NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7

BIOLOGICAL OPINION

Title:	Environmental Protection Agency approval of Delaware and Maryland's adoption of criteria for ammonia in freshwater and cadmium in freshwater and saltwater and Delaware's adoption of criteria for nonylphenol in freshwater and saltwater
Consultation Conducted By:	Endangered Species Act Interagency Cooperation Division, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce
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Table of Contents

Page

Contents

List of Tables

List of Figures

Page

1 INTRODUCTION

The Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1531 et seq.), jointly administered by the U.S. Fish and Wildlife Service and National Marine Fisheries Service (NMFS, taken together, the Services), establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat they depend on. ESA section 7(a)(2) requires Federal agencies to insure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Federal agencies must do so in consultation with NMFS for threatened or endangered species (ESA-listed), or designated and proposed critical habitat that may be affected by the action that are under NMFS's jurisdiction (50 CFR §402.14(a)).

Section 7(b)(3) of the ESA requires that at the conclusion of consultation, NMFS provides an opinion stating whether the Federal agency's action is likely to jeopardize ESA-listed species or destroy or adversely modify designated critical habitat. If NMFS determines that the action is likely to jeopardize ESA-listed species or destroy or adversely modify critical habitat, in accordance with ESA section 7(b)(3)(A), NMFS provides a reasonable and prudent alternative that allows the action to proceed in compliance with the ESA. Take under the ESA means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct (16 U.S.C. §1532(19)). If the action (or a reasonable and prudent alternative) is expected to cause incidental take without violating section 7(a)(2), section 7(b)(4), as implemented by 50 CFR §402.14(i), requires NMFS to provide an incidental take statement (ITS), which specifies: the impact (i.e., amount or extent of take) of incidental take; reasonable and prudent measures (RPMs) determined necessary or appropriate to minimize such impacts; if appropriate measure from an Marine Mammal Protection Act 101(A)(5) permit; terms and conditions to implement the RPMs; and, procedures to be used to handle or dispose of any individual species actually taken. Incidental take must also be monitored and reported as the action proceeds and consultation must be immediately reinitiated should the amount or extent of incidental take specified in the ITS be exceeded. Any incidental take which occurs in compliance with the terms and conditions in the ITS is exempted from the ESA's prohibition on take (16 U.S.C. §1536(o)(2)).

The Federal action agency for this consultation is the U.S. Environmental Protection Agency Region 3 (EPA). The EPA requested ESA section 7 consultation for the approval of certain Water Quality Standards for Waters of the United States located in Delaware and Maryland under Clean Water Act section 303(c). The state agencies that implement the standards are the Delaware Department of Natural Resources and Environmental Control (DNREC) and Maryland Department of the Environment (MDE).

Formal consultations result in NMFS developing a biological opinion. The intent of a biological opinion is to ensure that the action will not reduce the likelihood of survival and recovery of an

ESA-listed species. A biological opinion usually also includes conservation recommendations that further the recovery of ESA-listed species. A biological opinion includes reasonable and prudent measures as needed to minimize any harmful effects, and may require monitoring and reporting to ensure that the project or action is implemented as described.

This consultation, its biological opinion (Opinion), and associated ITS were completed in accordance with ESA section 7, associated implementing regulations (50 CFR §§402.01-402.17), and agency policy and guidance (NMFS/USFWS 1998). The NMFS Office of Protected Resources (OPR) Endangered Species Act Interagency Cooperation Division (hereafter referred to as "NMFS," "we," or "our") conducted this consultation.

On July 5, 2022, the U.S. District Court for the Northern District of California issued an order vacating the 2019 regulations that were revised or added to 50 CFR part 402 in 2019 ("2019 Regulations," see 84 FR 44976, August 27, 2019) without making a finding on the merits. On September 21, 2022, the U.S. Court of Appeals for the Ninth Circuit granted a temporary stay of the district court's July 5 order. On November 14, 2022, the Northern District of California issued an order granting the government's request for voluntary remand without vacating the 2019 regulations. The District Court issued a slightly amended order two days later on November 16, 2022. As a result, the 2019 regulations remain in effect, and we are applying the 2019 regulations here. For purposes of this consultation and in an abundance of caution, we considered whether the substantive analysis and conclusions articulated in the Opinion and incidental take statement would be any different under the pre-2019 regulations. We have determined that our analysis and conclusions would not be any different.

This document represents NMFS's Opinion on the effects of these actions on Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*, Carolina, South Atlantic, New York Bight, Chesapeake, and Gulf of Maine Distinct Population Segments [DPS]); shortnose sturgeon (*Acipenser brevirostrum*); green (*Chelonia mydas,* North Atlantic DPS*)*, Kemp's ridley (*Lepidochelys kempii*), leatherback (*Dermochelys coriacea*), hawksbill (*Eretmochelys imbricata*), and loggerhead (*Caretta caretta*, Northwest Atlantic Ocean DPS) sea turtles; North Atlantic right (*Eubalaena glacialis*), fin (*Balaenoptera physalus*), and sei (*Balaenoptera borealis*) whales; and critical habitat designated for the Chesapeake and New York Bight DPSs of Atlantic sturgeon and North Atlantic right whale.

A complete record of this consultation was filed electronically by the NMFS Office of Protected Resources in Silver Spring, Maryland.

1.1 Background

Under the ESA, it is the policy of Congress that all Federal agencies shall seek to conserve threatened and endangered species, use their authorities in furtherance of the ESA, and cooperate with state and local agencies to resolve water resource issues in concert with conserving endangered species (16 U.S.C.§1531). Water quality standards are regulations established under the Clean Water Act that are intended to: protect public health and welfare; enhance the quality of water; restore and maintain the chemical, physical, and biological integrity of State, territory, or Tribe waters; and provide water quality protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water. Water quality standards include designated uses and narrative or numeric criteria to protect those uses. Narrative water quality criteria describe the desired conditions of a water body as being "free from" certain negative conditions. Numeric water quality criteria are maximum allowable concentrations of toxic pollutants or acceptable aquatic chemistry conditions (e.g., pH or temperature range, nutrients). This Opinion uses the term “criteria” when discussing the numeric water quality criteria EPA proposes to approve to distinguish these from the broader term ”water quality standards” that also describe the desired condition of water bodies and the means by which conditions will be protected or achieved.

The uses designated for State, territory, or Tribe waters inform the narrative and numeric water quality criteria that will apply for each use designation. Numeric and narrative criteria are used to determine whether the waters meet their designated use. Numeric criteria are used to set permit limits for effluent discharges and pollutant loading limits to restore pollution-impaired waters. Only those permitted effluent discharges that have a reasonable potential to cause an aquatic impairment for a given substance have permit limits and are required to monitor for that substance. Specifically at 40 CFR 122.44(d)(1) reads: “Limitations must control all pollutants or pollutant parameters (either conventional, nonconventional, or toxic pollutants) which the [EPA] Director determines are or may be discharged at a level which will cause, have the reasonable potential to cause, or contribute to an excursion above any State water quality standard.”

Because the numeric criteria set the exposure conditions for each stressor, NMFS’s analysis determines whether adverse effects may result from exposure to the stressor within the limits of its criteria. Clean Water Act section 303(c)(2)(B) requires States, territories, and Tribes to adopt numeric criteria for all toxic pollutants for National Recommended Water Quality Guidelines (National Criteria) that have been published under Clean Water Act section 304(a). Most of the National Criteria were developed by EPA under the 1985 EPA Guidelines for Deriving Numerical National Water Quality Criteria (EPA Guidelines, Stephen et al. 1985). Some National Criteria are calculated using models that account for bioaccumulation or the effects of site-specific aquatic chemistry on biological availability and thus toxicity.

Clean Water Act Section 303(c) requires that, at least once every three years, States, territories, and Tribes review and, when necessary, modify their water quality standards or adopt new water quality standards to protect waters under their jurisdiction. Implementation of State, territory, or Tribe water quality standards can also affect water quality in neighboring entities when rivers cross or delineate borders. As required by Clean Water Act section 303(c) and 40 CFR 131, EPA reviews water quality standards proposed for adoption by a State, territory, or Tribe, and cannot be implemented under the Clean Water Act until approved by EPA.

In terms of ESA section 7 consultations for Clean Water Act-related actions, the goal of the 2001 Memorandum of Agreement among EPA, NMFS, and the U.S. Fish and Wildlife Service is to enhance coordination under both statutes. The EPA consults with the Services on newly proposed and/or revised water quality standards to ensure that any adopted water quality standards are protective of ESA-listed species and critical habitats in waters under that state, territory, or tribe's jurisdiction and have a water quality standards description that includes the protection and propagation of fish, shellfish, and wildlife.

1.1.1 Prior Consultations

NMFS has not consulted with EPA on approvals of any water quality standards for the states of Maryland and Delaware. NMFS has consulted with EPA on approvals for ammonia, cadmium, and nonylphenol for other states. The basis of our determinations in prior consultations for these chemicals were not identical for each state. They were based on, the ESA-listed species and designated critical habitat likely to be exposed, the protectiveness of the criteria for those species, the land uses and pollutants sources associated with waters where those species occur, and the state's planned implementation of the standards[1] (FPR-2017-9229, OPR-2019-03141, OPR-2021-00175, OPR-2022-00203, and OPR-2022-02170).

1.2 Preconsultation

On December 9, 2021, staff from EPA Region 3 and NMFS Office of Protected Resources, Interagency Cooperation Division (NMFS OPR), held a conference call to discuss coordination on upcoming EPA approvals of state-proposed water quality criteria under section 303(c) of the Clean Water Act. During this call NMFS OPR forwarded a link to the NMFS Greater Atlantic Region Consultation Mapper and indicated that consultation would need to consider the protectiveness of the criteria along with the consequent implementation of criteria in permitting discharges, listing impaired waters, and establishing total maximum daily pollutant loads (TMDLs) or other restoration plans to recover impaired waters. EPA subsequently transmitted Maryland's draft 303(d) list of impaired waters on December 27, 2021 and Delaware's 2022 Integrated Water Quality Report of assessed and impaired waters on March 9, 2022.

1.3 Consultation History

On July 1, 2022, EPA Region 3 sent NMFS OPR a draft Biological Evaluation (BE) on Maryland's proposed criteria for review and comment.

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[1] For example, some states limit hardness values used in calculators of hardness-based criteria.

On August 5, 2022, NMFS OPR responded to EPA with comments on the draft BE and shared the analysis for aluminum criteria to illustrate a concern noted in the comments.

On September 22, 2022, EPA Region 3 sent NMFS OPR a draft BE on Delaware's proposed criteria for review and comment.

On October 4, 2022, NMFS OPR responded with comments on the draft BE and described the information needed that would facilitate consultation.

On October 6, 2022, EPA Region 3 and NMFS met to discuss the draft BEs for Maryland and Delaware proposed criteria and NMFS shared an example BE from EPA Region 1 and a shapefile of HUC12s where ESA-listed sturgeon occur in Delaware, Maryland and Virginia.

On October 11, 2022, EPA Region 3 sent NMFS a draft request to initiate consultation, a draft set of Reasonable Prudent Measures (RPMs) based on the EPA Region 1 RPMs, and a checklist of Checklist of supplemental Info that will be submitted along with EPA's BEs based on information in NMFS's October 4, 2022 e-mail.

On October 31, 2022, EPA Region 3 and NMFS OPR exchanged a series of e-mails to determine what waters DNREC and MDE consider fresh water and what waters are considered salt waters for the purposes of applying water quality criteria.

On November 7, 2022, EPA Region 3 and NMFS met to discuss the proposed RPMs for Maryland and Delaware proposed criteria.

On December 2, 2022 EPA Region 3 sent NMFS OPR a request for formal consultation on their approval of water quality criteria proposed by the states of Delaware and Maryland.

On April 7, 2023 EPA Region 3 and NMFS agreed to a two week extension to allow for review and clearance of the biological opinion.

On April 26, 2023, EPA Region 3 and NMFS confirmed that the agreed upon RPMs had not changed.

2 THE ASSESSMENT FRAMEWORK

ESA section 7(a)(2) requires Federal agencies, in consultation with NMFS, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species; or adversely modify or destroy their critical habitat.

"Jeopardize the continued existence of" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of an ESA-listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR §402.02).

"Destruction or adverse modification" means a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species (50 CFR §402.02).

The assessment framework is designed to logically conclude whether EPA is able to ensure this action satisfies section 7(a)(2) of the ESA. This consultation involves the following steps:

Description of the Action (Section 3): Action is defined in the regulations at 50 CFR 402.02 and includes all direct and indirect modifications to land, water, or air. We describe the numeric water quality criteria EPA proposes to approve and their expected implementation.

Action Area (Section 4): We describe the action and those aspects (or potential stressors) of the action that may cause modifications to the physical, chemical, and biotic features of land, water, and air. We describe the action area with the spatial extent of the modifications from those actions.

Status of Species and Critical habitat (Section 5): We identify the ESA-listed species and critical habitat that are likely to co-occur with the potential stressors caused by the action in space and time and evaluate the status of those species and habitat. At this stage, we assess how the modifications to land, water, and air affect the species and critical habitat in the action area to determine which of these potential stressors are actual stressors. In section 5.1, we identify those species and critical habitats that may be affected, but are not likely to be adversely affected by the stressors caused by this action. We then identify the status of the remaining species and critical habitat likely to be adversely affected (Section 5.2).

Environmental Baseline (Section 6): We describe the environmental baseline as the condition of the listed species or its critical habitat in the action area, without the consequences to the listed species or critical habitat caused by the action. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process. The consequences to listed species or critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 C.F.R. §402.02).

Stressors Associated with the Action (Section 7): We discuss the stressors we expect to result from the action. In this Opinion the stressors of the action are the substances for which numeric water quality criteria are to be approved by EPA for use in Maryland or Delaware waters.

Effects of the Action (Section 8): refers to all consequences to listed species or critical habitat that are caused by the action, including the consequences of other activities that are caused by the action. A consequence is caused by the action if it would not occur but for the action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action. (50 CFR §402.02). In this consultation, if EPA approves adoption of water quality criteria for specific toxicants, a consequence of that approval is the implementation of the criteria. Once criteria are approved by EPA, DNREC and MDE may issue National Pollution Discharge Elimination System (NPDES) permits for discharges of these pollutants and may use the criteria to assess and list aquatic impairments under sections 305(b) and 303(d) of the Clean Water Act, respectively, and where necessary, calculate load limits for impaired waters based on the presence of pollutants above criteria limits.

Because this action involves independently implemented criteria, the analysis is provided as two independent effects analyses in order to maintain focus on one determination at a time. The structure of the effects of the action subsections for ammonia, cadmium, or nonylphenol, each “stressor X” in this Opinion is as follows:

> *Section 8.x Stressor X*: Introduces stressor “X” (i.e., ammonia, cadmium, or nonylphenol), summarizing uses, sources, environmental fate, mechanism(s) of effect, the BE analysis, and the criteria.
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> *Section 8.x.1 Exposure to Stressor X within the Action Area*: Identifies sources within the action area and evaluates monitoring and permitting data for stressor X to characterize current and future implementation of the criteria. This section also identifies the life stages of ESA-listed individuals that are likely to be exposed to stressor X.
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> *Section 8.x.2 Responses to Stressor X within Criteria Limits*: Analyzes the available evidence, using data from surrogate species when necessary and appropriate, to determine how individuals of ESA-listed species are likely to respond to exposures to X within criterion limits. This section also evaluates responses of forage species exposed within criteria limits.
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> *Section 8.x.3 Risk Analysis*: The risk analysis for those likely to adversely affect determinations identified in section 8.x.2 lays out the evidence supporting the determination then evaluates the consequences of effects in individuals to the populations those individuals represent, and the species those populations comprise. Where effects to critical habitat are expected, the risk analysis also considers the impacts of the proposed action on the physical or biological features and conservation value of critical habitat.
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> Risk hypotheses are statements that organize an analysis by describing the relationships among stressor, exposure, and the environmental values to be protected. Generally speaking, the values to be protected are the survival and fitness of individuals and the value of critical habitat for conservation of an ESA-listed species. The applicable risk hypotheses for direct stressors like toxic substances are straight forward, EPA’s approval will be likely to adversely affect an ESA-listed species if exposures to the toxic pollutant within criteria limits will result in:

- Reduced survival of individuals through direct mortality or effects favoring predation (e.g., immobility, reduced predator detection);
- Reduced growth of individuals through direct effects of toxicity or effects impairing foraging (e.g., swimming, deformity, prey detection, strike success);
- Reduced fecundity through direct effects of toxicity (e.g., reduced hatch, egg mass, egg counts) or effects impairing reproduction (e.g., impaired nest tending, gonad mass);
- Reduced survival, growth, and/or fecundity due to diminished quantity or quality of forage due to toxic effects on forage species abundance or toxic effects of body burdens of the stressor in forage species; and/or
- Toxic effects on biological features (e.g., forage species or vegetative habitat) of critical habitat that are essential to the conservation of the species.

Cumulative Effects (Section 9): Cumulative effects are the effects to ESA-listed species and critical habitat of future nonFederal or private activities that are reasonably certain to occur within the action area (50 CFR §402.02). Effects from future Federal actions that are unrelated to the action under consideration are not addressed because they require separate ESA section 7 cooperation.

Integration and Synthesis (Section 10): In this section, we integrate the analyses of Effects of the Action (Section 8), the Environmental Baseline (Section 6), and the Cumulative Effects (Section 9) and place this in context of the Status of Species and Critical habitat (Section 5) to formulate the agency's biological opinion as to whether the action agency has insured its action is not likely to reduce appreciably the likelihood of survival and recovery of an ESA-listed species in the wild or appreciably diminish the value of critical habitat as a while for the conservation of a listed species.

Conclusion (Section 11): With full consideration of the status of the species and the critical habitat, we consider the effects of the action within the action area on populations or subpopulations and on essential habitat features when added to the environmental baseline and the cumulative effects to determine whether the action could reasonably be expected to:

- Reduce appreciably the likelihood of both the survival and recovery of ESA-listed species in the wild by reducing its numbers, reproduction, or distribution, and state our conclusion as to whether the action is likely to jeopardize the continued existence of such species; or
- Appreciably diminish the value of critical habitat as a whole for the conservation of an ESA-listed species, and state our conclusion as to whether the action is likely to destroy or adversely modify critical habitat.

If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of ESA-listed species or destroy or adversely modify critical habitat, then we must identify reasonable and prudent alternative(s) to the action, if any, or indicate that to the best of our knowledge there are no reasonable and prudent alternatives. See 50 C.F.R. §402.14(h)(2).

If we determine EPA has satisfied ESA section 7(a)(2) or identify a reasonable and prudent alternative, we include an Incidental Take Statement (Section 12) that specifies the impact of the take, reasonable and prudent measures to minimize the impact of the take, and terms and conditions to implement the reasonable and prudent measures (ESA section 7(b)(4); (50 CFR 402.14(i) and 50 CFR 402.14(g)(7))). We also provide discretionary Conservation Recommendations (Section 13) that may be implemented by the action agency (50 CFR §402.14(j)). Finally, we identify the circumstances in which Reinitiation of Consultation is required (Section 14; 50 CFR §402.16).

> *Note: Discovery of toxicity data, either found or newly generated, indicating ESA-listed species may respond to exposures within criterion limits or information that indicates a previously unexpected stressor assessed in this consultation is present or will be discharged where ESA-listed species occur may be considered "new information" and may trigger reinitiation of consultation (Section 14) for EPA's approval of that criterion.*

2.1 Best Scientific and Commercial Data Available for the Consultation

To comply with our obligation to use the best scientific and commercial data available (16 U.S.C. 1536(a)(2)), we collected information identified through searches of Google Scholar, Web of Science, the literature cited sections of peer reviewed articles identified in these searches, reports published by government and private entities, and species listing documentation. The BE provided by EPA includes summaries of toxicity data that EPA used to evaluate whether proposed criteria may result in harm to ESA-listed species and critical habitat. Our assessment considers these summaries, but also considers other data found in EPA's ECOTOXicology Knowledgebase (ECOTOX), particularly data that were not available or considered suitable for the derivation of criteria, including data added or refreshed in the ECOTOX quarterly update. Use of additional data when vetting the criteria for effects to ESA-listed species is consistent with EPA's Guidelines and the requirement under the ESA that determinations be made based on the best available data. This Opinion is based on our review of this information and various other information sources, including:

- The BEs, spreadsheets, and interactive mapper submitted by EPA;

- Government databases, including ECOTOX[2], EPA's Enforcement and Compliance History Online Database (ECHO) and the National Water Quality Monitoring Council's Water Quality Portal were frequently consulted interactively during the preparation of this Opinion;
- Government reports, including NMFS opinions and stock assessment reports;
- National Oceanic and Atmospheric Administration (NOAA) technical memoranda; and
- Peer-reviewed literature.

These resources were used to identify information relevant to the potential stressors and responses of ESA-listed species and critical habitat under NMFS's jurisdiction that may be affected by the proposed action to draw conclusions on risks the action may pose to the continued existence of these species and the value of critical habitat for the conservation of ESA-listed species.

2.1.1 Toxicity Test Data

Toxicity tests expose laboratory-reared organisms to toxicants over a range of concentrations. Results are typically are reported as endpoints reflecting the magnitude of response or statistical significance from controls. Common endpoints include:

- concentration at which half of the exposed organisms die (lethal concentration for 50 percent of organisms, LC50);
- lowest test exposure at which a given effect or response did not differ from controls (no observed effects concentration, NOEC);
- lowest test exposure at which the effect or response differed significantly from controls (lowest observed effects concentration, LOEC);
- effect concentration (EC) at which a certain proportion of an effect was observed (EC##, such as EC10 = concentration at which ten percent of test organisms show an adverse response); and
- maximum acceptable toxic concentration (MATC), which is typically the geometric mean of the LOEC and NOEC, but other calculations have been used.

Interpreting toxicity test data is made challenging by the tremendous amount of diversity in the available data. The most abundant toxicity data are LC50s, followed by NOECs and LOECs and EC50s. Other fractional endpoint responses (e.g., EC10, LC20) and response endpoints (e.g. inhibition concentration: IC10) are less abundant. Data are not equally available for all types of endpoints or responses and can vary widely due to differences in the life stages of the organisms

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[2] The ECOTOX is refreshed quarterly to add new records and correct errors or add additional information to existing records. NMFS collects and screens toxicity data from ECOTOX for various chemicals, including ammonia, cadmium, and nonylphenol and these curated datasets are updated from ECOTOX and the open literature as necessary.

used and the study design (e.g., exposure duration, flow through versus static exposures). Data are typically not available for exposures of ESA-listed species under NMFS's jurisdiction. Saltwater exposures are particularly sparse. Limiting the data to a narrow set of toxicity test types for the sake of consistency would only result in loss of information that is otherwise useful for evaluating the protectiveness of the criteria. Given the variance around any point estimate, the concentration one standard deviation below an LC05 or EC05 could conceptually encompass an LC00 or EC00, but larger response magnitudes would occur at the LC05 plus one standard deviation. As such, NMFS does not consider LC05s or EC05s to be bright line decision points that, above and below which, determines "safe" from "not safe." Rather, when NMFS encounters these estimates they are viewed as context for potential effects to ESA-listed species.

It is important to note that LOEC and NOEC data are influenced by study design (e.g., distribution and number of concentrations tested). Depending on exposures tested and underlying variability in responses, the LOEC may actually result in a 30 percent difference in response from controls. In addition, the same exposure concentration may be reported as the NOEC for one type of response, such as growth, and as the LOEC for another, such as reproduction.

2.1.2 Mixture Toxicity

In point or nonpoint source pollution, chemicals occur together in mixtures, but criteria for those chemicals are developed in isolation, without consideration of additive toxicity or other chemical or biological interactions. A study by Spehar and Fiandt (1986) included effect-by-concentration information on the acute toxicity of chemical mixtures. Rainbow trout and *Ceriodaphnia dubia* were exposed for 96 and 48 hours, respectively, to a mixture of arsenic, cadmium, chromium, copper, mercury, and lead, each at their presumptively "safe" acute criterion. In combination, the acute criterion concentrations killed 100 percent of rainbow trout and *Ceriodaphnia*, but 50 percent of the acute criterion concentrations killed none (Spehar and Fiandt 1986). This gives support to the assumption that dividing a lethal exposure by two would usually kill few if any fish, although it conflicts with arguments that criteria are protective for mixtures of metals at their respective acute criterion. In chronic tests, the authors determined that rainbow trout embryo survival and growth were not reduced when exposed to combinations of these metals at their chronic criteria concentrations. However, adverse effects were observed at mixture concentrations of one-half to one-third the approximate chronic toxicity threshold of fathead minnows and daphnids, respectively, suggesting that components of mixtures at or below NOEC concentrations may contribute significantly to the toxicity of a mixture on a chronic basis (Spehar and Fiandt 1986).

Whether the toxicity of chemicals in mixtures is likely greater or less than that expected of the same concentrations of the chemicals singly is a complex and difficult problem. While long recognized, the "mixture toxicity" problem is far from being resolved. Even the terminology for describing mixture toxicity is dense and inconsistently used (e.g., Marking 1985; Sprague 1970;

Vijver et al. 2010). One scheme for describing the toxicity of chemicals in mixtures is whether the substances show additive, less than additive, or more than additive toxicity. The latter terms are roughly similar to the terms "antagonism" and "synergism" that are commonly, but inconsistently, used in the technical literature.

Relatively few toxicity studies have addressed this issue, and some studies have indicated conflicting results due to complex interactions that vary with the combination(s) and concentrations involved (Sorensen 1991). However, a number of studies have determined conclusively that adverse effects due to additive or synergistic toxicity mechanisms occur when one or more metals are near or equal to acute criteria concentrations (e.g., Alabaster and Lloyd 1982; EIFAC 1969; Enserink et al. 1991; Sorensen 1991; Spehar and Fiandt 1986).. Combinations of organic pollutants also have been shown to result in different toxic responses, as have combinations of organic and metals contaminants.

For both metals and organic contaminants that have similar mechanisms of toxicity (e.g., different metals, different chlorinated phenols), assuming chemical mixtures to have additive toxicity has been considered reasonable and usually protective (Alabaster and Lloyd 1982; Meador 2006; Norwood et al. 2003). The EPA water quality guidelines were developed for toxicants singly, as if the toxicant was the only chemical present. However, in the real world, chemicals always occur in mixtures. As a result, criteria and discharge permits based upon them may afford less protection than intended.

2.2 NMFS's Evaluation of Water Quality Criteria

Consultation on EPA 303(c) approvals apply an analysis protocol in addition to the Assessment Framework described in Section 2. Our purpose is to determine whether there is any indication that ESA-listed species or critical habitat under NMFS's jurisdiction are likely to be affected by exposures within criteria limits. This is actually a two-step analysis, first determining whether exposures are expected to occur followed by determining whether exposures within criteria limits may result in adverse effects.

Using the best available data to assess the implications of EPA's approval on ESA-listed species and critical habitat will not mirror how data were used for deriving criteria. Deriving criteria is a very different goal from evaluating criteria for protection of imperiled species. Most criteria are developed consistent with Guidelines using endpoints identified through toxicity tests. The EPA applies restrictions to the types of data that may be used in deriving criteria. The data must meet very specific and stringent requirements; thus, laboratory conditions are tightly controlled, which is quite different from variability in natural systems the criteria are expected to protect. This level of control is necessary to attribute the response to the exposure. Data requirements also limit the types of responses and how those responses are reported. This ensures consistency among data to allow aggregation of information on the responses of multiple species from multiple studies (i.e., meta-analysis) to derive criteria. Data that are not acceptable for criteria derivation include tests that: lack a control, have too few exposure concentrations, have unacceptable mortality or disease in controls, report atypical responses (e.g., behavior) or measures of response (e.g., time to death), have exposures of the wrong duration, or used species that do not have reproducing wild populations in North American waters.

Acute criteria are derived through a meta-analysis that ranks a chemical's LC50 data among species to form a "sensitivity distribution." The acute criterion for that chemical is set at one-half the LC50 concentration that is hazardous to five percent of species exposed to the toxicant for four days. An exposure in which half of exposed organisms die or are otherwise affected (e.g. an EC50 for immobilization) is clearly not an insignificant effect. It is EPA's expectation that one half the LC50 approximates a low or no effect threshold. However, as demonstrated in prior Opinions for EPA approval of water quality standards (NMFS 2012a; NMFS 2014; NMFS 2020b), the validity of the assumption that one half an LC50 is a safe exposure is reliant on the slope of the exposure-response relationship (Figure 1), with shallow exposure-response curves indicating up to 20 percent mortality at one-half the reported LC50.

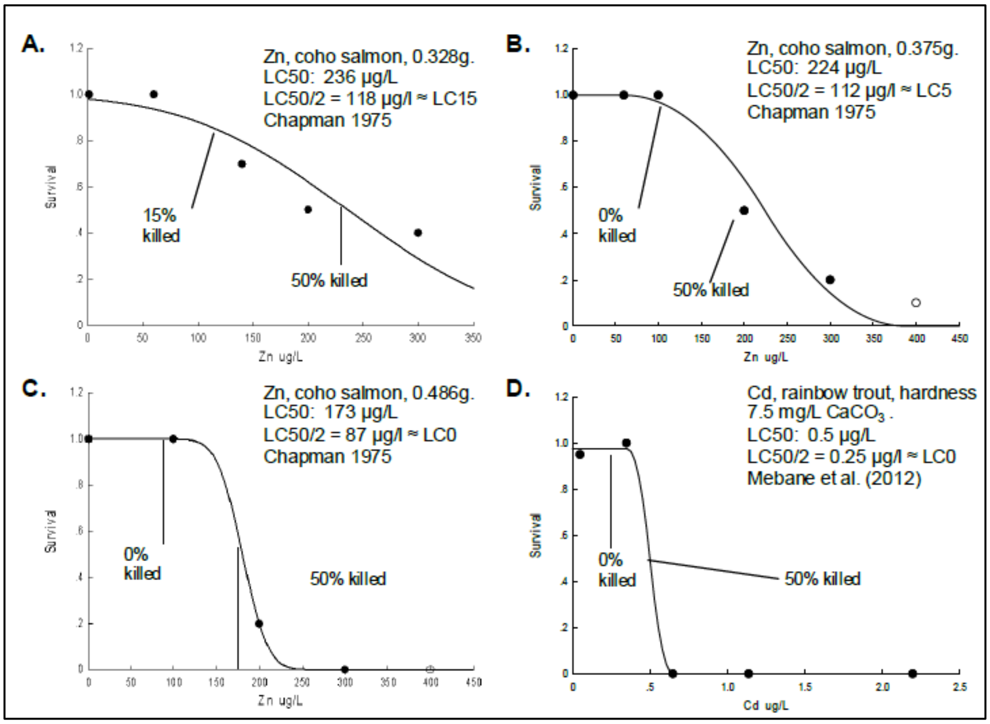

Figure 1. Plots Showing Proportion of Coho Salmon or Rainbow Trout Killed at One-Half Their LC50 Concentrations with Cadmium, Copper, and Zinc (NMFS 2014)

A more common pattern with metals data analyzed for a previous water quality consultation was that half an LC50 concentration would probably result in about a five percent death rate in salmon (NMFS 2012a). Testing with cutthroat trout and cadmium, lead, and zinc singly and in mixtures, Dillon and Mebane (2002) found that the LC50/2 concentration corresponded with death rates ranging from 0 percent to 15 percent.When the original toxicity test data are not provided, it is not possible to calculate the actual magnitude of response at the criterion concentration. In such cases, a comparison metric in some form is necessary to place median effect data (e.g., LC50s and EC50s) in context of the criterion. Comparison metrics used for this purpose are essentially ratio approaches. A risk or hazard quotient is the ratio of an anticipated exposure concentration to a reference concentration. When evaluating the protectiveness of a numeric water quality criterion, the anticipated exposure concentration is the criterion concentration and the reference concentration is the concentration at which a response, such as an EC10, LOEC, or LC50, was reported.

For this Opinion, NMFS evaluates monitoring and toxicity data in terms of risk quotients because quotients place the data directly in the context of the applicable criterion. The term "applicable criterion" refers to a criterion calculated to match the aquatic chemistry reported for a monitoring event or toxicity test. The term "test-specific criterion" is also used to identify a criterion calculated to match aquatic chemistry conditions of the test. The use of risk quotients allows simultaneous presentation of the entirety of the data landscape and transparently identifies responses that occurred at concentrations one or more orders of magnitude above or below the criterion (i.e., factors of ten), at concentrations that are multiples of the criterion (e.g., twice, four times) or within a "gray area" that demands more careful consideration.

For the evaluation of the acute and chronic cadmium criteria, NMFS used the hardness values reported with toxicity data to calculate toxicity test-specific criteria using the equations published in EPA's biological evaluation. NMFS then used the test-specific criteria to calculate risk quotients: the test-specific criterion, as the presumed exposure concentration, divided by the endpoint effect concentration (e.g., LOEC, NOEC, EC50, LC50 etc.). Considering the scale of uncertainty associated with interspecies and lab-to-field extrapolation, we conservatively applied the acute criterion, which is implemented as a one-hour average, for toxicity test exposures that were four days or less and applied the chronic criterion, which is implemented as a four-day average, to longer exposures.

Risk quotients for all available endpoint effect data from the screened datasets are plotted in context of reference values representing the applicable criterion concentration and one-half that criterion concentration. The toxicity data figures in this Opinion (Figures 8 through 11 and Figures 18, and 19) present test-specific risk quotients plotted in context of reference lines representing a risk quotient of one (purple) for exposures at the criterion concentration and a risk quotient of 0.5 (orange) representing exposures at one-half the criterion concentration. Risk quotients plotted to the right of the purple reference line indicate responses occurring at an exposure concentration below the applicable criterion (i.e., higher risk). Risk quotients are plotted on a log scale to enhance resolution. Those few data reported in with "<" operators are presented as hollow icons (i.e., □, Δ, □) to indicate that the response is expected to occur at a concentration less than the reported concentration. This typically happens when a response is observed at the lowest concentration tested in the study.

Less common endpoint types are defined in NMFS's analysis when they are represented in a dataset at concentrations suggesting adverse effects for exposures within criteria limits. Endpoints are sometimes reported with "<" and ">" to indicate studies in which only one exposure concentration was used or responses for that effect either occurred below the lowest exposure concentration, the less than sign "<", or above the highest exposure concentration used in that study, the greater than sign ">". This analysis excludes data reported with a greater than sign because they indicate that the response occurred at some unknown higher concentration than indicated and does not inform whether effects occur at concentrations within or below criterion limits.

While ratio approaches like risk quotients offer straightforward derivation and a "bright line" for interpretation, they do not reflect a plausible worst case scenario, capture the variation around individual endpoint estimates or the abundance, relevance, and overarching depth and quality of available data.

Considering the slope of exposure-response relationships reported for a vast majority of toxicants, for the reasons described below, we expect that ESA-listed species are extremely unlikely to respond to exposures within criterion limits if the criterion concentration is orders of magnitude lower (i.e., by ten or 100-fold or more) than the lowest reported acute lethal effect (e.g., LC50s or EC50s) or the lowest chronic exposure-response threshold (e.g., LOEC). Interpreting criteria when the minimum exposures resulting in toxic response (i.e., LC50s, LOECs, and MATCs) are not one or more orders of magnitude greater than the criteria is somewhat more complicated. The magnitude of response at the applicable criterion concentration may be at some lower, but adversely affect ESA-listed species.

2.2.1 Screening Data for Use in this Opinion

The screened datasets for NMFS's analysis include data that were not used in criteria derivation (e.g., LC10, IC50) because our purpose is to determine whether there is any indication that ESA-listed species under NMFS's jurisdiction are likely to be affected by exposures within criteria limits. In light of that purpose, data for all available organism-level effects are considered. This includes important but less commonly studied effects, such as altered behavior (e.g., prey strikes) or responses that affect behavior (e.g., acetylcholinesterase inhibition). Data for species that do not have reproducing populations in the United States were also included among data considered in this evaluation. When multiple effects were reported for a single endpoint, the effect was reassigned to a single type of response, favoring reproduction over growth, and growth over survival (i.e., effective mortality, mortality) when those options are among the effects reported.

In addition to extracting data from EPA's ECOTOX database, the analysis examined original sources to verify critical data and identify any important details not included in ECOTOX. Information from recently published literature in the Web of Science and Google Scholar was also collected. Queries of EPA's ECOTOX excluded records identified as having unacceptable controls. Data reported as formulations (i.e., a pesticide plus another active ingredient) were excluded to ensure the response was the result of exposure to the active ingredient. NMFS determined that data did not need to be adjusted for purity because, among those records reporting purity of the test substance, all reported values of 98 percent or greater pure. NMFS expects that a level of two percent is insignificant relative to typical confidence intervals among analytical data. Data were excluded if test organisms were pre-exposed (i.e., acclimation studies) or if test organisms were collected from polluted waters. Endpoints with effect magnitudes greater than 50 percent (e.g., EC75, LC90) were excluded because there is no way to place these in context of a criterion's protectiveness. Only records reporting mean exposure concentrations or concentration ranges where the maximum was less than two-fold the minimum were retained because a definitive effect threshold (i.e., the exposure concentration at which a response is altered) is needed for assessing the protectiveness of a criterion. When an effect threshold was reported as a range, NMFS's analysis conservatively used the minimum reported concentration. Studies reporting nominal rather than measured exposure concentrations were retained when this aspect did not influence the overall consistency among records.

Criteria for cadmium are calculated using data for hardness, an aquatic chemistry parameter that influences the biological availability of cadmium. Consequently, studies lacking the hardness data could not be included in the evaluation. Where necessary, reported cadmium concentrations were corrected to dissolved form using EPA's recommended conversion factor. We also excluded data for metals toxicity where only the free ion (i.e., labile) concentration was reported because the metals criteria are based on the dissolved fraction of the metal (i.e., the sample fraction that will pass through a 0.45-micron filter) and there is no standard approach to converting labile metal to dissolved metal.

CONSIDERING FLOW-THROUGH, RENEWAL, OR STATIC EXPOSURE TEST DESIGNS

Test organisms are typically exposed to test solutions through one of three methods. In "static" tests, organisms are in the same test solution for the duration of the test. In "renewal" tests, fresh test solution is replaced once every 24 or 48 hours. In "flow-through" tests, steady-state exposure is achieved by continuously providing fresh test solution throughout the test (ASTM 1997). A flow-through test does not create a current; it just means that test solution is introduced as a once-through, nearly continuous delivery of test solution. Historically, flow-through toxicity tests were thought to provide a better estimate of toxicity than static or renewal toxicity tests because they provide a greater control of toxicant concentrations, minimize changes in water quality, and reduce accumulation of the organism's waste products in test exposure waters (Rand et al. 1995).

While EPA Guidelines instruct that when there are data for flow-through tests, any static or renewal tests data for that species are to be discounted (Stephan 1978), an important consideration is that natural flowing waters should not be assumed to be in chemical equilibria. Tributary inputs, hyporheic exchanges, stormwater and snowmelt, and daily and seasonal fluxes in pH, carbon, light penetration, and temperature cycles will influence the bioavailability of aquatic pollutants (Stumm and Morgan 1996) and the physiology of aquatic organisms (Heath 1995; McCormick and Leino 1999).

Static exposure studies can yield LC50 values substantially higher than values obtained with flow-through tests or tests in which actual concentrations of contaminants in the system during the experiment are measured. For example, for DDT, LC50 values for static tests have been determined to be approximately 20 times higher than LC50s from flow-through tests (Earnest and Benville 1972). Mercury toxicity testing of trout embryos has indicated that effects concentration-based endpoints (e.g., ECXX, or the effects concentration that cause a specified percent reduction in a particular response) could be as much as one to two orders of magnitude lower in flow-through than static tests (Birge et al. 1981; Birge et al. 1979). Static tests also resulted in higher endpoint estimates for endosulfan when compared with data from flow-through tests (Naqvi and Vaishnavi 1993). Several additional studies with a variety of compounds report static exposures under estimating toxicity (i.e., providing higher endpoint estimates. (e.g., Burke and Ferguson 1969; Erickson et al. 1998; Hedtke and Puglisi 1982; Randall et al. 1983; Vernberg et al. 1977). There are a number of reasons static conditions can underestimate the true exposure concentration in a test. Fish will deplete the concentration in solution over time, causing a lack of steady-state exposure. Some toxicants may transform during the test or volatilize from the test chamber. Other toxicants can adsorb to the walls of the exposure chamber or to accumulating organic matter within the exposure chamber.

With metals, renewal tests can also produce higher EC50 concentrations than flow-through tests (i.e., metals were less toxic). This has been attributed to the adsorption to accumulated organic matter (Erickson et al. 1996; Erickson et al. 1998; Welsh et al. 2008). However, in contrast to earlier EPA and American Society for Testing and Materials recommendations favoring flow-through testing, Santore et al. (2001) suggested that flow-through tests were biased low because typical flow-through exposure systems allowed insufficient hydraulic residence time for complete copper-organic carbon complexation to occur. Copper complexation with organic carbon reduces acute toxicity, but is not instantaneous. Davies and Brinkman (1994) similarly found that cadmium and carbonate complexation was incomplete in typical flow-through designs, although they reported the opposite effect of copper studies, with cadmium in aged, equilibrated waters being more toxic.

When comparing data across different tests, it appears that other factors, such as testing the most sensitive-sized organisms or number of organisms per liter of test water, may be much more important than flow-through or renewal techniques. For instance, a Pickering and Gast (1972) study with fathead minnows and cadmium produced flow-through LC50 concentrations that were lower than comparable static LC50 values (~ 4,500 to 11,000 micrograms per liter [µg/L] for flow-through tests vs. ~30,000 µg/L for static tests). The fish used in the static tests were described as "immature," weighing about two grams. The size of the fish used in their flow-through acute tests was not given, but is assumed to have been similar. By contrast, using modern protocols and newly hatched fry weighing about 1/1000th of the fish used by Pickering and Gast (1972), cadmium LC50 concentrations for fathead minnows tend to be around 50 µg/L, with no obvious bias for test exposure (USEPA 2002). Studies examining exposure of brook trout to cadmium report dramatically different results using flow-through and static exposures on different life stages. NMFS identified two brook trout studies, one using flow-through and one using static acute tests, both conducted in waters of similar hardness (41 to 47 milligrams per liter, mg/L). The LC50 of the static test which used fry was <1.5 µg/L whereas the LC50 of the flow-through test using yearlings was >5,000 µg/L (Carroll et al. 1979; Holcombe et al. 1983).

When all other factors are equal, it appears that renewal tests may indicate chemicals are somewhat less toxic (e.g., higher LC50 values), but there is no clear consensus whether this indicates that renewal tests are biased toward lower toxicity than is "accurate" or whether conventional flow-through tests are biased toward higher toxicity. Comparisons with data across studies suggest that other factors, in particular the life stage of exposures (e.g., Carroll et al. 1979; Holcombe et al. 1983; Pickering and Gast 1972), can dwarf the influence of flow-through or renewal methods for the acute toxicity of, at least, metals. For this reason, data were not excluded on the basis of test design.

2.2.2 Evaluating Criteria Protectiveness for ESA-listed Species

Because the criteria developed using the EPA Guidelines are not expected to protect all species under all circumstances, waters compliant with the criteria may result in pollutant exposures that cause adverse effects in threatened and endangered species. When assessing risk to an ESA-listed species, the vulnerability of an imperiled population of that species to the loss of an individual, or key individuals such as reproductive age females, amplifies the fundamental threat posed by a toxic pollutant. The underlying assumptions in the methods used to arrive at criteria affect how well ESA-listed species and critical habitat are protected. These assumptions include:

- Effects that occur on a species exposed to a toxicant in laboratory tests will generally be the same for the same species exposed to that toxicant under field conditions (i.e., effects are not influenced by predation, competition, disease, exposure to other stressors in the field, and fluctuations in natural water quality parameters).

- Collections of single-species laboratory toxicity test data used to derive criteria reflect communities in natural ecosystems.
- Data on severely toxic effects from short-term "acute" toxicity tests used to derive acute criterion can be extrapolated to less severe effects that would be expected to occur in long-term "chronic" exposures to derive chronic criterion.
- Loss of a small number of species from an aquatic community will not affect the propagation of fish, shellfish, and wildlife.
- Loss of a small number of species from an aquatic community will not result in incidental loss of any “economically or recreationally valuable species” for which data were not available.
- Sensitive species and life stages are adequately represented such that criteria are not biased toward tolerant species or life stages.
- Derivation of criterion for a single chemical in isolation without regard to the potential for additive toxicity or other chemical or biological interactions is acceptable despite chemicals typically occur in mixtures in the environment.
- When applied to NPDES permits, unless the waters are already identified as impaired by a particular pollutant, the waters are free of that pollutant (i.e., the baseline concentration of that pollutant in the receiving water is zero).
- Accumulation of chemicals in tissues and along the food web does not result in ecologically significant latent toxicity or toxic exposures for predators.

In reality, data sets for sublethal responses are usually small and have gaps such that sensitive species and life stages are under-represented. In addition, Variability within and among species used in calculating a hazardous concentration to five percent of species may be substantial, but this variability is not reflected in the final estimate used to derive an acute criterion.

For an ESA section 7 consultation, NMFS is required to use “the best scientific and commercial data available” (ESA section 7 (a)(2); 50 CFR §402.14(d)). It is important to note that EPA’s use of data for criteria derivation and associated regulatory actions is not the same as NMFS’s use of data for this consultation. For example, the requirement that EPA only use data for species that are native to waters of the United States means data on effects to sturgeon of the same genus as ESA-listed sturgeon that occur only in foreign waters would be excluded. This consultation is vetting the criteria. It is not necessary to create reference values or extrapolation factors. This would require restricting data. NMFS considers all data meeting the screening criteria discussed in the following section. This is consistent with the EPA Guidelines, as it discussed the use of “Other Data” as follows:

> *Pertinent information that could not be used in earlier sections might be available concerning adverse effects on aquatic organisms and their uses. The most important of these are data on cumulative and delayed toxicity, flavor impairment, reduction in*

> *survival, growth, or reproduction, or any other adverse effect that has been shown to be biologically important. Especially important are data for species for which no other data are available. Data from behavioral, biochemical, physiological, microcosm, and field studies might also be available. Data might be available from tests conducted in unusual dilution water (see IV.D and VI.D), from chronic tests in which the concentrations were not measured (see VI.B), from tests with previously exposed organisms (see II.F), and from tests on formulated mixtures or emulsifiable concentrates (see II.D). Such data might affect a criterion if the data were obtained with an important species, the test concentrations were measured, and the endpoint was biologically important.*

EXTRAPOLATING DATA FROM OTHER SPECIES TO SHORTNOSE AND ATLANTIC STURGEON

Ideally, quantitative exposure-response data for shortnose and Atlantic sturgeon would be available for exposures at the applicable criterion concentrations. Toxicity tests are rarely conducted on threatened and endangered species or species that are not easily cultured in the lab. Those data that are available for shortnose and Atlantic sturgeon demonstrate that taxonomic relatedness is not always a good predictor for toxicity and that rainbow trout, which have abundant toxicity data, are not “excessively sensitive” to toxicants relative to shortnose and Atlantic sturgeon, and thus can be a suitable surrogate when data for sturgeon are absent.

Rainbow trout had similar sensitivity to copper as shortnose and Atlantic sturgeon, was less sensitive than either sturgeon to 4-nonylphenol, pentachlorophenol, and permethrin, was similarly sensitive to carbaryl as shortnose sturgeon, but not Atlantic sturgeon. Finally, shortnose sturgeon were less sensitive to PCB-126 than Atlantic sturgeon. Taken together, in terms of sensitivity to toxicants, these data suggest that rainbow trout are just as suitable a surrogate species for shortnose and Atlantic sturgeon as species within the same genus or family. The similarity in sensitivity to copper of rainbow trout, shortnose sturgeon, and Atlantic sturgeon suggests rainbow trout are a particularly good surrogate for metal toxicity.

Dwyer et al. (2005b) compared the relative toxicity of five chemicals to 18 fish species, including shortnose sturgeon, Atlantic sturgeon, and rainbow trout. Responses for all three species were similar for copper, suggesting rainbow trout are a good surrogate for metal exposures. A copper LC50 of 80 µg/L was reported for both shortnose sturgeon and rainbow trout while the LC50 for Atlantic sturgeon was only slightly lower, at 60 µg/L. Information supporting rainbow trout suitability as a surrogate for exposure to organic chemicals is mixed. Sturgeon were sometimes more sensitive. Shortnose sturgeon, Atlantic sturgeon, and rainbow trout 4-nonylphenol LC50s were 80, 50, and 190 µg/L respectively. The pentachlorophenol LC50 was less than 40 µg/L for Atlantic sturgeon and the LC50 for shortnose sturgeon was 70 µg/L while the rainbow trout LC50 was more than twice that, at 160 µg/L. Permethrin LC50s for both shortnose and Atlantic sturgeon were less than 1.2 µg/L while the LC50 for rainbow trout was 3.31 µg/L. The shortnose sturgeon LC50 for carbaryl was comparable to that of rainbow trout, at 1810 and 1880 µg/L, respectively while the carbaryl LC50 for Atlantic sturgeon was less than 800 µg/L. In this case, taxonomic relatedness did not ensure similar sensitivity. Chambers et al. (2012) reported a four-fold within-genus difference in sensitivity for early-life-stage effects of polychlorinated biphenyl-126 in Atlantic sturgeon in comparison with shortnose sturgeon. The Chambers et al. (2012) study did not evaluate effects in rainbow trout.

Allometric differences (e.g., body size, membrane area, organ size) are factors to be considered when evaluating toxicity data. A smaller individual generally succumbs to toxic effects more rapidly than a larger individual does because it takes a longer time for exposures to reach critical concentrations within the tissues of the larger individual. Therefore, higher exposure concentrations would be expected to elicit the same response over a similar exposure period. While adult sturgeon are much larger than adult rainbow trout, one year old sturgeon captured in the Connecticut River ranged in length from 22.8 to 63.5 centimeters (Savoy et al. 2017) while a one year old rainbow trout is about seven to nine inches (Kebus et al. 1992). Rainbow trout hatchlings are reported to be 10 to 18 mm long (Réalis-Doyelle et al. 2016) while shortnose and Atlantic sturgeon hatchlings are 7 to 11 mm long (COSEWIC 2005; Smith et al. 1980). While not identically sized, this similarity suggests greater confidence when using data for rainbow trout as a surrogate species to assess impacts on early-life-stage sturgeon.

In the absence of data for shortnose and Atlantic sturgeon, this Opinion prioritizes data from surrogate species as follows: other sturgeon species and rainbow trout > other salmonids > other fish species. Where the analysis must rely on other fish species, this Opinion applies a comprehensive perspective that considers all fish data in context of differences reported among sturgeon sensitivities to other toxicants, and the need to be protective of ESA-listed sturgeon. This perspective is based on the expectation that mechanisms of effect in tested fish species are generally similar to mechanisms in the ESA-listed fish species based on fundamental physiological functions (e.g., osmoregulation, ion exchange, antioxidant defense, nerve function). This approach uses a high-level review of ECOTOX data, data from government reports, and peer-reviewed literature, to focus on observations suggesting whether adverse effects could occur within criteria limits are reviewed more closely. This review takes into consideration dataset characteristics, such as the diversity of species represented, outliers, life stage effects, allometric influences, how responses were documented by researchers, the number and quality of the available toxicity studies, and the magnitude and types of effects reported.

2.2.3 Evaluating Criteria Implementation

NMFS's assessment addresses criteria that are likely to be implemented. Examples of criteria that are not likely to be implemented include those for non-persistent pesticides with no registered uses in the State, territory, or Tribe adopting the criteria and substances that are not expected to occur in the water column because they are no longer in domestic or industrial use. Because the criteria set the exposure conditions for each stressor, each analysis determines whether adverse effects may result from exposure to the stressor within the limits of its acute and chronic criteria. If NMFS's analysis determines that exposures and/or responses to a stressor within a criterion's limits are insignificant or extremely unlikely to occur for ESA-listed species under NMFS's jurisdiction, NMFS may make a not likely to adversely affect determination for EPA's approval of the adoption and implementation of that criterion. If exposure is reasonably certain to occur and adverse effects are expected in individuals of ESA-listed species under NMFS's jurisdiction exposed within criteria limits, NMFS proceeds with a risk analysis to estimate the implications for the population of affected individuals.

Because implementation of the criteria is an effect of EPA's approval, NMFS's exposure assessment evaluates monitoring and regulatory data to identify the pollutant's sources, determine whether the criteria are likely to be implemented, and whether implementation is expected to be successful. For example, some water quality monitoring occurs and uses "sufficiently sensitive analytical methods" as defined in the at Clean Water Act 122.44(i)(1)(iv) and existing sources of wastewater discharges submit discharge monitoring reports.

3 DESCRIPTION OF THE ACTION

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR §402.02). The action is EPA Region 4's approval of the water quality criteria proposed for adoption by the states of Delaware and Maryland under Clean Water Act section 303(c). The EPA proposes to approve the adoption of National Recommended Water Quality Guidelines as numeric water quality criteria for implementation of the Clean Water Act in Delaware and Maryland (Table 1).

Table 1. National Recommended Water Quality Guidelines for the Protection of Aquatic Life that EPA Proposes to Approve for Implementation by DNREC and MDE

	Freshwater		**Saltwater**		**Year Issued**
	Acute Criteria	**Chronic Criteria**	**Acute Criterion**	**Chronic Criterion**	
DNREC and MDE					
Ammonia	pH, temperature, life stage and/or species dependent,		--	--	2013
Cadmium	Hardness dependent		33	7.9	2016
DNREC only					
Nonylphenol	28	6.6	7	1.7	2005

The purpose of the criteria is to maintain or restore water quality conditions that support aquatic life. For both DNREC and MDE, EPA proposes to approve acute and chronic saltwater criteria for cadmium, water hardness-specific acute and chronic freshwater criteria for cadmium derived in EPA's 2016 Cadmium Guideline (USEPA 2016) and pH, temperature, and life stage-dependent acute and chronic freshwater criteria for ammonia derived in EPA's 2013 Ammonia Guideline (USEPA 2013).

For Delaware only, EPA proposes to approve acute and chronic saltwater and freshwater criteria for nonylphenol derived in EPA's 2005 Nonylphenol Guideline (USEPA 2005). Delaware's water quality standards regulation 7 Del. C. §4.4 indicates that "(f)or waters of the Delaware River and Delaware Bay, duly adopted Delaware River Basin Commission (DRBC) Water Quality Regulations shall be the applicable criteria. If the DRBC has not developed an applicable regulatory standard or criteria for these waters, and Delaware has, Delaware's criteria shall be applicable." NMFS verified with DRBC and determined that they have effective cadmium aquatic life criteria, but not ammonia or nonylphenol criteria. Any EPA-approved cadmium criteria for Delaware will not be implemented in the Delaware River and basin and therefore the proposed criteria for this action are not addressed for those waters in this Opinion.

For stressors that cause toxic effects due to exposures in ambient water, such as cadmium, ammonia, and nonylphenol, the concentration, duration, and frequency of exposure typically determines whether effects occur and, if so, the severity of the effects. For this reason, the EPA Guidelines are usually expressed as exposure concentrations over a specified duration and frequency at and below which ecologically relevant effects are not expected to occur. The criterion maximum concentration, also called the CMC or acute criterion, is the highest acceptable aquatic exposure concentration of a chemical in water that is not expected to cause severe effects in aquatic organisms during short-term (i.e., acute) exposure. The acute criterion concentration is calculated from an assemblage of data for various laboratory species exposed in four-day toxicity tests. The acute criterion is one-half the concentration that is hazardous to five percent of those species. This relies on the assumption that a concentration that is half the LC50 would be a no effect or LC01 (Stephen et al. 1985). The acute criterion is intended to protect aquatic life from acute adverse effects on survival. It is not intended to protect aquatic life from the sublethal effects such as growth/development, and reproduction, which are expected to occur over chronic exposure timeframes. Behavioral responses are not used in criteria derivation, but behavior changes caused by effects on external receptors such as olfactory and lateral line receptors occur over short frames.

The criterion continuous concentration, also called the CCC or chronic criterion, is the highest acceptable aquatic exposure concentration of a chemical in water that is not expected to cause adverse effects on survival, growth/development, and reproduction over indefinite (i.e., chronic) exposures. The acute criterion duration and frequency limit for cadmium and nonylphenol is a one-hour average not to be exceeded more than once in three years and the chronic criterion duration and frequency limit for each chemical is a four-day average not to be exceeded more than once in three years. The duration and frequency limit for the acute ammonia criterion is also a one-hour average not to be exceeded more than once in three years. The chronic ammonia criterion duration and frequency is the highest four-day average within the same 30-day period shall not exceed 2.5 times the chronic criterion and may not exceed the acute criterion more than once every three years. It is not practical to conduct monitoring that precisely matches these durations and time frames, so states infer compliance with criteria from monitoring strategies they are able to implement.

Delaware's implementation of criteria for the purposes of identifying impaired waters are described in the Assessment Methodology section of DNREC's Integrated Report (DNREC 2022). If two or more sampling events from the same station resulted in exceedances of the criteria within three years, the station was deemed not supporting for the aquatic life use. The state of Delaware coordinates with the DRBC and Chesapeake Bay Program in its water quality assessments and decision making. The DRBC prepares 305(b) water quality assessment reports every two years for the Delaware River and Delaware Bay. Delaware incorporated the most recent use attainment determinations made by the DRBC for the shared waters of the Delaware River and Delaware Bay into its 2020 303(d) impaired waters list. Delaware expects to work cooperatively with the DRBC, member states and stakeholders to develop and implement TMDLs in waters of the Delaware River and Bay that the DRBC determines to be impaired. The Chesapeake Bay Program conducts assessments for waters in the Chesapeake Bay and nearby waters that drain into the bay in co-operation with Maryland, Virginia, Washington D.C. and Delaware. Delaware incorporated the most recent use attainment determinations for waters of the state that use criteria developed by the Chesapeake Bay Program for waters that drain to the Chesapeake Bay.

Maryland's implementation of criteria for identifying impaired waters are described in the MDE's Methodology for Determining Impaired Waters by Chemical Contaminants for Maryland's Integrated Report of Surface Water Quality (MDE 2019). When assessing impairment based on acute exposures, a single water column sample showing a pollutant concentration above the applicable acute water quality criterion is considered an exceedance because MDE expects the ambient concentrations of water chemistry parameters are unlikely to vary significantly during a one-hour period. A waterbody is considered impaired if two or more samples exceed criteria. Optimally an assessment would be based on a minimum of ten representative sampling events in a water body. When assessing impairment due to chronic toxicity, it is unlikely that a chronic exceedance can be identified using one sample it does not represent a four-day average, so MDE performs statistical analysis on all available data to estimate the likelihood of a chronic criterion exceedance. If the analysis suggests the waterbody is impaired by exceedances of the chronic criterion, MDE will prioritize the water body for additional sampling efforts over ten four-day periods over a three-year time-span over which, a minimum of four samples will be taken in order to calculate a four-day average. If two or more four-day period averages exceed the chronic criterion, then the waterbody will be listed as impaired.

For both states, aquatic life criteria are implemented in the NPDES permit limits by assuming receiving streams are continually at low-flow conditions which significantly limits the probability of in situ pollutant concentrations reaching criteria magnitudes and durations. NPDES permit limits based on the acute ammonia criterion typically assume a receiving stream is continually at 1Q10 low-flow conditions, while the probability of these low-flow conditions occurring is exceedingly rare (i.e., 1-day average lowest flow over the course of a 10-year period). Similarly, NPDES permit limits based on the chronic ammonia criterion typically assume receiving streams are continually at 30Q10 or 30Q5 low-flow conditions (i.e., 30-day average lowest flow over the course of a 5 or 10-year period). As a result, excess dilution limits instream ammonia concentrations and drastically decreases the probability in situ ammonia concentrations will reach criteria magnitudes and durations. Independent of assuming low flow conditions, NPDES permits also layer on an additional level of conservatism by ensuring facilities discharge ammonia at long-term average concentrations that are based on waste load allocations set as the 99th centile of a log-normal distribution that describes effluent variability. Setting waste load allocations as the 99th centile of an effluent distribution ensures a 99 percent percent chance facilitates discharge ammonia at concentrations less than those that would cause receiving stream ammonia concentrations to reach criteria magnitudes under critical flow conditions: which are independent and also exceedingly rare events (USEPA 1991). Additionally, even if in situ exposures were to match the acute or chronic criteria magnitudes, the broad aquatic community, including sturgeon prey items, will be adequately protected because aquatic life criteria are based on the fifth centile of sensitive genera.

3.1 Numeric Criteria for the Protection of Aquatic Life

Because the EPA Guidelines are fundamental to development of criteria for substances in water, the assumptions and procedures directed by the EPA Guidelines are fundamental to the evaluation of the protectiveness of these criteria for ESA-listed species and critical habitats. Criteria for concentrations of substances in water were derived with the objective of protecting aquatic life from short and long-term adverse effects. They are derived from laboratory toxicity test data following the EPA Guidelines.

The EPA Guidelines are designed to arrive at criteria that, when applied as discharge limits, monitoring thresholds, and restoration goals, will achieve water quality that provides for the protection and propagation of fish, shellfish, and wildlife and provide for recreation in and on the water. As stated in Section 1.1 of the document:

> *Because aquatic ecosystems can tolerate some stress and occasional adverse effects, protection of all species at all times and places it is not deemed necessary for the*

> *derivation of a standard. ...[given adequate data]... a reasonable level of protection will probably be provided if all except a small fraction of the taxa are protected, unless a commercially or recreationally important species is very sensitive.*

By relying on toxicity tests conducted in a laboratory for our understanding of toxic effects requires us to assume that laboratory conditions are representative of environmentally relevant conditions and that "domesticated" cultures of test animals will produce similar effects, as would exposure to the same substance on the same, or closely related, wild species. The assumption that effects in laboratory tests are reasonable predictors of effects to individuals in the wild is dependent upon the specific factor being considered. While it is generally reasonable to interpret effects from laboratory tests as being applicable to field situations where a water quality criterion is applied to a particular waterbody, there is risk that laboratory tests under predict effects in wild animals under natural conditions. In nature, the abundance and quality of food and aquatic chemistry (e.g., pH, dissolved oxygen [DO], temperature, organic matter, ion composition) are variable, individuals are subject to predation, competition, parasitism and disease, and vulnerabilities differ among life stages and during life history events (e.g., migration, spawning). Considering this, arriving at a firm conclusion based on extrapolations from the lab to the field is challenging. It may be that the best overall conclusion is the same as that reached by Chapman (1983) that "when appropriate test parameters are chosen, the response of laboratory organisms is a reasonable index of the response of naturally occurring organisms." His conclusion in turn contributed to one of the most fundamental assumptions of EPA Guidelines, that is, "these National Guidelines have been developed on the theory that effects which occur on a species in appropriate laboratory tests will generally occur on the same species in comparable field situations." Even so, when test species and ESA-listed species have comparable sensitivities, the loss of an individual from an imperiled population has greater consequences than the loss of an individual from healthy populations, so a more conservative approach is warranted.

3.1.1 Criteria Duration and Frequency for Ambient Exposures

The one-hour and four-day duration and averaging periods for the chronic and acute criteria, respectively, were based upon judgments by the Guidelines' authors that included considerations of the relative toxicity of chemicals in fluctuating or constant exposures. The Guidelines considered an averaging period of one hour most appropriate to use with the acute criterion because high concentrations of some materials could cause death in one to three hours. The few known studies that tested for latent toxicity following short-term exposures have demonstrated delayed mortality following exposures on the order of three to six hours (Diamond et al. 2006; Marr et al. 1995; Meyer et al. 2007; Zhao and Newman 2004; Zhao and Newman 2006). Observations or predictions of appreciable mortality resulting from metals exposures on the order of only three to six hours supports the Guideline recommendation that the appropriate averaging periods for the acute criterion is on the order of one hour.

The Guidelines specifies a four-day averaging period for chronic criteria for two reasons. First, “chronic” responses with some substances and species may not really be due to long-term stress or accumulation, but rather the test was simply long enough that a briefly occurring sensitive stage of development was included in the exposure (e.g., Barata and Baird 2000; Chapman 1978a; De Schamphelaere and Janssen 2004; Grosell et al. 2006; Mebane et al. 2008b). Second, a much longer averaging period, such as one month, would allow for substantial fluctuations above the chronic criterion.

The Guideline’s once-per-three-years allowable exceedance policy was based on a review of case studies of recovery times of aquatic populations and communities from locally severe disturbances such as spills, fish eradication attempts, or habitat disturbances (Detenbeck et al. 1992; Yount and Niemi 1990). In most cases, once the cause of the disturbance ceased, recovery of populations and communities occurred on a timeframe of less than three years. The EPA has further evaluated the issue of allowable frequency of exceedances through extensive mathematical simulations of chemical exposures and population recovery. Unlike the case studies, these simulations addressed mostly less severe disturbances that were considered more likely to occur without violating criteria (Delos 2008). Unless the magnitude of disturbance was extreme or persistent, this three-year period seemed reasonably supported or at least was not contradicted by the information NMFS reviewed (NMFS 2012b; NMFS 2014).

4 ACTION AREA

The action area for EPA’s approval includes all waters where the criteria will be applied within the states of Delaware and Maryland and any waters in other states affected by waters the criteria are applied to. Delaware and Maryland have jurisdiction over coastal waters extending to three nautical miles from the mean high water mark. The action area includes approximately 54.65 kilometers (km, 33.96 miles) of critical habitat for the New York Bight DPSs of Atlantic sturgeon in the Delaware River in Delaware and 300.8 km (187 miles) of critical habitat for the Chesapeake Bay DPS of Atlantic sturgeon in Nanticoke River, Marshyhope Creek, and the Potomac River in Maryland.

5 ESA-LISTED SPECIES AND CRITICAL HABITAT

Table 2 identifies the ESA-listed species (including DPSs) that occur in the action area and are under NMFS’s jurisdiction.

Table 2. Endangered and Threatened Species and Critical habitat within the Action Area and Under NMFS's Jurisdiction

Species	Federal Register Listing	Critical habitat
Fin Whale (endangered, *Balaenoptera physalus*)	35 FR 18319	--
North Atlantic Right Whale (endangered, *Eubalaena glacialis*)	73 FR 12024	81 FR 4837
Sei Whale (endangered, *Balaenoptera borealis*)	35 FR 18319	--
Sperm Whale (Threatened, *Physeter microcephalus)*	35 FR 18319	--
Blue Whale (Endangered, *Balaenoptera musculus musculus)*	35 FR 18319	--
Green Sea Turtle (threatened, *Chelonia mydas*), North Atlantic DPS	81 FR 20057	
Kemp's Ridley Sea Turtle (endangered, *Lepidochelys kempii*)	35 FR 18319	--
Leatherback Sea Turtle (endangered, *Dermochelys coriacea*)	35 FR 8491	Critical habitat is not in action area
Hawksbill Sea Turtle (endangered, *Eretmochelys imbricata*)	35 FR 8491	Critical habitat is not in action area
Loggerhead Sea Turtle (threatened, *Caretta caretta*), Northwest Atlantic Ocean DPS	76 FR 58868	Critical habitat is not in action area
Atlantic sturgeon (endangered, *Acipenser oxyrinchus oxyrinchus*) Chesapeake DPS, Migrating and foraging New York Bight, Carolina, South Atlantic DPSs (endangered), and Gulf of Maine DPS (threatened)	77 FR 5879 77 FR 5913	82 FR 39160
Shortnose Sturgeon (endangered, *Acipenser brevirostrum*)	32 FR 4001	--

5.1 ESA-Listed Species Not Likely To Be Adversely Affected

NMFS uses two criteria to identify the ESA-listed species or critical habitat that are not likely to be adversely affected by the action. The first criterion is exposure, or some reasonable expectation of a co-occurrence, between one or more potential stressors associated with the proposed activities and ESA-listed species or critical habitat. If we conclude that an ESA-listed species or critical habitat is not likely to be exposed to the proposed activities, we must also conclude that the species or critical habitat is not likely to be adversely affected by those activities.

The second criterion is the probability of a response given exposure. An ESA-listed species or critical habitat that is exposed to a potential stressor but is likely to be unaffected by the exposure is also not likely to be adversely affected by the proposed action.

An action warrants a "may affect, not likely to be adversely affected" finding when its effects are *wholly beneficial, insignificant* or *discountable*. *Wholly beneficial* consequences have an immediate positive consequence without any adverse consequences to the species or habitat. Wholly beneficial effects are usually discussed when the project has a clear link to the ESA-listed species or its specific habitat needs, and consultation is required because the species may be positively affected.

Insignificant consequences relate to the response of exposed individuals or PBFs where the response would be undetectable, not measurable, or so minor that they cannot be meaningfully evaluated. Based on best judgment, a reasonable person would not be able to meaningfully measure, detect, or evaluate insignificant consequences on the listed species or critical habitat.

Discountable applies to those consequences that are extremely unlikely to occur to the listed species or PBFs. Based on best judgment, a reasonable person would not expect consequences to occur to the listed species or critical habitat.

Prior consultations concurred that implementation of EPA’s Water Quality Guidelines for aquatic toxicants are not likely to adversely affect ESA-listed sea turtles and baleen whales because their exposures to aquatic pollutants are expected to be far less than that of the fish and aquatic invertebrates the criteria were derived to protect (NMFS 2015; NMFS 2018a; NMFS 2020a). Fish and aquatic invertebrates are exposed to aquatic toxicants as water continuously passes over their gill filaments where mineral and gas exchange regulates ion balance and oxygenates blood. The folded, feather-like structure of gills maximizes contact between water and respiratory epithelia for this exchange but also maximizes exposure to aquatic toxicants. Saltwater and estuarine fish exposures also occur through ingestion because saltwater fish “osmoregulate” by continuously drinking seawater and excreting solute in order to maintain a lower concentration of solutes in their body fluids than saltwater (Larsen et al. 2014).

5.1.1 Whales

Ammonia criteria are proposed only for freshwater, so EPA’s approval of the Maryland and Delaware adoption and implementation of ammonia criteria will not result in exposures of ESA-listed marine mammal species such as Sei, blue, sperm, fin, and North Atlantic Right whales. The aforementioned species all occur offshore of the Maryland and Delaware coastlines, however only fin whales and North Atlantic right whale have the potential to occur within nearshore waters of the action area. Fin, sperm, blue and sei whales are highly migratory species and while they may transit the action area, they are more commonly associated with deep offshore habitats and typically prefer deep waters off the continental slope and into the mid-ocean regions (Hayes et al. 2022).

Fin whales are centered along the 100-meter isobath and are common past United States Atlantic Exclusive Economic Zone north of Cape Hatteras, North Carolina throughout the year (Hayes et al. 2022). Fin whales accounted for 46 percent of large whales sighted over the continental shelf during aerial surveys (CETAP 1982). During a few high resolution geophysical surveys offshore of Maryland and Delaware, protected species observers (PSOs) observed fin whales during observational periods and within state waters (Gardline 2020; Gardline 2022). One sei whale was also spotted during one of the high resolution geophysical surveys (Smultea Environmental Sciences 2019), however that is suspected to be a rare occurrence and none have been seen inshore in more recent surveys. Feeding areas for fin whales are located north near Massachusetts and feeding is considered rare in Delaware and Maryland.

In contrast to these deep-water species, North Atlantic right whales will frequent nearshore waters. Most individuals migrate northward to Canada during the summer and fall months. Aquatic toxicants are not readily absorbed through mammalian skin, so any exposure of these whales is primarily direct uptake from the water column through membranes that are in contact with ambient water or indirect uptake through ingesting organisms that have accumulated pollutants. However, North Atlantic right whale do not forage in Maryland or Delaware waters. The pathway for direct exposure, and subsequent response, of whales to aquatic pollutants is further limited because whales do not drink seawater. Whale osmoregulation employs physiological and allometric adaptations such as increased filtration rates, urine volume, and kidney size along with tolerance of high solute levels in urine and plasma (Birukawa et al. 2005; Kjeld 2003).

Exposures of sei, sperm, and blue whales to water quality conditions resulting from implementation of Maryland and Delaware’s water quality criteria are expected to be discountable because of their long migrations and affinity for deeper offshore waters, resulting in infrequent and short duration presence in Maryland/Delaware waters. Therefore, NMFS concurs that EPA’s approval of Maryland and Delaware’s adoption of saltwater cadmium criteria may affect, but is not likely to adversely affect, sei, sperm, and blue whales. Additionally, NMFS concurs that EPA’s approval of Delaware’s new nonylphenol criteria may affect, but is not likely to adversely affect, sei, sperm, and blue whales.

While both North Atlantic right whales and occasionally fin whales migrate through the waters offshore of Maryland and Delaware, exposures to water quality conditions resulting from implementation of Maryland and Delaware’s water quality criteria are expected to be insignificant because they breathe air, do not drink seawater, and do not forage while in these waters. Therefore, NMFS concurs that EPA’s approval of Maryland and Delaware’s adoption of saltwater cadmium criteria may affect, but is not likely to adversely affect North Atlantic right whale and fin whales. Additionally, NMFS concurs that EPA’s approval of Delaware’s new nonylphenol criteria may affect, but if not likely to adversely affect, North Atlantic right whale and fin whales.

5.1.2 Sea Turtles

As stated above, ammonia criteria are proposed only for freshwater, so EPA's approval of the Maryland and Delaware adoption and implementation of ammonia criteria will not result in exposures of ESA-listed marine species such as North Atlantic DPS of green sea turtle, Kemp's ridley sea turtle, leatherback sea turtle, and the Northwest Atlantic Ocean DPS of loggerhead sea turtle. Because ESA-listed sea turtles breathe air and do not have gills, their only direct exposures to aquatic toxicants would be through drinking seawater and limited absorption through exposed membranes. Sea turtles do not typically nest on the beaches of Maryland or Delaware and are temporary residents to coastal waters, undergoing long migrations between breeding and foraging habitats. While metals and persistent organic pollutants can accumulate in sea turtles through their diet, sea turtles are unlikely to accumulate a significant amount of persistent pollutants because they primarily consume lower trophic-level food species (Figgener et al. 2019). The presence of a contaminant in tissues does not necessarily indicate adverse effects on survival, reproduction, or growth and development. Contaminant burdens in tissues reflect exposures integrated over the lifetime and entire foraging area of these highly migratory species and cannot be directly attributable to exposures within an action area that comprises only a fraction of an individual's range.

Exposures of ESA-listed North Atlantic DPS of green sea turtle, Kemp's ridley sea turtle, leatherback sea turtle, and the Northwest Atlantic Ocean DPS of loggerhead sea turtle to water quality conditions resulting from implementation of DNREC and MDE's water quality criteria for cadmium and nonylphenol are expected to be insignificant because their only direct exposures to aquatic toxicants would be through drinking seawater and limited absorption through exposed membranes. This contrasts continuous ingestion and respiratory epithelial exposures of gilled saltwater species the criteria are meant to protect. Therefore, NMFS concurs that EPA's approval of Maryland and Delaware's adoption of saltwater cadmium criteria, as well as Delaware's adoption of saltwater nonylphenol, is not likely to adversely affect North Atlantic DPS of green sea turtle, Kemp's ridley sea turtle, leatherback sea turtle, and the Northwest Atlantic Ocean DPS of loggerhead sea turtle.

5.1.3 Critical Habitat Designated for Atlantic sturgeon

The critical habitat designation for the Chesapeake and New York Bight DPSs of Atlantic sturgeon physical and biological features (PBFs) does not include biological features such as prey or vegetative cover that may be affected by exposures to toxicants.

5.1.4 Conclusion

The action is not likely to adversely affect fin whale, North Atlantic right whale, sei whale, sperm whale, and blue whale, green sea turtle (North Atlantic DPS), hawksbill sea turtle, Kemp's ridley sea turtle, leatherback sea turtle, or loggerhead sea turtle (Northwest Atlantic Ocean DPS), or migrating and foraging Gulf of Maine, Carolina, and South Atlantic DPSs of Atlantic sturgeon along the coast and within the estuaries of Delaware and Maryland, or critical habitats designated for the North Atlantic right whale or New York Bight or Chesapeake DPS of Atlantic sturgeon. Accordingly, this action will not jeopardize the continued existence of these species or adversely modify these designated critical habitats.

5.2 Status of Species Likely to be Adversely Affected

The ESA-listed species that are likely to be adversely affected by EPA's approval of cadmium, ammonia, and nonylphenol water quality criteria proposed for Delaware and ammonia and cadmium water quality criteria proposed for Maryland are the shortnose sturgeon and the Chesapeake and New York Bight DPSs and migrating and foraging Gulf of Maine, Carolina, and South Atlantic DPSs of Atlantic sturgeon. Waters identified for potential shortnose sturgeon presence include the Delaware River, the Potomac River, the Susquehanna River and the Chesapeake Bay. The Gulf of Maine, New York Bight, Carolina and Chesapeake Bay DPSs of Atlantic sturgeon may migrate and forage along the Maryland and Delaware coast and estuary. Throughout this Opinion, these waters are referred to as "Sturgeon Waters."

The scope of the environmental baseline is largely focused on Sturgeon Waters and associated catchments within the action area, as identified in Figure 2 above, and include:

- The Delaware River
- Potomac River
- Nanticoke River and Marshyhope Creek
- Susquehanna River

Table 3 describes the sturgeon life stages and their behaviors in the Delaware, Potomac River, Susquehanna Rivers, and Nanticoke River and Marshyhope Creek while Table 4 compares historical and current spawning and presence data in Maryland and Delaware for shortnose sturgeon. Definitive historical and current spawning was not available for Atlantic sturgeon.

Table 3. Life Stages and Behaviors of Shortnose Sturgeon and Atlantic Sturgeon in the Waters of Maryland and Delaware

Body of Water (State)	Life Stages Present	Use of the Watershed
Atlantic Sturgeon		
Delaware River (DE)	Adults, Juveniles	Upstream migration, spawning, rearing
Potomac River (MD)	Adults, Subadults	Migrating, foraging
Nanticoke River and Marshyhope Creek (MD, DE)	Adults, Juveniles	Spawning

Body of Water (State)	Life Stages Present	Use of the Watershed
Chesapeake Bay (MD)	Juvenile, Sub-adult	Migratory
Shortnose Sturgeon		
Delaware River (DE)	Larvae (upstream in PA, NJ), Adult, early life stage	Migration, foraging, spawning*, overwintering
Susquehanna River (MD)	Adults	Foraging, overwintering, resting
Potomac River (MD)	Adults	Foraging, overwintering, migration
Chesapeake Bay (MD)	Adults	Migration

*Spawning occurs upriver in New Jersey and Pennsylvania

Table 4. Shortnose and Atlantic Sturgeon Historic and Current Presence and Spawning Location within Delaware and Maryland Rivers

Body of Water	Historic Presence?	Historic Spawning Location	Current Presence?	Current Spawning?	Spawning Location
Shortnose Sturgeon					
Delaware River	Yes	Unknown	Yes	Yes	Northern part of the river near Scudder Falls and Trenton Rapids (not within MD or DE)
Susquehanna River	Unknown	No Records	Yes	No Records	Shortnose sturgeon are precluded from accessing any historical spawning sites that may have existed above the dam.
Chesapeake Bay	Yes	Unknown	Yes	Unknown	Potential spawning in tributaries
Potomac	Yes	Little Falls (rkm 198)	Yes	Unknown	Suspected spawning at Fletcher’s Marina
Atlantic Sturgeon					
Chesapeake Bay	Yes	No	Yes	No	Spawning reported in tributaries but none in the bay itself
Delaware River	Yes	Yes	Yes	Yes	Historically the largest spawning population and currently supports a very small spawning population

Body of Water	Historic Presence?	Historic Spawning Location	Current Presence?	Current Spawning?	Spawning Location
Nanticoke River	Yes	Uncertain	Yes	Yes	Within the River and Marshyhope Creek
Susquehanna River	Yes	Potentially	Yes	Potentially	Historic and recent records of Atlantic sturgeon congregating below the Conowingo Dam, which suggests spawning may be occurring

This Opinion examines the status of each species that are likely to be adversely affected by the action. The evaluation of adverse effects in this Opinion begins by summarizing the biology and ecology of those species that are likely to be adversely affected and what is known about their life histories. The status is determined by the level of risk that the ESA-listed species face based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This helps to inform the description of the species' current "reproduction, numbers or distribution" that is part of the jeopardy determination as defined at 50 C.F.R. §402.02. More detailed information on the status and trends of these ESA-listed species, and their biology and ecology can be found in the listing regulations and critical habitat designations published in the Federal Register, status reviews, recovery plans, and on the NMFS Web site: [https://www.fisheries.noaa.gov/species-directory/threatened-endangered.

5.2.1 Threats Common to Shortnose and Atlantic Sturgeon

The viability of sturgeon populations is highly sensitive to juvenile mortality resulting in lower numbers of sub-adults available to recruit into the adult breeding population. The significant threats to ESA-listed sturgeon include dams that block access to spawning areas or lower parts of rivers, poor water quality, dredging, vessel strikes, water withdrawals from rivers, and unintended bycatch in some commercial fisheries. Recent reviews also identify climate change as a threat to ESA-listed sturgeon (NMFS 2022c; NMFS 2022d; SSSRT 2010).

5.2.1.1 DAMS

Archaeological records indicate that prior to the construction of dams in the 1950s and 60s, sturgeon swam further upriver to spawn than is possible today, leading experts to believe that dams severely impacted the natural breeding habits of the Atlantic and shortnose sturgeon (ASSRT 2007; Fernandes et al. 2010; SSSRT 2010). For exampe, the Conowingo Dam on the Susquehana River eliminated spawning access (Gomez and Sullivan Engineers 2012). Dams impede fish passage, fragmenting populations through eliminating or impeding access to historical habitat. Hydropower turbines, spillways, and fish passage devices can injure or kill fish attempting to migrate or are entrained in turbines. Dams also modify natural hydrology, altering downstream flows and water temperatures, affecting dissolved oxygen, channel morphology, nutrient cycling, stratification, community structure, and sediment regime, which can include redistribution of sediment-associated toxicants (Cooke and Leach 2004; Jager et al. 2001; Secor et al. 2002). Short-term negative impacts of dam removal include the influx of sediments into the stream flow, which embeds spawning substrates and negatively affect water, habitat and food quality. These effects are usually temporary. Several studies have demonstrated that after dam removal, sediments were flushed from river channels, natural sediment transport conditions resumed (American Rivers 2002).

5.2.1.2 IMPINGEMENT AND ENTRAINMENT

Depending on life stage and size, sturgeon are susceptible to impingement on or entrainment from cooling water intake screens at power plants. Impingement and entrainment are also risks during dredging operations. Other effects of dredging include burial of benthic communities, turbidity, siltation of spawning habitats, redistribution of sediment-associated toxicants, noise/disturbance, modified hydrology, and overall loss of habitat (Chytalo 1996; NMFS 1998a; NMFS 2018b; Smith and Clugston 1997; Winger et al. 2000).

5.2.1.3 BYCATCH

At this time, Atlantic sturgeon bycatch mortality is now considered a primary threat affecting the recovery of all five DPSs of Atlantic sturgeon (NMFS 2022b; NMFS 2022d). The level of bycatch and poaching of shortnose sturgeon is mostly unknown, but modeling suggests that bycatch could have a substantial impact on the status of shortnose sturgeon, especially in populations with small numbers (SSSRT 2010). Poaching of Atlantic sturgeon continues and is a potentially significant threat to the species, but the present extent and magnitude of such activity is largely unknown. Although directed fishing for Atlantic sturgeon is prohibited under the ESA, large numbers are still captured as “bycatch” in fishing operations targeting other species. The available bycatch data for fisheries indicate that sink gillnets and bottom otter trawl gear pose the greatest risk to Atlantic sturgeon; although, Atlantic sturgeon are also caught by hook and line, fyke nets, pound nets, drift gillnets and crab pots (ASMFC 2017b; Stein et al. 2004). Several authors have also demonstrated that sturgeon populations, shortnose in particular, are more sensitive to adult mortality than other species of fish (Boreman 1997a; Gross et al. 2002; Secor et al. 2002).

5.2.1.4 CONTAMINANTS

Life history of sturgeon species (i.e., long lifespan, extended residence in estuarine habitats, benthic foraging) predispose them to long-term, repeated exposure to environmental contamination and potential bioaccumulation of heavy metals and other toxicants (Dadswell 1979; NMFS 1998a). However, there has been little work on the effects of contaminants on sturgeon to date. Shortnose sturgeon collected from the Delaware and Kennebec Rivers had total toxicity equivalent concentrations of polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), PCBs, DDE, aluminum, cadmium, and copper all above adverse effect concentration levels reported in the literature (Brundage III and Meadows 1982).

Atlantic sturgeon rely on a variety of water quality parameters to successfully carry out their life functions. Low DO and the presence of contaminants modify the quality of Atlantic sturgeon habitat and in some cases, restrict the extent of suitable habitat for life functions. Secor (1995) noted a correlation between low abundances of sturgeon during this century and decreasing water quality caused by increased nutrient loading and increased spatial and temporal frequency of hypoxic (low oxygen) conditions. Using a multivariate bioenergetics and survival model, Niklitschek and Secor (2005) demonstrated that within the Chesapeake Bay, a combination of low DO, water temperature, and salinity restricts available Atlantic sturgeon habitat to 0-35 percent of the Bay's modeled surface area during the summer. Pulp mill, silviculture, agriculture, and sewer discharge can elevate temperatures and/or increase biological oxygen demand resulting in reduced DO levels that can be stressful to aquatic life. Niklitschek and Secor (2009) also simulated the effects of achieving EPA's DO-criteria for the Chesapeake Bay and water temperature effects on available habitat. The EPA adjusted their open water minimum DO-criteria for the Chesapeake Bay (increased from ~2 ppm to 3.5 ppm) to provide protection specifically for sturgeon species, which require higher levels of DO compared to other species. This study found that EPA's new DO-criteria would increase Atlantic sturgeon habitat by 13 percent per year, while an increase in water temperature by one degree Celsius would reduce available habitat by 65 percent. Similar trends in low DO have been observed in the lower portion of the Potomac River (ASSRT 1998).

The 2010 status review for shortnose sturgeon reviewed contaminant risks applicable to all sturgeon species. The life history characteristics of amphidromous sturgeon (i.e., long lifespan, extended residence in estuarine habitats, benthic foraging) predispose these species to long-term and repeated exposure to environmental contamination and potential bioaccumulation of heavy metals and other toxicants (Dadswell 1979; NMFS 1998a). Chemicals and metals such as chlordane, dichlorodiphenyl dichloroethylene (DDE), Dichlorodiphenyltrichloroethane (DDT), dieldrin, Polychlorinated biphenyls (PCBs), cadmium, mercury, and selenium settle to the river bottom and are later consumed by benthic feeders, such as macroinvertebrates, and then work their way higher into the food web, including to sturgeon. Some of these compounds may affect physiological processes and impede a fish's ability to withstand stress, while simultaneously increasing the stress of the surrounding environment by reducing DO, altering pH, and altering other physical properties of the water body.

Pesticide exposure in fishes may affect anti-predator and homing behavior, reproductive function, physiological development, and swimming speed and distance (Beauvais et al. 2000;

Moore and Waring 2001; Scholz et al. 2000; Waring and Moore 2004). Sensitivity to environmental contaminants also varies across life stage. Early-life-stages of fishes appear to be more susceptible to environmental and pollutant stress than older life stages (Rosenthal and Alderdice 1976). The presence of a contaminant in the tissues of an organism indicates exposure, but does not always mean these tissues residues are causing adverse effects. Elevated levels of contaminants in fish have been associated with reproductive impairment (Billsson 1998; Cameron et al. 1992; Giesy et al. 1986; Hammerschmidt et al. 2002; Longwell et al. 1992; Mac and Edsall 1991; Matta et al. 1997), reduced larval survival (Berlin et al. 1981; Giesy et al. 1986), delayed maturity (Jørgensen et al. 2004) and posterior malformations (Billsson 1998).

With the exception of few studies (Cope et al. 2011; Dwyer et al. 2000; Dwyer et al. 2005a; Dwyer et al. 2005b; Kocan et al. 1996) data on the effects of contaminants and tissue burdens in shortnose and Atlantic sturgeon pre-date listing, are from accidental sampling mortalities, or are from fish found dead.

Exposures of shortnose sturgeon embryos and larvae to weathered coal tar sediment from the Connecticut River near Holyoke, Massachusetts was >95 percent lethal (Kocan et al. 1996). A study evaluating the suitability of the Roanoke River for shortnose sturgeon placed caged juvenile shortnose sturgeon and the common laboratory species, fathead minnow in the river for 28 days. Shortnose sturgeon survival at the end of 28 days was none percent while fathead minnow survival was greater than 90 percent. Histopathology analysis determined that the mortality of the river-deployed shortnose sturgeon was likely due to liver and kidney lesions from one or more unknown agents as effects did not correlate well with those contaminant monitored for (Cope et al. 2011).

Accidental mortalities occurred during two gill netting surveys of shortnose sturgeon in the Delaware (N=2) and Kennebec Rivers (N=1). The fish had total toxicity equivalent concentrations of polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), PCBs, DDE, aluminum, cadmium, and copper above adverse effect concentration levels reported in the literature (ERC 2002; ERC 2003).

Between June and August for 2006 two Atlantic sturgeon and three shortnose sturgeon died during scientific sampling activities in the Penobscot River in Maine and one shortnose sturgeon was collected after being killed by a seal. In the summer of 2009, three additional shortnose sturgeon were recovered on the Kennebec River after a red tide event and two more seal-killed shortnose sturgeon were recovered further north in the river (Mierzykowski 2012). Tissues from these fish were analyzed for 21 organochlorine compounds including polychlorinated biphenyl (PCB), Polybrominated Diphenyl Ethers (PBDEs), and dichloro-diphenyltrichloroethane (DDT), and 19 trace metals including mercury. Total PCB in sturgeon muscle tissue ranged from below the detection limit of 5.00 micrograms per kilogram (µg/kg) to 1,900.00 µg/kg wet weight. Five shortnose sturgeon had PCB muscle concentrations that would exceed suggested criteria for protecting fish-eating wildlife (120 µg/kg) and aquatic life (400 µg/kg). Total PBDE in muscle tissue from five shortnose sturgeon ranged from 4.4 µ to 39.1 µg/kg. The PBDE concentration range in Kennebec sturgeon was similar to a study that measured PBDE levels in wild-caught fish sold in fish markets and large-chain supermarkets (0.04 to 38 µg/kg). DDT metabolites and isomers were detected in all sturgeon samples, but at low levels compared to toxicity threshold levels and consumption action levels. Other organochlorine compounds in fillet samples were below detection limits or detected at low concentrations (~ 5 µg/kg). Mercury in muscle tissue of shortnose sturgeon from the Penobscot and Kennebec (mean 0.49 milligrams per kilogram [mg/kg]; range: 0.19 to 1.00 mg/Kg wet weight) were elevated compared to freshwater regional and national fish tissue bio-monitoring programs. Mercury levels in both Atlantic sturgeon muscle tissue were 0.18 mg/kg. A suggested tissue threshold-effect concentration for mercury in whole-body fish is 0.20 mg/kg. Concentrations of 18 other trace metals in sturgeon tissue samples appeared consistent with levels reported in other sturgeon studies. The only exception was selenium at 2.40 mg/kg wet weight in muscle tissue from a Kennebec River shortnose sturgeon. The suggested tissue effect threshold for selenium is slightly lower, at 2 mg/kg.

Congeners[3] PCB, polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzo-p-furans (PCDFs) in Hudson River shortnose and Atlantic sturgeon obtained from museum archives and sampling between 2014 and 2016 indicated higher liver burdens in archived shortnose sturgeon than in more recently collected fish, with PCDFs at levels potentially impairing recruitment of juveniles into reproducing adults. Hepatic concentrations of 9 out of 11 PCB congeners were greater than five times higher in shortnose sturgeon than in Atlantic sturgeon collected contemporaneously during 2014 to 2016 (pre-print, Wirgin and Chambers 2022).

Dioxin and furans were detected in ovarian tissue from shortnose sturgeon caught in the Sampit River/Winyah Bay ecosystem, South Carolina. Results showed that four out of seven fish tissues analyzed contained tetrachlorodibenzo-p-dioxin concentrations > 50 ppt, a level that can adversely affect the development of sturgeon fry (NOAA, Damage Assessment Center, Silver Spring, MD, unpublished data).

Dadswell (1976) reported mercury concentrations averaging 0.29 (0.06 – 1.38) mg/kg wet weight in 30 juvenile Atlantic sturgeon collected in the Saint John River estuary, New Brunswick. Rehwoldt et al. (1978) analyzed cadmium, mercury, and lead in tissues from freshly captured Atlantic sturgeon from the Hudson River in 1976 and 1977 and found no chronological relationship when compared to preserved reference samples collected between 1924 and 1953.

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[3] Variations within a chemical group named for the quantity and position of key atoms such as chlorine, or nitrogen or structures such as phenyl rings.

The 1976-1977 average cadmium, mercury, and lead tissue concentrations were 0.02, 0.09, and 0.16 µg/g wet weight, respectively.

Twenty juvenile Gulf sturgeon, a subspecies of Atlantic sturgeon, exhibited an increase in metal body burdens with an increase in fish length (Alam et al. 2000). Gulf sturgeon collected from a number of rivers between 1985 and 1991 had arsenic, mercury, DDT metabolites, toxaphene, polycyclic aromatic hydrocarbons (PAHs), and aliphatic hydrocarbons at concentrations that were sufficiently high to warrant concern (Bateman and Brim 1994).

5.2.1.5 DREDGING

The effects of dredging directly impacts Atlantic or shortnose sturgeon at the time of the dredging activity and/or indirectly from modifications to their foraging habitat. Dredging activities have occurred in the Delaware River and Chesapeake Bay. Most of these projects are routine and ongoing.

5.2.1.6 CLIMATE CHANGE

Sturgeon are ranked as very highly vulnerable to climate change. Secor and Gunderson (1998) found that Atlantic sturgeon juvenile metabolism and survival were impacted by increasing hypoxia in combination with increasing temperature. Niklitschek and Secor (2005) used a multivariable bioenergetics and survival model to generate spatially explicit maps of potential production in the Chesapeake Bay; a one degree Celsius temperature increase reduced productivity by 65 percent (Niklitschek and Secor 2005). A population viability analysis for Shortnose Sturgeon at the southern end of their range found that salt-water intrusion and decreases in summer dissolved oxygen could reduce population productivity (Jager et al. 2013). In the Hudson River, Woodland and Secor (2007) found that flow volume and water temperature in the fall months preceding shortnose sturgeon spawning were significantly correlated with subsequent year-class strength. Habitat models coupled with global climate models for the cogener, European Atlantic Sturgeon (Acipenser sturio) indicate strong climate effects throughout the range, especially in the southern portions (Lassalle et al. 2010).

5.2.2 Shortnose Sturgeon

Shortnose sturgeon were first listed under the ESA’s predecessor, the Endangered Species Preservation Act on October 15, 1966 (32 FR 4001). No critical habitat has been designated for the shortnose sturgeon. Shortnose sturgeon occur along the Atlantic Coast from the Saint John River in Canada to the Saint Johns River in Florida. While shortnose sturgeon spawning has been documented in several rivers across its range, status for many other rivers remain unknown. Currently, shortnose sturgeon can be found in 41 bays and rivers along the East Coast, but their distribution across this range is broken up, with a large gap of about 250 miles separating the northern and mid-Atlantic metapopulations from the southern metapopulation[4]. In the northern and mid-Atlantic metapopulation, shortnose sturgeon are currently found in the Saint John (Canada), Penobscot, Kennecbec, Androscoggin, Piscataqua Merrimack, Connecticut, Hudson, Delaware, and Potomac Rivers. They have also been frequently spotted opportunistically foraging and transiting in the St. George, Medomak, Damariscotta, Sheepscot, Saco, Deerfield, East, and Susquehanna Rivers. On rare occasions, they have been seen in the Narraguagus, Presumpscot, Westfield, Housatonic, Schuylkill, Rappahannock, and James rivers. The Potomac and Susquehanna Rivers are within the state of Maryland, and the Delaware River is within the state of Delaware.

LIFE HISTORY

The shortnose sturgeon is a relatively slow growing, late maturing, and long-lived fish species. Shortnose sturgeon are amphidromous, inhabiting large coastal rivers or nearshore estuaries within river systems (Buckley and Kynard 1985; Kieffer and Kynard 1993). Sturgeon spawn in upper freshwater areas, and feed and overwinter in both fresh and saline habitats. Adult shortnose sturgeon typically prefer deep downstream areas with vegetated bottoms and soft substrates. During the summer and winter months, adults occur primarily in freshwater tidally influenced river reaches; therefore, they often occupy only a few short reaches of a river's entire length (Buckley and Kynard 1985). Older juveniles or sub adults tend to move downstream in the fall and winter as water temperatures decline and the salt wedge recedes. In the spring and summer, they move upstream and feed mostly in freshwater reaches; however, these movements usually occur above the saltwater/freshwater river interface (Dadswell et al. 1984; Hall et al. 1991). Young-of-the-year shortnose sturgeon are believed to move downstream after hatching (Bain 1997) but remain within freshwater habitats.

While shortnose sturgeon do not undertake the long saltwater migrations documented for Atlantic sturgeon, telemetry data indicate that shortnose sturgeon do make localized coastal migrations (Dionne et al. 2013). Inter-basin movements have been documented among rivers within the Gulf of Maine, between the Gulf of Maine and the Merrimack, between the Connecticut and Hudson rivers, between the Delaware River and Chesapeake Bay, and among the rivers in the Southeast region (Dionne et al. 2013; Fernandes et al. 2010; Finney et al. 2006; Welsh et al. 2002). Non-spawning movements include rapid, directed post-spawning movements to downstream feeding areas in the spring, and localized, wandering movements in the summer and winter (Buckley and Kynard 1985; Dadswell 1984). In the northern extent of their range, shortnose sturgeon exhibit three distinct movement patterns. These migratory movements are associated with spawning, feeding and overwintering activities. In the spring, as water

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[4] A metapopulation is a group of separate but interacting populations such that there is gene flow occurring among the populations.

temperatures reach between 7.0 and 9.7 ºC, pre-spawning shortnose sturgeon move from overwintering grounds to spawning areas.

Spawning times for shortnose sturgeon range geographically due to the specific water temperatures needed for spawning (7-10 degrees Celsius). In areas between South Carolina and New England, males reach sexual maturity at age three while females reach sexual maturity by age seven (SSSRT 2010). Shortnose sturgeon spawning migrations are characterized by rapid, directed and often extensive upstream movement (NMFS 1998a). Once males begin spawning, one to two years after reaching sexual maturity, they will spawn every other year or annually depending on the river they inhabit, and females will begin spawning five years after reaching sexual maturity and continue to do so every three years (Dadswell 1979; NMFS 1998a). Spawning is estimated to last from a few days to several weeks. Shortnose sturgeon are believed to spawn at discrete sites within their natal river (Kieffer and Kynard 1996), typically at the farthest upstream reach of the river, if access is not obstructed by dams (Kieffer and Kynard 1996; NMFS 1998a). Spawning occurs over channel habitats containing gravel, rubble, or rock-cobble substrates (Dadswell 1979; NMFS 1998a). Additional environmental conditions associated with spawning activity include decreasing river discharge following the peak spring freshet, water temperatures ranging from 6.5 to 18 degrees Celsius, and bottom water velocities of 0.4 to 0.8 m/sec (Dadswell 1979; Hall et al. 1991; Kieffer and Kynard 1996; NMFS 1998a). Adult shortnose sturgeon typically leave the spawning grounds shortly after spawning.

Estimates of annual egg production for shortnose sturgeon are difficult to calculate and are likely to vary greatly in this species because females do not spawn every year. Fecundity estimates range from 27,000 to 208,000 eggs/female, with a mean of 11,568 eggs/kg body weight (Dadswell 1984). At hatching, shortnose sturgeon are 7 to 11 millimeters (mm) long and resemble tadpoles (Buckley and Kynard 1981). In 9 to 12 days, the yolk sac is absorbed and the sturgeon develops into larvae which are about 15 millimeters total length (Buckley and Kynard 1981). Sturgeon larvae are believed to begin downstream migrations at about 20 millimeters total length.

Shortnose sturgeon are benthic omnivores that feed on crustaceans, insect larvae, worms, mollusks (Moser and Ross 1995; Savoy and Benway 2004), oligochaete worms (Dadswell 1979) and off plant surfaces (Dadswell 1984). Sub adults feed indiscriminately, consuming aquatic insects, isopods, and amphipods along with large amounts of mud, stones, and plant material (Bain 1997; Dadswell 1979).

POPULATION DYNAMICS

Historically, shortnose sturgeon are believed to have inhabited nearly all major rivers and estuaries along the entire east coast of North America. NMFS's shortnose sturgeon Recovery Plan identifies 19 populations based on the fish's strong fidelity to natal rivers and the premise that populations in adjacent river systems did not interbreed with any regularity (NMFS 1998a). Both mtDNA and nDNA analyses indicate effective (with spawning) coastal migrations are occurring between adjacent rivers in some areas, particularly within the Gulf of Maine and the Southeast (King et al. 2014).

The distribution of shortnose sturgeon is disjointed across their range, with northern populations separated from southern populations by a distance of about 400 km near their geographic center in Virginia. Genetic components of sturgeon in rivers separated by more than 400 km appear to be connected by very little migration, while rivers separated by less than 20 km would experience high migration rates. At the northern end of the species' distribution, the highest rate of gene flow (which suggests migration) occurs between the Kennebec, Penobscot, and Androscoggin Rivers (Wirgin et al. 2005).

STATUS

According to the 2010 status review (SSSRT 2010), water quality represents a major threat to one shortnose sturgeon population (Potomac River), a moderately high threat to six populations, a moderate threat to 13 populations, and a moderately low threat to one population. Specific sources of water quality degradation affecting shortnose sturgeon include coal tar, (a potential source of metal exposure, Gao et al. 2016), wastewater treatment plants, fish hatcheries, industrial waste, pulp mills, sewage outflows, industrial farms, water withdrawals, and nonpoint sources. These sources contribute to the following conditions that may have adverse effects on shortnose sturgeon: nutrient loading, low DO, algal blooms, increased sedimentation, elevated contaminant levels (mercury, PCBs, dioxin, polycyclic aromatic hydrocarbons [PAHs], endocrine disrupting chemicals, cadmium), and low pH levels. Impingement/entrainment at power plants and treatment plants was rated as a moderate threat to two shortnose sturgeon populations (Delaware and Potomac).

The shortnose sturgeon status review team (SSSRT 2010) reported results of an age-structured population model using software from Applied Biomathematics (Akçakaya and Root 2007) to estimate shortnose sturgeon extinction probabilities for three river systems: Hudson, Cooper, and Altamaha. The estimated probability of extinction was zero for all three populations under the default assumptions, despite the long (100-year) horizon and the relatively high year-to-year variability in fertility and survival rates. The estimated probability of a 50 percent decline was relatively high (Hudson 0.65, Cooper 0.32, Altamaha 0.73), whereas the probability of an 80 percent decline was low (Hudson 0.09, Cooper 0.01, Altamaha 0.23; SSSRT 2010).

The largest shortnose sturgeon adult populations are found in the Northeastern rivers: Hudson 56,708 adults (Bain et al. 2007); Delaware 12,047 (ERC 2002); and Saint Johns > 18,000 adults (Dadswell 1979). Shortnose sturgeon populations in southern rivers are considerably smaller by comparison. Peterson and Bednarski (2013) documented a three-fold variation in adult abundance (707 to 2,122 individuals) over a 7-year period in the Altamaha River. Bahr and Peterson (2017) estimated the adult shortnose population in the Savannah River was 1,865 in 2013, 1,564 in 2014, and 940 in 2015. Their estimates of juvenile shortnose sturgeon ranged from 81-270 age one fish and 123-486 age 2+ fish over the course of the three-year (2013-2015) study period. This study suggests that the Savannah River population is likely the second largest within the South Atlantic (Bahr and Peterson 2017).

STATUS WITHIN THE ACTION AREA

Delaware River

The historic distribution of shortnose sturgeon in the Delaware River is somewhat unknown, though there are reports of the species as far south as Delaware City, Delaware and north to Bristol, PA (SSSRT 2010). Throughout the 19th and 20th century, shortnose sturgeon were in high demand in Philadelphia markets and it was reported that the abundance of shortnose sturgeon had been substantial (SSSRT 2010). Shortnose sturgeon stocks ultimately crashed along the east coast after decades of sturgeon fishing (Saffron 2005).

Today, shortnose sturgeon occur throughout the Delaware River estuary and occasionally enter the nearshore ocean off Delaware Bay. In spring, spawning adults occur in the non-tidal river, and are common at least as far upstream as Scudders Falls. Acoustic tagging studies have indicated that an overwintering area exists in the lower portion of the river, below Wilmington, DE. Additionally, results from a tracking study of juvenile shortnose sturgeon suggest that the entire lower Delaware River from Philadelphia down is an overwintering area for juvenile shortnose sturgeon (ERC 2007). These acoustic tag studies also demonstrated that shortnose sturgeon may migrate between the upper tidal river and the Chesapeake and Delaware Canal.

Chesapeake Bay

The first published account of shortnose sturgeon in the Chesapeake system was from a specimen collected in 1876 from the Potomac River as reported in a general list of the fishes of Maryland (SSSRT 2010). There is evidence that in years past both Atlantic and shortnose sturgeon were prolific in the Potomac River, but it is generally accepted that at the turn of the 20th century shortnose sturgeon were essentially extirpated from the Potomac and rarely seen in the Chesapeake Bay (Hildebrand and Schroeder 1928).

The current distribution of shortnose sturgeon in the Chesapeake Bay is unknown as there is limited data regarding their distribution (SSSRT 2010). There is no information indicating that shortnose sturgeon are currently spawning in the Chesapeake Bay. Anecdotal reports from waterfolk indicate shortnose sturgeon presence in Gunpowder Falls, which enters the Gunpowder River in Baltimore County, MD, although there has not been any documentation of spawning activity here nor in any of the tributaries leading to the Chesapeake Bay. Similarly, there is no information available for shortnose sturgeon foraging areas in the Chesapeake Bay. A study by

Niklitschek (2001) indicated via modeling that suitable habitats were very restricted during the summer months with favorable foraging habitat limited to the upper tidal portions of the upper Bay, the Potomac, and the James rivers.

Tagging data from shortnose sturgeon in the upper Chesapeake Bay and Delaware River suggest movements through the Chesapeake and Delaware Canal (SSSRT 2010). Outside of tagged data, there is no information regarding movements to foraging or overwintering areas. Additionally, no information is available for shortnose sturgeon overwintering areas in the Chesapeake Bay or its tributaries.

Potomac River

Four documents dated between 1876 and 1929 state that shortnose sturgeon inhabited the Potomac River. Twelve shortnose sturgeon have been captured in the Potomac River between 1996 and 2010. Eleven of these captures were documented during the ongoing reward program sponsored by USFWS to compensate commercial anglers who report captures of Atlantic sturgeon in the Chesapeake Bay system (SSSRT 2010). Since 2010, only one shortnose sturgeon has been caught in the Potomac, which occurred in April of 2021 (Blankenship 2021).

The Potomac River is considered to be tidally influenced up to the Chain Bridge that lies just 2 km upstream of the suspected spawning area at Fletcher's Marina. Two late-stage females were captured and tracked within the Potomac, however only one was observed to make an apparent spawning migration in the spring (2005 – 2007, SSSRT 2010). Annual movements of shortnose sturgeon in the Potomac River seem typical of north-central adults. Both of the tracked female sturgeon remained in freshwater for at least one year with pre-spawning migration occurring in spring. Shortnose sturgeon that are found within the Chesapeake Bay may be migrants from the Delaware River.

Susquehanna River

The Susquehanna River is the main tributary to the Chesapeake Bay and contributes more than 50 percent of annual freshwater flow. Although historic distribution and abundance of shortnose sturgeon in the Susquehanna River is difficult to determine, sturgeon did exist here historically (SSSRT 2010). As mentioned previously, shortnose sturgeon are currently present in the Chesapeake Bay and some of its tributaries, including the Susquehanna River. The most recent information on shortnose sturgeon presence in the Susquehanna River comes from the USFWS Atlantic sturgeon Reward Program. As of 2010, there have been eight shortnose sturgeon incidentally captured within the lower Susquehanna River (Gomez and Sullivan Engineers 2012).

There are no current records of shortnose sturgeon spawning in the Susquehanna River, nor are there any historical spawning records indicating such. Little information exists on the foraging habitat of shortnose sturgeon in the Susquehanna River; however tagging studies from other rivers indicate that shortnose sturgeon migrate downstream to estuaries and bays presumably for foraging, suggesting that shortnose sturgeon in the Susquehanna River would likely utilize the Chesapeake Bay for foraging (SSSRT 2010). Shortnose sturgeon are also known to move upriver and seek deep, channel-like habitats for overwintering. Anecdotal reports of congregations of shortnose sturgeon found in deep holes near Lapidum and Perrysbille could indicate habitat utilization for overwintering and resting within the Susquehanna, however none has been confirmed. Lastly, there has been no documentation of shortnose sturgeon migrating in the Susquehanna River (SSSRT 2010).

The most recent status review for shortnose sturgeon was written in 2010 (SSSRT 2010). This review developed cumulative shortnose sturgeon population health scores, ranked stressors occurring to shortnose sturgeon within each river, and compared population health to stressors. Population health scores were based on number of individuals (one to five), demographics (three points per life stage present) and abundance trends (zero for unknown or no estimate to three for increasing trend). Stressor impact scores were ranked from one (low or no risk) to five (high risk, SSSRT 2010).

Table 5. Risk Assessment Scores for Shortnose Sturgeon in Maryland and Delaware Rivers (SSSRT 2010).

River	Abundance Score	Population Health Score[1]	Overall Stressor Score[2]
Potomac River	1.12	2.12	7.65
Delaware River	4.56	9.56	8.80
Susquehanna Rivers	1.12	1.12	7.25
Chesapeake Bay	2.23	3.23	7.70

[1] The population health score was calculated to represent shortnose sturgeon viability at a riverine scale and considers the number of individuals, demographics, and abundance trends as defined below. A population health score of 12 is the total possible.

[2] Sum of scores for each criterion to calculate the total population health score.

Currently, data supports some presence of shortnose sturgeon with the rivers of Delaware and Maryland, however the extent to which is unknown. The most recent population estimate of shortnose sturgeon in the Delaware River is 12,000, however this includes abundance for the entire river that extends into New Jersey and Pennsylvania. As of 2010, 78 shortnose sturgeon have been reported within the Chesapeake Bay, most of which have been adults, and 13 have been captured in the Potomac River. Abundance estimates in the Susquehanna River are unknown.

RECOVERY GOALS

The recovery plan identifies 19 population segments within their range with a goal of each segment maintaining a minimum population size to maintain genetic diversity and avoid extinction (NMFS 1998a). The actions needed are:

1. Establish listing criteria for shortnose sturgeon population segments;
2. Protect shortnose sturgeon and their habitats;
3. Rehabilitate shortnose sturgeon populations and habitats; and
4. Implement recovery tasks.

If the distance to rivers that could support a reproducing population exceeds the migration distance for sturgeon inhabiting the southeast or Delaware River/Chesapeake Bay metapopulations. King et al. (2014) recommends supplementation as a plausible restoration strategy. Accordingly, to ensure the long-term survival of populations, conservation actions should be based on available habitat and structural isolation.

5.2.3 Atlantic Sturgeon

The appearance of Atlantic sturgeon is similar to that of the sympatric shortnose sturgeon. Atlantic sturgeon are generally larger, have a smaller mouth relative to the size of their heads, have a different shaped snout, and different scutes along their abdomens, which are lacking in the shortnose sturgeon (SSSRT 2010).

LIFE HISTORY

The general life history pattern of Atlantic sturgeon is that of a long lived, late-maturing, iteroparous, anadromous species. Hager et al. (2020) reports return rates for fisch spawning in the York River system of once every 1.13 years for males and once every 2.13 years for females. Fecundity increases with age and body size (ranging from 400,000 – 8 million eggs, Dadswell 2006; Smith et al. 1982; Van Eenennaam and Doroshov 1998). The average age at which 50 percent of maximum lifetime egg production is achieved is estimated to be 29 years, approximately 3-10 times longer than for other bony fish species examined (Boreman 1997b).

While few specific spawning locations have been identified, at least 21 rivers are known to support reproducing populations. Smith (1985) reported that the timing of the arrival of mature adults into estuaries was temperature dependent and varied with latitude: February in Florida, Georgia, and South Carolina; April in the Delaware and Chesapeake Bay systems; and May-June in the GOM and Gulf of St. Lawrence systems. Traditionally, it was believed that spawning within all populations occurred during the spring and early summer months. More recent studies, however, suggest that spawning occurs from late summer to early autumn in two tributaries of the Chesapeake Bay (James River and York River, Virginia) and in the Altamaha River, Georgia (Balazik et al. 2012; Hager et al. 2014). A recent study by Balazik and Musick (2015) indicates that two races of Atlantic sturgeon repeatedly spawn during two different times (spring and fall) and places in the James River, and possibly the groups have become genetically distinct from each other. Based on a combination of telemetry data and historical documentation Balazik et al. hypothesize that a dual spawning strategy likely occurs in various degrees throughout the Atlantic sturgeon's range. Smith et al. (2015) identified fall spawning in the Roanoke River. These studies suggest that adult Atlantic sturgeon that show up in the southern estuaries spend the summer in the estuary before making a spawning run in the fall. Farrae et al. (2017) found genetically distinct fall- and spring-spawned Atlantic sturgeon in the Edisto River.

Sturgeon eggs are highly adhesive and are deposited in freshwater or tidal freshwater reaches of rivers on the bottom substrate, usually on hard surfaces such as cobble (Gilbert 1989; Smith and Clugston 1997). Hatching occurs approximately 94-140 hours after egg deposition, and larvae assume a bottom-dwelling existence (Smith et al. 1980). The yolk sac larval stage is completed in about 8-12 days, during which time larvae move downstream to rearing grounds over a 6 – 12 day period (Kynard and Horgan 2002). During the daytime, larvae use benthic structure (e.g., gravel matrix) as refugia (Kynard and Horgan 2002). Juvenile sturgeon continue to move further downstream into waters ranging from zero to up to ten parts per thousand salinity. Older juveniles are more tolerant of higher salinities as juveniles typically spend at least two years and sometimes as many as five years in freshwater before eventually becoming coastal residents as sub-adults (Boreman 1997b; Schueller and Peterson 2010; Smith 1985).

Atlantic sturgeon feed primarily on soft-bodied benthic invertebrates like polychaetes, isopods, and amphipods in the saltwater environment, while in fresh water, they feed on oligochaetes, gammarids, mollusks, insects, and chironomids (Brosse et al. 2002; Collins et al. 2008; Guilbard et al. 2007; Haley 1998; Haley 1999; Johnson et al. 1997; Moser and Ross 1995; Savoy 2007). Diets vary latitudinally and seasonally, though universally researchers have found that polychaetes constitute a major portion of Atlantic sturgeon diets. In North Carolina, Moser and Ross (1995) determined Atlantic sturgeon fed on 32 percent polychaetes, 28 percent isopods, 12 percent mollusks, and then other items. The directed movement of subadult and adult Atlantic sturgeon in the spring is from saltwater waters to river estuaries. River estuaries provide foraging opportunities for subadult and adult Atlantic sturgeon in addition to providing access to spawning habitat. The directed movement of subadult and adult Atlantic sturgeon reverses in the fall as the fish move back into saltwater waters for the winter. In the saltwater environment, sub adults and adults typically occur within the 50-m depth contour.

POPULATION DYNAMICS

The Chesapeake Bay DPS is comprised of all Atlantic sturgeon spawned in the watersheds that drain into the Chesapeake Bay and into coastal waters from Delaware-Maryland border on Fenwich Island to Cape Henry, Virginia (NMFS 2022b). Within this range, and depending on the information used to determine historical spawning, Atlantic sturgeon likely spawned in the

Susquehanna, Choptank, Nanticoke, Wicomico and Pocomoke rivers as well as the Potomac, Rappahannok, York River system and James rivers (NMFS 2022b).

Historically, Atlantic sturgeon were common throughout the Chesapeake Bay and its tributaries (NMFS 1998b). Several newspapers report large sturgeon in the lower reaches of the Susquehanna River from 1765-1895, indicating that at one time, Atlantic sturgeon may have spawned there. Historical harvests were also reported in the Patuxent, Potomac, Choptank, Nanticoke, and Wicomico/Pocomoke rivers.Secor (2002), using U.S. Fish Commission landings, Secor (2002) estimated approximately 20,000 adult females inhabited the Chesapeake Bay and its tributaries prior to 1890, when a sturgeon fishery began.

The Delaware River once supported the largest spawning subpopulation of Atlantic sturgeon in the United States, with 3,200 metric tons of landings in 1888 (ASSRT 2007; Secor 2002; Secor and Waldman 1999). Population estimates based on juvenile mark and recapture studies and commercial logbook data indicate that the Delaware subpopulation has continued to decline rapidly since 1990. Based on genetic analyses, the majority of subadults captured in the Delaware Bay are thought to be of Hudson River origin (ASSRT 2007). However, a more recent study by Hale et al. (2016) suggests that a spawning population of Atlantic Sturgeon exists in the Delaware River and that some level of early juvenile recruitment is continuing to persist despite current depressed population levels. They estimated that 3,656 (95% confidence interval from 1,935 to 33,041) juveniles (ages 0–1) used the Delaware River estuary as a nursery in 2014. These findings suggest that the Delaware River spawning subpopulation contributes more to the New York Bight DPS than was formerly considered.

The Delaware River, flowing through New Jersey, Delaware, Pennsylvania and into Delaware Bay, historically may have supported the largest stock of Atlantic sturgeon of any Atlantic coastal river system (NMFS 1998c). Prior to 1890, it is expected that more than 180,000 adult females were spawning in the Delaware River. Juveniles were once abundant enough to be considered a nuisance bycatch of the American shad fishery. The current abundance of all Atlantic sturgeon life stages in the Delaware River has been greatly reduced from historical levels. Brundage III and Meadows (1982) recorded 130 Atlantic sturgeon captures between the years of 1958-1980. Directed gill net surveys by Delaware Fish and Wildlife from 1991-1998 consistently took juvenile Atlantic sturgeon in the lower Delaware River near Artificial Island and Cherry Island Flats from late spring to early fall. Population estimates based on mark and recapture of juvenile Atlantic sturgeon declined from a high of 5,600 in 1991 to less than 1,000 in 1995; however, it is important to note that population estimates violated most tagging study assumptions and should not be used as unequivocal evidence that the population has declined dramatically (NMFS 1998c). However, a more recent study by Hale et al. (2016) suggests that a spawning population of Atlantic Sturgeon exists in the Delaware River and that some level of early juvenile recruitment is continuing to persist despite current depressed population levels.

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Although capture rates declined throughout the mid 1990s, the mature adults documented within the Delaware System provide evidence that a reproducing population exists. It is speculated, however, that the abundance of subadults within the Delaware River during the 1980s and early 1990s was the result of a mixture of stocks including the Hudson River stock. However, genetic data indicate that the Delaware River has a distinct genetic signature of a remnant population (NMFS 1998c). More recently, White et al. (2022) used microsatellite data to reconstruct pedigrees and arrived at an estimate of between 125 and 250 adult sturgeon in the Delaware River.

STATUS

The 1998 Atlantic sturgeon status review determined that the species did not warrant listing at that time since direct fishing pressure was essentially removed by a coast-wide moratorium on the fishery and water quality had improved substantially since the early 1900s (ASSRT 1998). The 1998 status review team, also determined that bycatch of Atlantic sturgeon in other fisheries was unsubstantial and did not pose a threat to the viability of species. The 2007 status review concluded that only a few subpopulations seem to be increasing or stabilizing since 1998, with the majority of subpopulations showing no signs of recovery (ASSRT 2007). New information also suggested that stressors such as bycatch, ship strikes, and water quality were resulting in substantial impacts on subpopulations. The Atlantic Sturgeon Status Review Team (ASSRT) also noted that subpopulation estimates of Atlantic sturgeon remained low, with the lack of recovery attributed to habitat degradation, ship strikes, bycatch and dams. In 2012 NMFS listed the New York Bight and Chesapeake Bay DPSs as endangered and the GOM DPS as threatened on the basis of low population size and the level of impacts and number of threats such as continued degraded water quality, habitat impacts from dredging, continued bycatch in state and federally-managed fisheries, and vessel strikes to each DPS. Historically, each of these DPSs likely supported more than 10,000 spawning adults (ASSRT 2007; MSPO 1993; Secor 2002). The best available data indicate that current numbers of spawning adults for each DPS are one to two orders of magnitude smaller (e.g., hundreds to low thousands) than historical levels (ASSRT 2007; Kahnle et al. 2007). The Carolina and South Atlantic DPSs were estimated to have declined to less than three and six percent of their historical population sizes, respectively (ASSRT 2007). Both of these DPSs were listed as endangered due to a combination of habitat curtailment and alteration, bycatch in commercial fisheries, and inadequacy of regulatory mechanisms in ameliorating these impacts and threats.

Lacking complete estimates of population abundance across the distribution of Atlantic sturgeon, the NMFS Northeast Fishery Science Center (NEFSC) developed a virtual population analysis model with the goal of estimating bounds of Atlantic sturgeon ocean abundance (Kocik et al.

2013). The Atlantic Sturgeon Production Index (ASPI) was developed to characterize uncertainty in abundance estimates arising from multiple sources of observation and process error, and to complement future efforts to conduct a more comprehensive stock assessment. Model inputs include empirical estimates of post-capture survivors and natural survival, probability estimates of recapture using tagging data from the USFWS sturgeon tagging (PIT and T-bar tags) database, and federal fishery discard estimates from 2006 to 2010.

Based on the ASPI, estimated mean abundance from 2006-2011 was 417,934 fish, with a 95 percent confidence interval of 165,381 to 744,597 fish. This estimate does not include juvenile Atlantic sturgeon that reside year-round in rivers and estuaries. Kocik et al. (2013) partitioned the coast-wide ASPI estimate across DPSs using a Mixed Stock Analysis developed by (Wirgin et al. 2015) based on genetic data (n=173 fish) from bycatch in Atlantic coast commercial federal fisheries. The DPS proportions and ocean population estimates are as follows: GOM (11 percent) 45,973 fish; New York Bight (49 percent) 204,788; Chesapeake Bay (14 percent) 58,511; Carolina (4 percent) 16,717; and South Atlantic (20 percent) 83,587 (note: remaining 2 percent partitioned to Canada).

Kocik et al. (2013) produced an alternative Atlantic sturgeon ocean population estimate by dividing the observed total discards by the five-year moving average exploitation rate derived from the ASPI tagging model (139,935 fish; coefficient of variation 21%). This estimate, which is based on more conservative assumptions, is considerably smaller than the ASPI model estimate. Partitioning this more conservative ocean population estimate by Atlantic sturgeon DPS results in the following: GOM 15,393 fish; New York Bight 68,568; Chesapeake Bay 19,590; Carolina 5,597; and South Atlantic 27,987.

An Atlantic sturgeon population abundance estimate was also derived from Northeast Area Monitoring and Assessment Program (NEAMAP) trawl survey data from 2007 to 2012. The NEAMAP estimates were based on sampling in a large portion of the marine range of the five DPSs (Cape Cod, Massachusetts to Cape Hatteras, North Carolina) in known sturgeon coastal migration areas, and during times of year that sturgeon are expected to be migrating north and south. The Atlantic sturgeon population estimates from fall surveys range from 6,980 to 42,160 fish (with coefficients of variation between 0.02 and 0.57), and the estimates from spring surveys range from 25,540 to 52,990 fish (with coefficients of variation between 0.27 and 0.65). These are considered minimum population estimates because the calculation makes the assumptions that the gear will capture all of the sturgeon in the water column along the tow path (i.e., 100 percent net efficiency) and that all sturgeon are within the sampling domain of the survey. Since the NEAMAP survey does not sample in rivers, these estimates will not include river resident young-of-year or juvenile Atlantic sturgeon. The NEAMAP derived estimates only include those subadults that are of a size vulnerable to capture in commercial sink gillnet and otter trawl gear and are present in the marine environment, which is only a fraction of the total number of subadults. Additionally, NEAMAP surveys are not conducted in the GOM or south of Cape Hatteras, NC. Atlantic sturgeon population abundance estimates based on NEAMAP data for catchabilities of 10 percent, 50 percent, and 100 percent are shown in Table 6, along with ASPI estimates for comparison. Partitioned the NEAMAP based estimate a conservative 50 percent efficiency across DPSs, using the proportions developed by Wirgin et al. (2015), results in the following: GOM 7,455 fish; New York Bight 33,210; Chesapeake Bay 9,489; Carolina 2,711; and South Atlantic 13,555.

Table 6. Comparison of estimated Atlantic sturgeon abundance and 95 percent confidence intervals based on two population models

Model	Model Years	95 percent low	Mean	95 percent high
ASPI	2006-2010	165,381	417,934	744,597
NEAMAP Survey, swept area assuming 100 percent efficiency	2007-2012	8,921	33,888	58,856
NEAMAP Survey, swept area assuming 50 percent efficiency	2007-2012	13,962	67,776	105,984
NEAMAP Survey, swept area assuming 10 percent efficiency	2007-2012	89,206	338,882	588,558

STATUS WITHIN THE ACTION AREA

While all five DPS may occur in the action area, the Chesapeake and New York Bight DPSs are expected to be dominant. Both the Chesapeake and New York Bight DPSs were listed as endangered in 2012.

The current abundance of all Atlantic sturgeon life stages in the Delaware River has been greatly reduced from the historical level with current numbers of spawning adults at one to two orders of magnitude smaller than historical levels (NMFS 2022d). The New York Bight DPS's risk of extinction is "High" due to low productivity (e.g., relatively few adults compared to historical levels and irregular spawning success), low abundance (e.g., only three known spawning populations and low DPS abundance, overall), and limited spatial distribution (e.g., limited spawning habitat within each of the few known rivers that support spawning). Genetic bottlenecks and low levels of inbreeding are indicated within the Hudson and Delaware spawning populations. There is a relatively high probability (75 percent) that the New York Bight DPS abundance has increased since the implementation of the 1998 fishing moratorium, and a relatively high probability (69 percent) that mortality for the New York Bight DPS does not exceed the mortality threshold used for the Stock Assessment (ASMFC 2017a). However, these conclusions primarily reflect the status and trend of only the Hudson River spawning population and do not necessarily reflect the status of Delaware River or the Nanticoke River/Marshyhope Creek populations. The portion of the Delaware River and Bay that is available to Atlantic sturgeon extends from the Delaware Bay to the fall line at Trenton, NJ, a distance of 140 river kilometers (rkm). There are no dams within this reach of the river. Thus, the entirety of the river is accessible; however, habitat suitability is unknown due to river augmentation and water quality issues. Historical spawning records indicate that Atlantic sturgeon spawned in the Delaware River at two sites outside of the action area. In the Delaware River, the effective population size has been estimated to be 40 (95 percent CL, 34.7-46.2; n = 108) and 60.4 (42-85.6; n = 488) by Waldman et al. (2019) and White et al. (2021), respectively. The significant difference between estimates is likely due to sample size. Therefore, White et al.'s (2021) estimate is likely most accurate. Additionally, a recent close-kin mark-recapture estimate was produced for the Delaware River and suggests there are fewer than 250 adults (census) in the Delaware River population (White et al. 2022).

Recent survival estimates do not suggest much of an improvement since the last estimates made during the commercial fishery (Boreman 1997b; Kahnle et al. 1998). Melnychuk et al. (2017) provided an updated estimate of survival of Hudson River Atlantic sturgeon of approximately 88.22 percent, while for similar life stages over a longer time frame, the Atlantic States Marine Fisheries Service (ASMFC 2017) estimated survival of the entire New York Bight to be 91 percent (95 percent confidence limits, 71-99 percent).

The Chesapeake Bay DPS's risk of extinction is "High" because of its low productivity (e.g., relatively few adults compared to historical levels and irregular spawning success), low abundance (e.g., only three known spawning populations and low DPS abundance, overall), and limited spatial distribution (e.g., limited spawning habitat within each of the few known rivers that support spawning). Genetic bottlenecks and low levels of inbreeding are also indicated. Based on U.S. Fish Commission landings data, approximately 20,000 adult female Atlantic sturgeon inhabited the Chesapeake Bay and its tributaries prior to development of a commercial fishery in 1890 (Secor 2002). Chesapeake Bay rivers once supported at least six historical spawning subpopulations (ASSRT 2007), but today reproducing populations are only known to occur in the James, York, and Nanticoke rivers. Estimates of James River effective population size from separate studies and based on different age classes are similar, ranging from 32 to 62 sturgeon (NMFS 2022b). Balazik et al. (2012) reported empirical evidence that James River Atlantic sturgeon spawn in the fall, and a more recent study indicates that Atlantic sturgeon also spawn in the spring in the James River (i.e., dual spawning races) (Balazik and Musick 2015). In 2007, the Atlantic Sturgeon Status Review Team concluded that the James River had a moderately high risk (greater than 50 percent chance) of becoming endangered in the next 20 years, due to anticipated impacts from commercial bycatch (ASSRT 2007). Kahn et al. (2019) estimated a spawning run size of up to 222 adults (but with yearly variability) in the Pamunkey River, a tributary of the York River in Virginia, based on captures of tagged adults from 2013-

2018. The highest ranked stressor for the York River was commercial bycatch, which received a moderate risk rank (ASSRT 2007). New information for the Nanticoke River system suggests a small adult population based on a small total number of captures (i.e., 26 sturgeon) and the high rate of recapture across several years of study (Secor et al. 2022). At the DPS level, the Chesapeake Bay DPS is estimated to have an apparent annual survival of approximately 88 percent (95 percent CL, 46-99 percent; ASMFC 2017). A recent estimate for adult York River Atlantic sturgeon by Kahn et al. (In Press) shows much higher survival than other estimates with an annual apparent survival of 99.2 percent (97.9-99.7 percent).

The Gulf of Maine, Carolina, and South Atlantic DPSs of Atlantic sturgeon will migrate and forage in waters of Maryland and Delaware. The threatened Gulf of Maine DPS of Atlantic sturgeon historically supported at least four spawning subpopulations. Only the Penobscot and Kennebec populations are extant (ASSRT 2007). Prior to any commercial fishing, the Kennebec supported approximately 10,000 to 15,000 spawning adults (ASSRT 2007; MSPO 1993). The construction of the Edwards Dam in 1837 was believed to have caused the commercial sturgeon catch to decline over 50 percent (MSPO 1993). Survival rates of all ages in the Gulf of Maine DPS of Atlantic sturgeon is estimated to be approximately 74 percent annually (95 percent confidence limits, 15-99 percent; ASMFC 2017). The endangered Carolina DPS consists of seven extant subpopulations; on subpopulation (Sampit) is believed to be extirpated. The current abundance of these subpopulations is likely less than three percent of their historical abundance based on 1890s commercial landings data (ASSRT 2007; Secor 2002). The survival estimate for the entire Carolina DPS is approximately 78 percent (95 percent CL, 39-99 percent). The endangered South Atlantic DPS historically supported eight spawning subpopulations but currently supports five extant spawning populations (ASSRT 2007). The current abundance of these subpopulations are suspected to be less than six percent of their historical abundance, extrapolated from the 1890s commercial landings (ASSRT 2007; Secor 2002). The Atlantic Sturgeon Status Review Team found that the South Atlantic DPS of Atlantic sturgeon had a moderate risk (greater than 50 percent) of becoming endangered in the next 20 years due primarily to dredging, degraded water quality, and commercial fisheries bycatch. Survival within the entire DPS was estimated to be approximately 86 percent (54-99 percent; ASMFC 2017).

CRITICAL HABITAT

Critical habitat for the Atlantic sturgeon Chesapeake Bay and New York Bight DPSs were designated in 2017 (82 FR 39160, see Figure 2). The Delaware River falls under New York Bight Unit 4. Critical habitat boundaries of the Chesapeake Bay DPS include the Potomac River, the Rappahannock River from U.S. Highway 1 Bridge, downstream to the mouth of the Chesapeake Bay, the York river from its confluence with the Mattaponi and Pamunkey rivers downstream to where the main stem river discharges at the mouth of the Chesapeake Bay, the James River and the Nanticoke River. Only the Nanticoke River, Marshyhope Creek, and the

Potomac River fall within the action area and are in Chesapeake Bay Unit 1 and Unit 2 respectively.

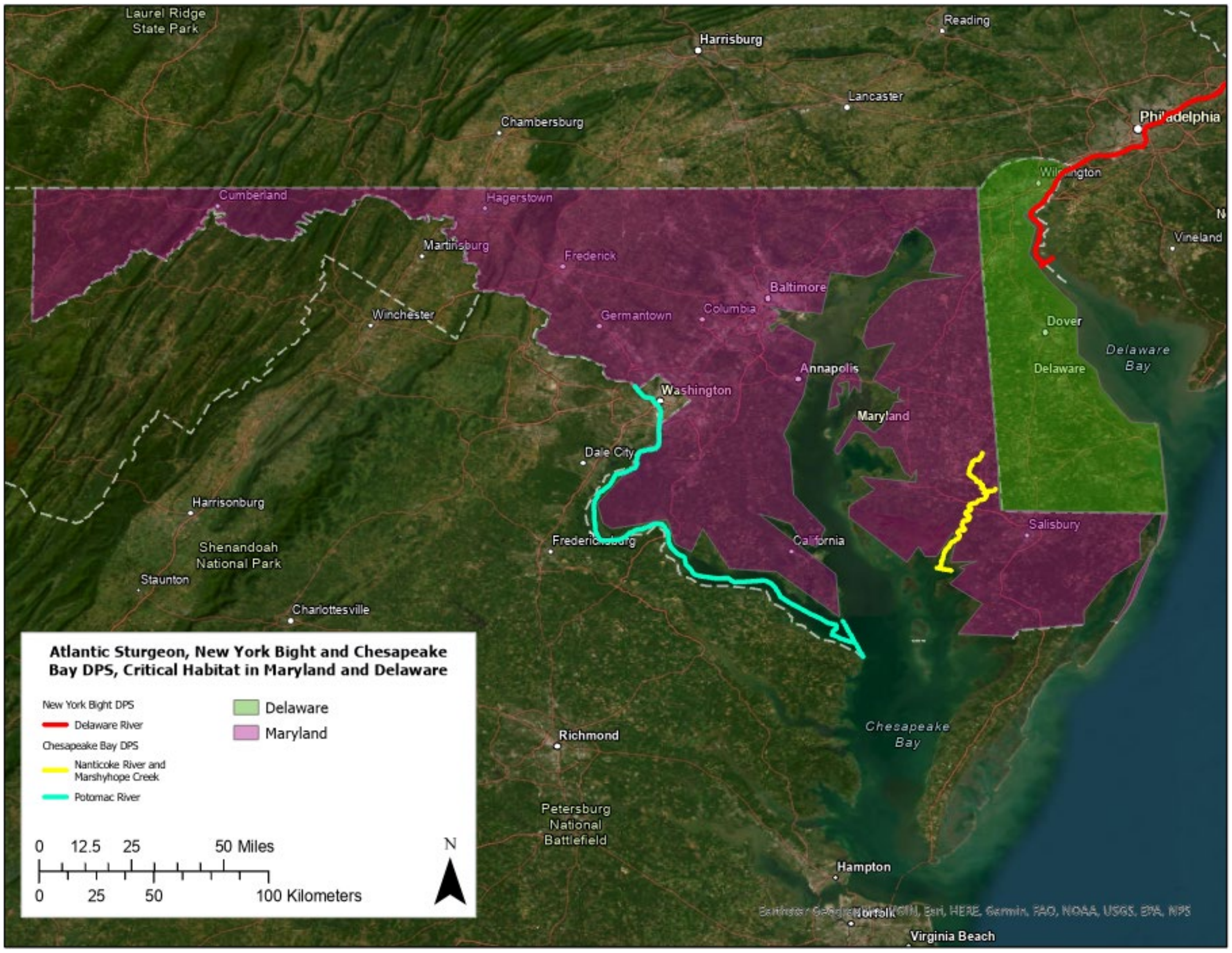


Figure 2. Critical habitat for Atlantic Sturgeon New York Bight and Chesapeake Bay DPS within Maryland and Delaware (82 FR 39160; August 17, 2017)

The PBFs identified as essential components of the critical habitat to conserve the Atlantic sturgeon include:

1. Hard bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0-0.5 parts per thousand range) for settlement of fertilized eggs and refuge, growth, and development of early life stages.
2. Aquatic habitat with a gradual downstream salinity gradient of 0.5 up to as high as 30 ppt and soft substrate (e.g., sand, mud) between the river mouth and spawning sites for juvenile foraging and physiological development;

3. Water of appropriate depth and absent physical barriers to passage (e.g., locks, dams, thermal plumes, turbidity, sound, reservoirs, gear, etc.) between the river mouth and spawning sites necessary to support (i) Unimpeded movement of adults to and from spawning sites, (ii) Seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary; and (iii) Staging, resting, or holding of subadults or spawning condition adults. Water depths in main river channels must also be deep enough (at least 1.2 meters) to ensure continuous flow in the main channel at all times when any sturgeon life stage would be in the river.
4. Water, between the river mouth and spawning sites, especially in the bottom meter of the water column, with the temperature, salinity, and oxygen values that, combined, support: Spawning; annual and interannual adult, subadult, larval, and juvenile survival; and larval, juvenile, and subadult growth, development, and recruitment (e.g., 13 degrees Celsius to 26 degrees Celsius for spawning habitat and no more than 30 degrees Celsius for juvenile rearing habitat, and 6 mg/L or greater DO for juvenile rearing habitat).

RECOVERY GOALS

A recovery plan has not been completed for the listed Atlantic sturgeon DPSs. However, a recovery outline has been prepared (NMFS 2018b). A recovery outline is an interim guidance to guide recovery efforts until a full recovery plan is developed and approved. NMFS's vision, explained in the recovery outline, is that subpopulations of all five Atlantic sturgeon DPSs must be present across the historical range. These subpopulations must be of sufficient size and genetic diversity to support successful reproduction and recovery from mortality events. The recruitment of juveniles to the sub-adult and adult life stages must also increase and must be maintained over many years. Recovery of these DPSs will require conservation of the riverine and marine habitats used for spawning, development, foraging, and growth by abating threats to ensure a high probability of survival into the future. The outline includes a recovery action to implement region-wide initiatives to improve water quality in sturgeon spawning rivers, with specific focus on eliminating or minimizing human-caused anoxic zones.

6 ENVIRONMENTAL BASELINE

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 C.F.R. §402.02). . This includes discharges and activities authorized by the EPA's Construction General Permit, and other activities authorized by the EPA (e.g., NPDES permits, cooling water intake, air emissions, and the cleanup and management of hazardous waste).

The U.S. Atlantic coast has undergone significant physical, biological, and ecological changes over the past few centuries. These changes are primarily the result of human population growth and associated activities that have drastically altered the natural environment in this region.

Water quality in riverine and estuarine systems is affected by human activities conducted in the riparian zone, as well as those conducted more remotely in the upland portion of the watershed Industrial activities can result in discharge of pollutants, changes in water temperature and levels of DO, and the addition of nutrients. In addition, forestry and agricultural practices can result in erosion, run-off of fertilizers, herbicides, insecticides or other chemicals, nutrient enrichment and alteration of water flow. Coastal and riparian areas are also heavily impacted by real estate development and urbanization resulting in stormwater discharges, non-point source pollution, and erosion. The Clean Water Act regulates pollution discharges into waters of the United States from point sources; however, it does not regulate non-point source pollution.

6.1 Existing Permitted Sources

Under the Clean Water Act, NPDES permits are renewed every five years and include permit limits for discharge constituents that have a reasonable potential to cause an aquatic impairment. No facilities have permit limits for nonylphenol and few facilities have permits for ammonia or cadmium. Many permits require monitoring for other pollutants and characteristics such as nutrients, biological oxygen demand, organic solvents, and other metals. At the time of this writing, there are 16 discharges with permit limits for ammonia and two discharges with permit limits for cadmium under Delaware NPDES permits. Under Maryland NPDES permits, there are 245 discharges with permit limits for ammonia and 47 discharges with permit limits for cadmium. There were three records of permit violations for ammonia in Delaware and 53 violations in Maryland. Additionally, in Maryland, there were five permit violations for cadmium. The National Recommended Water Quality Criteria these discharges are currently subject to are listed in Table 7. The locations of these facilities are illustrated in Figure 3.

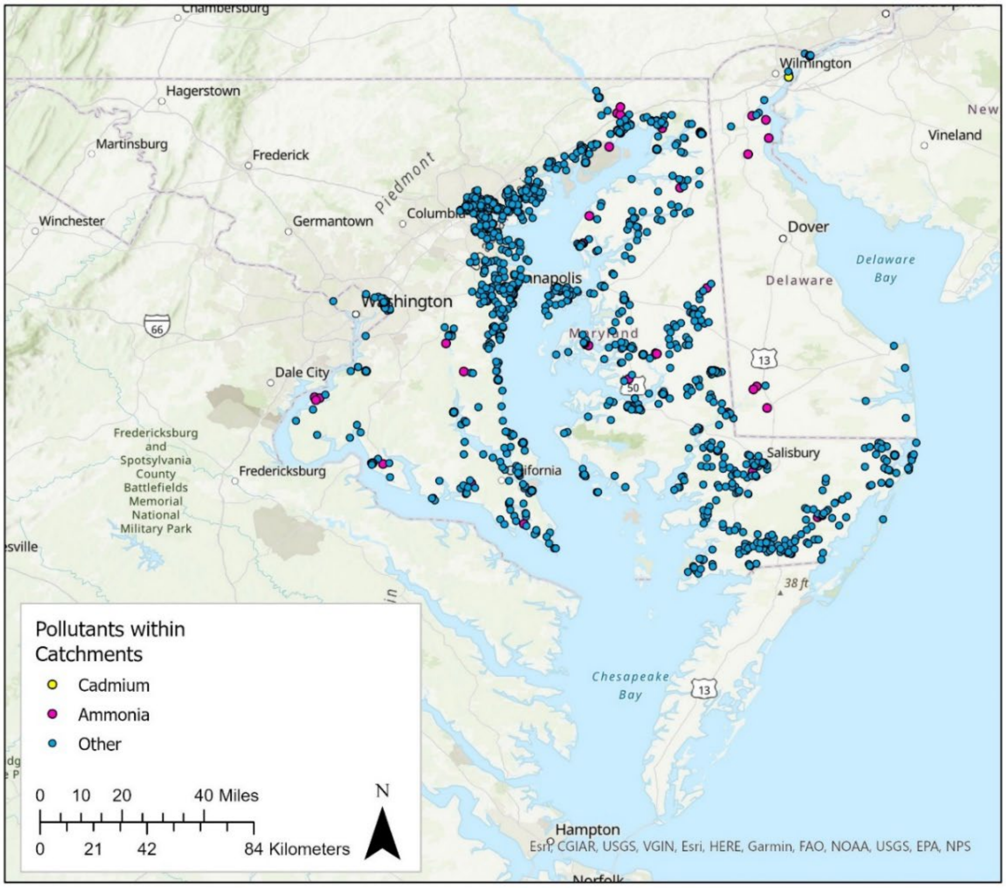
Table 7. Existing Water Quality Criteria

Pollutant	Fresh Water (µg/L)		Salt Water (µg/L)	
	Acute	Chronic	Acute	Chronic
Cadmium[a,b]				
2016 Delaware 2019 Maryland	1.8 1.8	0.72 0.72	40 33.13	8.8 7.9
Total Ammonia Nitrogen				
2016 Delaware 2019 Maryland	Temperature and pH dependent	Temperature and pH dependent	No criteria	No criteria
Nonylphenol[c]				
2005 Delaware	No criteria	No criteria	No criteria	No criteria

[a] Dissolved fraction

[b] Hardness at 100 mg/L calcium carbonate

[c] Total recoverable



Esri, CGIAR, USGS, VGIN, Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, NPS

Figure 3. Maryland and Delaware Discharges in Catchments Adjacent to Sturgeon Waters

6.2 Mixtures and Impairments

As noted above in Section 3.1.3, in point or nonpoint source pollution, chemicals occur together in mixtures, but criteria for those chemicals are developed in isolation, without consideration of additive toxicity or other chemical or biological interactions. Most importantly, a number of studies have determined conclusively that adverse effects due to additive or synergistic toxicity mechanisms occur when one or more metals are near or equal to acute criteria concentrations (e.g., Marking 1985; Sprague 1970; Vijver et al. 2010).

The Clean Water Act requires states and territories to assess water quality every two years under 305(b) and identify waters that are impaired under 303(d) and in need of restoration. Impairments may be based on a single or multiple stressors within the system. One stressor may mask the effects of other stressors that are also adversely affecting aquatic life. Restoration is achieved by establishing the maximum amount of an impairing pollutant allowed in a waterbody, or Total Maximum Daily Load[5] (TMDL). These assessments are sent as an integrated report every even numbered year to EPA, which must approve of each impaired waters' listing. As a result, many recent state assessments are not finalized until the following year or later.

Table 8. Impairments within Sturgeon Waters with Approved TMDLs

Basin	Impairment	Square Miles Impaired
Delaware River	Dioxins	30.46
	Low Oxygen	
	PCBs	
	Pesticides	
Potomac River	Nitrogen, Phosphorus	35.9
	Murky water	374.25
	Salts	320.1
Chesapeake Bay	Murky Water	47.05
	Unknown	355.6
	Nitrogen, Phosphorus	
Nanticoke	Nitrogen, Phosphorus	125.81 18.68
	Low Oxygen	10.42
	PCBs	
	Degraded Habitat	217.12
	Murky Water	

The EPA approved Delaware's most recent 303(d) list for freshwaters in May of 2022. There were 19 new segments of the Nanticoke River added to the 2022 Integrated Report for Delaware

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[5] A TMDL is the calculation of the maximum amount of a pollutant allowed to enter a waterbody so that the waterbody will meet and continue to meet water quality standards for that particular pollutant. A TMDL determines a pollutant reduction target and allocates load reductions necessary to the source(s) of the pollutant.

due to new data availability. The parameters for these listings include Zinc, total ammonia, enterococcus and dissolved oxygen. Only one segment of the Potomac River that intersects with the state of Delaware was added as a result of new data for total ammonia. No changes were made with regard to the Delaware River listing, however the Chesapeake and Delaware Canal and Chesapeake drainage system saw an additional seven waters as a result of new data availability in relation to enterococcus, total ammonia and dissolved oxygen.

In Maryland, the combined 2020-2022 Integrated Report of Surface Water Quality was approved by the EPA on February 25, 2022. The Integrated Report found that 505 bodies of water (32 percent) within Maryland met some water quality standard, 568 (35 percent) were listed as impaired with TMDL completed and 332 (21 percent) impaired with TMDL needed. Maryland saw 101 new Category 5 listings within the state, bringing the total to 359. The leading pollutant causing impairment in the 2020-2022 integrated report was temperature, which saw an increase of 73 impairments since 2018. Trends were consistent with the 2018 report with dissolved anions and bacteria following as the next leading pollutants in Maryland.

There are 53 waterbodies in the Lower Chesapeake Bay watershed that have been assessed for aquatic life and have been listed as impaired,. Two of these are within Maryland. None were listed as “good.” Within the Potomac, three waterbodies are listed as impaired within the action area. Conversely, out of the 295 waterbodies assessed for the Susquehanna River, none are listed as impaired.

6.3 Municipal Separate Storm Sewer Systems

Stormwater Municipal Separate Storm Sewer Systems (MS4s) permits regulate discharges on a system or jurisdiction-wide basis and must effectively prohibit non-stormwater discharges into the sewer system. Stormwater discharges regulated under an MS4 permit represent a baseline stormwater impact to which other regulated discharges are added.

Stormwater monitoring data for the states of Delaware and Maryland recorded for 1981 to 2005 in the National Stormwater Water Quality Database (https://bmpdatabase.org/national-stormwater-quality-database) summarizes ammonia, cadmium and other pollutants occurring in stormwater and potentially reaching surface waters and exposing ESA-listed sturgeon (Table 9).

Table 9. Summary of Available Stormwater Monitorng Data from the National Stormwater Water Quality Database (1981-2005).

	Delaware		Maryland	
Pollutant and units (all values total unless otherwise noted)	Detected	Detection limits	Detected	Detection limits
Phosphorous (dissolved) mg/L	0.06-1.8 (N=24)	0.05-0.1		
Phosphorous mg/L	0.043-4.6 (N=33)	0.04-0.1	0.005-19.9 (N=1001)	0.06-0.06
Fecal Coliform MPN/100 mL			2-640,000 (N=369)	1-200
Ammonia mg/L	0.1-1.7 (N=26)	0.1-1		

	Delaware		Maryland	
Pollutant and units (all values total unless otherwise noted)	**Detected**	**Detection limits**	**Detected**	**Detection limits**
Nitrate & Nitrite mg/L			0.005-41 (N=992)	0.02-0.2
Total Kjeldahl Nitrogen mg/L	0.49-4.7 (N=33)	0.5-2	0.05-36 (N=824)	0.5-1
Biological Oxygen Demand mg/L	3.2-50 (N=39)	4-11	1-433.4 (N=734)	1-100
Chemical Oxygen Demand mg/L	12-535 (N=46)	5	17-702 (N=52)	
Oil and Grease mg/L	0.15-9.1 (N=38)	1-9	0.5-79 (N=362)	0.5-17
Total Petroleum Hydrocarbon mg/L			1.8-9.1 (N=18)	
2-Chloroethylvinylether µg/L			0.2-36.85 (N=341)	
Acrolein µg/L			10-10 (N=1)	2-50
Chloroform µg/L			1.7-2.9 (N=2)	0.5-10
Ethylbenzene µg/L				0.5-10
Methylchloride µg/L			0.5-12 (N=11)	0.5-10
Toluene µg/L				0.5-10
Antimony µg/L			1-14 (N=10)	0.5-250
Arsenic µg/L			1-10 (N=14)	0.5-25
Beryllium µg/L			0.5-56 (N=11)	0.25-10
Cadmium µg/L	0.13	0.076-0.55	0.05-20 (N=629)	0.1-25
Chromium µg/L			1-140 (N=59)	2-50
Copper µg/L	0.33-5.25 (N=35)	2.8	1-540.54 (N=871)	2-60
Cyanide µg/L			5-60 (N=13)	2-10
Lead µg/L	0.46-2.9 (N=23)	0.33-1	0.5-689.07 (N=687)	1-250
Mercury µg/L			0.2-1.3 (N=5)	0.1-10
Nickel µg/L			2-110 (N=55)	1-100
Selenium µg/L			1-9 (N=8)	1-5
Silver µg/L			0.6-19 (N=7)	0.1-25
Thallium µg/L			1-6 (N=3)	1-250
Zinc µg/L	1.69-130 (N=46)	2.2	3-14,700 (N=878)	4-200

In Maryland, EPA has delegated authority to issue NPDES permits to the Maryland Department of the Environment. Stormwater permits are issued to advance Chesapeake Bay restoration while reducing flooding and making communities more resilient to the effects of climate change. Since its conception, Maryland Department of the Environment has issued 1444 permits. MS4 permits require counties and municipalities to report data on local water quality as well as various stormwater management efforts.

General NPDES wastewater permits currently exist for industrial sources that discharge storm water only; discharges of stormwater from construction activities; hydrostatic testing of tanks, pipes and other non-oil containment structures, seafood processing facilities, surface coal mining and related facilities; discharges from swimming pools and spas; mineral mines, quarries, borrow pits, and concrete and asphalt plants; discharges from marinas including boat yards and yacht; and discharges from the application of pesticides.

Management of the NPDES permit program was delegated to Delaware under Section 402 of the Clean Water Act, which is managed under by the Surface Water Discharges Section, within

DNREC Division of water. The Delaware River Basin Commission has regulations that apply to NPDES discharges to the Delaware River Watershed. In Delaware there are two types of NPDES permits, individual and general. General permits are issued for a given state-wide activity such as the discharge of storm water associated with industrial permits, while individual permits are permits developed and issued on a case-by-case basis for activities not covered by general permits.

6.4 Climate Change

Climate change, despite being a global phenomenon, is discussed in this section and in the cumulative effects section (Section 9), because it is a current and ongoing effect which influences environmental quality within the action area now and in the future. NMFS's policy guidance with respect to climate change when evaluating an agency's action is to project climate effects over the timeframe of the action's consequences. The EPA's approval and subsequent implementation of water quality criteria will be in effect indefinitely. Since Atlantic sturgeon can migrate widely, some aspects of global climate change are important to consider.

Climate change has the potential to influence species abundance, geographic distribution, migration patterns, and susceptibility to disease and contaminants, as well as the timing of seasonal activities and community composition and structure (Evans and Bjørge 2013; IPCC 2014; Kintisch and Buckheit 2006; Macleod 2009; Mcmahon and Hays 2006; Robinson et al. 2008). The loss of habitat because of climate change could be accelerated due to a combination of other environmental and oceanographic changes such as an increase in the frequency of storms and/or changes in prevailing currents (Antonelis et al. 2006; Baker et al. 2006).

Changes in the saltwater ecosystem caused by climate change (e.g., ocean acidification, salinity, oceanic currents, DO levels, nutrient distribution) could influence the distribution and abundance of lower trophic levels (e.g., phytoplankton, zooplankton, submerged aquatic vegetation, crustaceans, mollusks, forage fish), ultimately affecting primary foraging areas of ESA-listed species. Saltwater species ranges are expected to shift as they align their distributions to match their physiological tolerances under changing environmental conditions (Doney et al. 2012). Similarly, climate-related changes in important prey species populations are likely to affect predator populations. Changes in core habitat area means some species are predicted to experience gains in available core habitat and some are predicted to experience losses (Hazen et al. 2012).

As stated in Section 5.2.1.6, ESA-listed sturgeon are highly vulnerable to climate change. However, it is difficult to predict the magnitude and scope of those potential impacts. Sturgeon could be affected by changes in river ecology resulting from increases in precipitation and changes in water temperature, which, in turn, may affect recruitment and distribution in these rivers. The effects of increased water temperature and decreased water availability are likely to have a more immediate effect on Atlantic sturgeon populations that migrate and spawn in river systems with existing water temperatures that are at or near the maximum for the species, including the South Atlantic and Carolina DPSs. Atlantic sturgeon prefer water temperatures up to approximately 28 degrees Celsius; these temperatures are experienced naturally in some areas of rivers during the summer months. If river temperatures rise and temperatures above 28 degrees Celsius are experienced in larger areas, sturgeon may be excluded from some habitats. The increased rainfall predicted by some models in some areas may increase runoff and scour spawning areas, while flooding events could cause temporary decreases in water quality. Rising temperatures predicted for all of the U.S. could exacerbate existing water quality problems with changes in dissolved oxygen and temperature.

Increased droughts (and water withdrawal for human use) predicted by some models in some areas may cause loss of habitat including loss of access to spawning habitat. Drought conditions in the spring may also expose eggs and larvae in rearing habitats. If a river becomes too shallow or flows become intermittent, all life stages, including adults, may become susceptible to strandings or habitat restriction. Low flow and drought conditions are also expected to cause additional water quality issues. Any of the conditions associated with climate change are likely to disrupt river ecology causing shifts in community structure and the type and abundance of prey. Additionally, cues for spawning migration and spawning could occur earlier in the season causing a mismatch in prey that are currently available to developing sturgeon in rearing habitat.

Changes in oceanic conditions could also affect the marine distribution of sturgeon or their marine and estuarine prey resources. Rising sea level may result in the salt wedge moving upstream in affected rivers. Sturgeon spawning occurs in fresh water reaches of rivers because early life stages have little to no tolerance for salinity. In river systems with dams or natural falls that are impassable by sturgeon, movement of the salt wedge further upstream would further restrict spawning and rearing habitat. The effects of climate change on ESA-listed sturgeon will not occur independently from other stressors. Rather, the anthropogenic stressors already affecting the fitness and survival of sturgeon – including bycatch, loss of migratory habitat from dams, contamination of riverine habitat and overall decreased water quality – will be compounded by the anticipated effects of climate change.

CLIMATE CHANGE IN DELAWARE AND MARYLAND

Within the state of Maryland, the total annual precipitation has been above the long-term average for the last 26 years. Annual average precipitation in Maryland varies from about 1.01 meters in the Appalachian Mountain region to about 1.27 meters in the western and eastern areas of the state. Precipitation in Maryland is projected to increase, particularly in the winter and spring. The frequency and intensity of extreme precipitation events are also projected to increase, which could increase the risk of flooding (Runkle et al. 2022b). Temperatures in Maryland have risen about 2.5 ◦F since the beginning of the 20th century and temperatures in this century have been warmer than in any other period.

The Chesapeake Bay specifically is especially vulnerable to climate change through sea level rise, changes in river discharge from precipitation extremes, increased water temperatures, and potential acidification (ocean and biological). The Bay area is perceived to be the third most vulnerable area in the United States to sea level rise behind Louisiana and South Florida. Tidal gauge records show that sea level in the Chesapeake Bay have been increasing at an average rate of 3.3 to 3.8 centimeters per decade over the past 100 years. Additionally, increasing urban development, excess pollution levels, and changes in water temperature and salinity have impacted some plant and animal species, affecting the Chesapeake Bay area ecosystems (Runkle et al. 2022b).

Similarly, temperatures in Delaware have risen more than three degrees Fahrenheit since the beginning of the 20th century. Precipitation is projected to increase, as are the number and intensity of extreme precipitation events. Statewide, total annual precipitation has shown a slight upward trend since 1895 and has been above average since the mid-1990s and the number of two-inch extreme precipitation events at Dover, Delaware has generally been above average since the early 1990s (Runkle et al. 2022a). Since 1900, global sea level has risen about seven to eight inches and is project to continue to rise, with a likely range of one to four feet. Delaware sea level rise has been higher due to land subsidence and the number of tidal floods has been increasing.

6.5 Impervious Cover

The oldest available impervious cover data from the National Land Cover Dataset is from 2001 and the most recent is from 2019. Table 10 summarizes the change in impervious cover between 2001 and 2019 for catchments immediately adjacent to Sturgeon Waters and catchments abutting water-adjacent catchments. Data for Maryland and Delaware are divided into the *major* river basins within the states (Figure 4). To place impervious cover for these states in context: Arnold and Gibbons (1996) demonstrated that runoff doubles in forested catchments that are 10 to 20 percent impervious, triples between 35 and 50 percent and increases more than five-fold at above 75 percent impervious. Catchments that shifted from below ten percent impervious cover in 2001 to greater than ten percent impervious in 2019 are typically adjacent to existing areas of increased impervious cover. These are highlighted in Figure 5 using an aqua-to-fuchsia color scale to illustrate the degree of impervious cover change. For example, impervious cover at five percent in 2001 and 6.5 percent in 2019 is a 30 percent increase in impervious cover.

Overall, impervious cover has increased throughout Delaware and Maryland, with some regions seeing a larger change than others. Figure 5 shows the proportional change from 2001 to 2019. Since 2010, Delaware’s population grew 11.5 percent with Sussex County seeing the highest increase in population. The total population in Maryland's has increased by 6.5 percent in the last decade. Prince George's Country saw the largest growth, while Baltimore city saw the largest decline in population for not just the state, but the entire country, with 44,444 fewer residents (U. S. Census Bureau 2020).

Table 10. Summary of Impervious Cover and Proportion of Region, for Catchments Adjacent to Sturgeon Waters

Region	atchment area (km^2)	2001 catchment area already >10% impervious cover	atchment area increased to >10% impervious cover by 2019	19 catchment area still <10% impervious cover
Potomac River	1056.36	203.75 (19.3%)	4.35 (0.4%)	848.26 (80.3%)
Chesapeake Bay	152.44	47.36 (31.1%)	3.31 (2.2%)	101.76 (66.8%)
Nanticoke River	1521.46	196.50 (12.9%)	20.46 (1.3%)	1304.50 (85.7%)
Washington Metro	258.76	167.43 (64.7%)	8.16 (3.2%)	83.18 (32.1%)
Delaware River	1488.60	390.85 (26.3%)	80.73 (5.4%)	1017.02 (68.3%)

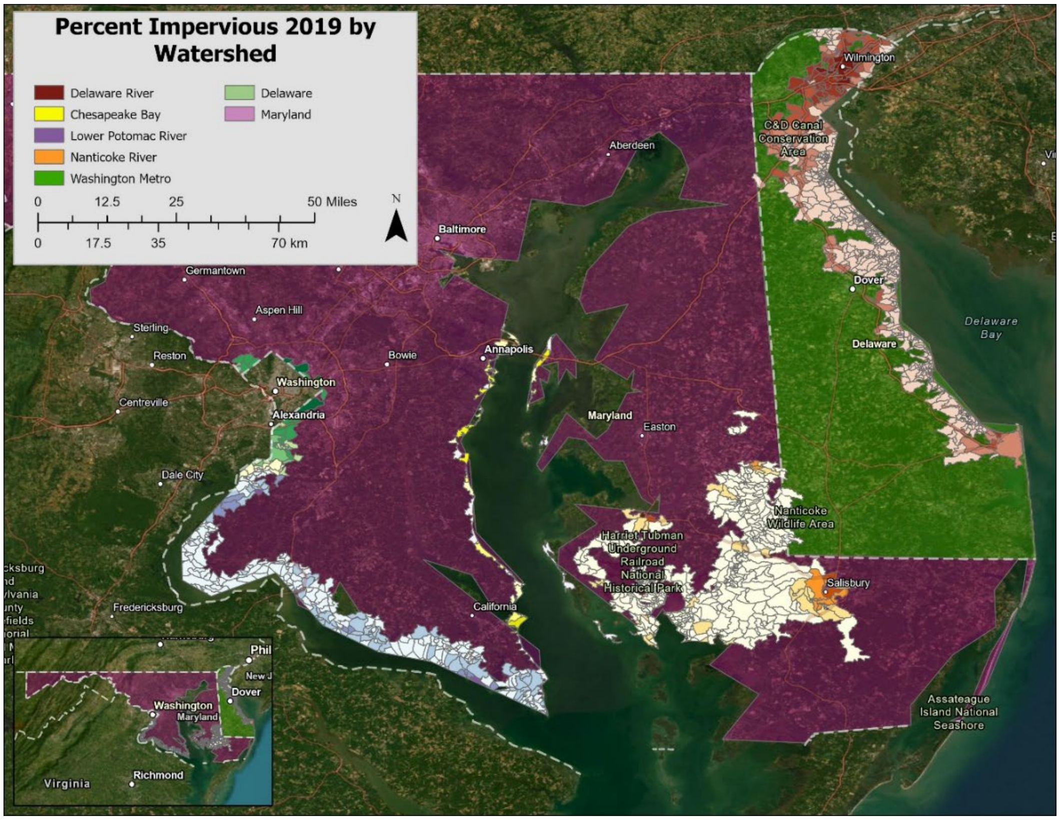


Figure 4. Relative Impervious Cover within Maryland and Delaware Catchments Associated with Sturgeon Waters (Darker Shades = Highly Impervious)

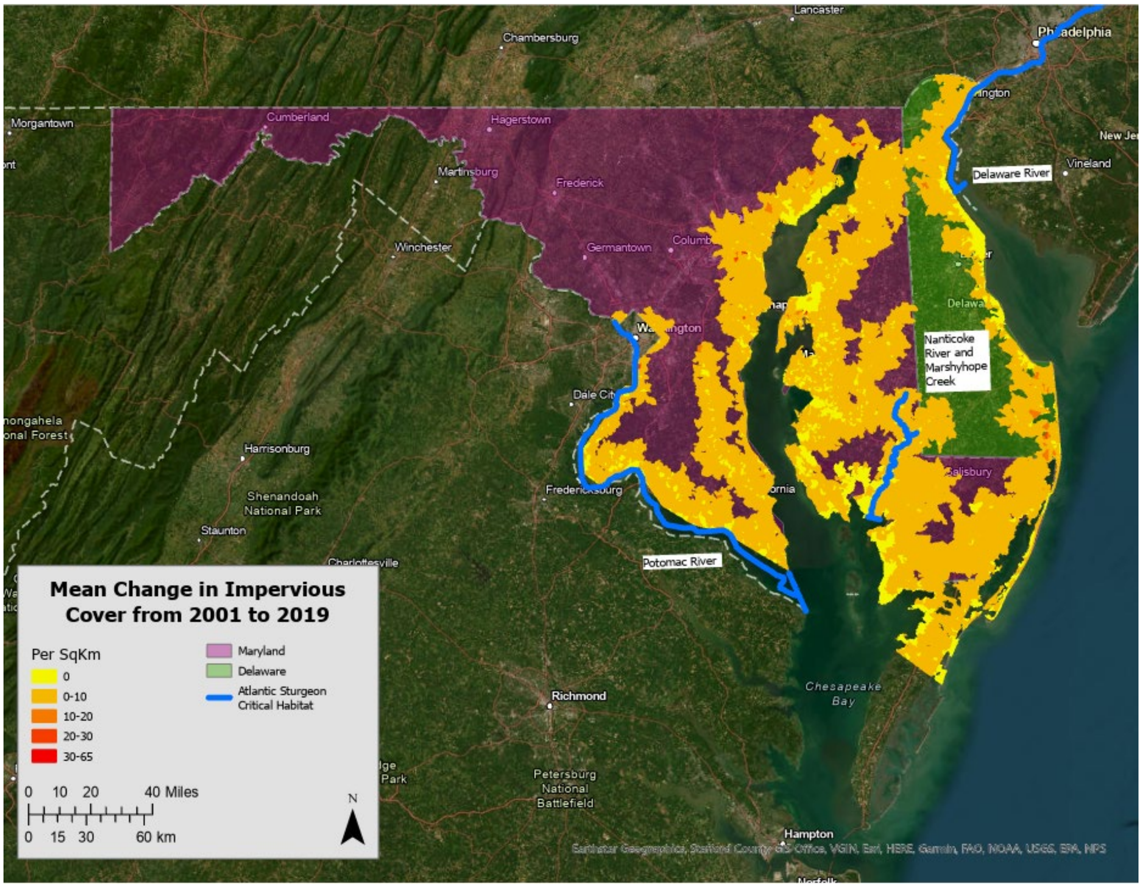


Figure 5. Change in Impervious Cover within Maryland and Delaware Catchments Associated With Sturgeon Waters between 2001 and 2019

6.6 Climate Change and the Built Environment

The aggregate effects of an increasingly built environment affecting watersheds where species and critical habitat under NMFS's jurisdiction occur interacts with climate change-driven shifts in precipitation to result in a continually shifting baseline. Aggregate impacts include:

- time-crowded perturbations (i.e., repeated occurrence of one type of impact in the same area) or perturbations that are so close in time that the effects of one perturbation do not dissipate before a subsequent perturbation occurs;
- space-crowded perturbations (i.e., a concentration of a number of different impacts in the same area) or perturbations that are so close in space that their effects overlap;
- interactions or perturbations that have qualitatively and quantitatively different consequences for the ecosystems, ecological communities, populations, or individuals exposed to them because of synergism (when stressors produce fundamentally different effects in combination than they do individually), additivity, magnification (when a combination of stressors have effects that are more than additive), or antagonism (i.e.,

when two or more stressors have less effect in combination than they do individually); and

- nibbling (e.g., the gradual disturbance and loss of land and habitat) or incremental and decremental effects are often, but not always, involved in each of the preceding three categories (NRC 1986).

Climate change influences on precipitation frequency and intensity interacting with increasing impervious cover intensifies risk to surface water quality through increased pollutant transport and erosive flow. Further, changes in plant cover and soil structure under climate change will influence infiltration potential (Lal 2015).

7 STRESSORS ASSOCIATED WITH THE ACTION

Stressors are any physical, chemical, or biological entity that may induce an adverse response in either an ESA-listed species or their critical habitat. The stressors of the action are the toxicants for which criteria are being proposed: cadmium and nonylphenol in fresh and salt waters and ammonia in freshwaters (see Section 3, Description of the Action).

8 EFFECTS OF THE ACTION

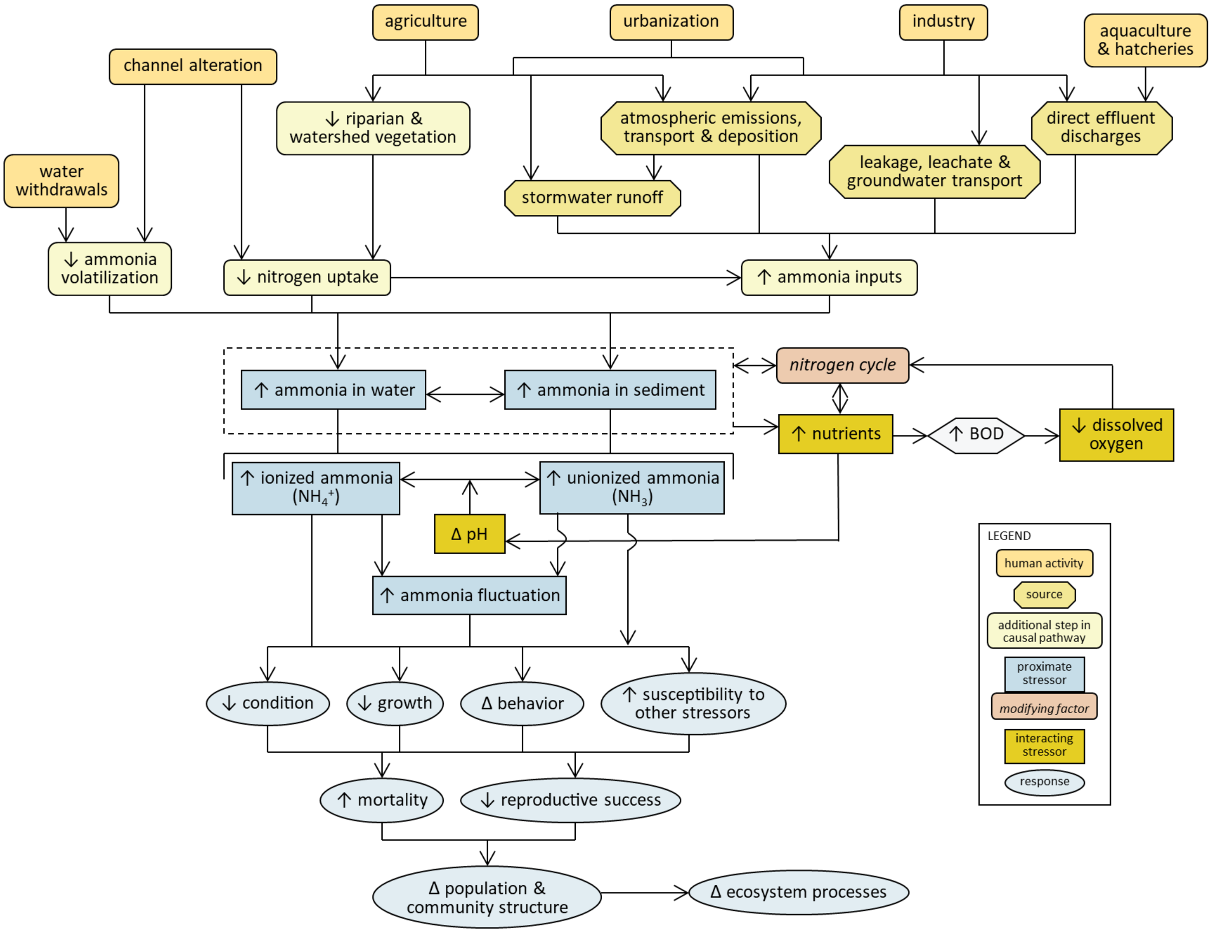
Under the ESA, "effects of the action" means "all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action" (see 50 C.F.R. §§ 402.02 and 402.17). This analysis focuses on any data that indicate exposures within criterion limits may result in short or long-term adverse effects to ESA listed shortnose and Atlantic sturgeon or result in reduction in the quantity or quality of available prey, as described through risk hypotheses identified in the Assessment Framework of this Opinion (Section 2) repeated below:

- Reduced survival of individuals through direct mortality or effects favoring predation (e.g., immobility, reduced predator detection)
- Reduced growth of individuals through direct effects of toxicity or effects impairing foraging (e.g., swimming, development, prey detection, strike success)
- Reduced fecundity through direct effects of toxicity (e.g., reduced hatch, egg mass, egg counts) or effects impairing reproduction (e.g., impaired nest tending, gonads mass)
- Reduced survival, growth, and/or fecundity due to reduced quantity or quality of forage due to toxic effects on forage species abundance or toxic effects of body burdens of the stressor in forage species

As discussed in Section 2.2.2 of this Opinion, the criteria developed using the EPA Guidelines are not expected to protect all species under all circumstances, so waters compliant with the criteria may result in pollutant exposures that cause adverse effects in some species. When assessing risk to an ESA-listed species, the vulnerability of an imperiled population of that species to the loss of an individual, or key individuals, amplifies the fundamental threat posed by a toxic pollutant. It is important to be mindful of the scale of uncertainty that accompanies lab-to-field extrapolation and the methods used to synthesize data for criteria derivation. Further, pollutants with criteria do not exist alone in effluents or natural waters. The toxicity of mixtures is dependent upon many factors, such as which chemicals are most abundant, their concentration ratios, differing factors affecting bioavailability, and organism differences. Because of this complexity, accurate predictions of the combined effects of chemicals in mixtures in every case where the criteria assessed in this Opinion are applied is not current practice. The work of Spehar and Fiandt (1986), which showed 100 percent mortality in rainbow trout and *Ceriodaphnia dubia* exposed to a mixture of six metals at their acute criterion concentrations, suggests severe effects can result from exposure to compliant discharges and within "unimpaired" waters.

8.1 Ammonia Criteria for the Protection of Aquatic Life in Freshwater

Whether from natural or anthropogenic sources, ammonia is a component of the aquatic nitrogen cycle Figure 6. Natural sources of ammonia include the decomposition or breakdown of organic waste matter, gas exchange with the atmosphere, forest fires, animal waste, the discharge of ammonia by aquatic biota, and nitrogen fixation processes (Canada 2001; Geadah 1985). Anthropogenic sources of ammonia in surface waters include domestic and industrial wastes, land management, and agricultural practices. Excess stormwater flow may be diverted from municipal waste treatment plants and public-owned treatment works (POTWs) into combined sewer overflows that deposit untreated municipal waste directly into streams and lakes. As wastewater treatment infrastructure ages, increasingly frequent treatment plant failures also may result in high ammonia releases to streams (Boulos 2017). Significant amounts of ammonia may leach into surface waters from failing septic tanks or their leach fields. Ammonia is also a manufacturing byproduct metal finishing and treating applications (e.g., nitriding; Appl 1999), in the chemical industry for the production of pharmaceuticals (Karolyi 1968) and dyes (Appl 1999), in the petroleum industry for processing of crude oil and in corrosion protection, and in the mining industry for metals extraction (USEPA 2004). Permitted dischargers are required to monitor for ammonia if their discharge has a reasonable potential to cause an ammonia impairment in the receiving water.



Adapted from https://www.epa.gov/caddis-vol2/ammonia

Figure 6. Sources, Fate and Transport Pathways, and Effects of Excess Ammonia in Surface Waters

Nonpoint sources of ammonia include fertilizer in runoff from golf courses, recreational fields, residences, cropland, livestock operations, land application of manure and grazing livestock, which spread urine and manure on pastures and even directly into streams if they have access (Camargo and Alonso 2006; Constable et al. 2003). Improperly managed aquaculture systems can release high levels of ammonia. Atmospheric sources include agricultural practices and nitrogen oxide emissions from automobiles and industry (NOAA 2000). Elevated ammonia contributes to depressed oxygen levels when oxidizing microbes convert ammonia into nitrite and nitrate. The resulting dissolved oxygen reductions can decrease species diversity and cause fish kills (Constable et al. 2003).

Total ammonia nitrogen in water includes both the ionized form (ammonium) and the un-ionized form (ammonia). The two species exist in water in dynamic equilibrium. It is the un-ionized form of ammonia, when in excess, that is highly toxic and can result in damaged gill tissue and disruption of ion metabolism and blood pH (Ip et al. 2001; Thurston and Russo 1981). The ratio of un-ionized ammonia to ammonium ion depends upon both pH and temperature, and generally increases by 10-fold for each rise of a single pH unit and by approximately 2-fold for each ten degrees Celsius rise in temperature over the 0-30 degrees Celsius range (Erickson 1985). The toxicity of ammonia is best expressed as total ammonia nitrogen as a function of pH and temperature. This has been the basis for calculating criteria since 1999 (USEPA 1999). The 2013 recommended criteria for total ammonia nitrogen incorporates data for several previously untested sensitive freshwater mussel species in the taxonomic family Unionidae. The highest four-day rolling average within the same 30-day period used to determine compliance with the chronic criterion shall not exceed 2.5 times the applicable chronic criterion and a one-hour average may not exceed the acute criterion.

The acute ammonia criterion is pH and temperature dependent, with invertebrates being more sensitive at higher temperatures (e.g., > 16 degrees Celsius) and fishes in the genus Oncorhynchus being the most sensitive organisms at lower temperatures. Thus at higher temperatures, the criteria are more strongly influenced by invertebrate data and at low temperatures the criteria are driven by Oncorhynchus data. The criteria are a set of calculations applicable for waters where species of the genus Oncorhynchus occur and waters where they are absent irrespective of the present of sensitive invertebrates. Under a standard pH of seven, the acute criterion calculated for waters where Oncorhynchus are present increases with decreasing temperature as a result of increased invertebrate insensitivity until it reaches a plateau of 24.10 mg TAN/L 15.7 degrees Celsius and below. For waters where Oncorhynchus are absent, the calculated acute criterion for a standard pH of seven increases with decreasing temperature until it reaches a plateau of 37.65 mg TAN/L at 10.2 degrees Celsius and below. Generally, the criteria are more strongly influenced by temperature than pH, with the salmonids absent acute criteria diverging from the salmonids present criteria at about 15 degrees Celsius (see Figure 7).

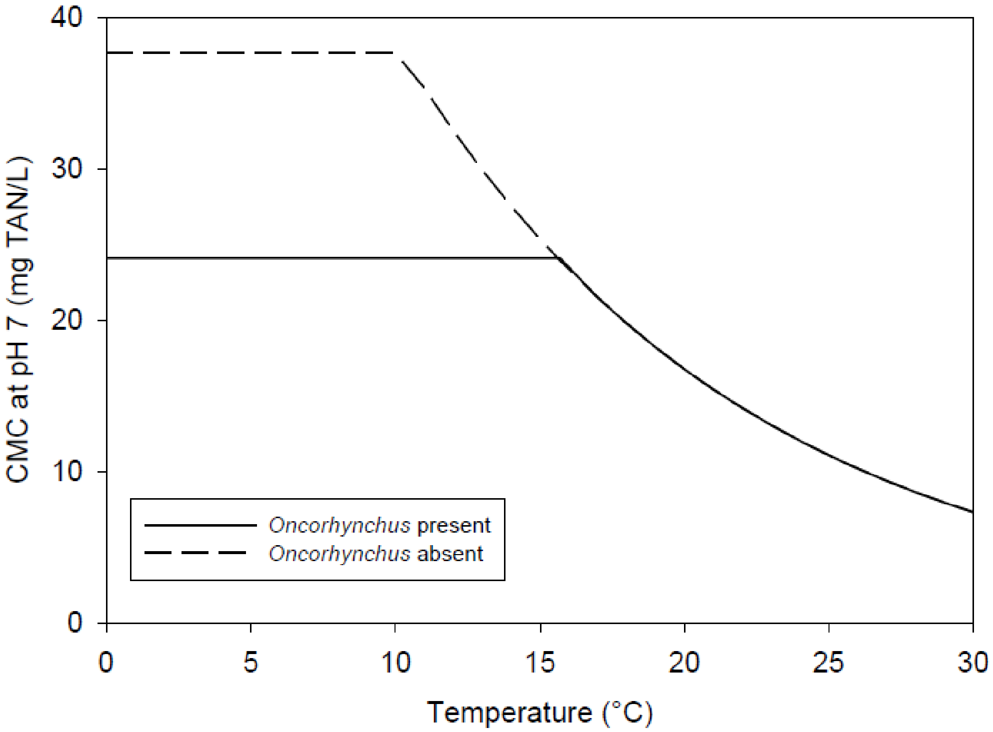


Figure 7. Comparison of Acute Criterion Magnitudes Calculated across a Temperature Gradient at pH 7

Although EPA's Ammonia Guideline allows for the demonstration that unionid mussels are not present at a site and that a site-specific acute and chronic criteria can be calculated for waters with mussels absent, Delaware is not allowing for such a provision. The chronic ammonia criterion is also pH and temperature dependent, but does not differ based on the presence of fishes in the genus *Oncorhynchus*, so under standard conditions the chronic criterion is 1.9 mg/L total ammonia nitrogen.

Because *Oncorhynchus* fishes are not present in Maryland waters, MDE proposes to adopt the criteria calculation that does not factor in *Oncorhynchus* sensitivity. The EPA Guidelines also allow states to develop alternative criteria that adjusted for the presence or absence of other species and MDE developed guidance on calculating "mussels absent" acute criteria for specific waters.

For its ammonia criteria, Maryland is proposing to implement "Procedures for Applying the Mussels-Absent Ammonia Criteria to Maryland Surface Waters" incorporated (by reference) into the regulation. The "mussels absent" criteria are applicable to streams with abiotic predictor variables that result in a calculated index of less than 0.03 based on a 75 meter sampling station schema. The approach has a <1 percent failure rate in identifying waters where mussels do not occur. The "mussels absent" streams are usually small first order streams with very low flow and/or are high gradient. Among ESA-listed species under NMFS's jurisdiction, Atlantic and shortnose sturgeon will use freshwaters subject to the freshwater ammonia criteria. It is reasonable to expect that the mussels-present criteria would be applied in Maryland's Sturgeon Waters because the mussels absent criteria are expected to only be applied to low order streams. ESA-listed sturgeon would not likely occur in "mussels-absent" waters because all sturgeon life stages occur in the mainstem of rivers/deep channel habitats (Bain 1997). Because sturgeon are not expected to occur in waters where "mussels-absent" criteria are applied, this Opinion will evaluate the protectiveness of mussels-present criteria for ESA-listed sturgeon when in freshwaters.

Exposures to Total Ammonia Nitrogen within the Action Area

According to the Maryland BE, Maryland's Chesapeake Bay region is home to 472 municipal and industrial wastewater treatment plants and failing septic systems are a problem throughout Maryland. The BE for Delaware did not address potential problematic sources of ammonia. Neither BE identified issues specific to Sturgeon Waters. According to NMFS analysis of permits within the ECHO database, accessed February 22, 2023, there are a total of 58 Public Owned Treatment Works (POTWs) and 189 concentrated animal feed lots within Maryland and Delaware catchments adjacent to Sturgeon Waters (Figure 8). The concentrated animal feed lots do not have permit limits and only three have been inspected within the past five years.

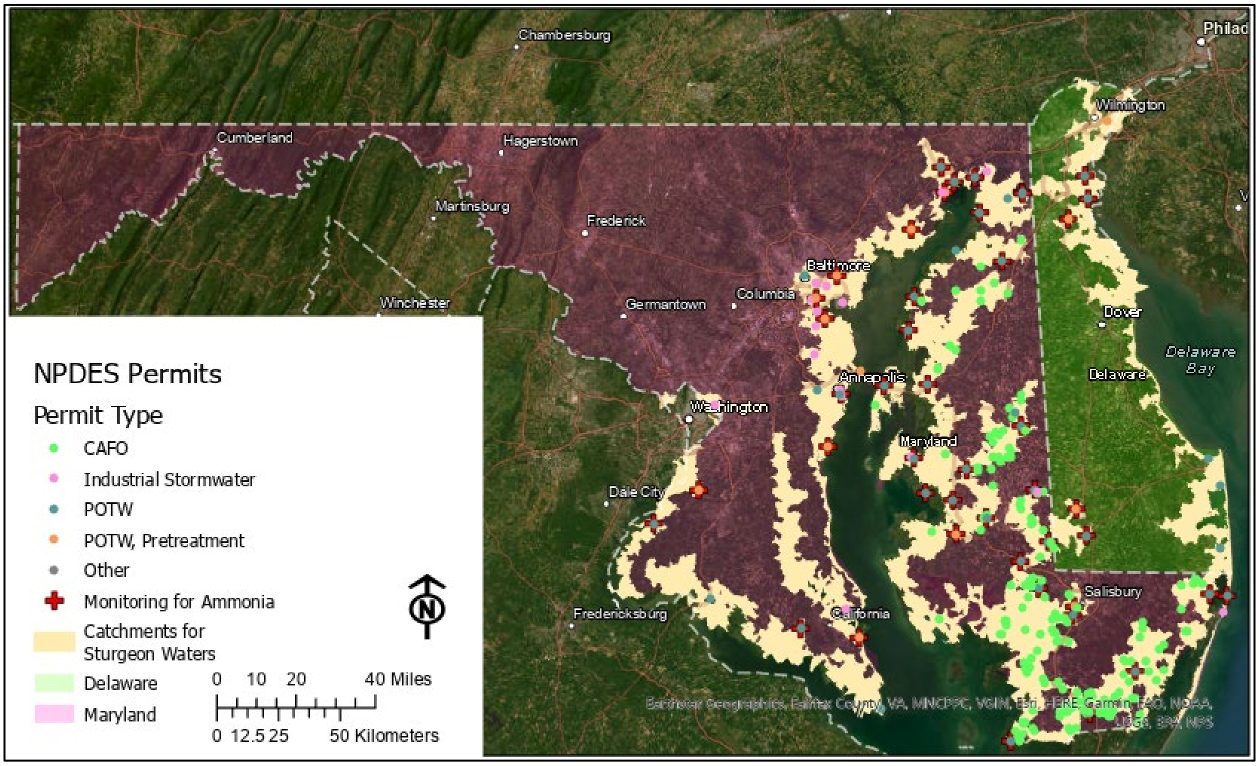


Figure 8. Locations of Public-Owned Treatment Works (POTWs) and Concentrated Animal Feed Operations (CAFOs), with Facilities Monitoring for Ammonia in their Discharges (red plus sign)

Forty-five of the POTWs are required to monitor for ammonia. Eight of these have had effluent exceedances over their current total ammonia nitrogen limits in the past three years and four were subject to a formal compliance action. Twelve POTWs have had formal enforcement actions in the past three years and one was subject to an informal enforcement action. Only one of these POTWs was listed as noncompliant because they failed to submit discharge monitoring reports. Failure to submit these reports can mask serious deficiencies. Impairments in the receiving waters for five POTWs do not identify ammonia as the causal agent for the impairment, but do list nitrogenous biological oxygen demand and total nitrogen among impairment causes. Recall that ammonia is not a static constituent of aquatic chemistry; rather it is a component of the aquatic nitrogen cycle (Figure 6). The ECHO database includes a list of possible NPDES parameters contributing to impairments. Ammonia is a candidate cause for impairment for 20 distinct receiving waters for 58 POTWs and 189 concentrated animal feedlots located in catchments adjacent to Sturgeon Waters (Figure 8). NMFS notes that some of these impaired waters, such as Delaware Bay and the C&D Canal, are tidal waters where the proposed freshwater ammonia criteria would not apply.

Table 11. CAFOs and/or POTWs in Impaired Waters with Ammonia is a Candidate Cause

Receiving Water	CAFO	POTW
Big Annemessex River	✓	
Bush River		✓
C&D Canal: East-Delaware River, West-Back Creek		✓
Corkers Creek	✓	
Cypress Swamp-Pocomoke River	✓	✓
Delaware Bay-Deep		✓
Gales Creek-Nanticoke River	✓	
Jutland Creek		✓
Little Assawoman Bay		✓
Lower Chester River	✓	
Lower Sassafras River		✓
Marsh Creek-Choptank River	✓	
Morgan Creek	✓	
Rewastico Creek		✓
Shiles Creek-Wicomico River	✓	
St. Martin River		✓
Stony Bar Creek-Marshyhope Creek	✓	
Choptank River: Warwick River and Williams Creek	✓	

Among 60 Water Quality Portal[6] monitoring stations within these catchments, about 5,200 monitoring events reported temperature, pH, and total ammonia nitrogen. Total ammonia nitrogen observations ranged from non-detect to 3.73 mg/L. The calculated acute criteria ranged from 1.2 to 38 mg/L total ammonia nitrogen for Delaware, and 1.7 to 60 mg/L total ammonia nitrogen in Maryland. About 16 percent of observations were within an order of magnitude below the calculated chronic criterion limits for their respective sampling events. Water temperature and pH can range broadly within a water body both over the seasons and over a 24-hour period, particularly for pH during the summer months, so it is important to consider the range in applicable criteria for a given monitoring station over different monitoring events. Calculated criteria for monitoring stations sampled multiple times within the same year differed by two-fold or more depending on season and time of day sampled. Fifteen percent of these differed by as much as an order of magnitude among sampling events within the same station and year. Water temperature and pH, and consequently calculated ammonia criteria, vary by season, time of day sampled, and other factors such as cloud cover and water clarity. Both time of day, cloud cover and water clarity influence photosynthesis. Photosynthesis by aquatic vegetation influences water pH by removing carbon dioxide from the water column. Since photosynthesis is driven by sunlight, water pH is highest mid-day and lowest prior to sunrise (Dodds 2002). For example, data reported for the USGS-01649500 monitoring station at the Northeast Branch of the Anacostia River at Riverdale, indicate applicable chronic ammonia criteria ranging from 4.02 mg/L TAN at 5:30 am (predawn) down to 1.69 mg/L TAN at 3 pm on September 30, 2010. Unfortunately, the available monitoring data are not sufficient to evaluate diurnal and seasonal trends or seasonal/annual/weather condition variability for most stations. For the purposes of identifying impaired waters, both DNREC and MDE rely on inference from available data (See Section 3). As stated in Section 6, Environmental Baseline, Delaware's 2022 Integrated Report indicates that 96 water bodies were newly classified as potentially impaired by ammonia for the propagation of fish, aquatic life, and wildlife use, but ammonia impairment could not be confirmed with current data. Maryland's 2020-2022 Integrated Report Database indicates that, statewide, 317 river miles are impaired for the propagation of fish, aquatic life, and wildlife use due to ammonia.

8.1.1 Responses to Total Ammonia Nitrogen Within Criteria Limits

Changes in data for ammonia made to the ECOTOX database since the August 31, 2022 Opinion was issued include an additional five records for acute, two day exposures to the snail *Potamopyrgus antipodarum* (Hosea and Finlayson 2005). These data cannot be used to evaluate the acute ammonia criterion because they are expressed as milliliters per liter and not mass per unit volume (e.g., mg/L, µg/L). The March 15, 2023 ECOTOX update includes data for exposures of fathead minnows (Pimephales promelas Pilie et al. 1975) and *Daphnia* (Alekseev et

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[6] Accessed 02.06.2023 (https://www.waterqualitydata.us/)

al. 2010; Pilie et al. 1975) that fall within the range of existing data, and thus do not affect determinations made in prior opinions. The dataset includes 1,070 entries for 48 fish species, including shortnose sturgeon and 32 invertebrate families for which pH and temperature data were reported, allowing test-specific criteria to be calculated (Figure 9). The fish data included responses for survival, behavior, growth, and development, but no data classified as a reproduction endpoint. However, the chronic criterion was derived using fathead minnow hatchability data tagged as an LC50 (Thurston et al. 1983) and, although not found in ECOTOX, there are additional EC50s from a study by the same authors for a five-year life cycle test for rainbow trout (Thurston et al. 1984b).

The availability of acute toxicity data for shortnose sturgeon simplifies NMFS's evaluation of the acute ammonia criterion. A four-day total ammonia nitrogen LC50 for fingerling shortnose sturgeon was reported by (Fontenot et al. 1998) at 149.86 +/- 55.20 mg/L under a temperature range of 17.9 +/- 0.62 degrees Celsius and a pH between 6.8 and 7.3. The ammonia criteria calculated using these temperature and pH values range from 13.76 to 24.43, yielding risk quotients from 0.107 to 0.161. The Ammonia Guideline document, and the BEs normalized the Fontenot et al. (1998) shortnose sturgeon LC50 to 156.7 mg/L under standard conditions of 20 degrees Celsius and a pH of 7 (USEPA 2013). The confidence interval around the reported LC50 indicates a coefficient of variation (mean/standard deviation) of about 37%. This suggests a confidence interval for EPA's normalized LC50 of 99 to 214 mg/L total ammonia nitrogen and the estimated LC05 would range from about 69 to 150 mg/L total ammonia nitrogen. Although the confidence intervals of EPAs estimated LC05 for shortnose sturgeon overlaps with the confidence interval for the LC50, the acute effect threshold is at least four fold the mean acute ammonia criterion under standard conditions of 17 mg/L[7], indicating a risk quotient between 0.25 to 0.11 for the estimated LC05. While there are no toxicity data available for ammonia effects on Atlantic sturgeon, the shortnose sturgeon data serves as a genus-level surrogate.

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[7] Under standard conditions, the acute criterion for salmonids present and salmonids absent are essentially the same. The criteria diverge from each other at and below temperatures of 15 degrees Celsius (59 degrees Fahrenheit)

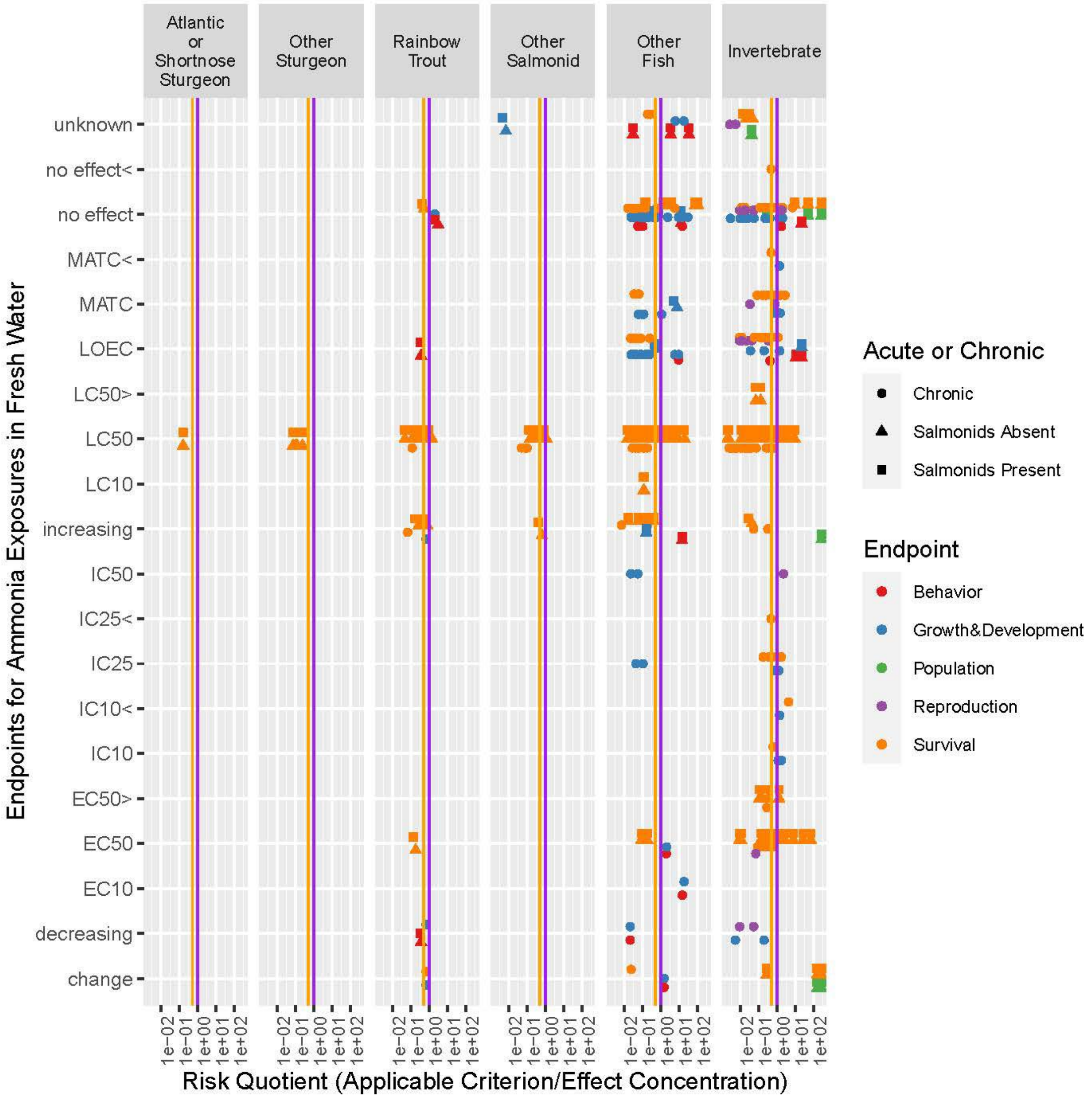

Figure 9. Distribution of Risk Quotients for Freshwater Exposures to Ammonia in Context of Reference Lines Representing the Applicable Criterion (Purple) and One-Half the Applicable Criterion (Orange)

The implications of the "salmonids present" and "salmonids absent" acute criteria are illustrated in Figure 10. At three degrees Celsius (37.4 degrees Fahrenheit), test-specific LC50 risk quotients increased by 36 percent under the salmonids absent criteria. While there are no data for sturgeon exposures below the salmonids present-salmonids absent divergence at 15 degrees

Celsius, a 36 percent increase in sturgeon risk quotients that are available indicate that lethality would not be expected under a worst-case acute criterion scenario (Figure 10, black triangles).

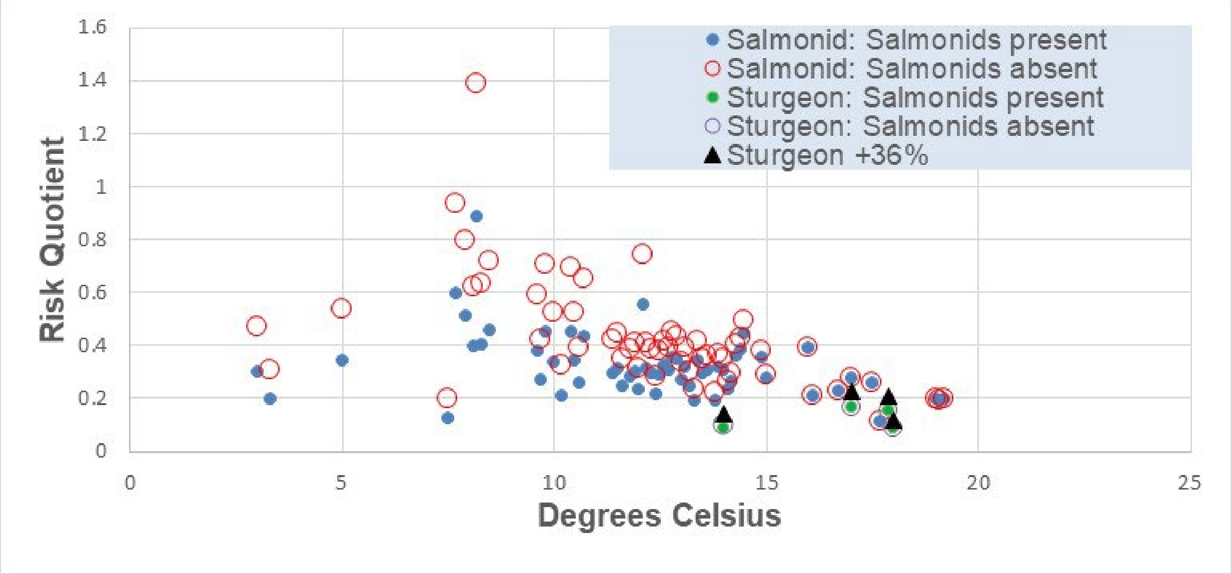

Figure 10. Comparison of Test-Specific LC50 Risk Quotients using the Salmonids Present (Solid Circles), Salmonids Absent (Hollow Circles) Criteria Calculations, and Risk Quotients for Sturgeon Increased by 36 Percent (Black Triangles) to Represent Worst-Case Acute Criterion Scenario

In the absence of growth and development data for sturgeon, we consider data reported for rainbow trout. Exposures of rainbow trout to 4.05 or 6.32 mg/L ammonia nitrogen exhibited increased feeding rate and weight gain and those exposed to 6.32 mg/L ammonia nitrogen had reduced mesenteric fat (Hanna 1992). The responses occurred at exposure thresholds above the test-specific chronic ammonia criterion of 2.7 mg/L ammonia nitrogen, resulting in risk quotients of 0.7 and 0.1. The screened ECOTOX dataset did not include fish data for the effects of ammonia on reproduction. One data line for effect on sperm motility was excluded because the response threshold was reported as a range from ten to 1000 mg/L ammonia nitrogen (Stroganov and Pozhitkov 1941). Two other studies on the effects of ammonia on fathead minnow were not reported in the ECOTOX database. Adverse effects were observed in fish at all exposure concentrations, so a no effect concentration was calculated to be 2.19 mg/L ammonia at a pH of 7.3 and temperature of 25.1 degrees Celsius (Armstrong et al. 2012). The applicable chronic criterion under these exposure conditions is about half that concentration, at 1.17 mg/L total ammonia. In a second study under the same conditions, ammonia exposures were evaluated at the estimated no effect threshold and in combination with estradiol at the estradiol no effect threshold. While a mixture effect was not evident, the study confirmed that adverse effects did not occur at 2.19 mg/L total ammonia nitrogen (Armstrong et al. 2015). Ammonia exposures resulted in avoidance/preference/activity-type behaviors and changes in feeding at exposures below test-specific criterion concentrations for bluegill (*Lepomis macrochirus*), largemouth bass

(*Micropterus salmoides*), and pikeperch (Sander lucioperca, Lubinski et al. 1980; Morgan 1979; Schram et al. 2014). The bluegill exposure was an abrupt gradient that resulted in a temporary exploratory response at low exposure concentrations, but either preference or avoidance responses of individual fish at higher exposures (Lubinski et al. 1980). Similarly, the largemouth bass study reported aberrations in behavior, but did not clearly suggest avoidance (Morgan 1979). The pikeperch study exposed fish to a continuous concentration of ammonia for 42 days and found that specific growth rate and consumption of food, provided above satiation levels, was decreased at all concentrations, yet the final weights of exposed and control fish were not significantly different and there were no effects on physiological metrics (Schram et al. 2014). The purpose of this study was to identify optimal aquaculture conditions to maximize production. Wild fish are not expected to have access to food in excess of satiety, so the fitness implications changes in fish appetite, taken with the absence of detectable effects on fish weight and physiological markers are irrelevant.

About 17% of the data indicate adverse effects to invertebrate species. The plotted risk quotients for the effects of ammonia on invertebrates include growth and development, reproduction, behavior, population productivity, and mortality responses. The bulk of the invertebrate data indicate responses occurring above criterion limits. Risk quotients with a reported endpoint (n=34) indicated effects occurring for exposures within criteria limits in species likely to serve as forage for early life stage fish: mayflies, amphipods, rotifers, and *Daphnia* (Ankley et al. 1995; Hickey et al. 1999; Kaniewska-Prus 1982; Khangarot and Das 2009; Liang et al. 2018; Snell and Persoone 1989; Whiteman et al. 1996). There were also risk quotients (n=60) indicating effects would not occur within criterion limits for these same species groups (Ankley et al. 1995; Besser et al. 1998; Borgmann 1994; Buikema et al. 1974; Cowgill and Milazzo 1991; De Rosemond and Liber 2004; Diamond et al. 2006; Hickey et al. 1999; Hyne and Everett 1998; McDonald et al. 1997; Mount 1982; Reinbold and Pescitelli 1982; Thurston et al. 1984a; Whiteman et al. 1996). Given the greater abundance of data indicating effects to prey species would not result from exposures within criteria limits, the criteria are likely to be sufficiently protective of the quantity and quality of invertebrate prey for sturgeon.

8.1.2 Not likely to Adversely Affect Determination for Total Ammonia Nitrogen Exposures Within Criteria Limits

The best available data indicate that it is reasonably certain that shortnose sturgeon and Atlantic sturgeon will be exposed to waters subject to implementation of the ammonia criteria and that both Maryland and Delaware will use the criteria in the regulation of discharges and identification and restoration of impaired waters. Although permit limit exceedances and failures to submit discharge monitoring reports will likely occur in the future, EPA’s action is not the violation of the criteria. Such events are met with technical assistance to bring the discharge into compliance. EPA's action is the establishment of criteria to be used in limiting ammonia in discharges and identifying ammonia-impaired waters.

The best available data indicate the salmonid present and salmonid absent acute criteria and the chronic criterion for total ammonia nitrogen are expected to be between four-fold and an order of magnitude lower than effect thresholds for ESA-listed sturgeon. While adverse effects may occur in some invertebrate species in Sturgeon Waters, the implications of any effects on the abundance and quality of forage species for shortnose and Atlantic sturgeon will be attenuated by the wide variety of forage species sturgeon consume. A reduction in the abundance of one benthic species is likely to be compensated for by an increase in other species (Wesolek et al. 2010). Therefore, NMFS does not expect that ammonia exposures within chronic criterion or acute criterion limits will reduce the abundance or quality of forage for shortnose sturgeon and the Chesapeake Bay and New York Bight, and migrating, Gulf of Maine, Carolina, and South Atlantic DPSs of Atlantic sturgeon.

NMFS concludes that the EPA's approval of adoption of the criteria for total ammonia nitrogen may affect, but is not likely to adversely affect, shortnose sturgeon or Gulf of Maine and New York Bight, and migrating Chesapeake Bay, Carolina, and South Atlantic DPSs of Atlantic sturgeon because the effects of exposures to ammonia within criterion limits are expected to be insignificant for both sturgeon and the abundance and quality of food.

8.2 Nonylphenol Criteria for the Protection of Aquatic Life

Nonylphenol (4-nonylphenol) is used in the manufacture of, and is a degradation product of, nonylphenol ethoxylate surfactants that were once commonly used in household products like laundry detergents. Nonylphenol was one of the most commonly detected pollutants in 1999-2000 monitoring survey of wastewater treatment plant discharges. EPA and detergent manufacturers have cooperated to eliminate domestic use. In addition, nonylphenol ethoxylate use was voluntarily phased out in 2013 from liquid industrial laundry detergents and in 2014 from industrial powder detergents. Discharges of 4-nonylphenol from publically owned treatment works are therefore no longer expected. Other uses of nonylphenol ethoxylate surfactants, such as dust-control agents and deicers, lead to direct release to the environment. While nonylphenol ethoxylates have been phased out from domestic products, they are still in use by some industries. For example, nonylphenol ethoxylates are in some hydraulic fracturing fluids used to extract oil and gas (McAdams et al. 2019). Treatment and disposal of wastewater from these activities have contaminated surface waters in Western Pennsylvania (Burgos et al. 2017). Though less toxic and persistent than 4-nonylphenol, nonylphenol ethoxylates are still highly toxic to aquatic organisms (USEPA 2017). Only the state of Delaware is proposing to adopt criteria for nonylphenol. Although oil and gas exploration does not occur in the Delaware River basin, DRBC voted to ban fracking in February of 2021.

In the environment, 4-nonylphenol is persistent and accumulates in sediment to concentrations several orders of magnitude greater than concentrations in water. Bottom-feeding fish can be significantly exposed to these persistent and toxic compounds (Brooke 1993b; USEPA 2010). Half-life in water and sediment is determined by ambient conditions. Nonylphenol accumulates in sediment. Half-lives have been reported to range from 1.1 to 99 days in sediment (Reviewed by Mao et al. 2012) and from 28 to 104 days (Maguire 1999) both reports indicated that persistence was reduced by increased light intensity and the presence of microorganisms (Reviewed by Mao et al. 2012). Concentrations within saltwater sediment cores aged to 30 years using 210Pb dating and plotted as a fraction of the surface concentration showed limited degradation that was directly proportional to nonylphenol concentrations at a rate indicating a half-life of 60 years (Shang et al. 1999).

Accumulation rates vary, depending on exposure duration, concentration, species, and lipid content (Hecht 2002; Hu et al. 2005). Dietary exposures result in accumulation of 4-nonylphenol, but trophodynamic studies indicate that 4-nonylphenol is metabolized and does not biomagnify (i.e., increase in concentration from prey to predator) in the food web (Diehl et al. 2012; Hu et al. 2005; Korsman et al. 2015). The EPA's 2005 water quality criteria document reported bioconcentration factors ranging from 4.7 to 344 (Brooke 1994, after EPA 2005; Ward and Boeri 1991) in freshwater and 78.5 to 2,168 in salt water (Ekelund et al. 1990). Accumulated 4-nonylphenol may be transferred to offspring (Thibaut et al. 2002) with concentrations in eggs increased over maternal levels 30-100-fold (Ishibashi et al. 2006). Persistence and global distribution is indicated by the presence of 4-nonylphenol in organisms living among saltwater debris. Plastic debris contains 4-nonylphenol, but also absorbs 4-nonylphenol from ambient water. The presence of debris can result in enhanced exposures through the creation of 4-nonylphenol-concentrated microhabitats (e.g., poorly flushed areas, relatively sheltered areas of reefs and rocky substrates) or incidental ingestion (Gassel et al. 2013; Guerranti et al. 2014; Hamlin et al. 2015; Ishibashi et al. 2006; Staniszewska et al. 2016). While the proposed criteria are intended to limit exposure of aquatic organisms to harmful levels of 4-nonylphenol, the dynamic flux between ambient water, sediment, and debris may result in unregulable fluctuating microhabitat exposures to concentrations above the proposed criteria in otherwise 4-nonylphenol-compliant waters.

Toxicity tests show that 4-nonylphenol disrupts endocrine systems by mimicking the female hormone 17β-estradiol. Exposure of aquatic animals resulted in abnormal gonad development, changes in reproductive behavior, altered sex ratio of offspring, and the production of yolk proteins (vitellogenin) by immature male fish. Vitellogenin induction in fish by 4-nonylphenol at ambient fresh and salt water occurred at concentrations ranging from 5-100 µg/L (Arukwe and Roe 2008; Hemmer et al. 2002; Ishibashi et al. 2006; Zhang et al. 2005) and resulted in altered sex ratios after dietary exposures as low as one mg/kg feed (Demska-Zakes and Zakes 2006). Vitellogenin is an egg yolk protein produced by mature females in response to 17-β estradiol.

Vitellogenin is a robust biomarker of 4-nonylphenol exposure potentially affecting fitness, but without concurrent indicators of exposure and response magnitudes for fitness, a linkage between the intensity of the response and consequences to the survival and fecundity of individuals is not estimable. Ishibashi et al. (2006) reported vitellogenin induction and reduced egg production and fertility after exposure of medaka to 100 µg/L 4-nonylphenol for 21 days. Tilapia gonad development and, sperm abnormalities, and intersex (the presence of oocytes in the testes) after two months of exposure to the same concentration (Ali et al. 2014). A retrospective analysis of an Atlantic salmon population crash implicated 4-nonylphenol, applied as an adjuvant in a series of pesticide applications in Canada as the causal agent (Brown et al. 2003; Fairchild et al. 1999). Additionally, processes involved in sea water adaptation of salmonid smolts are impaired by 4-nonylphenol (Jardine et al. 2005; Lerner et al. 2007a; Lerner et al. 2007b; Luo et al. 2005; Madsen et al. 2004; McCormick et al. 2005). While these data are not for vertebrate species that are present in Delaware, they establish 4-nonylphenol as a persistent pollutant with endocrine disrupting properties, providing a plausible mechanism for fitness effects and survival in the wild, while providing a broad sense of its potency in causing such effects.

The nonylphenol criteria proposed for adoption are straightforward pollutant concentrations of 28 and 6.6 µg/L for acute and chronic freshwater exposures, respectively, and 7 and 1.7 µg/L for acute and chronic saltwater exposures, respectively. The acute criterion duration for nonylphenol is a one-hour average, and the chronic criterion is a four-day average. The frequency of these values is not to be exceeded more than once in three years on average.

8.2.1 Exposure to Nonylphenol in the Action Area

EPA is proposing to approve criteria for nonylphenol to be implemented by the state of Delaware. The Water Quality Portal[8] reports no monitoring data for nonylphenol in surface waters of Delaware. A search of EPA's ECHO database did not identify any permitted facilities required to monitor for nonylphenol or discharge monitoring reports for nonylphenol submitted between 2007 and 2022. Legacy nonylphenol is likely resident in sediment contaminated by discharges from wastewater treatment plants, facilities that formerly used deicing fluids containing nonylphenol ethoxylates, and industrial operations that formerly used nonylphenol ethoxylates in manufacturing processes. For example, in 1978 nonylphenol isomers were reported in the Delaware River near Philadelphia, Pennsylvania at concentrations ranging from 0.04 to 2.00 µg/L (Sheldon and Hites 1978). A 2003 study of sediment nonylphenol levels along the Schuylkill and Delaware Rivers near Philadelphia and Camden, New Jersey indicated sediment concentrations ranging from 0.14 to 12.8 µg/g dry weight. Nonylphenol concentrations were more closely related to proximity to the historical sources, such as the Philadelphia Water

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[8] National Water Quality Monitoring Council Water Quality Portal (https://www.waterqualitydata.us/) Accessed March 3, 2023

Department's southeast municipal waste water treatment plant, than sediment organic matter content (Ashley et al. 2003).

On September 25, 2014, EPA proposed, but never finalized, a Significant New Use Rule to require agency review before a manufacturer starts or resumes use of 15 nonylphenols and nonylphenol ethoxylates (79 FR 59186). This rule provides EPA the opportunity to review and evaluate any intended new or resumed uses of these chemicals and, if necessary, take action to limit those uses. On June 7, 2018, EPA finalized a different rule to include nonylphenol ethoxylates on the Toxics Release Inventory list of reportable chemicals (81 FR 80624). In the rulemaking, EPA estimated that 178 facilities would be expected to submit reporting forms for nonylphenol ethoxylates. Nevertheless, a search of available Toxics Release Inventory data between 2007 and 2022 did not identify any discharges of nonylphenol ethoxylates (ECHO, accessed May 13, 2023).

8.2.2 Responses to Nonylphenol Exposures Within Criteria Limits

The nonylphenol data from ECOTOX includes 619 records from 54 sources exposing 33 species of fish. Data for invertebrates, representing forage species, were provided by 41 studies that conducted 666 toxicity tests evaluating the effects of nonylphenol on 48 invertebrate species. Risk quotients for all available endpoint effect data are aggregated in Figure 11 for freshwater exposures and Figure 12 for saltwater exposures.

Changes in data for nonylphenol made to the ECOTOX database since the August 31, 2022 Opinion (NMFS 2022a) that assessed nonylphenol effects in ESA-listed sturgeon was issued include new entries for paramecium, diatom, and green algae species and revised data for shovelnose sturgeon, Atlantic sturgeon, and fountain darter from Dwyer et al. (2005a). Data for paramecium, diatom, and green algae species are not applicable to this consultation. The only quantitative change for fish was a correction of percent purity for the fountain darter LC50 from Dwyer et al. (2005a). The March 15, 2023 ECOTOX update did not include nonylphenol data that met the screening criteria. For example, the update included data for exposures to formulations or through injection.

The availability of data for ESA-listed sturgeon simplifies this analysis. The four freshwater LC50s for shortnose sturgeon and Atlantic sturgeon in the proximity of the reference lines are from two studies from the same research group (Figure 11). Corrected for the percent of nonylphenol in the formulation, the shortnose sturgeon LC50 was 68 µg/L (risk quotient 0.4) while the Atlantic sturgeon LC50s were 42.5 µg/L (risk quotient 0.65) and 68 µg/L (Dwyer et al. 2000) to 42.5 µg/L (risk quotient 0.4, Dwyer et al. 2005b). Confidence intervals and original exposure-response data were not provided with these estimates. Interpretation of the Atlantic sturgeon results in Dwyer et al. (2005b) is complicated by mortality in one replicate of the solvent control, and, if a few sturgeon died in either a control or exposure replicate, the water quickly fouled and most or all of the fish then died in that replicate. The risk quotients for other sturgeon indicate that the LC50s were generally an order of magnitude higher than the acute criterion concentration (Dwyer et al. 1999; Dwyer et al. 2005b) as were quotients for salmonids from the same research group (Sappington et al. 2001; USEPA 1995) and other investigators (Brooke 1993a; Calamari et al. 1979; Ernst et al. 1980; Spehar et al. 2010). The LC50s reported for rainbow trout in other studies ranged from 119 µg/L over four days for fry (Dwyer et al. 1999) to 920 µg/L over two days for embryos (Ernst et al. 1980). It is not surprising for an embryo LC50 to be higher than that of older life stages because the vitelline membrane and chorion of the egg are protective (Finn 2007).

Among the sublethal data, salmonid development and growth LOEC risk quotients ranged from 0.13 to 0.71 appear to be from two sources. However, the brook trout studies reported in Spehar et al. (2010) appear to be a peer reviewed publication of an earlier Brooke (1993a) government report. Response magnitudes at the LOEC for this work included ~30% reduction in weight (risk quotient 0.71) and 60% reduction in mean percent post-hatch survival (risk quotient 0.32) at 51 days. The study also reported an LC50 at 221 µg/L, and reported an EC50 of 109 µg/L for loss of equilibrium, immobility, and morbidity at 51 days. The LC50 is more than twice LC50s reported for ESA-listed sturgeon in either of the Dwyer et al. studies (2000, 2005) suggesting that growth and development effects would be expected to occur in shortnose and Atlantic sturgeon at lower exposure concentrations than reported in Spehar et al. (2010).

Several of the freshwater invertebrate acute LC50 and LOEC risk quotients indicate effects occurring at and below the acute criterion. These include data for paper pondshell (Black 2003), scud (Brooke 1993a; Spehar et al. 2010), and Daphnia magna (Campos et al. 2016; Campos et al. 2012; Hong and Li 2007). The Campos et al. (2016) was a multigenerational study indicating changed sensitivity over three generations of exposed organisms. The EC10s reported for population growth were 14+/- 2.4 µg/L in the parental generation and 25.5 +/-2.6 µg/L in the third generation but fecundity was 35.7+/- 11.4 µg/L in the parental generation and 27.36+/- 4.9 in the third generation. The freshwater toxicity data did not suggest adverse effects for invertebrate exposures within the nonylphenol chronic criterion.

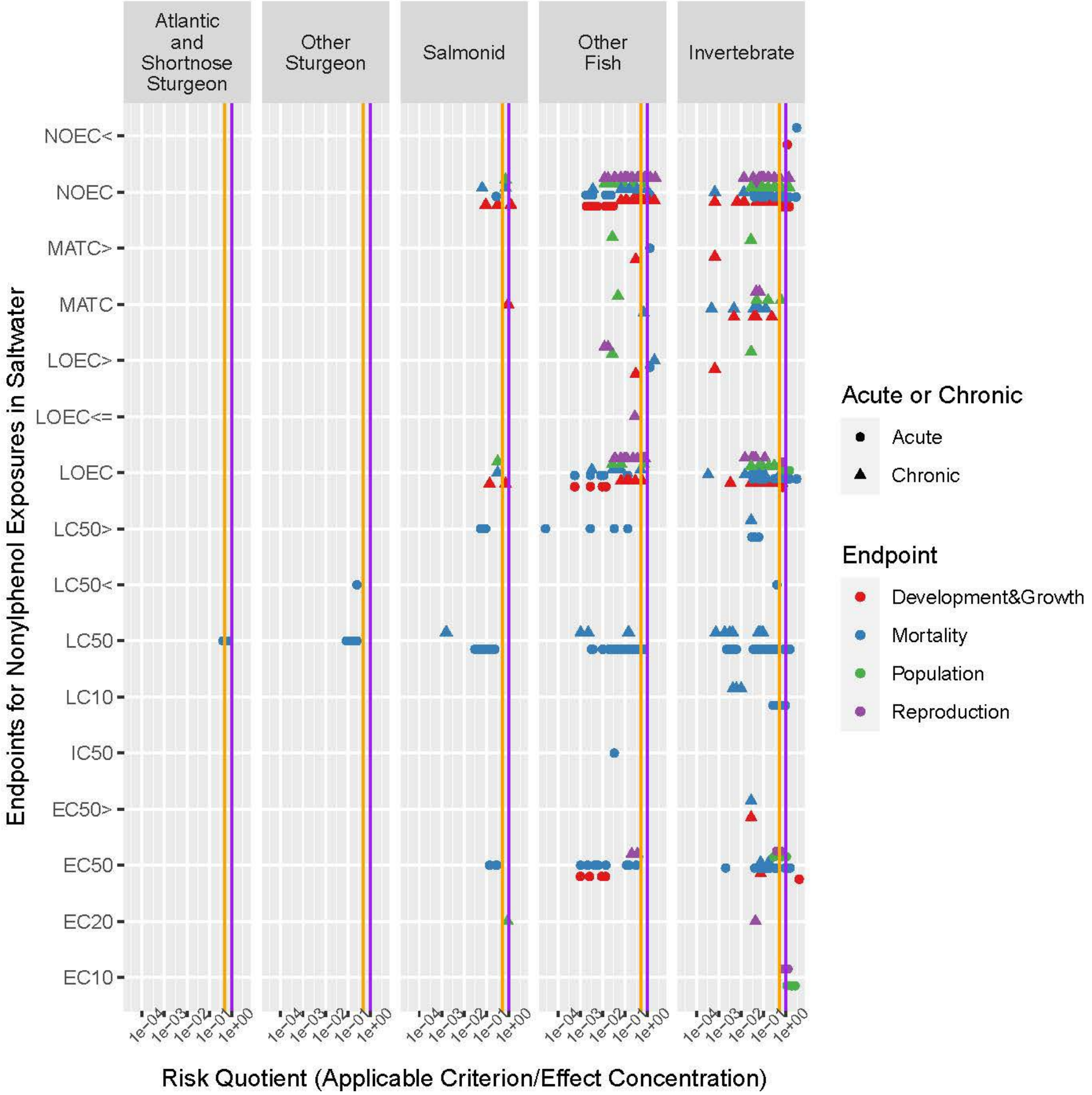

Figure 11. Distribution of Risk Quotients for Freshwater Exposures yo Nonylphenol in Context of Reference Lines Representing the Applicable Criterion (Purple) and One-Half The Applicable Criterion (Orange)

The available toxicity data for saltwater exposures are sparse but indicate that invertebrates are more sensitive to nonylphenol than fish (Figure 12). The risk quotient adjacent to the 0.5 reference line represents an LC50 for winter flounder larva. This test was part of a study collecting information on nonylphenol in order to form a database of acute toxicity specifically for calculating a national acute criterion (Lussier et al. 2000). The chronic LOEC is for increased weight in juvenile turbot. At an exposure of 30 mg/L nonylphenol over three weeks, the fish increased significantly in size, but plasma testosterone and beta-estradiol declined (Martin-Skilton et al. 2006). The authors discussed other hormonal and physiological changes, but did not address morphometric effects on plasma hormone levels like changes in blood volume, edema or somatic indices. Data for saltwater invertebrates indicate that adverse effects are expected, but there were no data for adverse effects on reproduction.

The population-level risk quotients for saltwater invertebrates represent approximately 20% inhibition of barnacle larvae settlement at 0.059 +/-0.001 µg/L nonylphenol (Billinghurst et al. 1998) and enhanced intrinsic rate of increase (births minus deaths) for a marine copepod in a study using exposure concentrations ranging from 31 to 500 µg/L (Bechmann 1999). The Billinghurst et al. (1998) study also contributed several of the development and growth risk quotients reflecting delayed maturation at exposure concentrations below the saltwater acute criterion. Other effects reported to occur at concentrations below the acute criterion include decreased size and disrupted molting cycles in opossum shrimp (Hirano et al. 2009) and delayed maturation persisting into the next generation of harpacticoid copepods with the parental exposure initiated at the nauplii stage (Marcial et al. 2003).

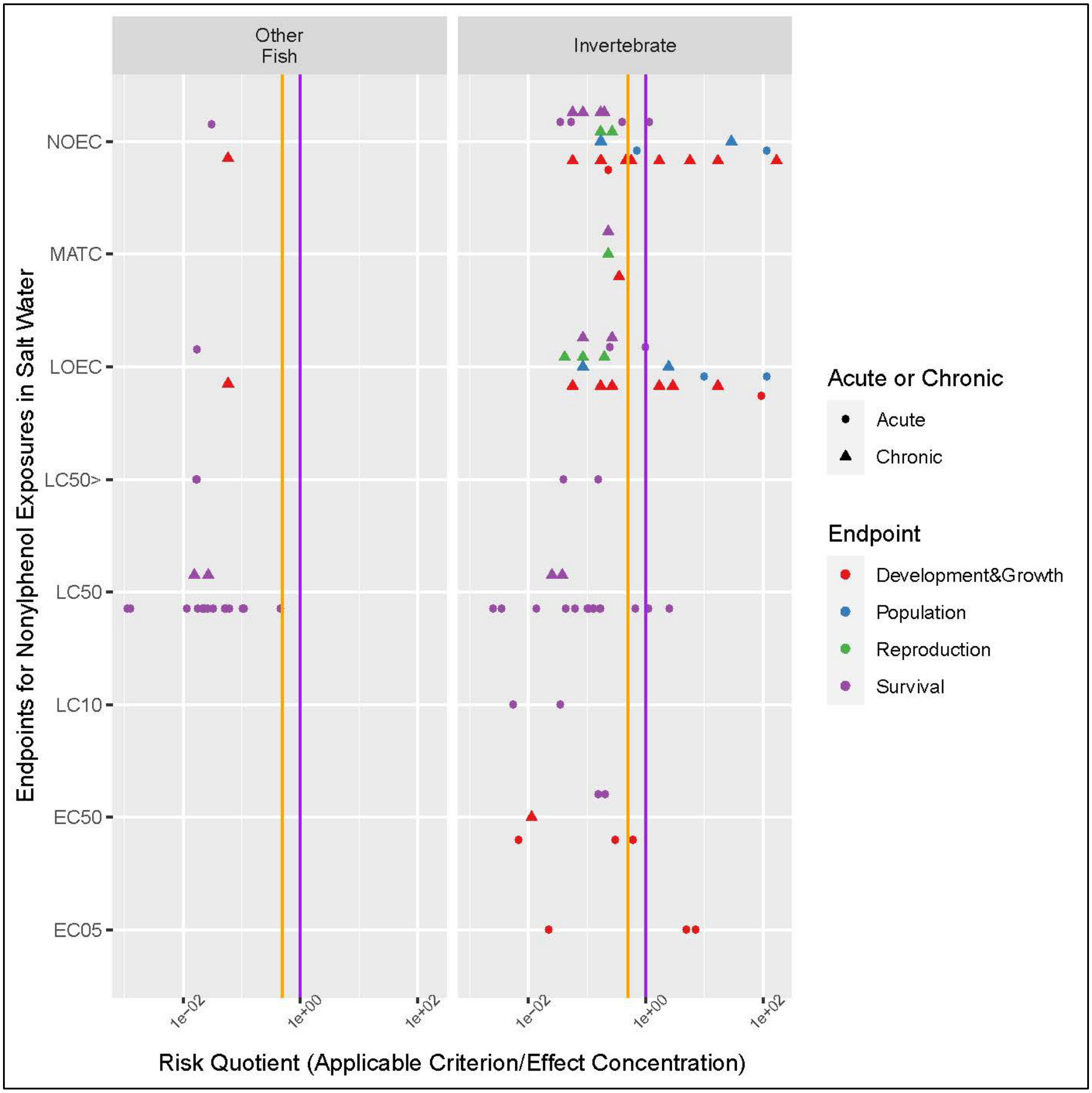

Figure 12. Distribution of Risk Quotients for Saltwater Exposures to Nonylphenol in Context of Reference Lines Representing the Applicable Criterion (Purple) and One-Half the Applicable Criterion (Orange)

8.2.3 Not Likely to Adversely Affect Determination for Nonylphenol Exposures Within Criteria Limits

NMFS concludes that EPA's approval of Delaware's adoption and implementation of the recommended National Recommended Water Quality Criteria for nonylphenol is not likely to adversely affect shortnose sturgeon or the Chesapeake Bay and New York Bight, and migrating, Gulf of Maine, Carolina, and South Atlantic DPSs of Atlantic sturgeon, or prey species because exposures to nonylphenol are extremely unlikely to occur and are therefore discountable for the following reasons:

1) domestic and industrial use of nonylphenol has been phased out;
2) there are no fracking activities in the Delaware River Basin;
3) there are no regulable sources of nonylphenol within catchments adjacent to Sturgeon Waters.

8.3 Cadmium

Cadmium is a naturally occurring element in the earth's crust that is most commonly associated with zinc ore as a small, but significant, impurity. Cadmium is used in batteries and pigments and in the manufacture of electronics and plastics. It is a component of fossil fuels, alloys, cement, and some fertilizers (ATSDR 2012). Given its abundant usage, cadmium is a common pollutant in stormwater. Shaver et al. (2007) reported the median cadmium concentration in urban runoff at 1.0 +/- 4.42 µg/L with highway runoff ranging from 0-40 µg/L and parking lot runoff ranging from 0.5-3.3 µg/L. Median dissolved cadmium concentrations in stormwater from commercial, industrial, and freeway land use areas were reported at 0.3, 0.6, and 0.7 µg/L, respectively.

The biological availability of cadmium in water is strongly influenced by aquatic chemistry: the abundance of ligand ions, organic acids, organic matter, and clay particles which may bind to cadmium. While complexation with substances in the water column results in precipitation and incorporation in bed sediments, bed sediment is not a static sink. Cadmium can return into the water column and become biologically available when sediments are disturbed and conditions, such as low pH, favor cadmium release in the free ion form (Cadmium Guideline USEPA 2016). Scenarios in which this might occur include storm events (Krein and Bierl 1999; Paus et al. 2014; Vidal-Dura et al. 2018) and re-inundation of exposed sediments after drought (Mosley et al. 2014).

Cadmium is a calcium analog that competes with calcium receptors at the gill. This disrupts calcium and ionic homeostasis in both freshwater and saltwater species (Adiele et al. 2010; Garcia-Santos et al. 2011; Onukwufor et al. 2015; Tang et al. 2016). Cadmium can accumulate at the gill, but is also transported throughout the body, accumulating to the highest extent in the organs with important roles in filtration and detoxification, the liver and anterior kidneys for fish and the hepatopancreas of arthropods and mollusks (Kouba et al. 2010; Paschoalini and Bazzoli 2021; Rodrigues et al. 2022). At the cellular level, cadmium induces oxidative stress, interfering with mitochondrial function and cellular repair that can lead to organ-level effects. If cellular injury is extensive, consequences for organ function will influence the survival and health of individuals (Paschoalini and Bazzoli 2021; Sun et al. 2022). A study by Mebane (2006) included a review of other data for cadmium dietary exposures and body burdens. Although there were not adequate data to establish acceptable tissue effect concentrations for aquatic life, Mebane (2006) concluded that cadmium is unlikely to accumulate in tissue to levels that would result in adverse effects to aquatic invertebrates or fish at the calculated chronic criterion. In the Cadmium Guideline, EPA concluded that the evaluation of direct exposure effects to organisms via water is more applicable to the development of criteria for aquatic life than dietary exposure.

The EPA proposes to approve Maryland and Delaware's adoption and implementation of EPA's National Cadmium Guidelines. For fresh waters, these criteria are hardness-based values for the acute criterion and chronic criterion using state specific equations. The saltwater acute criterion and chronic criterion concentrations are 33 and 7.9 µg/L, respectively (USEPA 2016). The acute criteria are one-hour averages and the chronic criteria are four-day averages not to be exceeded more than once in three years on average.

8.3.1 Exposure to Cadmium in the Action Area

Before addressing the potential for adverse effects from implementing the cadmium criteria, it is first necessary to identify natural and anthropogenic sources of cadmium that may contribute to aquatic impairments or be regulated under the criteria. Regarding natural sources, cadmium co–occurs with zinc ore, which was historically mined in the upland piedmont of Maryland (Weaver 1965). Presently there are mine claims northwest of Baltimore in the towns of Libertytown, New Windsor, and Union Bridge, Maryland.[9] These mines are located above the fall line, which is geologically distinct from the coastal plain where Sturgeon Waters occur. We would not expect cadmium to be redistributed to aquatic habitats through sediment and soil disturbing activities within the coastal plain areas without anthropogenic sources. There are 15 active and two proposed Superfund Sites with cadmium contamination within Sturgeon Waters catchments. Five out of 1,318 NPDES permitted facilities[10] within catchments adjacent to Sturgeon Waters are required to monitor for cadmium because their discharge has the reasonable potential to cause an impairment. These include two wastewater treatment plants discharging to Delaware River and Chesapeake Bay, a marine terminal and dredged material containment center discharging to Patapsco River-Northwest Baltimore Harbor, and the Smithsonian Environmental Research Center discharging to the West River, then flowing to Chesapeake Bay. The Smithsonian Environmental Research Center has been in significant noncompliance for ten out of the past 12 quarters and cadmium is among the pollutants with violations (https://echo.epa.gov/). Cadmium is among the potential pollutants responsible for the impaired receiving water for the marine terminal and dredged material containment center. Due to the

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[9] https://thediggings.com/usa/maryland/mines?commodity=zinc accessed 03.14.2023

[10] Excluding permitted discharges from concentration animal feed operations and stormwater from construction operations because these are no expected to include cadmium.

ubiquity of cadmium in various commonly used products, wastewater treatment plants are also likely to have some amount of cadmium in their discharges. There are 89 other wastewater treatment plants discharging to Sturgeon Waters and within catchments adjacent to Sturgeon Waters facilities that are not required to monitor for cadmium, but may contribute cadmium below levels considered to have "reasonable potential" to contribute to an aquatic impairment.

In order to establish that a facility or surface water is in compliance with water quality criteria limits, it is critical that monitoring data are collected using methods and procedures with detection limits that allow quantification of pollutants below their respective criteria concentrations. Otherwise, a "non-detect" does not indicate whether or not pollutants are within regulatory limits. The EPA standard methods for cadmium identify instrument and method detection limits ranging from 0.02 to 3.4 µg/L using Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES), Inductively Coupled Plasma-Mass Spectrometry (ICP-MS), and Graphic Furnace Atomic Absorption (GF-AA) instrumentation Table 12.

Table 12. EPA Approved Clean Water Act Instrument and Method Detection Limits for Cadmium

Method	Mode	Instrument Detection Limit (µg/L)	Method Detection Limit* (µg/L)
200.7 Revision 4.4 ICP-AES	Total cadmium Recoverable cadmium	3.4 1	
200.8 Revision 5.4: ICP-MS	Scanning multiple analytes Cadmium-targeted	0.1 0.02	0.5 0.03
200.9 Revision 2.2: GF-AA			0.05

*Method detection limits are influenced by the various components in the sample matrix (e.g., organic acids, salinity)

STORMWATER

Precipitation either infiltrates into the ground, enters stormwater conveyance systems where it is potentially treated, or enters surface waters through overland flow. Factors such as the amount of dry deposition, storm intensity, rain acidity, inter-storm period, seasonality, and the physical properties and material composition of the surfaces contributing pollutants to the runoff event determine the constituents and their concentrations within the discharge. Added to this is the variability contributed by the receiving water itself and other stormwater sources and land uses within the watershed. For catchments with a large amount of impervious cover, stormwater pollutant data are strongly affected by the timing of sampling, with "first flush" samples collected early in the precipitation event containing the highest concentrations of pollutants.

The National Stormwater Quality Database reported cadmium in greater than 80 percent of stormwater samples from freeways throughout the nation at concentrations ranging from 0.10 to 16.05 µg/L. Meanwhile cadmium was detected in 40 percent of stormwater samples from urban developed areas (commercial, residential, institutional) at concentrations ranging from 0.04 to 105 µg/L. Cadmium was detected in fewer than 20 percent of stormwater samples from undeveloped areas, however concentrations of up to 90 µg/L were reported (Pitt et al. 2018). The most recent stormwater monitoring data available for Delaware and Maryland span the years 1992 through 2005 with cadmium concentrations ranging from below detection limits to 22.19 µg/L. Table 13 summarizes cadmium observations for specific land use types within land uses.

Whether a given storm event results in exposures to cadmium at harmful levels depends on the mass of pollutant in the volume of stormwater discharge entering the receiving water (i.e. pollutant load), the extent of the mixing zone, dilution volume of the receiving water, any cadmium already present in the receiving water, and aquatic chemistry factors influencing cadmium bioavailability. The EPA's cadmium criteria are calculated using water hardness because that was determined to be the most critical factor in influencing the bioavailability, and therefore toxicity, of cadmium in water. Hardness data were not included with the Delaware and Maryland stormwater data, so the applicable cadmium criteria for the specific stormwater discharges, or their receiving waters, could not be calculated. To place stormwater data in context of waters receiving stormwater runoff, we rely on monitoring data reported in the National Water Quality Monitoring Council's Water Quality Portal (https://www.waterqualitydata.us/) for Sturgeon Waters and associated tributaries within adjacent catchments in Delaware and Maryland. These data indicate that about 40 percent of hardness values for streams and rivers were below 50 mg/L $CaCO_3$ (202 out of 520 observations). Of course, stormwater would be diluted within the receiving water, but that dilution would not be instantaneous. Rather there would be an impact zone surrounding points of discharge. Using reported hardness data, calculated acute criteria for these waters range from 0.27 to 3 µg/L, but until 2002, the cadmium detection limits for the stormwater data were often greater than this lower value. In order to identify pollutant contributors to water quality degradation, it is important for detection limits to be below concentrations at which adverse effects are expected to occur.

Table 13. Stormwater Cadmium Concentrations within Maryland and Delaware Land Use Classes.

Principle Land Use	Cadmium range (µg/L)	Detection Frequency	Detection limit range (µg/L)
Commercial	0.71-23.2	115 out of 144 samples (80%)	0.076-5
Freeways	0.13-16.05	73 out of 103 samples (71%)	0.076-0.55
Industrial	0.5-20	45 out of 111 samples (40%)	0.076-5
Institutional	0.25-2.05	28 out of 28 samples (100%)	--
Open space	<0.25-<1	--	0.25-1
Residential	0.15-22.19	366 out of 598 samples (61%)	0.076-5
Unclassified	1.9-14.34	3 out of 128 samples (2%)	1-10

MONITORING DATA

Streams and rivers integrate the multiple point and nonpoint sources affecting water quality conditions, but unless monitored continuously or systematically, monitoring data are merely snapshots in time of the water chemistry and conditions at the time each sample was taken. The most recent cadmium monitoring data reported in the National Water Quality Monitoring Council's Water Quality Portal for Delaware and Maryland is from 2015. There were only 18 cadmium monitoring events for Delaware and these occurred between 1974 and 1998. Cadmium was monitored for, but not detected, in samples taken during these events. The detection limits reported with the data include one event with a detection limit of 0.5 µg/L, six events with a detection limit of 2 µg/L, and five events with a detection limit of 10 µg/L. Detection limits were not provided for the remaining six sampling events. More than 1,000 monitoring events were reported for Maryland between 1969 and 2015. Comparison of these data for freshwaters, relative to applicable chronic, criteria when hardness data were available, indicates many instances of elevated cadmium concentrations. Risk quotients range from 0.44 at a station in Piscataway Park and up to 33 for a station in the Susquehanna River at Conowingo, Maryland. Prior to 2003, detection limits ranged from 0.1 to 10 µg/L, detection limits from 2003 through 2011 were 0.016 to 0.05, but were at 1 and 2 µg/L for sampling events from 2013 to 2015. For saltwater. Risk quotients for chronic criteria ranged from <0.01 to 1089 in Back Creek.

Cadmium occurs in Maryland Sturgeon Waters at concentrations within and greater than criterion limits. Monitoring of Delaware waters is insufficient to determine if upstream sources in Pennsylvania and New Jersey have resulted in elevated levels in Delaware waters. In Maryland, cadmium criteria adopted by the DRBC take precedence over state-adopted criteria and the Delaware River Basin overlaps with the majority of catchments associated with Sturgeon Waters in Delaware (Figure 13).

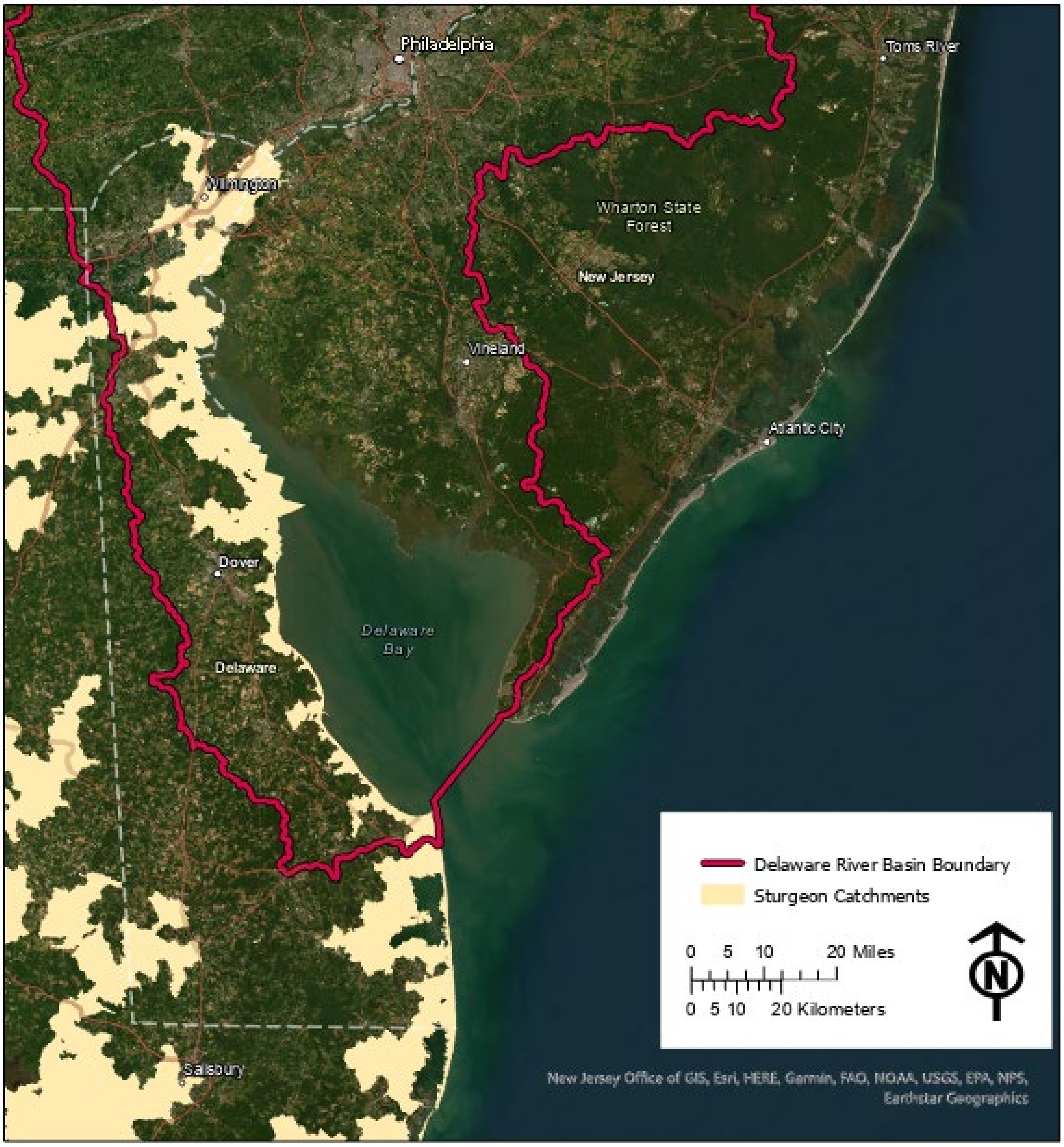

Figure 13. Extent of Delaware River Basin where the DRBC Criteria are in Effect

While sources for cadmium occur in both Delaware and Maryland, the extent to which cadmium occurs within or above criterion limits within Sturgeon Waters is uncertain. Detection limits for monitoring data may not reliably identify the presence of cadmium. Cadmium is not routinely monitored for in Sturgeon Waters, and when cadmium is monitored for, the water hardness data needed to calculate applicable criterion limits are not always collected concurrently.

8.3.2 Responses to Cadmium Exposure within Criteria Limits

Risk quotients for all available endpoint effect data from screened ECOTOX data for the effects of cadmium and additional data from the open literature are plotted in context of reference lines representing a risk quotient of one (purple) for exposures at the criterion concentration and a risk quotient of 0.5 (orange) representing exposures at one-half the criterion concentration. Risk quotients that occur to the right of the purple reference line indicate responses occurring at an exposure concentration below the applicable criterion (i.e., higher risk). Risk quotients are plotted on a log scale to enhance resolution. Those few data reported in with "<" operators are presented as hollow icons (i.e., ○, ∆, ☒) to indicate that the response is expected to occur at a concentration less than the reported concentration. This typically happens when a response is observed at the lowest concentration tested in the study.

FRESHWATER CADMIUM CRITERIA LIMITS

The screened ECOTOX cadmium data for freshwater exposures included 1,113 toxicity tests from 127 studies exposing 52 species of fish from 21 taxonomic families. About half of the freshwater fish toxicity tests were for exposures of rainbow trout. The March 15, 2023 update of the ECOTOX included two additional data points for fathead minnows that met the screening criteria for use in this Opinion (Pilie et al. 1975). The risk quotients for these were less than 0.001. Data for invertebrates, representing forage species, were provided by 108 studies that conducted 707 toxicity tests evaluating the effects of cadmium on 87 invertebrate species from 46 taxonomic families. Nearly 60% of the invertebrate data are for exposures of *Daphnia* or *Hyallela*. The March 15, 2023 update of ECOTOX included two additional data points for *Daphnia* that met the screening criteria for use in this Opinion (Lagerspetz 1993). The risk quotients for these observations were also less than 0.001.

While Figure 14 indicates that LC50s for white sturgeon are generally an order of magnitude higher than the test-specific criteria, the magnitude of responses at the LOECs from the same tests suggest adverse effects would occur within proposed acute criterion limits. Twenty percent of individuals exhibited loss of equilibrium and immobilization at a LOEC of 3.06 µg/L in an acute test reported by (Calfee et al. 2014). With a test-specific criterion of 2.99 µg/L cadmium, the risk quotient for this LOEC is 0.98, which means the LOEC is essentially equivalent to the acute criterion. The four-day survival LOECs for fish exposed at age two days through 89 days post hatch had risk quotients ranging from 0.02 to 0.68, but the effective mortality (mortality plus loss of equilibrium and immobilization) magnitudes at these LOECs ranged from 20+/-11.55% to 95 +/-10% (Ingersoll et al. 2014).

Ingersoll et al. (2014) also reported a biomass LOEC for white sturgeon at 5.29 µg/L (RQ=0.15) for a chronic exposure that reduced fish mass by 25%, the EC10 calculated for this exposure was 2.4 µg/L with a confidence interval of 1.5 to 4.0 µg/L.

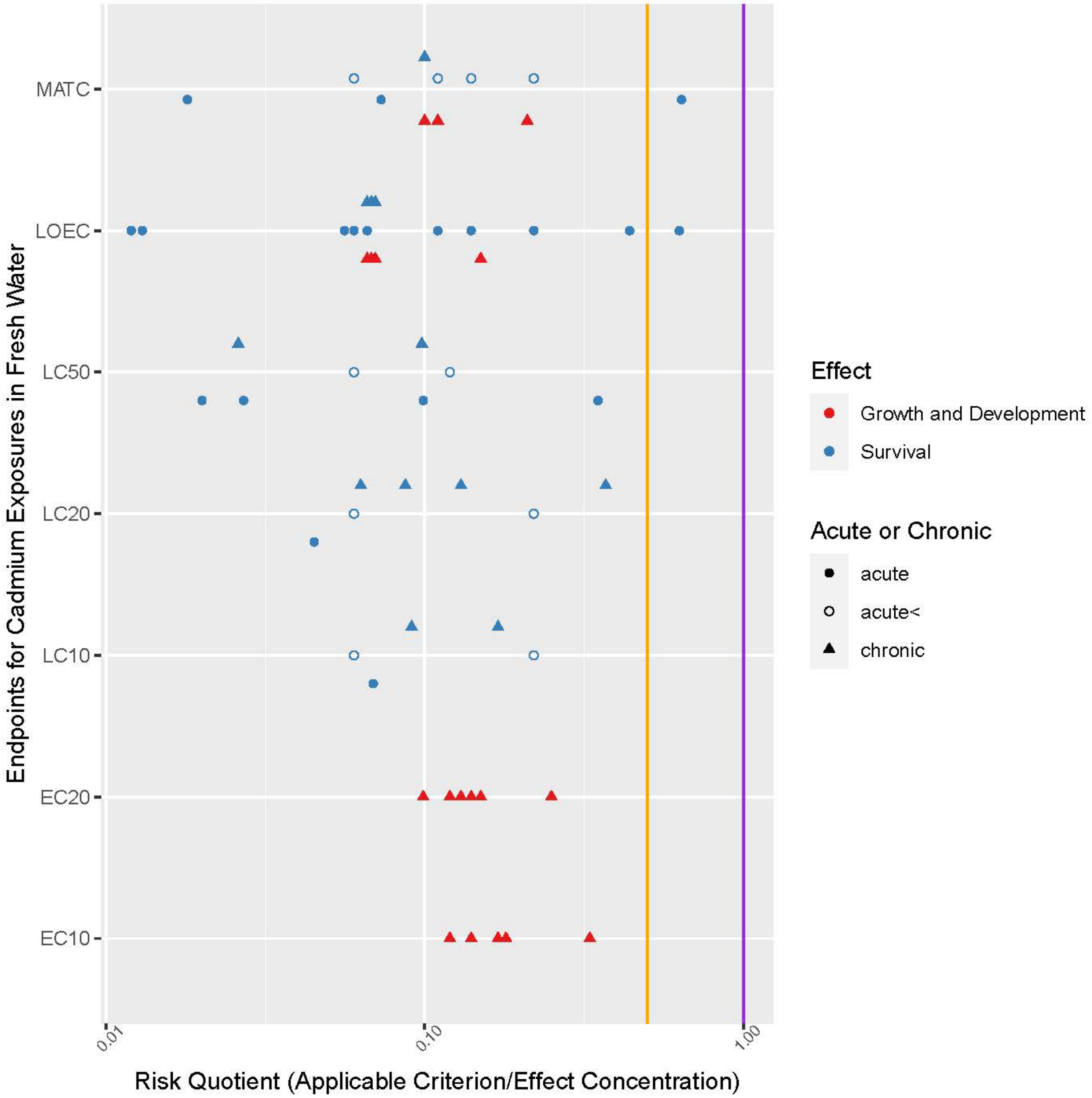

Figure 14. Distribution of Risk Quotients for Freshwater Exposures of White Sturgeon to Cadmium in Context of Reference Lines Representing the Applicable Criterion (Purple) and One-Half the Applicable Criterion (Orange)

As explained in Section 2.2.2, data support the use of rainbow trout as a surrogate for sturgeon. Toxicity data for rainbow trout summarized in Table 14 and illustrated in Figure 15 include data from the Ingersoll et al. (2014) study discussed above. The hardness-normalized LC50s for effective mortality for sturgeon exposed at 30 days post hatch and trout exposed at 32 days post hatch were 54.63 and 2.55 µg/L, respectively. Yet the effective mortality LC50s for sturgeon exposed at 72 days post hatch and rainbow trout exposed 74 days post hatch were comparable, at 3.02 and 2.62 µg/L, respectively. Four-day survival LOECs for rainbow trout exposed at 18, 32, 46, 60, 74, and 95 days post hatch had risk quotients ranging from 0.57 to 1.6 but response magnitudes were substantial, ranging from 20+/-14.14% to 92.5 +/-9.57% (Ingersoll et al. 2014). Risk quotients for the LC10s reported for these exposures by Ingersoll et al. (2014) ranged from 0.76 to 3.7.

Data indicating adverse effects may occur due to waterborne exposures within the freshwater acute criteria limits include altered behavior, growth, and development of juvenile fish. Sloman et al. (2003a) exposed rainbow trout to cadmium at a concentration that was equivalent to the acute criterion concentration limit for 24 hours, indicating a risk quotient of one, then the ability to establish dominance by aggression in terms of attempted and successful attacks. Many fish species, including salmonids, develop a social structure within shared habitat (Gilmour et al. 2005; Villegas-Ríos et al. 2022). Dominance, usually established through aggression, conveys advantages in food, sheltering, and reproduction. Subordinate fish have reduced activity and feeding, lower growth rates, immunosuppression, poor condition and increased mortality (Gilmour et al. 2005). Sloman et al. (2003a) evaluated aggression in rainbow trout when paired with another cadmium-exposed fish or an unexposed control fish of the same size. A successful attack is an aggressive action that results in actual body contact. The dominant fish was identified as the individual with lighter coloration swimming freely in the tank and the submissive fish as the individual with darker coloration hovering either at the bottom of the tank or near the surface. Cadmium-exposed fish pairs attempted fewer attacks than control fish pairs during the period over which dominance was established. Cadmium-exposed fish that were paired with control fish had a decreased ability to establish dominance.

In a companion study, juvenile rainbow trout were exposed to a lower concentration of cadmium, providing a risk quotient of 1.6, to assess the ability of cadmium-exposed fish to establish dominance over one, two, three, and five days (Sloman et al. 2003b). Control fish were more likely to establish dominance than cadmium-exposed fish up until the fifth day, and at five days post exposure, cadmium-exposed and control fish were equally likely to establish dominance. This corresponded with clearance of cadmium from olfactory rosettes of the cadmium-exposed fish. In fish, olfaction is important for homing, avoiding predators, finding mates, and locating food (Bett and Hinch 2016; Gerlach et al. 2019; Hara 1994; Kelley and Magurran 2003; Leduc et al. 2013; Scott and Sloman 2004; Tierney et al. 2010). The authors described the ecological implications of this effect in context of fish migrating from a contaminated area and competing with non-exposed fish for foraging and breeding.

While the Sloman et al. (2003a, 2003b) studies' 24 hour exposure duration exceeds the acute criterion exposure duration limit of one hour, the time required for cadmium exposure to affect olfaction or other receptors influencing behavior (e.g., taste, lateral line) was not addressed.

NMFS expects that short exposures would have likely resulted in the same or similar response because effects at sensory receptors occur rapidly. A 2.3–3.0 µg/L increase in copper over background can impair olfaction in coho salmon within minutes of exposure (Baldwin et al. 2003) and four-hour exposures of sea bass to 5 µg/L cadmium resulted in damage lateral line system damage and impaired C-start escape response[11] that persisted for 20 days (Faucher et al. 2006).

NMFS is taking these acute behavioral studies into consideration because, while sturgeon are a primitive species group, there is evidence that they have a complex of social behaviors usually attributed to less primitive species (Kynard and Horgan 2002; Lilly et al. 2020). Kynard and Horgan (2002) reported a dominance hierarchy based on fish size and competition for foraging space in shortnose sturgeon. Their tests of Atlantic sturgeon did not indicate a dominance hierarchy, but this was attributed to an absence of competition due to abundant food and lower fish density.

While the four-day EC50 risk quotient of 0.57 reported for effects on growth in rainbow trout (Wang et al. 2014) suggests that some impact on growth would be expected for acute exposures within criterion limits (Table 14), the actual criterion duration limit is one hour and NMFS does not expect growth effects resulting from a one hour exposure would be detectable.

Adverse effects on survival of rainbow trout exposed within acute criterion limits is suggested by the magnitude of responses in reported LOECs, risk quotients for LC10s, and the abundance of LC50s with risk quotients exceeding a value of 0.5 among acute toxicity tests. The LC50 risk quotients for rainbow trout reported in 108 toxicity tests ranged from less than 0.001 to 2.9, averaging 0.79+/-0.6 (n=108). Among these, 73 tests reported LC50s exceeding a risk quotient of 0.5 and 32 LC50s exceeded a risk quotient of one.

Among screened data, chronic toxicity tests those with exposure durations exceeding four days. Hansen et al. (2002) reported five-day LC50s that ranged from 0.36 to 2.07 µg/L for rainbow trout exposed to cadmium under differing temperature and water hardness conditions. Risk quotients for these data ranged from 0.84 to 0.86 for exposures under an average water hardness of 30.4 mg/L calcium carbonate and temperature of 9.4 degrees Celsius. At a mean temperature of 7.8 degrees Celsius, risk quotients ranged from 0.35 to 0.58 correlating with water hardness values of 30 to 90 mg/L calcium carbonate. Risk quotients for LC50s reported by a larger study with a similar design ranged from 0.24 to 0.81 (Stratus Consulting Inc. 1999).

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[11] Fish lateral line sensory system detects movement and vibration in the surrounding water. The c-start escape response is a rapid startle escape reflex so named because it causes the fish to first contract in tight bend to the opposite side of a predator's approach forming a "C shape" followed by a "kick" out of the contraction to dart away from the threat Tytell, E. D., and G. V. Lauder. 2002. The C-start escape response of *Polypterus senegalus*: bilateral muscle activity and variation during stage 1 and 2. Journal of Experimental Biology 205(17):2591-2603..

Table 14. Summary of Toxicity Data for Rainbow Trout Exposures to Cadmium

Effect	Endpoint	N	Exposure Range µg/L	Risk Quotient range	Sources
Acute					
Behavior	MATC	1	30	0.1	Birge et al. 1993; Sloman et al. 2003a,b
	LOEC	4	2-50	0.061-1.6	
Growth and Development	EC50	1	5.1	0.57	Wang et al. 2014
Survival	MATC	8	1.86-4.02	0.75-1.6	Besser et al. 2007; Birge et al. 1983; Calfee et al. 2014; Call et al. 1981; Chapman 1978; Cusimano et al. 1986; Daoust 1981; Davies 1976; Davies and Brinkman 1994; Davies et al. 1993; Goettl and Davies 1976; Goettl et al. 1976; Hansen et al. 2002; Hollis et al. 1999; Ingersoll et al. 2014; Mebane et al. 2012; Naddy et al. 2015; Niyogi et al. 2004; Pascoe et al. 1986; Phipps and Holcombe 1985; Stratus Consulting Inc. 1999
	LC10	14	0.11-3.67	0.57-5.7	
	LC20	19	0.16-4.04	0.51-3.9	
	LC50	108	0.32-5700	<0.001-2.9	
	LOEC	14	1.01-8.45	0.18-1.6	
	LT50	58	0.51-10.6	0.16-1.8	
Chronic					
Growth and Development	MATC	7	0.16-7.5	0.049-1.9	Adiele et al. 2011; Besser et al. 2007; Ingersoll et al. 2014; Mebane et al. 2008; Wang et al. 2014
	EC10	7	0.15-9.2	0.083-2	
	EC20	6	1.8-6.8	0.032-0.42	
	LOEC	9	0.16-11.2	0.031-1.9	
Survival	MATC	24	0.4-17.6	0.089-4.5	Anadu et al. 1989; Besser et al. 2007; Birge 1978; Birge et al. 1978, 1979, 1980; Call et al. 1983; Chapman 1978; Chapman and Stevens 1978; Cusimano et al. 1986; Davies and Brinkman 1994; Davies and Gorman 1987; Davies et al. 1993; Goettl et al. 1976; Hansen et al. 2002; Ingersoll et al. 2014; Mebane et al. 2008; Roch and Maly 1979; Roch and McCarter 1986; Stratus Consulting Inc. 1999; Stubblefield et al. 1999; Wang et al. 2014
	LC10	13	0.7-11	0.075-0.34	
	LC20	14	0.25-17	0.048-1.1	
	LC50	34	0.35-280	0.0048-0.86	
	LETC	5	6.1-123	0.013-0.26	
	LOEC	10	0.7-26	0.041-2.3	
		26			

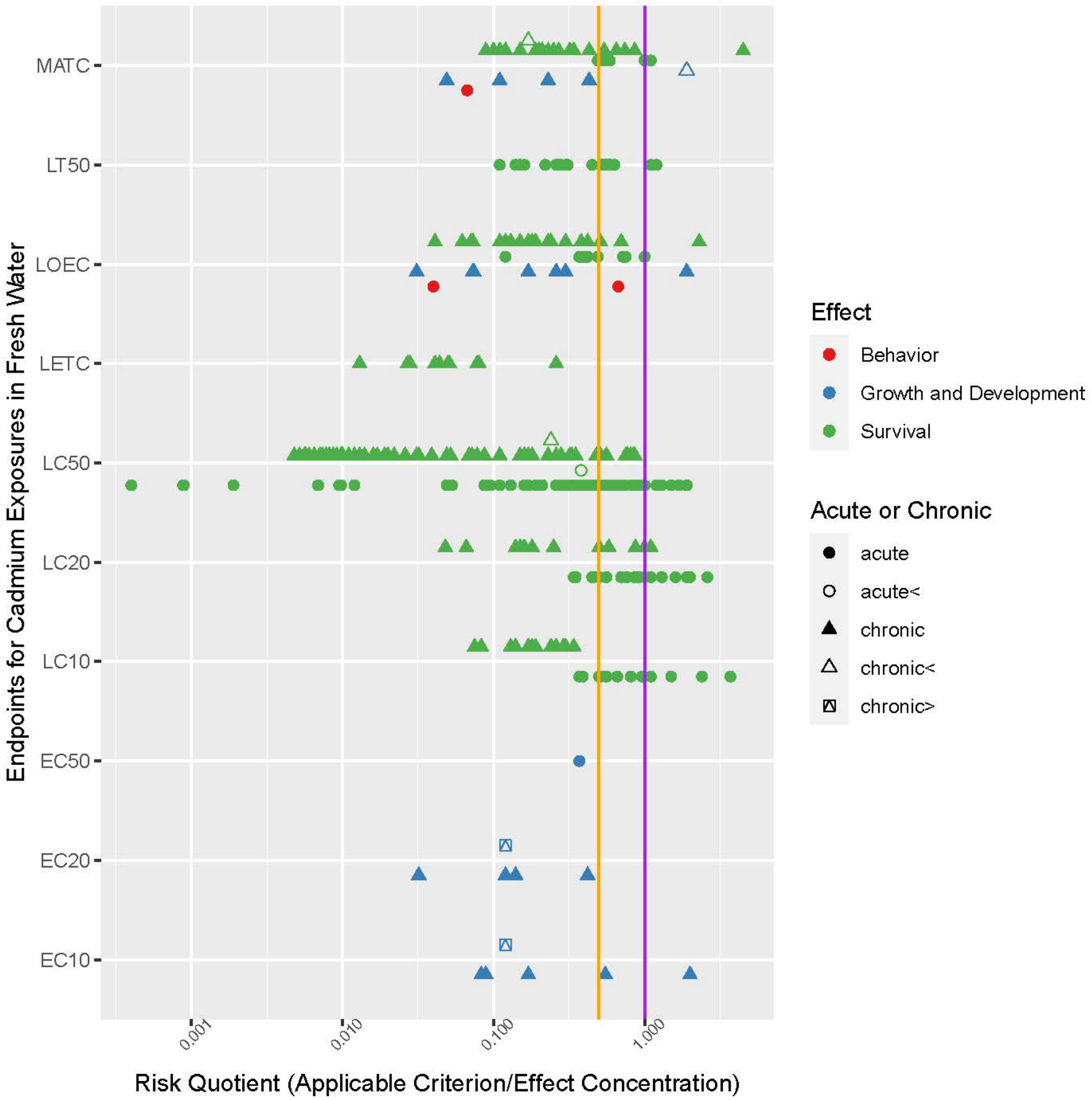

Figure 15. Distribution of Risk Quotients for Freshwater Exposures of Rainbow Trout to Cadmium in Context of Reference Lines Representing the Criterion Applicable to Sturgeon Waters (Purple) and One-Half the Applicable Criterion (Orange)

The risk quotients representing growth and development of rainbow trout ranged from 0.03 to 2 (Adiele et al. 2011; Besser et al. 2007; Ingersoll et al. 2014; Mebane et al. 2008a; Wang et al. 2014). The LOECs reported by Mebane et al. (2008) underscore the influence of temperature on cadmium toxicity. The risk quotient of 1.78 represents response magnitudes of five percent reduction in length and 17% reduction in weight at 12.5 degrees Celsius and hardness of 29.4

mg/L calcium carbonate. At 9.8 degrees Celsius and hardness of 19.7 mg/L calcium carbonate, risk quotients were 0.03 and 0.07 Mebane et al. (2008).

NMFS concludes that EPA's approval of DNREC and MDE's adoption of the chronic freshwater water quality criteria for cadmium is likely to adversely affect individual shortnose sturgeon, the New York, Bight and Chesapeake DPSs of Atlantic sturgeon and migrating and foraging Gulf of Maine, Carolina, or South Atlantic DPSs of Atlantic sturgeon because the magnitude of responses at LOECs for exposures at or near the proposed freshwater acute and chronic cadmium criteria were substantial for both white sturgeon and rainbow trout and rainbow trout LC10 and LC50 data indicate adverse effects will result from exposures to cadmium within criterion limits.

The implications of EPA's approval of the proposed freshwater chronic cadmium criteria for ESA-listed sturgeon will be addressed in the Risk Analysis Section of this Opinion.

QUANTITY AND QUALITY OF FORAGE WITHIN THE FRESHWATER CADMIUM CRITERIA LIMITS

Examination of the data behind the risk quotients presented in Figure 16 indicates that adverse effects will occur in invertebrates exposed to cadmium within the chronic and acute criteria limits. While the diets of larval shortnose and Atlantic sturgeon have not yet been characterized, there are studies of larval green sturgeon (Zarri and Palkovacs 2019) and larval white sturgeon (Muir et al. 2000) diets. Although diets are likely to be location-specific based on availability, larval stages of both green and white sturgeon were reported to rely on zooplankton and small benthic macroinvertebrate species such as copepods, amphipods, and dipterans. An assessment of effects for listed species must address any evidence indicating adverse effects may occur to an individual of that species, but when evaluating effects to forage species it is the abundance and quality of forage species that is of concern. NMFS does not expect that EPA's approval of the cadmium acute criterion and chronic criterion will affect the quality of forage species through toxic exposures in the diet because Mebane (2006) concluded that exposures to cadmium within criterion limits is unlikely to result in tissue accumulation to levels that would cause adverse effects.

While adverse effects may occur in invertebrates exposed to cadmium within both the freshwater and saltwater acute criterion and chronic criterion limits, the bulk of the data indicate effects occurring above criterion limits. Early-life-stage sturgeon rely on zooplankton. Excluding the extreme risk quotient value greater than 100 in Figure 16, risk quotients for freshwater planktonic species ranged from less than 0.001 to 7.9 in 26 species. Data indicating adverse effects within criteria limits are for *Hyalella*, *Daphnia*, and *Ceriodaphnia* species. About half of the risk quotients in Figure 16 are from toxicity tests of *Daphnia* and *Ceriodaphnia* species, which are used in toxicity tests because they are extremely sensitive to aquatic pollutants. Among food items consumed by larger sturgeon, including mollusks, worms, and larger crustaceans like crayfish or crab, risk quotients ranged from less than 0.001 to 0.45 in 26 freshwater species.

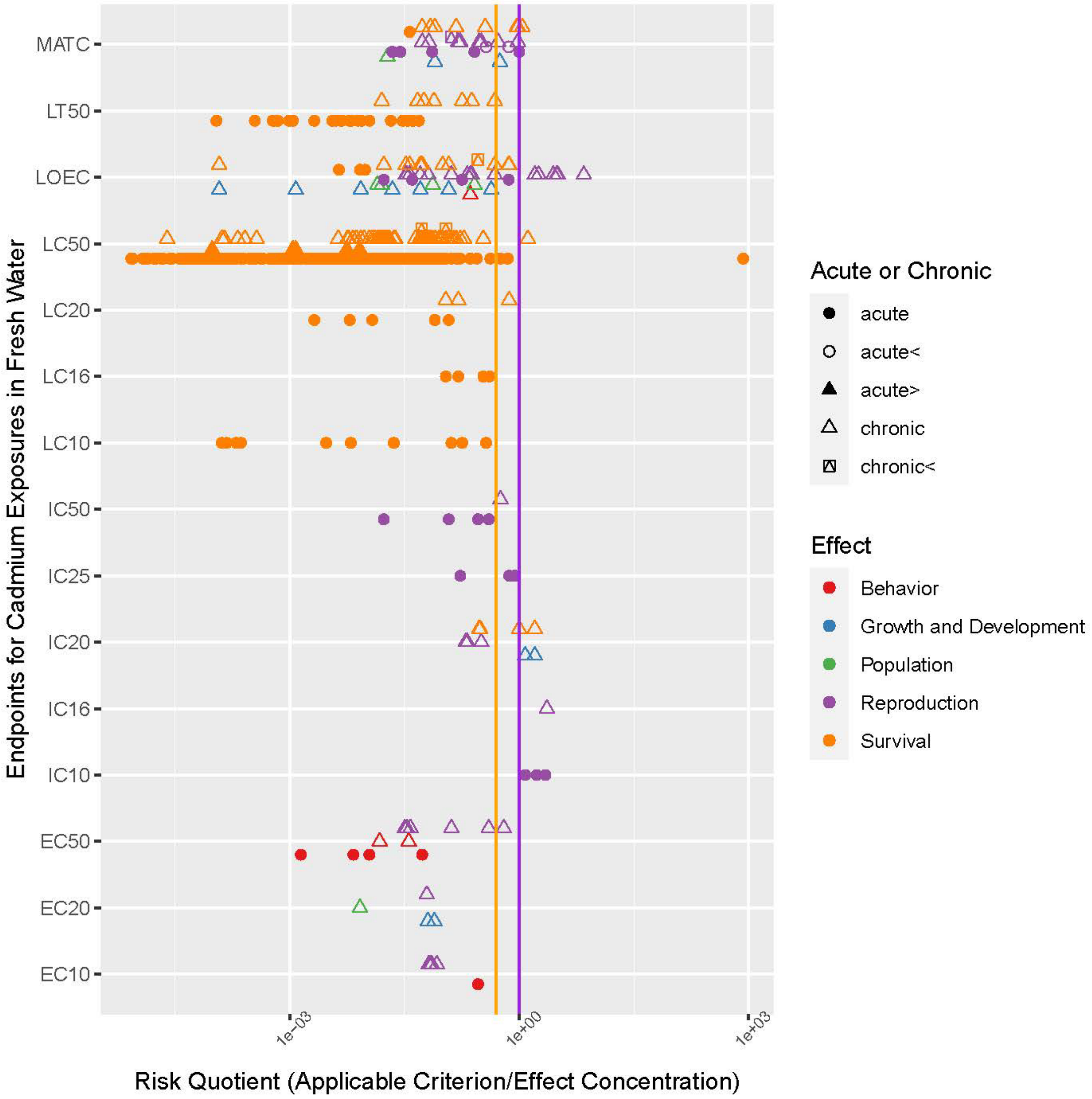

Figure 16. Distribution of Risk Quotients for Freshwater Exposures of Invertebrates to Cadmium in Context of Reference Lines Representing the Criterion Applicable to Sturgeon Waters (Purple) and One-Half the Applicable Criterion (Orange)

The implications of any effects on the abundance and quality of forage species for shortnose and Atlantic sturgeon is attenuated by the wide variety of forage species sturgeon consume. A reduction in the abundance of one benthic species is likely to be compensated for by an increase in other species (Wesolek et al. 2010). NMFS does not expect that cadmium exposures within chronic or acute criteria limits are likely to affect the abundance or quality of forage for shortnose sturgeon and the Chesapeake Bay, New York Bight, and migrating Gulf of Maine, Carolina, and South Atlantic DPSs of Atlantic sturgeon.

NMFS concludes that the exposure of forage species to cadmium within the freshwater chronic criterion limits may affect, but is not likely to adversely affect the quantity and quality of prey for ESA-listed sturgeon because they consume a wide range of invertebrate taxa and the criteria were derived to protect aquatic life based on the fifth centile of sensitive genera. The criteria are also implemented under conservative exposure durations and frequencies (i.e., the acute criterion is a one hour average derived from four-day tests and the chronic criterion is a four day average).

SALTWATER CADMIUM CRITERIA LIMITS

Data for exposures of saltwater fish species in Figure 17 do not indicate that increased mortality would be expected to occur within the cadmium saltwater acute criterion limits. Given that mortality, growth and development LOECs, inhibition concentrations, and lethal thresholds (ICxx and LETC in Figure 17, respectively) are at concentrations close to an order of magnitude higher than the chronic criterion and acute criterion, it is reasonable to expect that reproduction and other effects would not occur within the saltwater acute criterion or chronic criterion limits either. However, a single study using sea bass indicates that a four-hour exposure to 5 µg/L cadmium resulted in a nearly 60% decline in the c-start escape response and damage to the lateral line receptors. Their lateral line system seemed to regenerate about one month after exposure and fish escape behavior was not significantly different from controls (Faucher et al. 2006). With the acute saltwater criterion of 33 µg/L, the risk quotient for this response is 6.6. Escape behaviors are critical to early life stage sturgeon that are vulnerable to predation. For example, juvenile C-start escape reflex in lake sturgeon was one quarter that of larval fish (Wishingrad et al. 2014). Only juvenile and adult shortnose and Atlantic sturgeon occur in marine waters and these life stages have few predators but may require an intact escape reflex to avoid vessel strikes (NMFS 2022d; SSSRT 2010). The plotted risk quotients for the effects of cadmium on saltwater invertebrates include growth and development, reproduction, behavior, population productivity, and mortality responses.

While the bulk of the invertebrate data indicate responses occurring above criterion limits, risk quotients representing LC50s for amphipod (Rhepoxynius abronius, Meador 1993), daggerblade grass shrimp and mud crab (Rhithropanopeus harrisii and Palaemonetes pugio, respectively, Thorpe 1990), harpacticoid copepod (Forget et al. 1998), opossum shrimp (Mysidopsis bahia, Nimmo et al. ; Roberts et al. 1982; Voyer and Modica 1990; Ward 1989), and rock crab (Cancer productus, Johns and Gentile 1981) indicate that mortality will occur at concentrations below the saltwater acute criterion. Effects within the chronic criterion limits are also indicated by risk quotients representing reproduction LOECs for sea urchin (Paracentrotus lividus, Arizza et al. 2009; Jonczyk et al. 1991), growth and development of cuttlefish (Sepia officinalis, Lacoue-Labarthe et al. 2010) and daggerblade grass shrimp (Manyin and Rowe 2009) and reproduction and population stability of *Moina monogolica* (Wang et al. 2009).

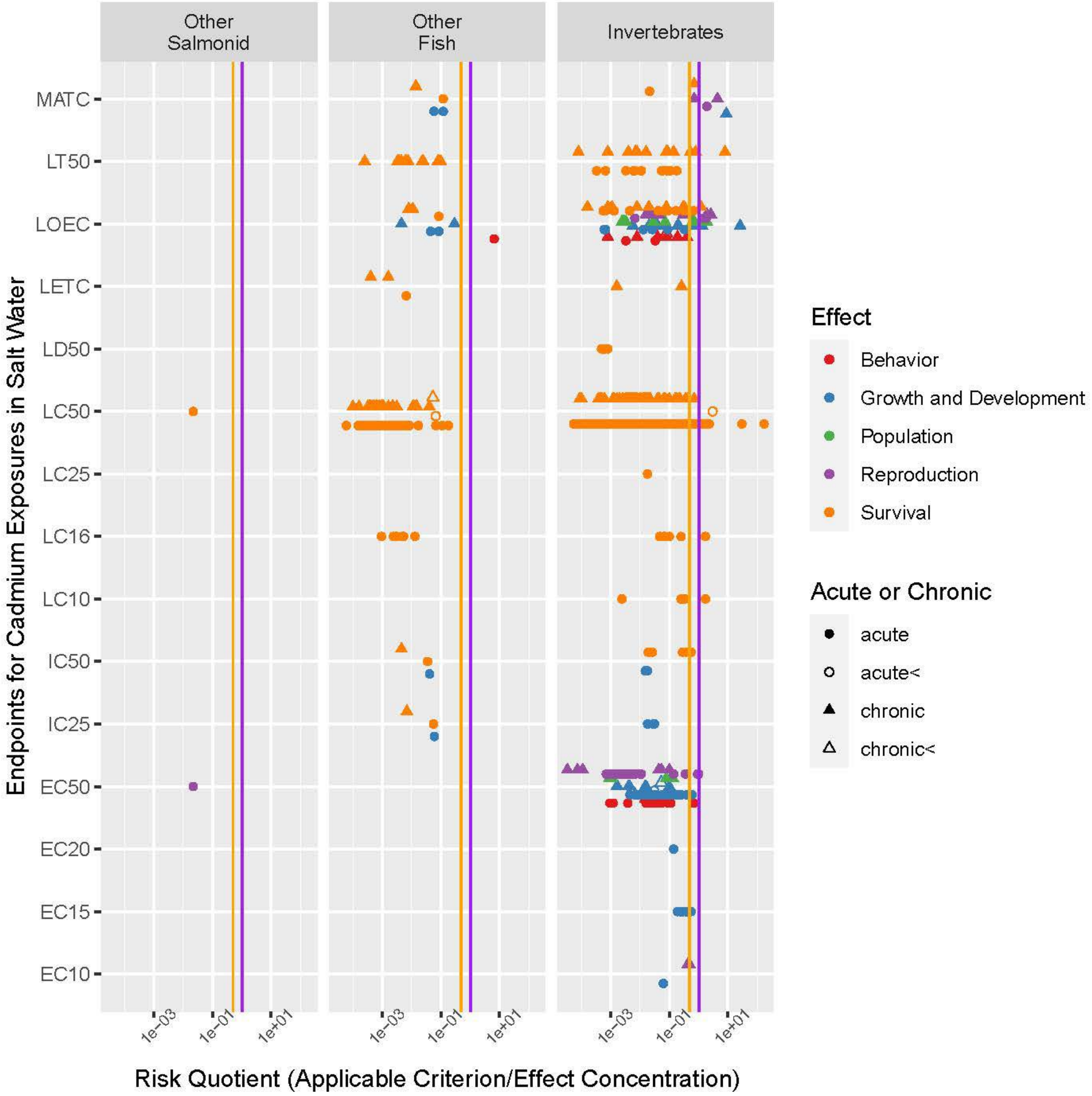

Figure 17. Distribution of Risk Quotients for Saltwater Exposures to Cadmium in Context of Reference Lines Representing the Applicable Criterion (Purple) and One-Half the Applicable Criterion (Orange).

Only adult and juvenile sturgeon occur in marine waters, so larger prey items that would be consumed are of interest: mollusks, gastropods, polychaetes, crabs, oysters, and mussels (excluding larval stages). The risk quotients for effects (i.e., excluding NOECs) in species likely to be consumed by adult and juvenile sturgeon ranged from less than 0.001 to 0.44, with 85% of risk quotients below 0.05.

NMFS concludes that EPA's approval of DNREC and MDE's adoption of the acute and chronic saltwater National Criteria for cadmium may affect, but is not likely to adversely affect shortnose sturgeon, the Chesapeake or New York, Bight DPSs of Atlantic sturgeon or migrating and foraging Gulf of Maine, Carolina, or South Atlantic DPSs of Atlantic sturgeon because responses in surrogate species are extremely unlikely to occur such that effects are expected to be discountable in ESA-listed sturgeon.

NMFS also concludes that the exposure of forage species to cadmium within the saltwater criteria limits is not likely to adversely affect the quantity and quality of prey available to ESA-listed sturgeon because they consume a wide range of invertebrate taxa and the criteria were derived to protect aquatic life based on the fifth centile of sensitive genera. The criteria are also implemented under conservative exposure durations and frequencies (i.e., the acute criterion is a one-hour average derived from four-day tests and the chronic criterion is a four-day average).

8.3.3 Risk of Cadmium Exposures within Criteria Limits

This risk analysis evaluates the consequences of effects in individuals to the populations those individuals represent, and the species those populations comprise. Thus far this Opinion concluded that exposures to cadmium within the acute and chronic freshwater criteria limits are likely to adversely affect individual shortnose and Atlantic sturgeon (Section 8.2.2.1), but not the quantity and quality of their forage species (Section 8.2.2.2). Meanwhile Section 8.2.2.3 concluded that exposures to cadmium within the acute and chronic saltwater criterion limits are not likely to adversely affect individual shortnose or Atlantic sturgeon or the quantity and quality of forage species. Therefore, this risk analysis section addresses the population level risk posed by freshwater exposures of shortnose and Atlantic sturgeon to cadmium within criteria limits.

SURVIVAL

Although the risk quotients for white sturgeon survival, growth and development LOECs and MATCs indicate responses at exposures above cadmium acute criterion and chronic criterion limits, the magnitude of the responses at the MATCs and LOECs suggest that exposures of shortnose sturgeon and Atlantic sturgeon to cadmium within the acute criterion and chronic criterion limits would result in mortality and reduced growth. In addition, within genus comparability of sensitivity to toxicants is not always consistent (see discussion in 2.2.2). NMFS considers rainbow trout to be a suitable surrogate and data from multiple sources indicate mortality in early-life-stage fish exposed to cadmium within both the acute and chronic criterion limits. While data are not available to perform a population viability analysis for ESA-listed sturgeon populations, these data are important because the viability of these populations are highly sensitive to juvenile mortality resulting in lower numbers of sub-adults recruiting into the adult breeding population (ASSRT 2007; NMFS 1998a).

GROWTH AND DEVELOPMENT

Growth is an important determinant of survival, and thus recruitment into the reproductive population (Anderson 1988; Poletto et al. 2018). Significant effects of cadmium on growth was reported to occur within criterion limits, but was temperature dependent (Mebane et al. 2008b). The white sturgeon studies did not evaluate the effect of temperature on cadmium toxicity. The studies comparing white sturgeon to rainbow trout ran toxicity tests at each species' optima, 15+/-1 degrees Celsius for sturgeon and 12+/-1 degrees Celsius for trout (Calfee et al. 2014; Ingersoll et al. 2014; Wang et al. 2014). The test in the Mebane et al. (2008b) study reporting rainbow trout growth effects within criteria limits was conducted at 12.5 degrees while the tests conducted at 9.8 degrees Celsius had LOECs resulting in risk quotients of 0.03 and 0.07. With increasing temperatures expected under climate change (IPCC 2021), NMFS expects that cadmium exposures within chronic criterion limits may impair growth of early life stage and juvenile shortnose and New York Bight and Chesapeake DPS of Atlantic sturgeon spawned and rearing in Delaware and Maryland waters. Exposures are not expected to be significant for juvenile and adult New York Bight and Chesapeake DPS of Atlantic sturgeon and migrating and foraging adult and juvenile members of the Gulf of Maine, Carolina, and South Atlantic DPSs of Atlantic sturgeon.

REPRODUCTION

Data for the effects of cadmium on reproduction in sturgeon and salmonid species are not available. Data for other fish species do not indicate effects on reproduction within cadmium criteria limits. While reproduction is critical to population persistence, fish must first survive and grow in order to reproduce. Given that cadmium exposures within criteria limits are expected to adversely affect early-life-stage survival and growth, it is reasonable to expect that these effects will, in turn reduce recruitment of reproductive fish.

8.3.4 Likely to Adversely Affect Determination for EPA Approval of DNREC and MDE's Adoption of Freshwater Cadmium Criteria

NMFS concludes that EPA's approval of DNREC and MDE's adoption and implementation of the National Recommended Water Quality Criteria for chronic exposure to cadmium in freshwater is likely to adversely affect shortnose sturgeon and the Chesapeake and New York DPSs of Atlantic sturgeon because:

1. Permitting and monitoring of regulated waters indicate that exposures to cadmium will occur;

2. The toxicity of cadmium in surrogate species indicate that exposures within criteria limits will likely result in adverse effects to the survival and fitness of early-life-stage shortnose and Atlantic sturgeon;
3. With increasing temperatures under climate change (IPCC 2021), temperature-dependent effects of cadmium exposure on growth in surrogate species indicates that exposures within criteria limits are likely to affect growth of shortnose sturgeon and Atlantic sturgeon; and
4. The viability of ESA-listed sturgeon populations is highly sensitive to juvenile mortality resulting in lower numbers of sub-adults recruiting into the adult breeding population (NMFS 1998a, ASSRT 2007).

Migrating and foraging Gulf of Maine, Carolina, and South Atlantic DPSs of Atlantic sturgeon may be affected, but are not likely to be adversely affected, by exposures in Sturgeon Waters of Delaware and Maryland to cadmium within the freshwater chronic cadmium criterion limits because their exposures to freshwaters within both states are expected to be brief. Further adult and juvenile life stages are expected to be less sensitive to cadmium's effects than rapidly growing and developing larvae.

9 CUMULATIVE EFFECTS

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

The future intensity of specific non-Federal activities in the action area is influenced by the difficult-to-predict future economy, funding levels for restoration activities, and individual investment decisions. In addition, the need for communities to adapt to climate change and recover from severe climatic events will influence how wetlands, inland surface waters, and coastal areas are managed. Due to their additive and long-lasting nature, the adverse effects of non-Federal activities that are stimulated by general resource demands and driven by changes in human population density and standards of living, are likely to compound in the future. Specific human activities that may contribute to declines in the abundance, range, and habitats of ESA-listed species in the action area include the following: urban and suburban development, shipping, infrastructure development, water withdrawals and diversion, recreation (including off-road vehicles and boating), and expansion of agricultural and grazing activities (including alteration or clearing of native habitats for domestic animals or crops), and introduction of non-native species which can alter native habitats, out-compete or prey upon native species.

Activities that degrade water quality will continue into the future. These include conversion of natural lands, land use changes from low impact to high impact activities, increases in impervious cover (e.g., Section 6.5), water withdrawals, effluent discharges, the progression of climate change, the introduction of nonnative invasive species, and the introduction of contaminants and pesticides. In particular, many nonpoint sources of pollution, which are not subject to Clean Water Act NPDES permit and regulatory requirements, have proven difficult for states to monitor and regulate. Nonpoint source pollution has been linked to loss of aquatic species' diversity and abundance, fish kills, seagrass bed declines, and toxic algal blooms (Gittings et al. 2013). Nonpoint sources of pollution are expected to increase as the human population continues to grow. Given the challenges of monitoring and controlling nonpoint source pollution and accounting for all the potential stressors and effects on listed species, chronic stormwater discharges will continue to result in aggregate impacts.

9.1 Climate Change

Climate change is discussed in both the environmental baseline section of this Opinion and in the cumulative effects because it is a current and ongoing circumstance that, for the most part, is not subject to consultation, yet influences environmental quality in the action area currently and in the future. As climate change proceeds, precipitation rates will increase by five to ten percent in Delaware and Maryland. The Chesapeake Bay area is the third most vulnerable area of the United States to sea level rise, behind Louisiana and South Florida (Runkle et al. 2022b). The foremost impacts of sea level rise on both states include more frequent and severe coastal flood events, increased shore erosion, resulting in unmanaged pollutant discharges and redistribution of legacy pollutants in sediments, inundation of wetlands and low-lying lands, and saltwater intrusion into groundwater (Runkle et al. 2022a; Runkle et al. 2022b). The rise on Delaware's coasts has been greater due to land subsidence (Runkle et al. 2022a).

10 INTEGRATION AND SYNTHESIS

The *Integration and Synthesis* section is the final step in our assessment of the risk posed to species and critical habitat because of implementing the action. In this section, we add the *Effects of the Action* (Section 8) to the *Environmental Baseline* (Section 6) and the *Cumulative Effects* (Section 9) to formulate the agency's biological opinion as to whether the action is likely to reduce appreciably the likelihood of both the survival and recovery of a ESA-listed species in the wild by reducing its numbers, reproduction, or distribution. This assessment is made in full consideration of the *Status of the Species Likely to be Adversely Affected by the Action* (Section 5.2). Populations that occur in the Sturgeon Waters within Delaware and Maryland are of primary concern for this action.

Some ESA-listed species and critical habitat are located within the action area but the effects of the action on these ESA resources were determined to be insignificant or discountable and thus not likely to adversely affect these resources. Some exposures and responses evaluated individually (e.g., exposure of Sei whale to affected waters, responses of invertebrates within the saltwater cadmium criterion limit) were determined to have insignificant effects or discountable effects and thus to be not likely to adversely affect some ESA-listed species and critical habitat (Sections 5.1 and 8).

The following discussions provide an overview of the findings of this Opinion and a Jeopardy Analysis that summarizes the probable risks the action poses to shortnose surgeon and the Atlantic sturgeon New York Bight and Chesapeake Bay DPSs in the action areas and migrating and foraging Atlantic sturgeon Gulf of Maine, Carolina, and South Atlantic DPSs. These summaries integrate the exposure profiles presented previously with the results of our response and risk analyses (Section 8) for each of the water quality criteria considered further in this Opinion.

10.1 Overview

This Opinion concludes that EPA approval of DNREC and MDE's adoption and implementation of Nationally Recommended Freshwater Criteria for cadmium is likely to adversely affect early life stage and young of year shortnose sturgeon and the Chesapeake DPS of Atlantic sturgeon that may spawn within Delaware and Maryland rivers. The viability of ESA-listed sturgeon populations in Delaware and Maryland waters is highly sensitive to juvenile mortality resulting in lower numbers of sub-adults recruiting into the adult breeding population (NMFS 1998a, ASSRT 2007).

For example, poor water quality in these rivers contributes to the stressor scores for shortnose sturgeon (Section 5.2.2). If sufficient up to date monitoring data on cadmium in Sturgeon Waters were available, it could indicate whether baseline conditions attenuate the concern that the criteria concentrations are not sufficiently protective. When revised criteria are more protective than those currently applied to discharge permits, and rigorous monitoring information indicates that baseline instream concentrations are below effects thresholds, then it is reasonable to expect more stringent criteria applied to permits would not result in exposures above those thresholds. In the absence of adequate monitoring information, NMFS takes a conservative approach and gives the species the benefit of the doubt.

Current water quality impairments with TMDLS in Sturgeon Waters are attributed to organic chemicals, DO, habitat metrics, and nutrients (Section 6.2). Exposures of shortnose and Atlantic sturgeon to cadmium are likely to occur through stormwater runoff and discharges from facilities that use either these metals or treat waste containing these metals. Under section 402 of the Clean Water Act, an NPDES permit will require monitoring for substances if there is a reasonable potential that the discharge would result in pollutant levels that would impair the designated use of the receiving water (40 CFR 122.44(d)(1)). Permitting decisions are made on an individual basis and aggregate impacts of discharge authorizations are only considered when an impairment is identified.

EPA's approval of criteria will be implemented by DNREC and MDE's NPDES programs. EPA delegated the authority to implement the Clean Water Act NPDES program to both states; however, the memorandum of agreement for each state does not incorporate measures that satisfy EPA's obligations under the ESA. In addition, those memoranda of agreement between EPA Regions and delegated states that include ESA measures only allows for review of individual permits potentially affecting ESA-listed species. Criteria are in place indefinitely and are applied to multiple sources within a watershed. Thus, there is an aggregate impact to EPA's approval, and a delegated state's implementation, of the criteria that is not addressed by existing mechanisms.

In the absence of rigorus monitoring information, water quality data collected *after* implementation of revised criteria may or may not indicate actual instream concentrations below effects thresholds. Often the constituents monitored for are selected based on what is likely to be present given local land usage and industries. For example, if sampling in the Everglades, one might monitor for nutrients and sugarcane pesticides, but not industrial chemicals. Sources for cadmium exist along Sturgeon Waters.

The analyses in section 8.3.2 establish that early-life-stage shortnose sturgeon and Atlantic sturgeon are likely to be exposed to cadmium in Delaware and Maryland Sturgeon Waters and that adverse effects are expected to occur in early-life-stage individuals exposed to these metals within their respective criteria limits. The majority of the monitoring data are historical or may not reflect current conditions because the practical quantitation limits are too high to detect cadmium in freshwater within the chronic criterion limits.

10.2 Jeopardy Analysis

The jeopardy analysis relies upon the regulatory definition of to "jeopardize the continued existence of" a listed species, which is "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 C.F.R. §402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species, by focusing on effects to reproduction, numbers, and distribution.

10.2.1 Shortnose Sturgeon

Whether the potential effects to reproductive output would appreciably reduce the likelihood of survival of shortnose sturgeon in the wild depends on the probable effect the changes in reproductive output would have relative to current population sizes and trends. The most recent population estimates available for the species indicate that the largest shortnose sturgeon adult populations are found in the northeastern rivers.

Shortnose sturgeon occur throughout the Delaware River estuary and occasionally enter the nearshore ocean off Delaware Bay. In spring, spawning adults occur in the non-tidal river and are common at least as far upstream as Scudders Falls. Acoustic tagging studies have indicated that the lower portion of the river, below Wilmington, is used for over wintering. Studies also demonstrated that shortnose sturgeon may migrate between the upper tidal river and the Chesapeake and Delaware Canal. The current distribution of shortnose sturgeons in the Chesapeake Bay is unknown as there is limited data regarding their distribution (SSSRT 2010), and there is no information available for shortnose sturgeon foraging areas in the Chesapeake Bay. A study by Niklitschek (2001) indicated via modeling that suitable foraging habitat during the summer months is limited to the upper tidal portions of the upper Bay, the Potomac, and the James rivers. The Potomac River is considered to be tidally influenced up to the Chain Bridge which lies just 2 km upstream of the suspected spawning area at Fletcher's Marina. Two late-stage females were captured and tracked within the Potomac, however only one was observed to make an apparent spawning migration in the spring (2005 – 2007, SSSRT 2010). Annual movements of shortnose sturgeon in the Potomac River seem typical of north-central adults. Both of the tracked female sturgeon remained in freshwater for at least one year with pre-spawning migration occurring in spring. Shortnose sturgeon that are found within the Chesapeake Bay may be migrants from the Delaware River. There are neither current or historical records of shortnose sturgeon spawning in the Susquehanna River. Shortnose sturgeon in the Susquehanna River would likely utilize the Chesapeake Bay for foraging (SSSRT 2010). Shortnose sturgeon are also known to move upriver and seek deep, channel-like habitats for overwintering and anecdotal reports of congregations of sturgeon found in deep holes near Lapidum and Perrysbille could indicate habitat utilization for overwintering and resting within the Susquehanna, however none has been confirmed (SSSRT 2010).

The 1998 recovery plan identifies 19 population segments within their range with a goal of each segment maintaining a minimum population size to maintain genetic diversity and avoid extinction (NMFS 1998a). Even though shortnose sturgeon were listed under the ESA over 50 years ago, population dynamics and distribution data are lacking for many population segments. A range-wide genetic assessment and reliable estimates of population size, age structure, and recruitment are needed to review the status of each population segment. The recovery tasks for the Delaware River shortnose sturgeon population segment that are relevant to the impacts of the action include analyzing contaminant loads in sturgeon tissue and habitat, determining effects of contaminants on sturgeon fitness, and identifying contaminant sources and reducing contaminant loading. These are classified as Priority 2 tasks, which are actions "that must be taken to prevent a significant decline in population numbers, habitat quality, or other significant negative impacts short of extinction" (NMFS 1998a). These tasks are not flagged for the Chesapeake population segment.

Based on the evidence available, including the Environmental Baseline, Effects of the Action, and Cumulative Effects, effects resulting from EPA approval of the freshwater cadmium criterion would not be expected to appreciably reduce the likelihood of the survival of shortnose sturgeon in the wild by reducing the reproduction, numbers, or distribution of these populations. We also conclude that effects from EPA's approval of the cadmium criterion would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of shortnose sturgeon in the wild by reducing the reproduction, numbers, or distribution of these populations.

10.2.2 Atlantic Sturgeon

Whether the potential effects to reproductive output would appreciably reduce the likelihood of survival of the Chesapeake and New York Bight DPSs of Atlantic sturgeon in the wild depends on the probable effect the changes in reproductive output would have relative to current population sizes and trends.

In the absence of quantitative population estimates of Atlantic sturgeon DPSs, the Atlantic States Marine Fisheries Commission considers qualitative criteria such as the appearance of Atlantic sturgeon in rivers where they were not documented in recent years, discovery of spawning adults in rivers they had not been documented in before, and increases in anecdotal interactions. Kahn et al. (2019) proposed the following ranking of qualitative evidence of Atlantic sturgeon spawning:

Confirmed spawning:

1. Recently spawned-out female still releasing nonviable eggs in freshwater in the presence of milting males;
2. spawning female (actively releasing viable eggs in freshwater in the presence of milting males);
3. presence of eggs to 180 d post-hatch fish.

Near certain spawning;

1. Juveniles under 400 millimeters FL in fresh- water or low-salinity areas;
2. gravid female in upstream freshwater (at least 15 km upstream of the freshwater/ saltwater interface).

Possible Spawning;

1. Milting male in upstream freshwater.

Uncertain spawning;

1. Capture of adult in any condition in lower freshwater (near salinity interface);
2. Telemetry detection of adult female in unknown reproductive stage in freshwater.

Uninformative Evidence;

1. Telemetry detection of adult male in unknown sexual condition in upstream or lower freshwater.

Qualitative metrics can be the result of increased research and attention, not a true increase in abundance (ASMFC 2017a). Both the New York Bight and Chesapeake Bay DPSs of Atlantic sturgeon are considered depleted and are highly vulnerable to climate change due to their low likelihood to change distribution in response to current global climate change. They will also be exposed to effects of climate change on estuarine habitat such as changes in the occurrence and abundance of prey species in currently identified key foraging areas (NMFS 2022b; NMFS 2022d).

Atlantic sturgeon are considered in danger of extinction in Maryland and Delaware. The Chesapeake Bay DPS's risk of extinction is "High" because of its low productivity (e.g., relatively few adults compared to historical levels and irregular spawning success), low abundance (e.g., only three known spawning populations and low DPS abundance, overall), and limited spatial distribution (e.g., limited spawning habitat within each of the few known rivers that support spawning). There is also new information indicating genetic bottlenecks as well as low levels of inbreeding. The New York Bight DPS's demographic risk is also "High" for the the same reasons. Similarly, recent information indicates genetic bottlenecks as well as low levels of inbreeding within the Hudson and Delaware spawning populations.

The portion of the Delaware River and Bay that is available to Atlantic sturgeon extends from the Delaware Bay to the fall line at Trenton, a distance of 140 rkm. There are no dams within this reach of the river. Thus, the entirety of the river is accessible, however habitat suitability is unknown due to river augmentation and water quality issues. Historical spawning records indicate that Atlantic sturgeon spawned in two areas of the Delaware River, both sites outside of the action area.

Based on the evidence available, including the Environmental Baseline, Effects of the Action, and Cumulative Effects, effects resulting from EPA approval of the freshwater cadmium criterion would not be expected to appreciably reduce the likelihood of the survival of the New York Bight or Chesapeake Bay DPSs of Atlantic sturgeon in the wild by reducing the reproduction, numbers, or distribution of these populations. We also conclude that effects from EPA's approval of the cadmium criterion would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of New York Bight or Chesapeake Bay DPSs of Atlantic sturgeon in the wild by reducing the reproduction, numbers, or distribution of these populations.

11 CONCLUSION

After reviewing the current status of the ESA-listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is NMFS's biological opinion that the action is likely to adversely affect, but is not likely to jeopardize the continued existence of shortnose sturgeon or the Chesapeake Bay or New York Bight DPSs of Atlantic sturgeon.

12 INCIDENTAL TAKE STATEMENT

ESA section 9 of the ESA and Federal regulations pursuant to section 4(d) prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct (16 U.S.C. §1532(19)). Harm is further defined by regulation to include significant habitat modification or degradation that results in death or injury to ESA-listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering (see 50 CFR § 222.102).

Incidental take is defined as take that results from, but is not the purpose of, carrying out an otherwise lawful activity (see 50 CFR §402.02). Section 7(b)(4) of the ESA requires that when a proposed agency action is found to be consistent with section 7(a)(2) of the ESA and the proposed action may incidentally take individuals of ESA-listed species, NMFS will issue a statement that specifies the impact of any incidental taking of endangered or threatened species. Sections 7(b)(4) and 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking if that action is performed in compliance with the terms and conditions of this incidental take statement.

Exposures of shortnose sturgeon and Chesapeake Bay and New York Bight DPSs to cadmium within chronic criteria limits in the action area is reasonably certain to result in incidental take due to the reductions in survival of early life stage fish and fitness of these species.

12.1 Amount or Extent of Take

Section 7 regulations require NMFS to specify the impact of any incidental take of endangered or threatened species; that is, the amount or extent, of such incidental taking on the species (50 CFR §402.14(i)(1)(i)). The amount of take represents the number of individuals that are expected to be taken by the proposed action. The extent of take represents the "extent of land or marine area that may be affected by an action" and may be used if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (51 FR 19953).

Where it is not practical to quantify the number of individuals that are expected to be taken by the action, a surrogate (e.g. similarly affected species or habitat or ecological conditions) may be used to express the amount or extent of anticipated take (50 CFR §402.14(i)(1)(i)). To use a surrogate we must describe the causal link between the surrogate and take of the listed species, explain why it is not practical to express the amount or extent of anticipated take or to monitor take-related impacts in terms of individuals of the listed species, and set a clear standard for determining when the level of anticipated take has been exceeded

Incidental take under the cadmium chronic criterion cannot be accurately quantified or monitored as a number of individuals because the action area includes all waters of Delaware and Maryland. Data do not exist that would allow us to quantify how many individuals of each species and life stage exist in affected waters, considering that the numbers of individuals vary with environmental conditions, and changes in population size due to recruitment and mortality, and in the case of Atlantic sturgeon, emigration from other populations. In addition, currently we have no means to detect or determine which impairments to reproduction, development, and growth are due to the water quality within criteria limits versus other natural and anthropogenic environmental stressors.

Further, NMFS cannot precisely predict the number of shortnose sturgeon and Atlantic sturgeon that are reasonably certain to demonstrate behavioral and injurious effects due to the presence of cadmium within criteria limits. Also, there is no feasible way to count, observe, or determine the number of individuals of each species that would be affected by exposures because the effects of the action will occur over a large geographic area and effects may occur in areas where animals are not likely to be observed due to water depth. Even if affected animals are observed, it is unlikely that the exact cause of injury, mortality or behavioral effects could be determined.

Because we cannot quantify the amount of take, we will use the regulatory application of the criteria in setting permitting and TMDL limits and identifying water quality impairments as a measure reflecting the potential for harmful exposures to cadmium for the extent of authorized take as a surrogate for the amount of authorized take. Take would be exceeded if receiving waters for sources discharging cadmium are found to be impaired by cadmium even though permitted sources are complying with discharge limits and the impairment can not be attributed solely to nonpoint sources. This suggests that other permitted sources discharging to the water body should have been assigned permit limits for cadmium. Take may also be exceeded if cadmium within criteria limits is identified as a contributing causal agent for impairment of an aquatic assemblage sensu Spehar and Fiandt (1986).

For the reasons discussed above, the specified amount or extent of incidental take of ESA-listed shortnose and Atlantic sturgeon species requires that DNREC and MDE’s intended level of protection is met, as confirmed through the terms and conditions specified in this incidental take statement. The amount or extent of incidental take applies only to exposures when waters are monitored using sufficiently sensitive analytical methodology as defined in the 122.44(i)(1)(iv) of the Clean Water Act. Effects of the action could manifest later in time. Discharge limits are determined using sufficiently sensitive analytical methodology. If sufficiently sensitive analytical methodology is not applied, it will be not possible to confirm whether DNREC and MDE’s intended level of protection is met. NMFS expects that, upon identification, Delaware, Maryland,

and EPA will address any noncompliance with 40 CFR 136. This reflects DNREC, MDE's and EPA's intended level of protection for aquatic life and ensures that exceedances will be detected and addressed, thereby minimizing take.

12.2 Reasonable and Prudent Measures

"Reasonable and prudent measures" are measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take. (50 CFR 402.02). NMFS believes the RPMs described below are necessary and appropriate to minimize the impacts of incidental take on threatened and endangered species resulting from exposure to cadmium within the freshwater chronic criterion limits:

1. EPA Region 3, Water Division will work within its authorities to ensure that the implementation of water quality standards for cadmium adopted by Maryland and Delaware minimize aggregate adverse effects to ESA-listed species and designated critical habitat under NMFS's jurisdiction.
2. EPA Region 3 will ensure that persons applying EPA-approved standards in regulatory actions and those who are subject to regulations applying EPA-approved standards are aware of the prohibition of take of ESA-listed species under section 9 of the ESA and where ESA-listed species under NMFS's jurisdiction occur.

12.3 Terms and Conditions

In addition to RPMs, section 7(b)(4) of the ESA requires the Services to identify terms and conditions (including, but not limited to reporting requirements) that must be complied with by the Federal agency or applicant, or both, to implement the RPMs. Only incidental take resulting from the agency actions that is in compliance with the terms and conditions identified in the incidental take statement are exempt from the taking prohibition of section 9(a), pursuant to section 7(o) of the ESA. Therefore, to be exempt from the ESA prohibitions of take, the EPA must comply with the following terms and conditions, which implement the RPMs described above. These include the take minimization, monitoring and reporting measures required by the section 7 regulations (50 C.F.R. § 402.14(i)). As stated above, these terms and conditions are non-discretionary in order for the EPA to be exempt from the ESA prohibition against take. If EPA fails to ensure compliance with these terms and conditions and their implementing reasonable and prudent measures, the protective coverage of section 7(o)(2) may lapse.

TERMS AND CONDITIONS FOR RPM 1:

In order to be exempt from the prohibitions of section 9 of the ESA, the Federal action agency must comply with the following terms and conditions. The EPA Region 3, Water Division shall achieve RPM 1 by providing guidance to DNREC and MDE on use of the revised criteria in NPDES permits for new sources and existing NPDES permits upon renewal, by encouraging monitoring to identify and address impairments, and by participating in sustained attention to water quality within waters where Atlantic and shortnose sturgeon occur. Specifically:

The EPA Water Division will notify the MDE, DNREC, and EPA-Region 3 NPDES Permit Branch of: 1) updated water quality criteria for cadmium, and 2) the importance of compliance with permit limits based on such criteria in all NPDES permits, including general permits, to protect threatened and endangered species, including the Atlantic and shortnose sturgeon.

1) EPA Guidance to MDE and DNREC:
    a) EPA will strongly encourage MDE and DNREC to monitor cadmium in areas where ESA-listed Atlantic and shortnose sturgeon occur.
    b) If EPA becomes aware of new information that indicates revisions to criteria subject to this consultation may be necessary to protect threatened and endangered species, EPA will work with Maryland and Delaware regulatory authorities to revise water quality standards or take other actions, as appropriate.
2) Baseline Water Quality Review
    a) Within six months of the signature of the Biological Opinion, EPA will collaborate with NMFS on the development of a baseline water quality condition review for those stressors addressed in this consultation in waters where Atlantic and shortnose sturgeon occur.
    b) Thereafter, EPA will meet with NMFS at least biennially, for at least a period of six years, but not to exceed a period of 12 years, to review water quality conditions for those stressors addressed in this consultation potentially affecting Atlantic and shortnose sturgeon and discuss changes in water quality, gaps in information regarding water quality, and approaches to resolving those gaps.

TERMS AND CONDITIONS FOR RPM 2:

EPA Region 3 Water Division will support other EPA Region 3 branches applying EPA-approved criteria subject to this consultation in providing notice of EPA's obligations under the ESA in its communications, as appropriate, including, but not limited to, 303(c) decision letters, NPDES permit reviews and decisions, permit application materials, training, and/or informational websites. Such notice shall contain the following:

1) Section 7(a)(2) of the ESA requires Federal agencies to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated and proposed critical habitat.
2) Take of ESA-listed endangered species is prohibited under section 9 of the ESA, and these prohibitions apply to all individuals, organizations, and agencies subject to United States

jurisdiction. These take prohibitions have also been extended to the Gulf of Maine DPS of Atlantic Sturgeon under section 4(d) of the ESA (50 CFR §223.211).

a) "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct 16 U.S.C. 1532(19). "Harm" for purposes of the ESA is further defined by regulation to mean "an act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including, breeding, spawning, rearing, migrating, feeding or sheltering" 50 CFR §222.102.

3) Endangered shortnose sturgeon, threatened Gulf of Maine Atlantic sturgeon, and the endangered New York Bight, Chesapeake Bay, South Atlantic, and Carolina DPSs of Atlantic sturgeon may spawn, migrate, and forage within accessible inland rivers, estuaries, and coastal waters from Canada to Florida. The species may occur in the following waters of Maryland: Anacostia River, Chesapeake Bay, Choptank River, C&D Canal, Nanticoke River including Marshyhope Creek, Patuxent River, Pocomoke River, Potomac River, St. Marys River, Susquehanna River, and Wicomico River and waters of Delaware: Chesapeake Bay, Delaware Bay, Delaware River including C&D canal, and Nanticoke River including Broad Creek. Poor water quality is among the most significant threats to the species due to harm to offspring development. Sensitive early life stages may occur in the following waters of Maryland: Potomac River and Nanticoke River, including Marshyhope Creek and Delaware: Chesapeake Bay, Delaware Bay, Delaware River including C&D canal, and Nanticoke River, including Broad Creek.

12.4 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on ESA-listed species or critical habitat, to help implement recovery plans or develop information (50 C.F.R. § 402.02).

1) Actions or measures that could also minimize or avoid adverse effects of adopted freshwater chronic cadmium criterion on ESA-listed sturgeon species under NMFS's jurisdiction include:

2) Revise the Memoranda of Agreement with the states of Delaware and Maryland to include measures that support EPA's obligations under the ESA.

3) Coordinate with nationally recognized sturgeon experts from government and academic institutions to close gaps in our understanding of the effects of cadmium on the biology, ecology, and recovery of shortnose and Atlantic sturgeon.

4) Coordinate with state and Federal agencies that carry out water quality monitoring in waters where sturgeon occur or could reestablish to sample and analyze for cadmium where sources occur or are suspected.
5) Use information gained in items 3) and 4) above, along with up-to-date toxicity data, to determine whether sturgeon are at risk from exposure to ammonia, cadmium, or nonylphenol.
6) If the analysis in item 5) above indicate species are currently at risk or may be at risk in the future, coordinate with private, state, and Federal stakeholders to develop and implement actions that minimize or prevent such risks.
7) Collaborate with NMFS on the development of a baseline water quality condition tool for all stressors in waters, including ammonia and nonylphenol, where Atlantic and shortnose sturgeon occur. Periodically review water quality conditions potentially affecting Atlantic and shortnose sturgeon and discuss changes in water quality, gaps in information regarding water quality, and approaches to resolving those gaps.
8) In order for the NMFS Office of Protected Resources ESA Interagency Cooperation Division to be kept informed of actions minimizing or avoiding adverse effects on, or benefiting, ESA-listed species or their critical habitat, EPA should notify the ESA Interagency Cooperation Division of any conservation recommendations they implement in their final action.

12.5 Reinitiation Notice

This concludes consultation on EPA approval of water quality standards proposed in 2023 by the states of Delaware and Maryland. Consistent with 50 CFR §402.16(a), reinitiation of formal consultation is required and shall be requested by the Federal agency, where discretionary Federal involvement or control over the action has been retained or is authorized by law and:

1. The amount or extent of taking specified in the incidental take statement is exceeded;
2. New information reveals effects of the agency action that may affect ESA-listed species or critical habitat in a manner or to an extent not previously considered;
3. The identified action is subsequently modified in a manner that causes an effect to the ESA-listed species or critical habitat that was not considered in this Opinion; or
4. A new species is listed or critical habitat designated under the ESA that may be affected by the action.

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