertebrate Animals Used in Testing, Research, and Training (USGP) and follow the guidelines in the National Research Council **Guide for the Care and Use of Laboratory Animals.***

B. Justifications

This is a request to establish new Approved Protocols contained in the Assurance of Animal Care and Use (AAC&U) Form with IACUC Number ODFW, WDFW & IDFW 2021-1 entitled "Columbia River Predatory California and Steller sea lion Removal" dated 31 August 2021.

In accordance with USGP #2, "Procedures involving animals should be designed and performed with due consideration of their relevance to human or animal health, the advancement of knowledge, or the good of society."

1. Research Goals:

a. What are the scientific issues addressed by the research? Specifically, how will this research improve human or animal health or advance knowledge?

Predatory California and Steller sea lions foraging for salmonids, sturgeon, lamprey, and other species in the Columbia River below Bonneville Dam are having a significant negative impact on the recovery of populations of threatened and endangered (T&E) fish populations. This action, as permitted by 2020 Amendments to the Marine Mammal Protection Act, will reduce predator-associated mortality of fish stocks from depleted or ESA-listed populations. In particular, salmonids attempting to pass fishways to reach upriver spawning areas are subjected to bottleneck effects as they stage below upriver obstacles or attempt to pass through fish ladders. The objective of this work is to remove a number of upriver, habituated individual California and Steller sea lions from a large, robust, and healthy populations to protect T&E salmonids, lamprey, and sturgeon, many from very small and highly at-risk populations. This management tool was provided to the states by the U.S. Congress in Section 120 of the MMPA, as originally amended in 1994. This current management authorization was granted the states by the Dept of Commerce, NOAA-NMFS under a Permit and Letter of Authorization (LOA) dated August 14, 2020, providing authorization for a duration of five years until August 14, 2025.

b. What are the specific goals of the animal studies described in this protocol?

The goal of this work is to reduce pinniped predation on T&E salmonids, and populations of lamprey, sturgeon, and other at-risk stocks in the lower Columbia River (River Mile 112 to River Mile 292) and its tributaries to aid in the recovery of these fish populations. This will be accomplished by lethally removing California and Steller sea lions in these areas. After pinnipeds are captured and euthanized, numerous biological samples (e.g., GI tracts, blood, tissues, organs, teeth) will be collected for a variety of scientific study purposes including food habits analyses, histology, and studies of pathogens and disease as per Task Force recommendation (See Letter of Authorization, 14 Aug 2020).

2. Explain why animal studies are preferred to non-animal alternatives in achieving these research goals.

The permanent removal of these predatory sea lions is required to achieve the objective of protecting fish stocks in the Columbia River and its tributaries. Multiple years of capture and transport, capture and holding, and all other non-lethal tools currently available have been shown to be statistically and biologically ineffective in reducing pinniped predation in these areas.

In accordance with the Animal Welfare Act – "…the principal investigator has provided written assurance that the activities do not unnecessarily duplicate previous experiments."

3. Does this research duplicate previous experiments? ☐ YES ☒ NO

If YES, please explain why this duplication is necessary. N/A

4. Do the animal procedures planned for this research involve only simple field observation with no impact on either the animals or their environment? (e.g., aerial surveys, brand or tag resighting, focal "animal" follow, vessel surveys)

☐ YES ☒ NO

If YES, it is not necessary to complete the informational sections of this protocol form. Instead, answer the following:

Use Appendix A to describe the study activities. Include all precautions to ensure no adverse impact on the study animals and their environment.
Include copies of any required permits.
Sign this form under Section H

If NO, the remainder of this form must be completed. Complete Appendix A for observational studies and then proceed to the next section.

In accordance with the USGP #3, "The animal selected for a procedure should be of an appropriate species and quality and the minimum number required to obtain valid results."

5. List the research species (and stock) and describe why is the most appropriate species to use in these studies:

California sea lions (*Zalophus californianus*), U.S. Stock; Steller sea lions (*Eumetopias jubatus*). The relatively small number of adult and sub-adult male sea lions present within the management zone of the Columbia River are responsible for significant mortalities of adult salmonids, sturgeon, and lamprey below Bonneville Dam, Willamette Falls and other sites along the lower Columbia River and its tributaries (Tidwell et al. 2019, Rub et al. 2019, Falcy 2017). Removal of predatory sea lions in this area will permit more salmonids to reach upriver spawning areas contributing to the recovery of these T&E fish populations, prevent predation on other fish stocks, and reduce the numbers of animals annually recruiting to bottleneck sites where fish are especially vulnerable.

6. How many animals do you plan to use for the protocol? Please provide a justification for the numbers of animals used (e.g., statistical power, survey, etc.).

The NMFS Bonneville Pinniped-Fishery Interaction Task Force set the maximum lethal removal number for this project to be 540 California sea lions and 176 Steller sea lions over the 5-year period of the permit. These management actions will not exceed 10% of the potential biological removal (PBR) levels for either species.

Complete the following table below to define the numbers(s) of animal(s) to be used in each category and type procedure(s). Use the following animal welfare categories:

Category (adapted from AWAR):

B: Applies only to animals held captive in non-research status (display, rehabilitation, brood stock, holding).

C: Applies to little or momentary pain or discomfort

D: Applies to potential discomfort or pain which is relieved by the appropriate anesthetic or analgesic

E: Applies to discomfort or pain which is not relieved thus requires written justification and full IACUC (must consider the 3 R's)

Species (Common Name)	**Age/Sex**	**Category C (List Procedure)**	**Category D (List Procedure)**	**Category E (List Procedure)**	**Total # of animals needed for duration of project**
California sea lion (*Zalophus californianus*)	Adult males, subadult males	A maximum of 540 during the study period, minor pain or discomfort during trapping and transport to work facility. or trapping and release at site of capture	A maximum of 540 individuals during the study period, chemically anesthetized and euthanized	N/A	540 maximum
Steller sea lion (*Eumetopias jubatus*)	Adult males, subadult males	A maximum of 176 during the study period, minor pain or discomfort during trapping and transport to work facility, or trapping and release at site of capture.	A maximum of 176 individuals during the study period, chemically anesthetized and euthanized.	N/A	176 maximum

In accordance with the AWA: "The principal investigator has considered alternative to procedures that may cause more than momentary or slight pain or distress to the animals, and has provided a written narrative description of the methods and sources (e.g., the Animal Welfare Information Center) used to determine that alternative were not available…."

7. If you have placed any animal numbers in categories D and E, you must complete the following (use Appendix B if additional space is necessary)

a. Explain why the pain or discomfort cannot be relieved and what procedure will be used to minimize discomfort.

SECTION I: CAPTURE VIA TRAPS AND SUBSEQUENT EUTHANASIA

Capture and handling of pinnipeds by use of floating traps, transfer cages, and squeeze cages result in no pain and very little physical discomfort to pinnipeds included in this work. California and Steller sea lions that are to be euthanized are given appropriate primary (e.g., Telazol) and/or secondary (e.g., Telazol, Midazolam, Xylazine, or Medetomidine) doses of anesthetic (e.g., Telazol, Xylazine) via direct injection (syringe or jabstick) to be administered to the animal in the squeeze cage or transfer cage. Animals are to be in late Stage 3 anesthesia as defined by the AVMA (i.e., surgical or deep anesthesia characterized by loss of blink reflexes, shallow breathing) prior to euthanasia and verification of death. A secondary means of euthanasia may be required if death cannot be verified, and is given via approved chemical or physical means (e.g., sodium pentobarbital (Euthasol), potassium chloride or overdose of an anesthetic, or captive bolt). The licensed veterinarian on site shall use discretion to choose the AVMA-approved euthanasia method most appropriate to the circumstances (with the exception of gunshot, which is prohibited for this work). Monitoring devices and physical exam findings should be used to confirm cessation of respiratory and cardiac function, thus verifying death.

Method	**Tools**
Secondary euthanasia method*	Pentobarbital IV IC/ IV potassium chloride Captive Bolt Exsanguination
Monitoring devices	Doppler unit EKG

*All of these secondary methods of euthanasia should only be performed when then animal is completely unconscious and unresponsive.

SECTION II: IMMOBILIZATION AND REMOVAL VIA DARTING
Darting will be used when appropriate as a method for immobilizing and capturing pinnipeds under the Marine Mammal Protection Act Section 120(f) authorization, and

subsequent NMFS authorization (14 Aug 2020). The following methodologies for darting, immobilization, handling, and subsequent humane euthanasia are designed with an emphasis on maximizing human and animal safety. Protocols will reflect best scientific methodologies for darting, handling, and immobilizing pinnipeds, as well as safety considerations for other wildlife, people, or pets that may encounter the carcass of a darted animal or a partially injected dart. Darting is to be method of lethal removal secondary to trapping efforts and would be used in situations where trapping is not a practical or effective means of capture, and darting is deemed appropriate by all Eligible Entities (See Section 120(f) Letter of Authorization, 14 Aug 2020).

Darting of animals under MMPA Section 120(f) authority is to be utilized specifically for permanent removal efforts related to sea lion management in relation to conservation of fisheries species in the Columbia River Basin management area. Darting methods in this protocol do not include animals handled under state MMPA Section 109(h) authorization. Darts with tracking capabilities (e.g., acoustic, VHF) may be used, within consideration for the ultimate outcome of darting, including best effort to retrieval of the dart and/or the darted animal

The specific methods proposed for darting activities are as follows:

Pre-Darting Monitoring and Assessment
Animals residing in removal areas may be evaluated remotely or in person to determine patterns of behavior to increase the probability of success. This could include situational assessment, remote monitoring by camera, UAV, or in-person resights to confirm predictability of behavior and hauling out at the site of management.
Dart Application
During darting, at least two boats and five staff will be present. One person not operating each vessel will be designated to visually track the animal. If beneficial, one or more additional staff members may be present on shore to monitor the animal from land.
Each darting attempt will include at least one veterinarian on staff, and a designated veterinarian or another qualified, experienced darter may conduct the darting attempt. All staff handling drugs, darts, or applying remote delivery of anesthetics will be trained, certified, and approved under their agency capture and immobilization training and policy. Primary preference is to first dart the animal while it is hauled out. Animals will be darted using an appropriate dart delivery system depending on individual scenarios. Animals will be darted with an appropriate dose using a combination of Midazolam-Butorphanol-Medetomidine (Frankfurter et al. 2016, Haulena 2007).

Post-Darting Monitoring
After an animal is darted, it will be observed for anesthetic effect leading to induction, and tracked at an appropriate distance for safe and rapid retrieval to secure and transport the animal for subsequent euthanasia.
Handling and Euthanasia

Nets, donut poles (a pole with a round section of PVC attached), noose poles, Shepherd's hooks or other similar tools may be used to secure the animal or retain the animal in the direct management area.
Once the animal displays signs of full induction on land or water (i.e., non-responsiveness to direct stimuli, bubble blowing, and/or aimless swimming or treading water), it will be approached and secured in a manner that allows for controlled administration of euthanasia as per existing IACUC protocols for sea lion management. After the animal has been secured, it may be euthanized in the field by the attending veterinarian[1], or transported to a secure facility for euthanasia, necropsy, and disposal.
Documentation and Reporting
Documentation will be collected of all darting attempts, including (but not limited to): managing parties initiating the darting activity; veterinary staffing; gun and dart type; drug combinations; animal reaction to anesthesia and ultimate results; means of physical immobilization, handling, and euthanasia; and a recap of efforts with notes for improvement or debriefing before future attempts. A report regarding the removal effort will be filed to NMFS within 72 hours as per MMPA Section 120(f) requirement.

b. What informational methods and resources did you use to determine that (no-animal or non-painful) alternative were not appropriate for this research?

Include the databases that were searched (include keywords used).
Include literature citations
Include meetings with knowledgeable individuals (name, date)
Include other methods/resources

Beginning in the early 2000s, the number of California, and subsequently Steller sea lions observed foraging for salmonids below Bonneville Dam has increased annually (along with the number of salmonids, lamprey and sturgeon killed by these predators). Beginning in 2005, through 2008, the States of Oregon and Washington used all available non-lethal tools, at increasing levels of intensity, in efforts to non-lethally deter California sea lions from foraging at this location. Over that period and to this date, non-lethal hazing has proven to be ineffective at deterring CSL and reducing their predation rates on salmonids at this site (Brown et al. 2008, Annual Report on Field Activities at Bonneville Dam, Willamette Falls Task Force Meeting 2018). Known individual California sea lions observed killing salmonids below Bonneville Dam exposed to significant hazing efforts continue to kill salmonids and return to this area to forage year after year, despite ongoing hazing efforts by USACE. As a result of the failure of effective non-lethal tools to reduce predation, and at the recommendation of the NMFS Pinniped-Fishery Interaction Task Force, NMFS has issued a Permit & Letter of Authorization to the states and tribes for lethal removal of California and Steller sea lions between River Mile 112 and 292 in the Columbia River and Columbia River Tributaries, under certain outlined criteria and methodologies.

[1] Mortality can be confirmed via several methods including the following: (1) lack of vital signs (heartbeat, respiration measured manually); (2) lack of retinal responsiveness; (3) lack of intraocular Doppler signal; (4) lack of cardiac activity via EKG monitor, or other (5) AVMA-approved methodologies.

LITERATURE CITED I

Dennison S, Haulena M, Colette-Williams D, Dawson J, Yandell BS, Gulland FMD. 2008. Determination of a sedative protocol for use in California sea lions (*Zalophus californianus*) with neurologic abnormalities undergoing electroencephalographic examination. *Journal of Zoo and Wildlife Medicine*. 39(4): 542-547.

Haulena, M. 2007. *In:* Zoo Animal and Wildlife Immobilization and Anesthesia. G. West, D. Heard, and N. Caulkett (eds)., Blackwell Publishing, Ames. Pp. 469-478.
Spelman L. 2004. Reversible anesthesia of captive California Sea Lions (*Zalophus californianus*) with medetomidine, midazolam, butorphanol, and isoflurane. *Journal of Zoo and Wildlife Medicine*. 35(1): 65-69.

Falcy M. Population viability of Willamette River winter steelhead: An assessment of the effect of sea lions at Willamette Falls. *Oregon Department of Fish and Wildlife*, Corvallis. 2017.

Frankfurter G, E DeRango, S Johnson. "Use of acoustic transmitter-equipped remote sedation to aid in tracking and capture of entangled California sea lions (Zalophus californianus)." *Journal of wildlife diseases* 52.3 (2016): 730-733.

Haulena, M. "Otariid seals." *Zoo animal and wildlife immobilization and anesthesia* 2 (2007): 661-72.

Tidwell KS, Van der Leeuw BK, Magill LN, Carrother BA, Wetheimer RH, Bayley KN. Evaluation of Pinniped Predation on Adult Salmonids and Other Fish in the Bonneville Dam Tailrace: 2017. *US Army Corps of Engineers, Bonneville Lock and Dam*; 2019 Jan 24.

Wargo Rub AM, Som NA, Henderson MJ, Sandford BP, Van Doornik DM, Teel DJ, Tennis MJ, Langness OP, van der Leeuw BK, Huff DD. Changes in adult Chinook salmon (Oncorhynchus tshawytscha) survival within the lower Columbia River amid increasing pinniped abundance. *Canadian Journal of Fisheries and Aquatic Sciences*. 2019;76(10):1862-73.

C. Experimental Procedures

1. General Procedures. ***(Detail research procedures in Appendix A)***

In accordance with the AWA, "Procedures that may cause more than momentary or slight pain or distress to the animals will a) be performed with appropriate sedatives, analgesics, or anesthetics unless withholding such agents is justified for scientific reasons in writing by the principal investigator and will continue for only the necessary period of time; b) involve in their planning, consultation with the attending veterinarian…, c) not include the use of paralytics without anesthesia…"

Capture, Samples, and methods of collection

Sample Type	Collection method	Sample size	Number of animals
None	Trap, barge, and euthanize	Up to 540 CSL, 176 SSL during study period	Up to 540 CSL, 176 SSL during study period
Entire carcass	Trap, barge, and euthanize identified and authorized animal	Up to 540 CSL, 176 SSL	Up to 540 CSL, 176 SSL
Blood from deceased animals	Syringe	As needed	Up to 540 CSL, 176 SSL
Tissues, organs, skeletal remains	Necropsy and pathological/ histological preparation	Samples of tissues from major organs and tissue types; Multiple samples from up to 540 CSL, 176 SSL	Up to 540 CSL, 176 SSL
Hide, organs, muscle, skeletal remains	As needed for subsistence use by qualifying recipient tribe	As needed	Up to 540 CSL, 176 SSL

2. Animal Restraint

Physical (*Describe method, duration, equipment used)*

CAPTURE VIA FLOATING TRAPS

For full darting methodologies, please see section above

Sea lions are captured on a floating trap used by animals for a resting area. Traps are locked open (unarmed) when staff are not present or weather conditions (excessive heat, cold or precipitation) prohibit a safe working environment to prevent accidental or unintended trapping which could result in injuries or mortality to animals. Trap doors are closed by a magnetized remote release system (TrapSmart™, SkyHawk™, or similar mechanized system) by team members within line of sight of traps and animals. Tarps are lowered around the seven-foot chain-link walls of the trap to calm animals and reduce visual stimuli. Animals may be moved between traps via an enclosed chain-link tunnel system and either retained or released. Animals that are to be transported and removed are herded or allowed to move freely from the trap into a transfer cage that is tall enough for the animals to walk into on a handling barge. In rare cases sea lions that are not possible to move either due to size (i.e., over 1500lbs) or behavior may be chemically immobilized in the trap, removed mechanically by crane or winch, and placed in a transfer cage and moved by vehicle to the designated work area for processing. Animals are transported via barge and transfer cage, then subsequently into a transfer cage on the back of a vehicle to the work area for processing. Chemical immobilization will take place by use of a jab pole or blow dart – whichever can be most safely administered- to deploy a dose of immobilizing drugs (i.e., Telazol-see chemical restraint table). At the work site, live sea lions are restrained in a squeeze cage at the work area where injectable or gas anesthesia or sedation and euthanasia are administered (see chemical restraint table). A variety of biological samples are collected from each euthanized animal prior to disposal or transfer of the carcass to tribal co-managers.

b. Chemical

Anesthetics and Analgesics:

If anesthetics or analgesics are to be used, please provide the following information: procedure, anesthetic, recommended starting dose and method of administration

Procedure	**Anesthetic***	**Recommended Starting Dose (to effect) & Method of Administration**	**Intervention**
Anesthesia	Telazol, or generic	IM injection 1-4 mg/kg	N/A
Anesthesia	Telazol Ketamine	1-4 mg/kg IM 0.5-1.0 mg/kg IM	N/A

	Xylazine, or generic	0.5-1.0 mg/kg IM	
Anesthesia	Telazol Xylazine, or generic	1-4 mg/kg IM 1-2 mg/kg IM	N/A
Anesthesia	Isoflurane gas	Cone / mask induction and maintenance at 3-5% saturation.	N/A
Anesthesia	Medetomidine Ketamine, or Xylazine	140 μg/kg IM 0.5-1.0 mg/kg IM 0.5-1.0 mg/kg IM	N/A
Anesthesia	Midazolam-Butorphanol-Medetomidine combination	0.2-0.26 mg/kg Midazolam 0.2-0.4 mg/kg Butorphanol 10-13 μg/kg Medetomidine IM	N/A
Sedation	Diazepam	0.1-0.2 mg/kg IM	N/A
Sedation	Midazolam	0.15-0.2 mg/ kg IM	N/A

*Those drugs that pose the lowest risk to human safety will be considered first for this work, at the discretion of the veterinarian on site.

3. **Marking and Instrumentation** ***(Describe mark or tag type, or instrument type to be used. Provide mass of attachment device, range of body mass of study animal, device mass a proportion of body mass and the recommended device mass as a percent of body mass)***

Tag or Instrument	**Size (dimensions & mass)**	**% of body mass**	**Attachment Method**
Duflex flipper tag	2.25x7/8" 5g	(<<1.00%)	Punch
Branded Digits	5" lettering	N/A	Hot Iron Brand

In accordance with AWA: "Activities that involve surgery include appropriate provision for pre-operative and post-operative care of the animal in accordance with established veterinary medical and nursing practices. All survival surgery will be performed using aseptic procedures, including surgical gloves, masks, sterile instruments, and aseptic techniques."

4. Surgical Procedures – Is surgery to be performed? ☐ YES ▣ NO

a. If YES, list surgery location/room:
b. If YES,

i. is it a terminal procedure? ☐ **YES** ☐ **NO**

ii. is it a survival procedure? ☐ **YES** ☐ **NO**

c. If YES, then describe the surgical procedure to be performed in Appendix A. Be sure to include the protocol to be followed to ensure asepsis.

d. If aseptic procedures are not to be performed, use this space below to justify why not and describe the procedure of choice.
e. Describe the post-operative care (both immediate and long-term).

5. Injury to animals – Accidental injuries which might occur to animals during handling (Describe the most likely injuries which might occur to research animals, how frequent injuries are expected and planned procedures to treat injuries.)

Possible injuries to CSL that will be euthanized, held, or released include minor scrapes, abrasions, and bites during the trapping and marking operations (Appendix A). This type of superficial injury may occur in up to 10% of animals handled during any trapping and/or marking operation. Traps are locked (disarmed) open when not in use to prevent accidental or unintended trapping which could result in injury or mortality. When traps are open, at least three staff will be available and in the area in case emergency response is needed. Animals being held or transported are monitored for physiological distress and continually cooled with pumped water to prevent overheating in warm conditions.

6. Euthanasia – All methods of euthanasia must follow the American Veterinary Medical Association Guidelines for the Euthanasia of Animals: 2013 Edition. (2013, 102 pp). Any deviations must be scenically justified. Even if you do not intend to euthanize animals as part of the project, a method of euthanasia must be listed in case of emergency. (Describe agent, dose, and route of administration).

-Will the animals be terminated if severely injured during handling?

☒ YES ☐ NO

-Will animals be terminated as part of handling protocol

☒ YES ☐ NO

If YES, provide the method of euthanasia and disposal of animal upon completion. If NO, provide method of euthanasia in case of emergency.

Method	**Recommended Starting Dose (to effect) and Method of Administration**	**Disposal**
Pentobarbital sodium	IV 60-120 mg /kg or 1ml/4.5 kg (10-20 lbs) BW to effect	Incineration or burial*
Potassium Chloride	IV, IC 75 -150 mg/kg [34.1 to 68.2 mg/lb] BW	Rendering facility, incineration or burial*
Overdose of anesthetic	Recommended starting dosages on previous page, Table of Anesthetics	Rendering facility, incineration or burial*
Captive Bolt	Administered to cranium	Rendering facility, Incineration or burial*

**Disposal method selected based on method of euthanasia, agreement with facility and/or federal guidelines. Tribal co-managers may request use of the carcass or parts of the carcass for traditional use purposes. This will occur on a case-by-case basis, and a database will be maintained regarding the disposition of samples used for research and traditional use.*

Please consult NMFS Research Protocol Guidelines (TBD) for acceptable practices. (AVMA Guidelines, AAZV Guidelines, etc.)

In accordance with the AWA, "Personnel conducting procedures on the species being maintained or studied will be appropriately qualified and trained in those procedures."

7. Training

Please describe below the training and qualifications of yourself and other individuals who are included in this protocol. In particular, please be very specific about the hands-on training of those individuals performing procedures which may produce animal discomfort (i.e., restraint, injections, blood collection, surgery, tagging, biopsy, tooth extraction, urine, fecal, gastric, milk, semen, sample collection, euthanasia, etc.). Use Appendix B to further describe training and experience.

The state program leaders and veterinary staff directing this work have at more than 20 years combined experience in capturing, handling, and marking pinnipeds from California to Alaska (Appendix B). This experience includes a wide variety of methods and equipment for accomplishing this work. All euthanasia procedures will be conducted and overseen by licensed agency veterinarians. Program leaders have extensive experience performing necropsies and collecting biological samples of all types. All ODFW and WDFW project support staff have multiple years of direct experience in pinniped capture, handling, marking, necropsies, and biological sample collection. Several support staff and veterinarians have worked on this project since its inception providing extensive experience related to procedures and methodologies described herein. All support staff were trained directly by the state program leaders and several have had additional experience with similar programs conducted in other areas.

Each year, staff involved in handling or managing animals in the field are required to complete an in-person (or virtual) training by their Program Leaders that includes considerations for animal handling safety, euthanasia, and psychological effects staff may experience in relation to euthanasia of wildlife. They also are required to read a material packet regarding the ethical use and treatment of animals and wildlife in research.

D. Husbandry Practices (In Laboratory and Field)

Temporary holding (period greater than 1 hour and less than 24 hours)
Long-term holding (periods greater than 24 hours)
(Describe holding facilities or equipment, i.e., pens, cages, nets ,shade, water, etc.)

1. Will the research require holding the animals in captivity? ☒ YES ☐ NO

2. If YES, describe the husbandry practices that will be used.

Sea lions to be lethally removed or permanently placed under human care in a NMFS-approved facility may be held in transfer cages or a specially built trailer for up to 48 hours. In the case of permanent placement, the purpose for holding is to perform a veterinary health assessment and transfer the animal alive to an approved placeholder facility for quarantine. In the case of lethal removal, animals may be held overnight prior to euthanasia. In both cases, animals are held in a secure area and monitored with access permitted only to authorized staff. The holding area is temperature-controlled and with light adjusted as appropriate. Requests for animals for permanent holding are facilitated by federal partners, the interim holding facility (local aquarium or zoo), and the approved permanent holding facility (aquarium or zoo).

3. If YES, describe procedures for disposition of dead animals, including whether or not a necropsy will be performed.

Necropsies and biological sample collection are performed on all sea lions that are euthanized. Multiple biological samples are archived, cataloged, and can be made available to external collaborators or researchers for study and analyses as appropriate, via proper permitting and sample use agreements completed by the requesting party. Carcasses (minus biological samples, GI tracts, and skulls) will be transported to a rendering plant for disposal, transferred to tribal co-managers, incinerated, or buried via landfill.

4. Will the animals be removed from the facility? ☒ YES ☐ NO

a. If YES, for how long?

For the life of the animal.

b. If YES, to where?

Occasionally live California or Steller sea lions may be made available to permanent holding facilities in the U.S. at the request of the facility and with the approval of NMFS.

c. If YES, will they be returned to the facility? ☐ YES ☒ NO

d. If NO, why not?

California and Steller sea lions on the approved removal list will either be euthanized at the project work facility or will be transferred to a permanent holding facility and will not be returned to the project or released into the wild.

E. Environmental Safety

1. Are infectious agents to be used and is there potential for exposure?

☐ YES ☒ NO

If YES, the agent(s) is…
If YES, is the agent infectious to humans?

2. Are chemical hazards to be used?

☐ YES ☒ NO

If YES, the chemical hazard is…

3. Are radioisotopes to be used? ☐ YES ☒ NO

If YES, the radioisotope is…

Are there other biohazards of concern like exposure to zoonotic agents?

☒ YES ☐ NO

IF YES, the biohazard(s) is…

A range of diseases that naturally occur in the CSL population, including bacterial and viral agents. Some of these are potentially zoonotic:

Leptospira spp., found primarily in urine samples
Brucella pinniipedialis, B. ceti, Brucellosis
Bisgaardia hudsonensis, seal finger
Mycoplasma phocacerebrale, M. phocarhinis, M. phocidae, mycoplasmosis
Calicivirus, San Miguel sea lion virus, seal finger
Parapoxvirus, seal finger
Mycobacteriia marinum, M. pinnipedii, Mycobacteriosis
Erysipelothrix insidiosa, Erysipeloid
Coxiella burnetti
Toxoplasma gondii, Toxoplasmosis
Ajellomyces dermatiditis, Blastomycosis
Lacazia lobio, Blastomycosis
Influenza A

Note – If any of the above questions are answered YES, all procedures must comply with NMFS Environmental Safety requirements (TBD).

F. Use of Controlled and/or Prescription Substances (*Source, arrangements for use, ordering, record keeping, storage and precautions taken to avoid unauthorized access)*

Drugs for animal sedation and euthanasia are administered by licensed state veterinarians for this project. They acquire the drugs and maintain a record of purchase, storage, use and disposal of all drugs used.

G. Occupational Health and Safety

Awareness of potential stress disorders in project staff resulting from participation in lethal sea lion removal work under MMPA Section 120 authorizations.

Employees involved with the repeated euthanasia of apparently healthy, live animals can suffer from work-related stress. Studies of these phenomena have shown the negative effects on employee mental health can include compassion fatigue, burnout, traumatic or chronic stress, subconscious fears or anxieties, the general hardening of emotions, depression, and the development of unhealthy coping mechanisms (e.g., substance abuse) (See Literature Cited 1-9, Below).

We aim to be aware of potential issues that may arise related to the experiences of our employees.

Prior to the initiation of work each season, our project leaders and veterinary staff will discuss with all management staff the importance of demonstrating respect and ethical treatment of the animals that we capture, handle and ultimately may euthanize as part of project operations. These cautions and sensitivities will be repeated through the season as appropriate and needed.

An annual in-person or virtual training for all project personnel that discusses animal welfare and the concept of euthanasia. The training describes the effects of handling and anesthesia on wildlife and prioritizing the animal's state of wellbeing in all stages of capture, handling, and euthanasia. Another section of this training discusses PITS (perpetuation-induced traumatic stress), compassion fatigue or burnout, and state and agency employee assistance resource programs available to staff.

Conversations will be conducted before, during and after the season to address the need for all staff to be aware of any possible negative feelings or responses that might result from this work, particularly as a result of the acts of euthanizing and processing (performing necropsy and disposing of) the animals.

Additionally, we will encourage staff to feel comfortable discussing concerns with supervisors. Staff, supervisors, or crew leads are not to diagnose themselves or others, but are encouraged to seek professional medical or counseling assistance if they feel they (or staff working on the project) are affected by PITS (perpetuation-induced traumatic stress), compassion fatigue or burnout related to project activities.

State agency Human Resources and Safety Programs for information on exposure of staff to PTSD is also available as a resource to staff.

Concerns or other discussions by staff related to work performance and production, and employee attitude toward the work and sense of overall wellbeing should be directed to managers or crew leads. Staff will be provided appropriate options for addressing any concerns or health needs as a result of field operations, including reminders of how to

access specific health resources including the Oregon and Washington Employee Assistance Programs (EAPs).

Resources:
Oregon
https://www.oregon.gov/dcbs/RightStart/Pages/EAP.aspx
https://inside.dfw.state.or.us/safety/wellness.asp

Washington
https://des.wa.gov/services/hr-finance/washington-state-employee-assistance-program-eap
http://inside.dfw.wa.gov/employees/wellness/stress.html

LITERATURE CITED II

American Association for Laboratory Animal Science. Compassion Fatigue: The Cost of Caring. 2020 [Accessed 3 Mar 2020]. Available from: https://www.aalas.org/education/educational-resources/cost-of-caring

American Veterinary Medical Association. Work and Compassion Fatigue [Internet]. 2020 [Accessed 31 Mar 2020]. Available from: https://www.avma.org/resources/wellbeing/work-and-compassion-fatigue

Arluke A. Coping with euthanasia: a case study of shelter culture. Journal of the American Veterinary Medical Association. 1991 Apr 1;198(7):1176.

Bennett P, Rohlf V. Perpetration-induced traumatic stress in persons who euthanize nonhuman animals in surgeries, animal shelters, and laboratories. Society & Animals. 2005 Jan 1;13(3):201-20.

Mathieu F. Running on Empty: Compassion Fatigue in Health Professionals [Internet]. 2007 [Access 31 Mar 2020]. Available from: http://www.compassionfatigue.org/pages/RunningOnEmpty.pdf

MacNair R. Perpetration-induced traumatic stress: The psychological consequences of killing. Greenwood Publishing Group; 2002.

Penix EA, Whitmer DL, Thomas JL, Wilk JE, Adler AB. Behavioral health of US military veterinary personnel deployed to Afghanistan. Journal of the American Veterinary Medical Association. 2019 Feb 15;254(4):520-9.

Pierce J. Animal Euthanasia and Traumatic Stress: An Unexplored Area of Suffering? [Internet]. 15 October 2013 [Accessed 14 Mar 2020]. Available from: https://www.psychologytoday.com/us/blog/all-dogs-go-heaven/201310/animal-euthanasia-and-traumatic-stress

Whiting TL, Marion CR. Perpetration-induced traumatic stress—A risk for veterinarians involved in the destruction of healthy animals. The Canadian Veterinary Journal. 2011 Jul;52(7):794.

G. Training on Animal Care and Use

Have you and all of the personnel listed in the table below as investigators completed Training Module 1 of the AFSC/NWFSC Animal Care and Use Training Program?

☒ YES ☐ NO

If **NO**, you must complete this Training Module before the IACUC will consider this Animal Care and Use Assurance Form.

Animal Welfare Act IACUC Training Module 1

List all the names and telephone numbers of personnel associated with this project and identified in this protocol who will work with animals or animal tissue. Check the appropriate box to indicate whether or not each individual has completed the NMFS Animal Care and Use Training Program.

IACUC Training	Name	Affiliation	Phone	Email
☒Y ☐N	Casey Clark	WDFW	206-503-4244	casey.clark@dfw.wa.gov
☒Y ☐N	Sheanna Steingass	ODFW	541-257-7118	sheanna.m.steingass@odfw.oregon.gov
☒Y ☐N	Michael Brown	ODFW	971-707-1764	michael.l.brown@odfw.oregon.gov
☒Y ☐N	John Edwards	WDFW	360-280-2155	john.edwards@dfw.wa.gov
☒Y ☐N	Bryan Wright	ODFW	541-757-5225	bryan.e.wright@odfw.oregon.gov
☒Y ☐N	Shay Valentine	ODFW/PSMFC	360-789-2627	shay.w.valentine@odfw.oregon.gov
☒Y ☐N	Bradley Triplett	ODFW	971-673-6018	bradley.z.triplett@odfw.oregon.gov
☒Y ☐N	Zane Kroneberger	ODFW	928-814-6265	zane.p.kroneberger@odfw.oregon.gov
☒Y ☐N	Buddy Phibbs	ODFW	541-602-0240	buddy.r.phibbs@odfw.oregon.gov
☒Y ☐N	Colin Gillin	ODFW (Vet)	541-231-9271	colin.m.gillin@odfw.oregon.gov
☒Y ☐N	Julia Burco	ODFW (Vet)	541-207-7305	julia.d.burco@odfw.oregon.gov
☒Y ☐N	Katherine Haman	WDFW (Vet)	360-902-2832	katherine.haman@dfw.wa.gov
☒Y ☐N	Brian Mitchell	IDFG (Vet)	208-995-3993	brianmvet@gmail.com
☒Y ☐N	Mike Howell	IDFG (Vet)	425-754-5922	mike@evergreenequinevet.com
☒Y ☐N	Dyanna Lambourn	WDFW	253-208-2427	dyanna.lambourn@dfw.wa.gov
☒Y ☐N	Elliot Johnson	WDFW	916-580-4923	elliot.johnson@dfw.wa.gov
☒Y ☐N	Trever Barker	WDFW	360-609-8128	trever.barker@dfw.wa.gov
☒Y ☐N	Coral Pasi	WDFW	717-422-2506	coral.pasi@dfw.wa.gov
☒Y ☐N	Doug Hatch	CRITFC	503-731-1263	hatd@critfc.org
☒Y ☐N	John Whiteaker	CRITFC	503-476-7649	whij@critfc.org
☒Y ☐N	Devayne Lewis	CRITFC	503-238-0667	dlewis@critfc.org
☒Y ☐N	Theodore Walsey	CRITFC	503-238-0667	rwalsey@critfc.org
☒Y ☐N	Michael Wampler	IDFG	307-589-3349	michael.wampler@idfg.idaho.gov
☒Y ☐N	Lucas Swanson	IDFG	208-799-5010	lucas.swanson@idfg.idaho.gov

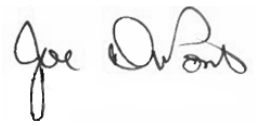
I. Assurance

I attest to the accuracy and completeness of the information provided. As a permitted managing party, I promise to ensure this work with animals is conducted in accordance with the outlined protocols as approved by the Columbia River California sea lion lethal removal IACUC under the NMFS Animal Care and Use Policy. I will not make any substantive changes in the above protocol without first obtaining the approval of the NMFS IACUC, and I will not use any procedures not included in this form.

Principal Investigators/Applicants:

Casey Clark
Washington Dept. of Fish & Wildlife
caseyclark@dfw.wa.gov
Signed: 08/26/2021

Sheanna Steingass
Oregon Dept. of Fish and Wildlife
Sheanna.m.steingass@state.or.us
Signed: 08/30/2021



Joe DuPont
Idaho Dept. of Fish and Game
Joe.dupont@idfg.idaho.gov
Signed: 08/27/2021

Douglas Hatch
Columbia River Intertribal Fish Commission
hatd@critfc.org
Signed: 08/27/2021

Colin Gillin
State Wildlife Veterinarian, Oregon Department of Fish and Wildlife
colin.m.gillin@odfw.oregon.gov
Signed: 09/08/2021

Robin Brown
Community Member-At-Large
tanager@comcast.net
Signed: 08/30/2021

Douglas Hatch, signing for:

Dave Johnson
Nez Perce Tribe
davej@nezperce.org

Carl Scheeler
Confederated Tribes of the Umatilla Reservation
carlscheeler@ctuir.org

Phillip Rigdon
Confederated Tribes and Bands of the Yakama Nation
prigdon@yakama.com

Appendix A

Experimental Procedures Description(s)

Describe the animal procedures that are to be performed and the necessity in fulfilling the goals and objectives of the project. Be sure to be specific about any procedures which may impact the health and comfort of the study animals (e.g., frequency of performance of any procedures, methods of restraint, blood sample volumes, etc.). Please provide a justification for the animal numbers used.

Additional procedures continued from above:

Blocking panels between traps are used to prevent animals from hauling out in-between traps where they potentially could become injured or entangled. Each panel is made of 3/8" thick x 48" wide commercial grade rubber belting material. Belting is 54" high and hangs from top of trap corner posts with ½" Blue Steel line with no gap at the bottom decking. Note: bottom of the panel can be secured to the corner posts with short lines if needed.

Appendix B

Training and Experience description(s)

The state program leaders directing this work (Steingass, Brown, Clark, and Edwards) have at least a combined 20 years of experience in capturing, handling, and marking pinnipeds from California to Alaska. This experience includes a wide variety of methods and equipment for accomplishing this work. All euthanasia procedures will be conducted and overseen by licensed agency veterinarians. Program leaders have extensive experience performing necropsies and collecting biological samples of all types. All ODFW and WDFW project support staff have multiple years of direct experience in pinniped capture, handling, marking, necropsies, and biological sample collection. Several support staff and veterinarians have worked on this project since its inception providing extensive experience related to procedures and methodologies described herein. All support staff were trained directly by the state program leaders and several have had additional experience with similar programs conducted in other areas.

Appendix 2. Tissue samples collected from euthanized animals

SEA LION SAMPLING COMPREHENSIVE SAMPLE/RESEARCH LIST - 2022			
PRIMARY SAMPLING - ALL ANIMALS			
Recipient	Tissue	Purpose	Collection Quantity and Procedure
ODFW	Blood serum	Archive	Collect up to 6 mL of blood into two Red Top glass vials. Spin down and aliquot serum into 2 cryovials
ODFW	Blood plasma	Archive	Collect up to 6 mL of blood into two Green Top glass vials. Spin down and aliquot plasma into 2 cryovials
ODFW	Gastro-Intestinal Tract	Food Habits	Collect stomach and large intestine. Use Ziptie to seal each. Put all bags into one contractor bag with ID label.
WDFW	Teeth	Aging	Collect flensed snout posterior to upper canine teeth. Freeze for later post-canine and canine extraction
ODFW	Blubber	PBDE Analysis; PCBs, DDTs, Organochlorines	Collect 1 baseball-sized blubber samples and put into 250 mL amber glass jars. Do not use foil. Collect blubber in the same place where the blubber depth is measured.
ODFW	Whiskers	Stable isotopes and total mercury	Collect 3 whiskers, approximately the same length (~10 cm), and put into labeled envelope
ODFW	Lip	Contaminants	Collect section of lip with at least 2 whiskers
ODFW	Skin	Genetics	Take one small piece of skin and place in a labeled Cryovial filled with 95% EtOH.
NOAA	Skin	Genetics	Stellers only. Take one small piece of skin and place in a labeled Cryovial. Freeze immediately.
ODFW	Fur	Heavy metals	Collect 1-inch^2 fur from the same location for each animal using stainless steel scissors or sheers. Put into envelope
ODFW	Muscle	Heavy metals	Use a scalpel to collect 1 muscle sample (5-10 g) into a 50 mL Falcon tube.
ODFW	Penis	Urogenital Cancer/OHV	1 x 2-3cm section of junction of lesion/ normal tissue; If no visible lesion still take section.
ODFW	Penis	Urogenital Cancer/OHV	1 cm^2 section of lesion tissue. Take normal tissue if no lesion.
ODFW	Penis	Urogenital Cancer/OHV	Take photo, archive for Julia

ODFW	Lymph Node	Urogenital Cancer/OHV	Collect one sublumbar lymph node. Remove 1 cm^2 tissue sample and store in formalin
ODFW	Lymph Node	Immune Assay Validation	Collect one lymph node from a consistent location (note location).
ODFW	Liver	Toxicology	1-2cm cube or biopsy in Whirlpak. Freeze at -20 or -80.
SUBSAMPLING - AS POSSIBLE			
Recipient	Tissue	Purpose	Collection Vial and how much
ODFW	Heart	Microfilaria life cycle	Collect whole in plastic bag
ODFW	Kidney	Leptospirosis study	1-2cm cube or biopsy in Whirlpak.
WDFW	Skull	Morphometrics	Collect entire skull, flense as much tissue away as possible. Freeze for later cleaning and measurement

Appendix 3. Agent-based model for predicting cumulative post-removal prey requirements of sea lions removed under section 120 of the Marine Mammal Protection Act.

1. Introduction

Under §120 of the Marine Mammal Protection Act (MMPA), NOAA Fisheries has authorized the lethal removal of sea lions in the Columbia River basin to reduce predation on salmon and steelhead listed under the Endangered Species Act as well as other species of conservation concern (NMFS 2022). As part of the terms and conditions of that authorization, permit holders are required to report annually on the expected benefits of the takings such as the actual or predicted predation impacts on prey species of concern.

Direct observation of prey consumption by marine mammals is usually not possible except for unique situations such as surface feeding on large or difficult to consume prey (adult salmonids, sturgeon, and lamprey) from elevated observation substrates such as at Bonneville Dam and Willamette Falls (e.g., van der Leeuw and Tidwell 2022, Wright et al. 2022). Even in these exceptional situations, however, estimates are typically conservative (i.e., underestimates) since they include only an unknown fraction of an individual animal's daily foraging activity in both space and time. Furthermore, it is usually not possible to attribute predation events to individual sea lions due to unknown inclusion and detection probabilities which are typically less than unity. Lastly, consumption estimates based on direct observation only address past events and not predation that was hypothetically prevented in the future due to the removal program.

One method that overcomes some of these limitations is bioenergetics modeling. In this approach, the daily energy requirement of an animal is estimated and then translated into prey-specific biomass requirements which in turn can be translated into numbers of individual prey. Furthermore, the bioenergetics model can be nested in a series of models that describe other processes affecting total lifetime biomass requirements such as survival, growth, site fidelity, residency, and diet composition. Since such a complex series of models quickly becomes intractable using standard analytical approaches, one possible approach to analyzing such a system is to use agent- or individual-based models (ABMs/IBMs) (An et al. 2021, Grimm et al. 2020, Macal 2016, Sibley et al. 2013).

The objective of this exercise was to develop a sea lion management ABM to predict the cumulative, post-removal prey requirements of sea lions removed under MMPA §120. Note that this model is still under active development and will be updated annually as new data become available.

2. Methods

This draft model description follows the Overview, Design concepts, and Details (ODD) protocol for describing individual- and agent-based models (Grimm et al. 2006), as updated by Grimm et al. (2020). Additional detail will be added in future reports. The model was developed and implemented in R 4.2.1 (R Core Team 2022).

2.1. Overview: Purpose and pattern

The primary purpose of the sea lion management ABM is to predict the cumulative number of prey (particularly salmonids) required over the projected post-removal lifetime of California sea lions and/or Steller sea lions authorized for removal under MMPA §120 (Table 1).

We define three patterns as the criteria for model usefulness: 1) estimates of per capita biomass consumption that are consistent with the published literature; 2) per capita biomass consumption as a percent of body mass that are consistent with the published literature; and 3) estimates of numbers of prey consumed that are consistent with observed data.

2.2. Overview: Entities, state variables, and scales

Entities in the model are individual sea lions that were removed under MMPA §120(f) authorization.

Each sea lion has a unique ID and the following variables: age in years; whether or not they survived the annual time step; growth in body mass per annual time step; whether or not they returned (site fidelity) to an upriver site per seasonal time step; and the residency duration in days per seasonal time step. Within a seasonal time-step, additional variables included biomass requirements for up to three prey items including salmonids, sturgeon, lamprey, and "other". Species (CSL, SSL), sex (male), location (Bonneville Dam, Willamette Falls), season (fall = July–December; spring = January–June), and diet composition were fixed and did not vary by annual, seasonal, or daily time steps.

The model is currently non-spatial, so the environment is not represented, and sea lions only have one location per season (Bonneville Dam or Willamette Falls). The model runs at three different time scales: annual (survival, growth), seasonal (fidelity, residency, diet), and daily (bioenergetics).

2.3. Overview: Process overview and scheduling

Processes: The model was developed to cover the life cycle of nuisance sea lions as it pertains to their time at terminal upriver feeding sites in the Columbia River Basin. It is structured in a combination of several deterministic and stochastic processes (Figure 1).

Schedule: The simulation starts one year after removal for each sea lion (within-year biomass requirements will be added at a later date). Each animal's probability of surviving to the next year is determined by a species-, sex- (male), and age-specific survival probability as defined in a Bernoulli trial where the probability of success (survival) is based on the published literature. If an animal survives then its age is incremented and body mass increases by an age-specific factor based on the published literature (stochasticity in growth may be added at a later date).

Next, the probability of returning to an upriver site for a given location and season is determined independently for each sea lion based on a Bernoulli trial where site fidelity (return probability) is based on empirical data from marked animals from Bonneville Dam and Willamette Falls (stochasticity in return location may be added at a later date). Next, residency duration is estimated independently for each sea lion based on a single sample from a Poisson distribution where the parameter is based on empirical data from marked animals from Bonneville Dam and Willamette Falls.

Next, a within-season daily loop starts based on the residency where, for each day-location-season combination, biomass requirements are estimated based on a bioenergetics model for up to three prey types. Currently the biomass requirement is converted to number of fish at the end of the simulation based on mean prey weights but future updates to the model may convert biomass to fish numbers at the daily level (e.g., using a multinomial distribution to select prey types). Sea lions migrate downriver at the end of the residency period and the annual loop begins again with the survival step.

2.4. Design: Design concepts

The 11 design concepts (basic principles, emergence, adaptation, objectives, learning, prediction, sensing, interaction, stochasticity, collectives, and observation,) will be described at a later date.

2.5. Details: Initialization

Individual state variables (age, mass, fidelity, residency) were initialized based on either individual-specific empirical data or population averages estimated from such data (Table 2). The one exception was Steller sea lions of unknown age. Due to a relatively low sample size of tooth-aged Steller sea lions, coupled with a suspected negative bias in tooth-based aging, we instead used the median age of California sea lions (i.e., 8) for unknown-age Steller sea lions. See below for additional details on estimated initialization parameters.

2.6. Details: Input data

Three input files (besides agent data) are imported into the model: survival data, growth data, and diet composition data. These are defined in separate model scripts and are based on published literature and/or observed data.

2.7. Details: Sub-models

There are six sub-models in the ABM; two of these operate at the annual time scale (survival, growth), three at the seasonal time scale (fidelity, residency, diet), and one at the daily time scale (bioenergetics). Each agent (sea lion) only occurs at one location based on where it was removed (Bonneville Dam or Willamette Falls) but may occur in more than one season if its resight history included more than one season (which by definition would only apply to identifiable

animals). Future versions of the ABM will allow for multiple locations per year (but not within season) for both identifiable and un-identifiable animals.

2.7.1. Survival sub-model (annual)

The probability of an animal surviving each annual time step was based on a species-, sex-, and age-specific survival rate (Table 3, Figure 2). Each individual at each time step lives or dies based on the outcome of a Bernoulli trial where the probability of success (survival) equals the species-, sex-, and age-specific survival rate. If the animal survives, then it advances to the growth sub-model after which its age is increased by one year regardless of whether it was removed in the spring (before its birthday) or the fall (after its birthday); future versions of the model will explicitly account for the timing of the birthday with respect to removal season.

For animals removed in the spring, the probability of surviving from spring of year i to spring of year $i + 1$ closely matches the assumptions of the survival estimates since parturition is during the summer (assumed July 1 for modeling purposes). For fall removals of animals, the meaning of annual survival becomes more ambiguous and will be refined in subsequent models. If the animal dies, then that particular run in the overall simulation is complete for that animal. Model runs that result in no biomass requirements due to mortality and/or not returning to the upriver sites are temporarily retained, however, in order to accurately estimate summary statistics. The model is run for 18 years to ensure mortality for every individual.

2.7.2. Growth sub-model (annual)

The amount of food an animal requires per day is a function of many factors but the most important is an animal's metabolic rate which in turn is a function of its body mass as stated in Kleiber's equation (adults; from Winship et al. 2002):

$$\text{Basal metabolism (BM in kJ d}^{-1}) = 292.88 \times M^{0.75}$$

where M is body mass (kg). The growth sub-model is still under development but is currently based on relative rates of change from the mass-at-age models of Winship et al. (2006) (Figure 3). Asymptotes of 1000 lbs (454 kgs) and 2000 lbs (907 kgs) were used to cap growth for CSLs and SSLs, respectively. In the ABM, the growth process is currently deterministic but future versions of the model may add stochasticity.

2.7.3. Site fidelity sub-model (seasonal)

The site fidelity sub-model estimates the probability of an animal returning to an upriver location in a given season, given that it's known to be alive. For example, CSL "2n11" was branded at Bonneville Dam in 2016 but not detected there again until 2018; his estimated fidelity rate or probability of returning was therefore one year (2018) out of two (2017, 2018) or 0.5. If that same animal had also been seen on the coast in 2020 his estimated fidelity would have been one year (2018) out of four (2017-2020) or 0.25. Removal animals that were unmarked or marked

but only seen one year (e.g., removed same year as marking) were given the average fidelity rate for that species-, location-, and season combination (Table 4). The probability of an animal returning is based on the outcome of a Bernoulli trial where the probability of success (returning) equals the fidelity parameter for that animal.

It is important to note that the estimated fidelity rates are likely biased low due to imperfect detectability of marked animals since 1) in any given year a marked animal may occur but not be detected and 2) prior to marking they are undetectable by definition even though they may have occurred there for multiple years. In addition, as with other datasets, there is a time lag between data collection and data entry so new resights are continually being added and therefore fidelity estimates will likely be revised in future model runs. In addition, future versions of the ABM may include a step where the probability of returning is drawn from a multinomial distribution with three outcomes possible outcomes: not return, return to Bonneville Dam, return to Willamette Falls.

2.7.4. Residency sub-model (seasonal)

The residency sub-model estimates the number of days an animal stays at a given location in a given season, given that it has returned. Residency rates were calculated based on the elapsed days between the first and last date a marked animal was observed but only after first removing seasons in which they were marked and/or removed in order to avoid negatively biasing rates by including artificially left- or right-censored seasons. Removal animals with unknown residency histories were assigned the average residency rate for that species-, location-, and season combination (Table 4, Figure 4).

As with the site fidelity sub-model, imperfect detectability of marked animals likely led to conservative estimates of residency (i.e., too low). On the other hand, residency may have been overestimated in some cases if animals made temporary within-season trips to and from an upriver site rather than staying there the entire time between first and last detection. This latter behavior was observed in the early years of research at Bonneville Dam, but it is unknown to what extent it currently occurs. In addition, apparent residency rates for CSLs at both Bonneville Dam and Willamette Falls have declined over time. Future versions of this ABM could incorporate the apparent decline in residency rather than including the mean value although the point of this exercise is to predict what might have happened had there been no intervention and in that case the residency rates would most likely have remained high or have even increased.

2.7.5. Diet sub-model (seasonal)

The current version of the diet sub-model consists of three prey (Table 5). The percent biomass contribution of each prey type is based on a synthesis of results from scat and gastro-intestinal tract analyses as well as direct observations of surface feeding events at and below Bonneville Dam and Willamette Falls. Currently the diet composition is fixed but future versions of the ABM may include stochasticity by drawing from a multinomial distribution of prey types.

Energetic densities (kJ g^{-1}) of prey are treated as fixed except for the "other" category which draws from a uniform distribution.

Total biomass requirements are converted to numbers of fish based on average prey weights. Currently only salmonid fish numbers are calculated but future versions of the model may include sturgeon and lamprey. Prey size currently enters the modeling process after the ABM run is complete and total prey-specific biomass estimates have been calculated. Future versions of the ABM may treat prey size as a separate sub-model and also include stochasticity by randomly drawing prey sizes from a distribution of values rather than treating it as fixed.

2.7.6. Bioenergetics sub-model (daily)

The final component of the ABM is the bioenergetics sub-model which was modified from Winship et al. (2002). This sub-model estimates the daily biomass requirement for prey category *i* and predator *j* based on the following formula

$$BR_{ij}[kg\ d^{-1}] = \frac{GER[kJ\ d^{-1}] \times prey_i}{ED_i[kJ\ g^{-1}]} \div 1000$$

where GER is the gross energy requirement

$$\frac{P + (A_j \times BM_j)}{E_{HIF} \times E_{f+u}}$$

and A is the energetic cost of activity

$$A_j = water_j * A_{water} + (1 - water_j) * A_{land}$$

Additional parameter definitions and values are described in Table 6. (Note that the update to the denominator of GER found in Winship and Trites (2003) was not used since it is not applicable to high energetic densities such as that found in Pacific lamprey.)

In contrast to many other bioenergetic models (e.g., Winship et al. 2002), for this particular application the model was greatly simplified since it is only for one sex (males), one age-class (non-pups), and for relatively short periods of time which meant that production (growth in body mass) could be omitted. Future versions may include production, however, since Steller sea lions are now included and have longer annual residency times at Bonneville Dam than California sea lions for which the model was originally intended. On the other hand, biomass requirements for growth in adults have shown to be small relative to requirements such as basal metabolism, activity, and waste (e.g., see Figure 1 in Winship et al. 2002) so omitting it from the model is not likely to negatively bias the results.

2.8. Sensitivity analysis

Sensitivity analysis will be implemented in a future version of this ABM.

2.9 Output

Results are based on 200 runs[1] of the ABM. The method of summary, however, varies depending on whether statistics are at the individual level or the population level. At the population level, estimates are based on percentiles from the 200 runs, where point estimates are equal to 50^{th} percentile (median) and interval estimates (95% CIs) are based on the 2.5^{th} and 97.5^{th} percentiles.

For individual-level attributes, results are summarized using a multi-step approach. First, for each location-species-season-agent-run-year combination, annual summaries are stored (e.g., residency) or calculated (e.g., mean daily biomass requirement), conditional on surviving and returning if applicable. At this step, mean values per run (across up to 18 years) are retained and the number of records equals the number of runs. Next, for each location-species-season-agent combination, mean values per agent (across 200 runs) are calculated and the number of records equals the number of agents. Lastly, the mean and range are calculated for each of the five location-species-season combinations (across agents).

3. Results

The predicted lifetime salmonid requirements for the 91 sea lions removed under MMPA §120(f) was 20,086 fish (95% CI = 10,582–33,869) (Figure 5). Individual-level summary statistics are summarized in Table 7.

4. Discussion

Section 2.1 defined three patterns as the criteria for model usefulness: 1) estimates of per capita biomass consumption that are consistent with the published literature; 2) per capita biomass consumption as a percent of body mass that are consistent with the published literature; and 3) estimates of numbers of prey consumed that are consistent with observed data. Regarding the first two criteria, while it's important to note that bioenergetic models produce estimates of food requirements and not food consumption, ABM results (Table 7) were nonetheless consistent with published data on food consumption by captive animals. For example, Kastelein et al. (2000) reported that one captive 16-year-old male California sea lion consumed an average 9.5 kg day^{-1} and up to a maximum of 35.5 kg day^{-1}. Similarly, Kastelein et al. (1990) reported that one captive 16-year-old male Steller sea lion consumed an average of approximately 20 kg day^{-1} and a maximum of 26 kg day^{-1}. Likewise, when expressed as a percentage of body weight, estimates of daily food consumption by captive male California sea lions and Steller sea lions aged 3–15 years old ranged from 3–9% and 3–6%, respectively (Winship et al. 2006). While per capita ABM estimates were generally higher than those of the captive animals that would be expected given the higher activity levels of wild animals.

[1]~76 hours running time.

Regarding the third criteria, while direct comparisons between the ABM results and surface-based predation estimates (i.e., van der Leeuw and Tidwell 2022, Wright et al. 2022) are problematic for a variety of reasons (e.g., differing predator population sizes, limited fall observation effort), results from the ABM are nonetheless a similar order of magnitude. One potentially surprising result, however, is the high level of predation in the fall by Steller sea lions at Bonneville Dam (Figure 5) compared to the spring. This was due to the fact that even though salmonids were assumed to be a smaller proportion of their diet (Table 5), higher rates of both fidelity and residency (Table 4) translated into higher rates of predation than in the spring. And while both observed fall Chinook salmon and coho salmon take by Stellers sea lions at Bonneville Dam are estimated to be in the hundreds (van der Leeuw and Tidwell 2022), it is suspected that most salmonid predation is on chum salmon further downriver of the dam.

In conclusion, agent-based modeling has proven to be a useful and effective framework for the ongoing analysis of the benefits of sea lion management in the Columbia River Basin. Future work on the model will include a restructuring of how spring and fall removals are treated as well as addition of additional stochasticity to diet composition and site fidelity (Figure 6).

References

An L, Grimm V, Sullivan A, Turner II BL, Malleson N, Heppenstall A, Vincenot C, Robinson D, Ye X, Liu J, Lindkvist E, Tang W. 2021. Challenges, tasks, and opportunities in modeling agent-based complex systems. Ecological Modelling 457.

Clemens B, Weitkamp L, Siwicke K, Wade J, Harris J, Hess J, Porter L, Parker K, Sutton T, Orlov A. 2019. Marine biology of the pacific lamprey *Entosphenus tridentatus*. Reviews in Fish Biology and Fisheries 29:767-788.

DeLong R, Melin S, Laake J, Morris P, Orr A, Harris J. 2017. Age and sex-specific survival of California sea lions (*Zalophus californianus*) at San Miguel Island, California. Marine Mammal Science 33:1097–1125.

Grimm V, et al. 2006. A standard protocol for describing individual-based and agent-based models. Ecological Modelling 198: 115–126.

Grimm V, et al. 2020. The ODD protocol for describing agent-based and other simulation models: a second update to improve clarity, replication, and structural realism. Journal of Artificial Societies and Social Simulation 23(2).

Jepson MA, Keefer ML, Caudill CC, Clabough TS, Erdman CS, Blubaugh T, Sharpe CS. 2015. Migratory behavior, run timing, and distribution of radio-tagged adult winter steelhead, summer steelhead, spring Chinook salmon, and coho salmon in the Willamette River—2011-2014. Technical Report 2015-1.

Kastelein, RA, Vaughan N, Wiepkema PR. 1990. The food consumption of Steller sea lions (Eumetopias jubatus). Aquatic Mammals 15:137-144.

Kastelein, RA, Schooneman NM, Vaughan N, Wiepkema PR. 2000. Food consumption and growth of California sea lions (Zalophus californianus californianus). Zoo Biology 19:143-159.

Macal CM. 2016. Everything you need to know about agent-based modeling and simulation. Journal of Simulation 10:144-156.

Maniscalco JM, Springer AM, Adkison MD, Parker P. 2015. Population trend and elasticities of vital rates for Steller sea lions (*Eumetopias jubatus*) in the eastern Gulf of Alaska: a new life-history table analysis. PLoS ONE 10(10):e0140982.

NMFS (National Marine Fisheries Service). 2022. https://www.fisheries.noaa.gov/west-coast/marine-mammal-protection/marine-mammal-protection-act-section-120-pinniped-removal [last accessed 2022-10-25].

O'Neil SM, Ylitalo GM, West JE. 2014. Energy content of Pacific salmon as prey of northern and southern resident killer whales. Endangered Species Research 2:265-281.

R Core Team (2022). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Schakner ZA, Buhnerkempe MG, Tennis MJ, Stansell RJ, van der Leeuw BK, Lloyd-Smith JO, and Blumstein DT. 2016. Epidemiological models to control the spread of information in marine mammals. Proc. R. Soc. B 283: 20162037.

Sibley, R. M., et al. 2013. Representing the acquisition and use of energy by individuals in agent based-models of animal populations. Methods in Ecology and Evolution 4:151-161.

van der Leeuw, BK, Tidwell KS. 2022. Evaluation of pinniped predation on adult salmonids and other fish in the Bonneville Dam tailrace, 2021. U.S. Army Corps of Engineers, Portland District Fisheries Field Unit. Cascade Locks, OR.

Winship AJ, Trites AW, Rosen DAS. 2002. A bioenergetic model for estimating the food requirements of Steller sea lions in Eumetopias jubatus in Alaska, USA. Marine Ecology Progress Series 229:291-312.

Winship AJ, Trites AW. 2003. Prey consumption of Steller sea lions (Eumetopias jubatus) off Alaska: how much prey do they require? Fishery Bulletin 101(1):147-167.

Winship AJ, Hunter AMJ, Rosen DAS, Trites AW. 2006. Food consumption by sea lions: existing data and techniques, in Sea Lions of the World. University of Alaska Press, 177–191.

Wright BE, Brown RF, DeLong RL, Gearin PJ, Riemer SD, Laake JL, Scordino JJ. 2017. Survival rates of Steller sea lions from Oregon and California. Journal of Mammalogy 98(3):885–894.

Wright BE, et al. 2022. Annual report: pinniped monitoring at Willamette Falls, 2021-2022. Oregon Department of Fish and Wildlife, Corvallis, Oregon.

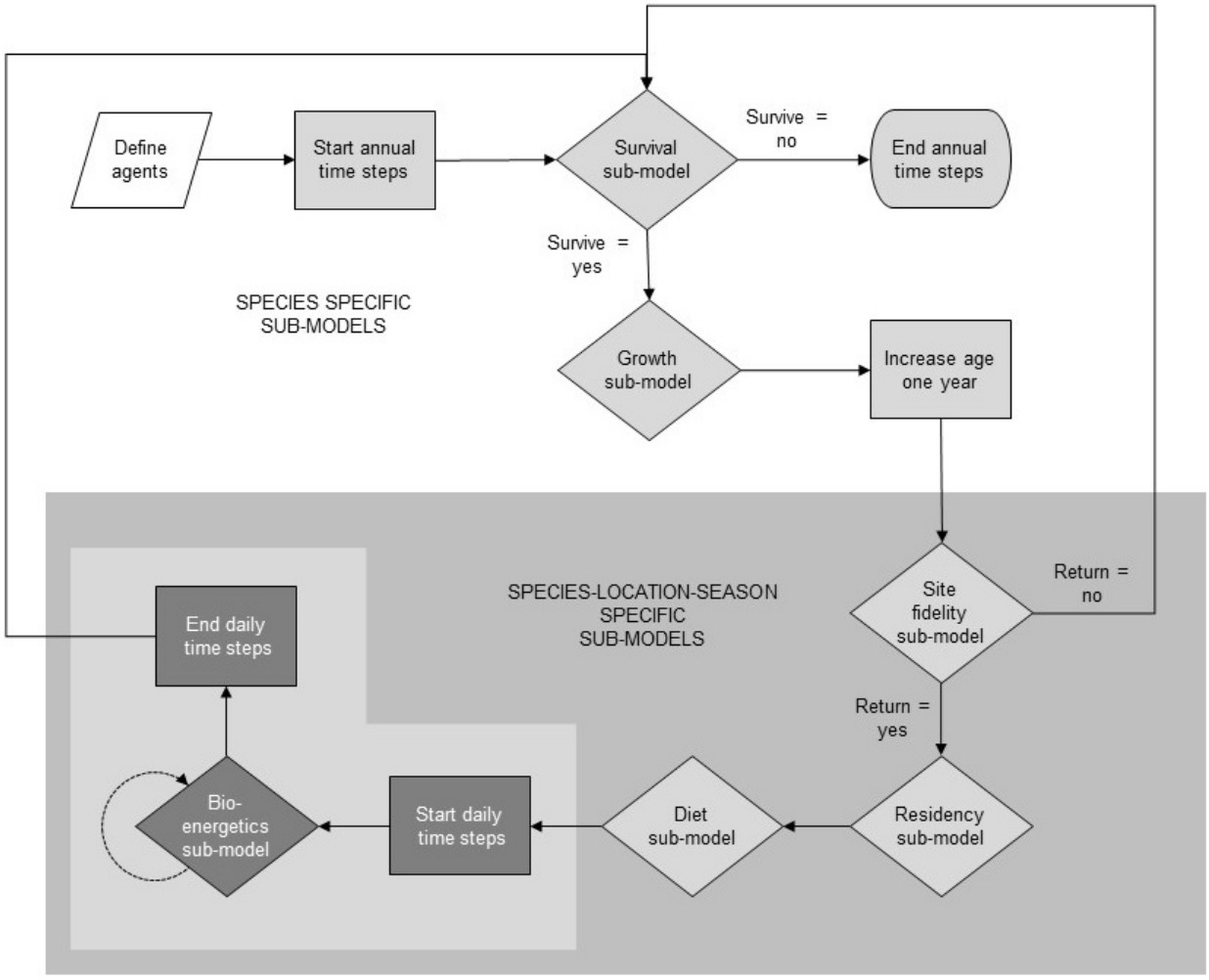


Figure 1. Flowchart of sea lion management agent-based model.

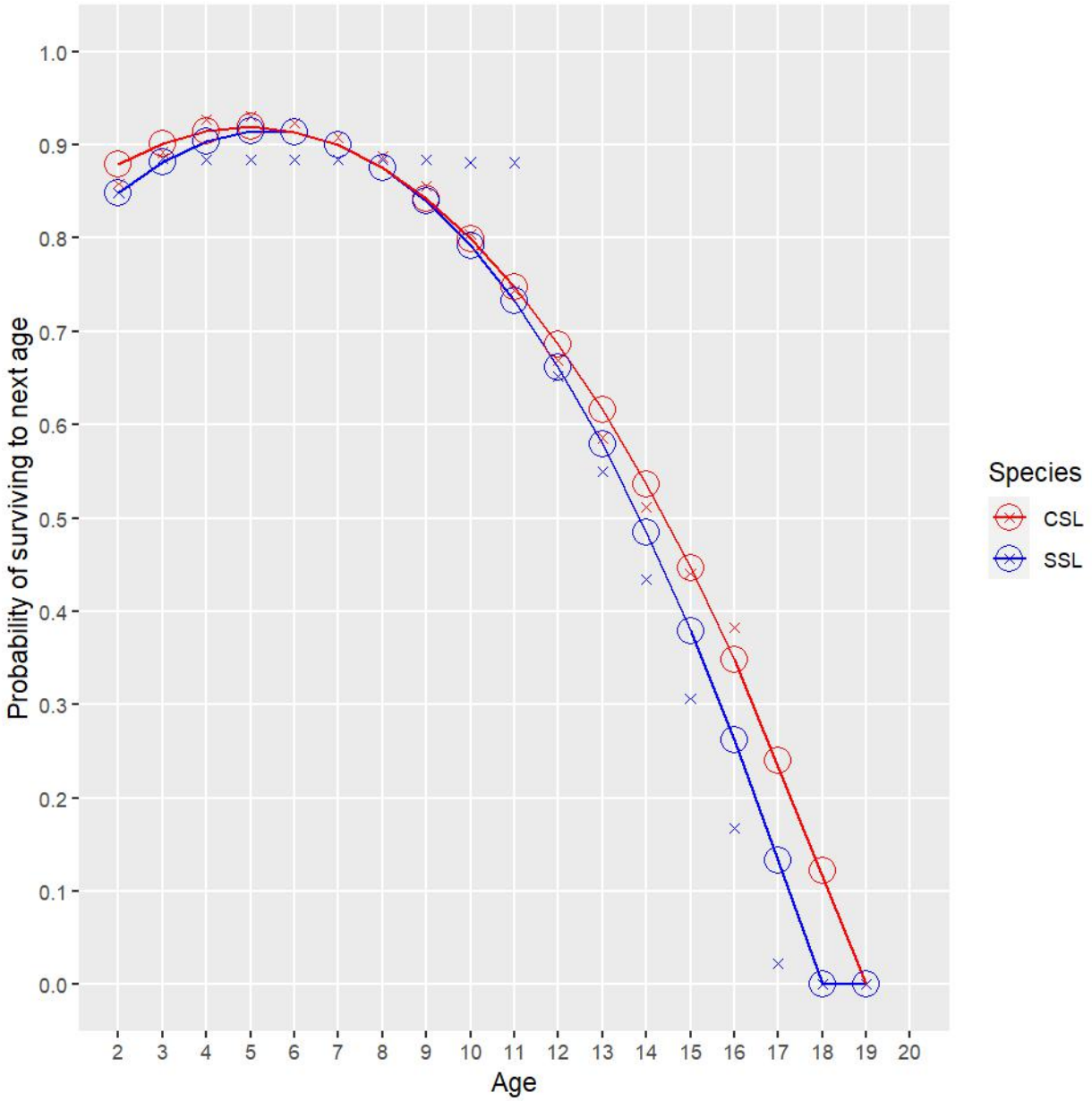


Figure 2. Survival sub-model. California sea lion (CSL) data from DeLong et al. (2017); Steller sea lion (SSL) data from Wright et al. (2017; ages 0-11) and Maniscalco et al. (2015; ages >11); lines indicate second order polynomial fits to data. See Table 3 for additional details.

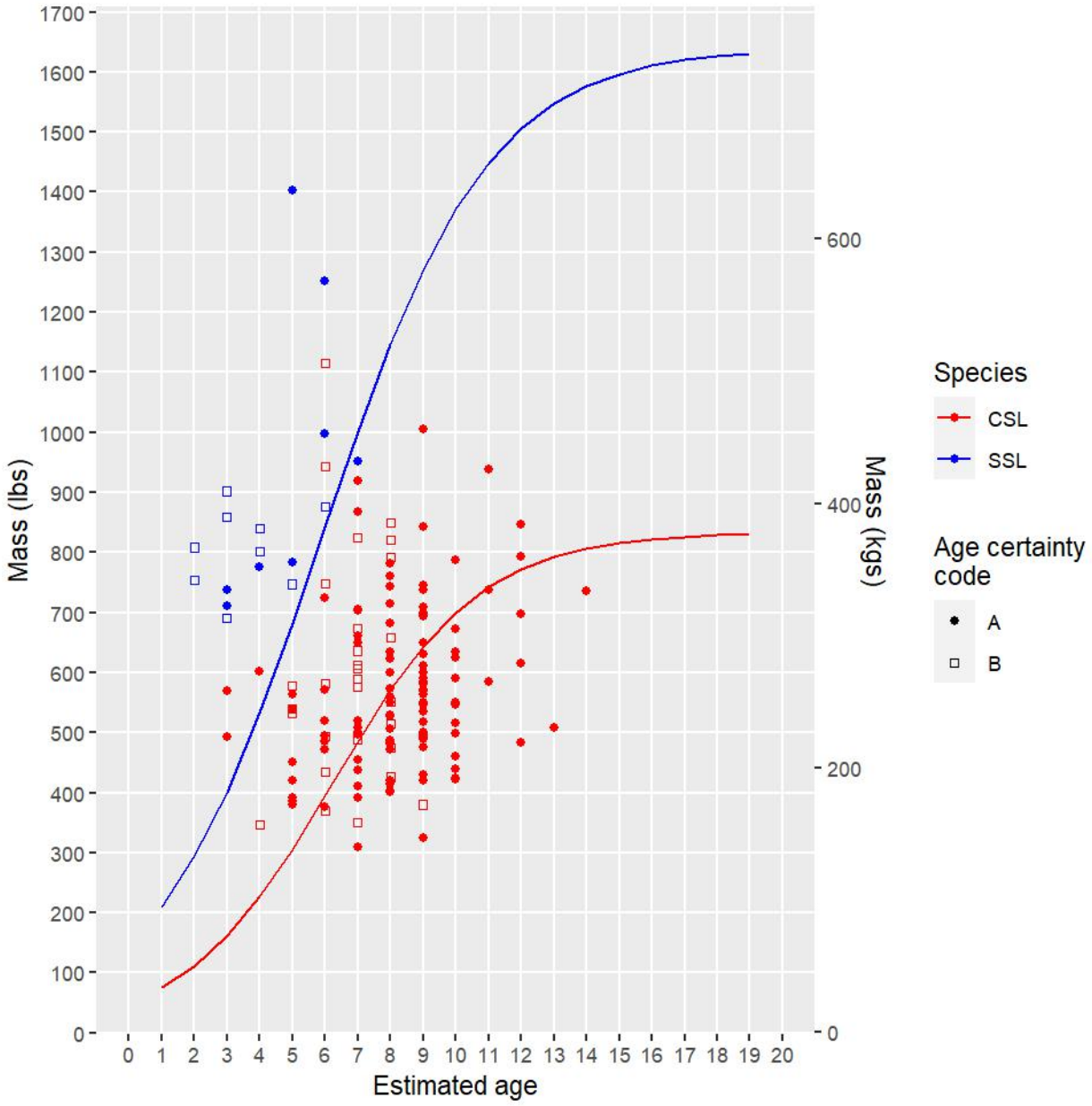


Figure 3. Growth sub-model. Lines represent mass-at-age growth curves for male California sea lions (CSL) and Steller sea lions (SSL) (Winship et al. 2006); points represent empirical age and weight data from sea lions removed at Bonneville Dam and Willamette Falls. Age certainty code is a reliability index provided by Matson's Laboratory, where "A" is the highest reliability rating.

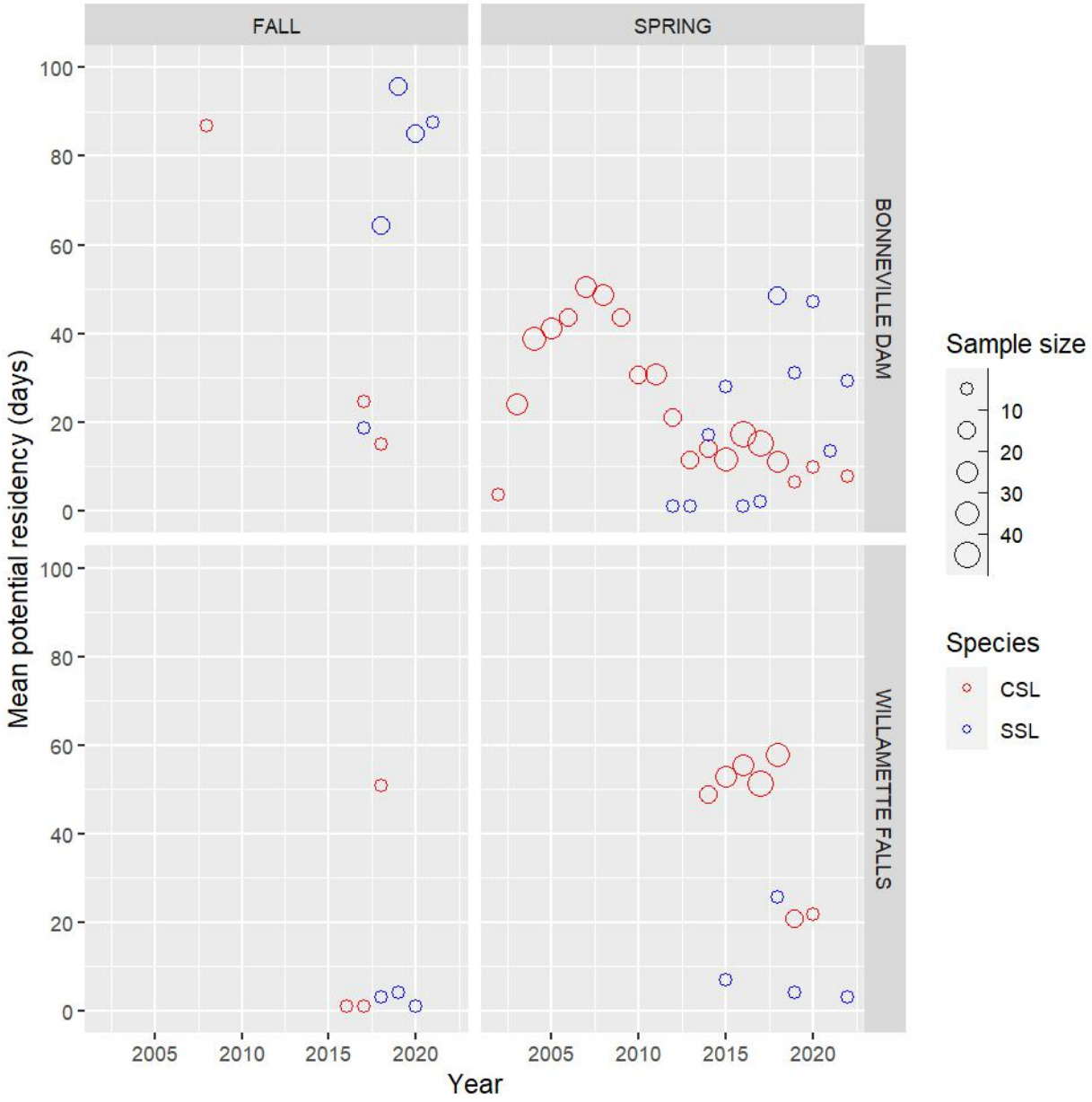


Figure 4. Residency sub-model. Points equal annual average potential residency by year, season, location, and species (based on all identifiable upriver animals, not just removals).

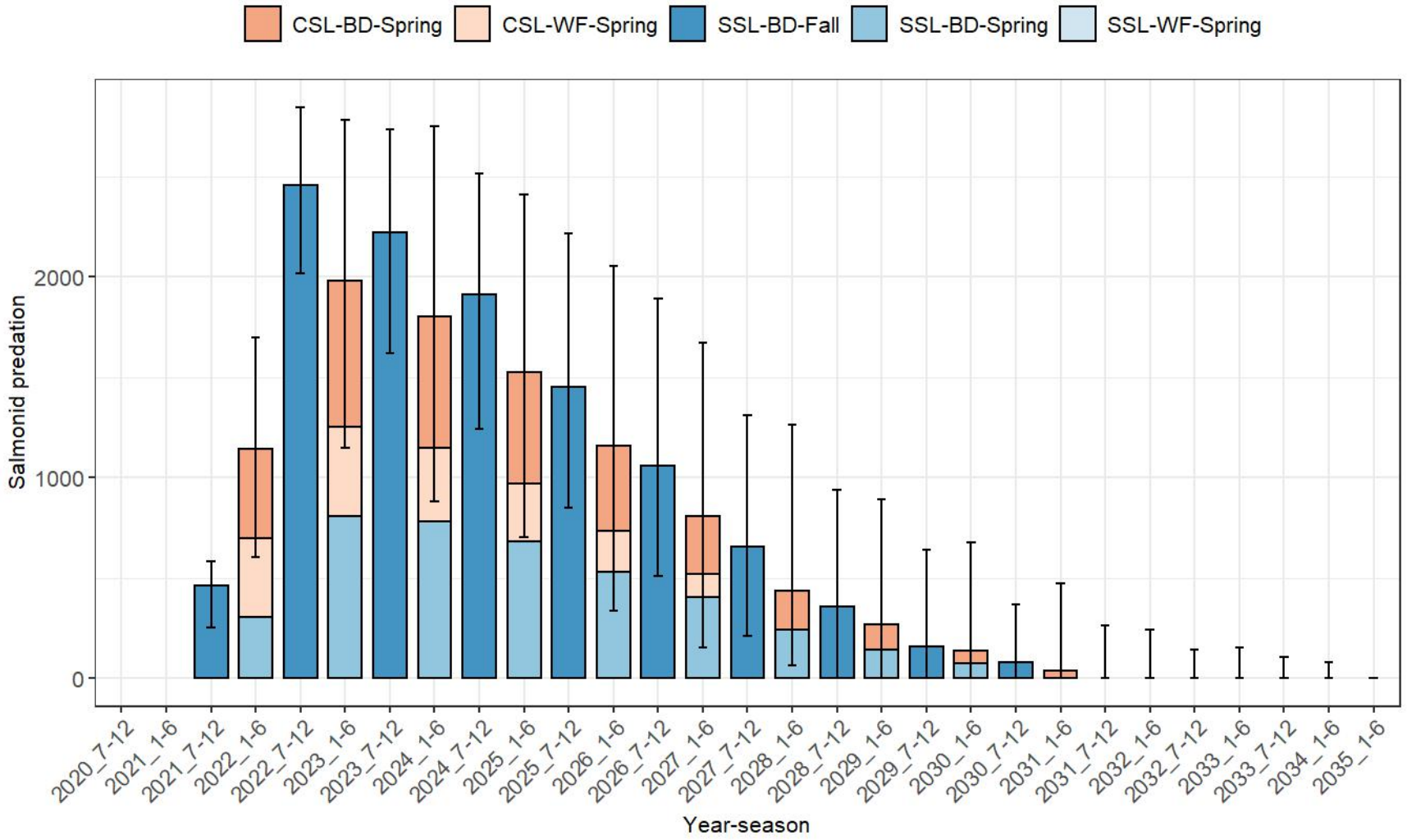


Figure 5. Predicted lifetime salmonid requirements of 38 California sea lions (CSLs) and 53 Steller sea lions (SSLs) removed at Bonneville Dam (BD) and Willamette Falls (WF) from fall 2020 to spring 2022 under MMPA §120(f). Confidence intervals were summed across species-location-seasons.

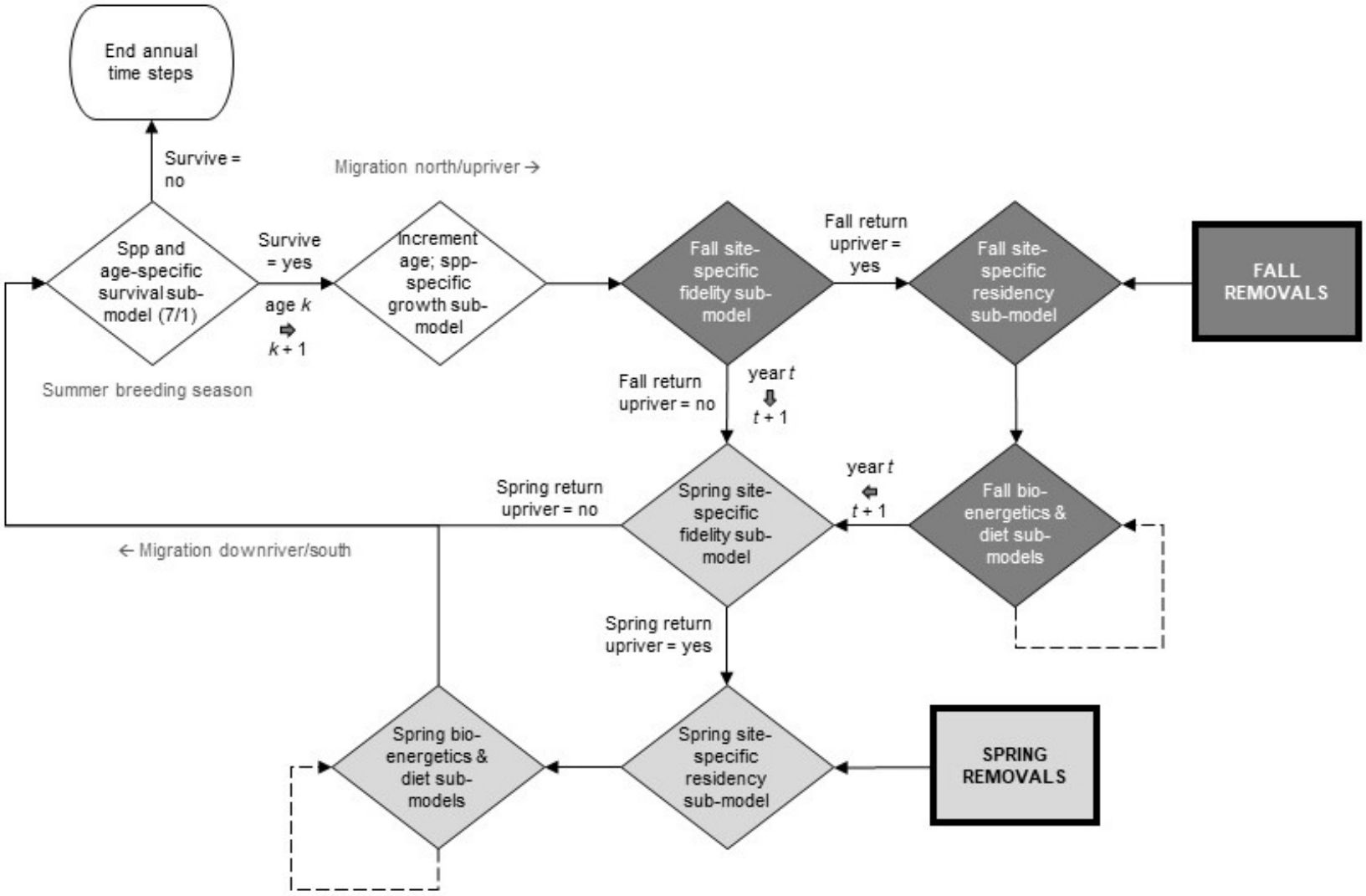


Figure 6. Schematic of future version of sea lion management ABM.

Table 1. California sea lions (CSLs) and Steller sea lions (SSLs) removed at Bonneville Dam (BD) and Willamette Falls (WF) from fall 2020 to spring 2022 under MMPA §120(f).

Location	Species	Season	2020	2021	2022	Total removals
BD	CSL	Spring		17	14	31
	SSL	Spring		13	9	22
		Fall	6	24		30
WF	CSL	Spring		6	1	7
	SSL	Spring		1		1
Total			6	61	24	91

Table 2. Dataset used to initiate the ABM, sorted by date of capture. The variable 'Actual' indicates whether actual individual-level (1), or estimated population-level (0), data was used to parameterize the preceding variable to its left.

Individual	Spp	ID	Location	Season	Date	Age	Actual	Mass_kgs	Actual	Fidelity_p	Actual	Residency_d	Actual
1	SSL	EB001	BD	Fall	20201014	8	0	403	1	0.90	0	57	0
2	SSL	EB002	BD	Fall	20201015	3	1	322	1	0.90	0	57	0
3	SSL	O53	BD	Fall	20201022	5	1	339	1	1.00	1	123	1
	SSL	O53	BD	Spring	20201022	5	1	339	1	1.00	1	26	0
4	SSL	EB003	BD	Fall	20201103	4	1	352	1	0.90	0	57	0
5	SSL	O44	BD	Fall	20201104	7	1	431	1	1.00	1	48	1
	SSL	O44	BD	Spring	20201104	7	1	431	1	0.67	1	1	1
6	SSL	EB004	BD	Fall	20201105	3	1	409	1	0.90	0	57	0
7	SSL	EW001	WF	Spring	20210302	8	0	445	0	0.12	0	16	0
8	SSL	EB005	BD	Spring	20210406	4	1	364	1	0.39	0	26	0
9	CSL	ZW001	WF	Spring	20210413	8	0	259	0	0.87	0	39	0
10	CSL	ZW002	WF	Spring	20210413	8	0	259	0	0.87	0	39	0
11	CSL	ZW003	WF	Spring	20210413	8	0	259	0	0.87	0	39	0
12	SSL	EB006	BD	Spring	20210414	6	1	567	1	0.39	0	26	0
13	CSL	ZB001	BD	Spring	20210414	5	1	242	1	0.72	0	22	0
14	SSL	EB007	BD	Spring	20210415	3	1	390	1	0.39	0	26	0
15	SSL	EB008	BD	Spring	20210415	2	1	367	1	0.39	0	26	0
16	CSL	ZB002	BD	Spring	20210415	9	1	338	1	0.72	0	22	0
17	CSL	ZW004	WF	Spring	20210415	8	0	259	0	0.87	0	39	0
18	SSL	O41	BD	Fall	20210420	5	1	636	1	1.00	1	1	1
	SSL	O41	BD	Spring	20210420	5	1	636	1	0.75	1	22	1
19	CSL	ZW005	WF	Spring	20210420	8	0	259	0	0.87	0	39	0
20	CSL	ZW006	WF	Spring	20210420	8	0	259	0	0.87	0	39	0

21	SSL	EB009	BD	Spring	20210421	6	1	397	1	0.39	0	26	0
22	SSL	EB010	BD	Spring	20210422	6	1	452	1	0.39	0	26	0
23	SSL	EB011	BD	Spring	20210428	2	1	342	1	0.39	0	26	0
24	SSL	EB012	BD	Spring	20210428	4	1	381	1	0.39	0	26	0
25	CSL	ZB003	BD	Spring	20210428	10	1	250	1	0.72	0	22	0
26	SSL	EB013	BD	Spring	20210429	3	1	313	1	0.39	0	26	0
27	CSL	06n3	BD	Spring	20210429	8	1	282	1	1.00	1	1	1
28	CSL	ZB004	BD	Spring	20210429	6	1	506	1	0.72	0	22	0
29	CSL	X693	BD	Spring	20210504	10	1	209	1	0.72	0	22	0
30	CSL	ZB005	BD	Spring	20210504	8	1	288	1	0.72	0	22	0
31	CSL	ZB006	BD	Spring	20210504	9	1	272	1	0.72	0	22	0
32	CSL	ZB007	BD	Spring	20210504	6	1	264	1	0.72	0	22	0
33	CSL	ZB008	BD	Spring	20210504	5	1	245	1	0.72	0	22	0
34	SSL	EB014	BD	Spring	20210505	3	1	335	1	0.39	0	26	0
35	CSL	ZB009	BD	Spring	20210505	6	1	339	1	0.72	0	22	0
36	CSL	ZB010	BD	Spring	20210505	6	1	259	1	0.72	0	22	0
37	CSL	ZB011	BD	Spring	20210505	5	1	262	1	0.72	0	22	0
38	SSL	EB015	BD	Spring	20210506	5	1	355	1	0.39	0	26	0
39	CSL	ZB012	BD	Spring	20210506	3	1	223	1	0.72	0	22	0
40	CSL	ZB013	BD	Spring	20210511	5	1	244	1	0.72	0	22	0
41	CSL	ZB014	BD	Spring	20210511	6	1	224	1	0.72	0	22	0
42	CSL	ZB015	BD	Spring	20210511	8	0	552	1	0.72	0	22	0
43	SSL	EB016	BD	Spring	20210512	8	0	721	1	0.39	0	26	0
44	SSL	EB017	BD	Fall	20210914	8	0	352	1	0.90	0	57	0
45	SSL	EB018	BD	Fall	20210915	8	0	435	1	0.90	0	57	0
46	SSL	EB019	BD	Fall	20210915	8	0	259	1	0.90	0	57	0

47	SSL	EB020	BD	Fall	20210916	8	0	361	1	0.90	0	57	0
48	SSL	O49	BD	Fall	20210921	8	0	504	1	1.00	1	133	1
	SSL	O49	BD	Spring	20210921	8	0	504	1	1.00	1	2	1
49	SSL	EB021	BD	Fall	20210922	8	0	492	1	0.90	0	57	0
50	SSL	EB022	BD	Fall	20210923	8	0	634	1	0.90	0	57	0
51	SSL	EB023	BD	Fall	20210928	8	0	390	1	0.90	0	57	0
52	SSL	EB024	BD	Fall	20210929	8	0	709	1	0.90	0	57	0
53	SSL	EB025	BD	Fall	20210930	8	0	292	1	0.90	0	57	0
54	SSL	EB026	BD	Fall	20211006	8	0	673	1	0.90	0	57	0
55	SSL	EB027	BD	Fall	20211006	8	0	626	1	0.90	0	57	0
56	SSL	O48	BD	Fall	20211007	8	0	610	1	1.00	1	84	1
	SSL	O48	BD	Spring	20211007	8	0	610	1	1.00	1	89	1
	SSL	O42	BD	Fall	20211014	8	0	541	1	1.00	1	76	1
57	SSL	O42	BD	Spring	20211014	8	0	541	1	1.00	1	33	1
58	SSL	EB028	BD	Fall	20211102	8	0	457	1	0.90	0	57	0
59	SSL	EB029	BD	Fall	20211103	8	0	450	1	0.90	0	57	0
60	SSL	O47	BD	Fall	20211103	8	0	670	1	1.00	1	83	1
	SSL	O47	BD	Spring	20211103	8	0	670	1	1.00	1	14	1
61	SSL	EB030	BD	Fall	20211109	8	0	377	1	0.90	0	57	0
62	SSL	EB031	BD	Fall	20211109	8	0	529	1	0.90	0	57	0
63	SSL	EB032	BD	Fall	20211110	8	0	449	1	0.90	0	57	0
64	SSL	EB033	BD	Fall	20211116	8	0	572	1	0.90	0	57	0
65	SSL	EB034	BD	Fall	20211116	8	0	784	1	0.90	0	57	0
66	SSL	EB035	BD	Fall	20211117	8	0	724	1	0.90	0	57	0
67	SSL	EB036	BD	Fall	20211117	8	0	695	1	0.90	0	57	0
68	SSL	EB037	BD	Spring	20220419	8	0	538	1	0.39	0	26	0

69	SSL	EB038	BD	Spring	20220420	8	0	655	1	0.39	0	26	0
70	SSL	EB039	BD	Spring	20220420	8	0	754	1	0.39	0	26	0
71	CSL	ZB016	BD	Spring	20220420	8	0	195	1	0.72	0	22	0
72	SSL	O37	BD	Spring	20220422	8	0	873	1	0.56	1	36	1
73	CSL	X842	BD	Spring	20220426	8	0	230	1	0.72	0	22	0
74	CSL	ZB017	BD	Spring	20220426	8	0	329	1	0.72	0	22	0
75	CSL	ZV018	BD	Spring	20220426	8	0	317	1	0.72	0	22	0
76	SSL	EB040	BD	Spring	20220427	8	0	441	1	0.39	0	26	0
77	SSL	EB041	BD	Spring	20220428	8	0	743	1	0.39	0	26	0
78	CSL	ZB019	BD	Spring	20220428	8	0	362	1	0.72	0	22	0
79	SSL	EB042	BD	Spring	20220503	8	0	375	1	0.39	0	26	0
80	CSL	C096	BD	Spring	20220503	8	0	378	1	0.57	1	13	1
81	CSL	ZB020	BD	Spring	20220503	8	0	224	1	0.72	0	22	0
82	CSL	ZB021	BD	Spring	20220503	8	0	201	1	0.72	0	22	0
83	CSL	ZB022	BD	Spring	20220503	8	0	211	1	0.72	0	22	0
84	CSL	2n61	BD	Spring	20220504	8	0	316	1	0.50	1	1	1
85	CSL	ZB023	BD	Spring	20220505	8	0	371	1	0.72	0	22	0
86	SSL	EB043	BD	Spring	20220510	8	0	395	1	0.39	0	26	0
87	SSL	EB044	BD	Spring	20220510	8	0	330	1	0.39	0	26	0
88	CSL	ZB024	BD	Spring	20220510	8	0	298	1	0.72	0	22	0
89	CSL	ZB025	BD	Spring	20220511	8	0	269	1	0.72	0	22	0
90	CSL	ZB026	BD	Spring	20220511	8	0	272	1	0.72	0	22	0
91	CSL	ZW007	WF	Spring	20220516	8	0	311	1	0.87	0	39	0

Table 3. Survival sub-model parameters. Estimate is value from the published literature and indicates probability of surviving to next age (e.g., probability of male CSL surviving from age 2 to age 3 is 0.858). Final indicates predicted value from second order polynomial fit to published estimates (see footnotes).

	Male California sea lion survival probabilities			Male Steller sea lion survival probabilities		
Age	Estimate	Source	Final	Estimate	Source	Final
2[a]	0.858	Table 3, DeLong et al. 2017	0.879	0.848	Averaged 2002-2009 cohorts, Table S2, Wright et al. 2017	0.849
3	0.892	Ibid	0.901	0.885	Ibid	0.882
4	0.927	Ibid	0.915	0.884	Ibid	0.904
5	0.931	Ibid	0.919	0.884	Ibid	0.914
6	0.923	Ibid	0.914	0.884	Ibid	0.913
7	0.908	Ibid	0.899	0.884	Ibid	0.900
8	0.887	Ibid	0.876	0.884	Ibid	0.875
9	0.856	Ibid	0.842	0.884	Ibid	0.839
10	0.804	Ibid	0.800	0.881	Ibid	0.792
11	0.744	Ibid	0.748	0.881	Ibid	0.732
12	0.669	Ibid	0.686	0.652	Table S1/Appendix 1b, Maniscalco et al. 2015	0.661
13	0.586	Ibid	0.616	0.550	Ibid	0.579
14	0.512	Ibid	0.536	0.434	Ibid	0.485
15	0.440	Ibid	0.446	0.306	Ibid	0.379
16	0.383	Ibid	0.348	0.168	Ibid	0.262
17	0.354[b]	Ibid	0.240	0.023	Ibid	0.133
18	0.350[b]	Ibid	0.122	0.001	Ibid	0.001
19	0.366[c]	Ibid	0.000	0.001[c]	Ibid	0.000

[a] No CSLs <2 years of age have been observed in removal population

[b] Set to NA due to small sample size and high uncertainty in estimates

[c] Set to zero since no male CSL in the study was sighted >19 years of age; survival of male SSL >19 was also effectively zero.

Table 4. Fidelity and residency sub-model parameters based on mark-resight data of all upriver animals (not just removals). Note that some individuals may occur in multiple locations and/or seasons.

				Fidelity*		Residency (days)**	
Location	Species	Season	Removals (agents)	Mean	n	Mean	n
Bonneville	CSL	Spring	31 (31)	0.72	360	21.6	253
	SSL	Spring	22 (28)	0.38	48	26.4	30
		Fall	30 (31)	0.90	20	57.2	24
Willamette	CSL	Spring	7 (7)	0.87	56	39.2	71
	SSL	Spring	1 (1)	0.12	5	16.1	6

* Base dataset consisted of 16,278 resights of 569 individual sea lions. Excluding cases where an animal was only seen upriver one season and then never again (anywhere) resulted in 14,214 resights of 437 individual sea lions.
**Base dataset consisted of 16,278 resights of 569 animals. Excluding season of initial marking and/or removal resulted in 12,736 resights of 368 animals. Further excluding cases where <20% of the residency was actually resighted resulted in a dataset of 11,800 resights of 341 animals.

Table 5. Diet sub-model parameters based on scat and gastro-intestinal tract analyses as well as surface feeding observations at and below Bonneville Dam (BD) and Willamette Falls (WF).

				Diet component #1				Diet component #2			Diet component #3		
Location	Spp	Season	Removals (agents)	Prey	%	ED (kJ/g)*	Weight (kg)**	Prey	%	ED (kJ/g)*	Prey	%	ED (kJ/g)*
BD	CSL	Spring	31 (31)	Spring Chinook salmon	90	7.2	5.7	Pacific lamprey	5	25.65	Other	5	*U*(3, 7.2)
	SSL	Spring	22 (28)	Spring Chinook salmon	70	7.2	5.7	White sturgeon	20	4.4	Other	10	*U*(3, 7.2)
		Fall	30 (31)	Salmonid	40	5.9	5.4	White sturgeon	40	4.4	Other	20	*U*(3, 7.2)
WF	CSL	Spring	7 (7)	Salmonid	85	5.9	5.4	Pacific lamprey	10	25.65	Other	5	*U*(3, 7.2)
	SSL	Spring	1 (1)	Salmonid	15	5.9	5.4	White sturgeon	70	4.4	Other	15	*U*(3, 7.2)

*Energetic density (ED) sources: salmonids (O'Neil et al 2014), sturgeon (pers. com. P. Stevens, ODFW), lamprey (Clemens et al. 2019), other (Winship and Trites 2003).
**Mean weight sources: salmonids (predation-weighted mean of salmon and steelhead at Willamette Falls, Jepson et al. 2015); spring Chinook salmon (CRTIFC, 2004-2007).

Table 6. Bioenergetics sub-model parameters as modified from Winship et al. (2002).

Symbol	Description	Value	Units	Source
P	Production (energy invested in growth)	0	kJ d^{-1}	See methods
A_{water}	Water metabolic rate multiplier	~triangle(2.5, 4.0, 5.5)	Unitless	Winship et al. (2002)
A_{land}	Land metabolic rate multiplier	~triangle(1.0, 1.2, 1.4)	Unitless	Winship et al. (2002)
$water_{j = CSL}$	Percent of time spent in the water	~triangle(0.08, 0.78, 1)	%	Unpublished data, ODFW & WDFW
$water_{j = SSL}$	Percent of time spent in the water	~triangle(0, 0.68, 1)	%	Unpublished data, ODFW & WDFW
BM_j	Basal metabolism	$292.88 \times M_j^{0.75}$	kJ d^{-1}	Winship et al. (2002); adults
M_j	Body mass	f_i(mass, age)	kgs	Growth sub-model
E_{f+u}	Fecal and urinary digestive efficiency	~U(0.81, 0.89)	%	Winship et al. (2002)
E_{HIF}	Energy utilization efficiency	~U(0.85, 0.90))	%	Winship et al. (2002); maintenance
$prey_i$	% of total diet biomass comprised of prey i	0-100	%	Diet sub-model
ED_i	Energetic density of prey i	3-25.65	kJ g^{-1}	Diet sub-model

Table 7. Individual-level results summary for sea lion management ABM.

Location	Species	Season	Removals (agents)	Mean (range)					
				Lifetime return rate	Seasonal residency rate	Daily biomass requirement	Daily requirement as proportion of body mass	Daily salmonid biomass requirement	Daily salmonid requirement
BD	CSL	Spring	31 (31)	3.3 yrs (1.8-6)	20.1 days (1.6-22.3)	13.3 kgs (9.4-18.1)	0.037 (0.033-0.041)	12.1 kgs (8.5-16.5)	2.1 fish (1.5-2.9)
	SSL	Spring	22 (28)	3.2 (2-5)	27 (1.6-88.6)	24 (16.1-29.5)	0.035 (0.033-0.04)	14.3 (9.5-17.6)	2.5 (1.7-3.1)
		Fall	30 (31)	3.5 (2.9-5.6)	61.9 (1.6-133)	27.4 (16.2-35.6)	0.044 (0.04-0.052)	9.3 (5.5-12.1)	1.7 (1-2.2)
WF	CSL	Spring	7 (7)	3.2 (3.1-3.3)	39.3 (38.8-39.8)	14.1 (13.8-15.9)	0.043 (0.041-0.043)	12.8 (12.6-14.4)	2.4 (2.3-2.7)
	SSL	Spring	1 (1)	0.8 (0.8-0.8)	16.4 (16.4-16.4)	26.4 (26.4-26.4)	0.048 (0.048-0.048)	3.1 (3.1-3.1)	0.6 (0.6-0.6)