National Marine Fisheries Service Endangered Species Act (ESA) Section 7(a)(2) Biological and Conference Opinion

Consultation on Fisheries Research Conducted and Funded by the Northwest Fisheries Science Center, and Issuance of ESA Section 10(a)(1)(A) Scientific Research Permits in the West Coast Region Pursuant to those Research Activities

NMFS Consultation Number: *WCRO-2023-01601*

Action Agency: The National Marine Fisheries Service (NMFS) (including NMFS' Northwest Fisheries Science Center and West Coast Region)

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?[1]	Is Action Likely to Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?[1,2]	Is Action Likely to Destroy or Adversely Modify Critical Habitat?[2]
Marine Mammals					
Blue whale (*Balaenoptera musculus*)	Endangered	No	No	NA	NA
Fin whale (*Balaenoptera physalus*)	Endangered	No	No	NA	NA
Humpback whale, Mexico DPS (*Megaptera novaeangliae*)	Threatened	No	No	No	No
Humpback whale, Central America DPS	Endangered	No	No	No	No
Sei whale (*Balaenoptera borealis*)	Endangered	No	No	NA	NA
Sperm whale (*Physeter macrocephalus*)	Endangered	No	No	NA	NA
Killer whale, Southern Resident DPS (*Orcinus orca*)	Endangered	No	No	No	No
Gray whale, western North Pacific DPS (*Eschrichtius robustus*)	Endangered	No	No	NA	NA
Guadalupe fur seal (*Arctocephalus townsendi*)	Threatened	No	No	NA	NA
Steller sea lion, Eastern DPS (*Eumetopias jubatus*)	Delisted[3]	NA	NA	No	No
Sea Turtles					

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?[1]	Is Action Likely to Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?[1,2]	Is Action Likely to Destroy or Adversely Modify Critical Habitat?[2]
Leatherback turtle (*Dermochelys coriacea*)	Endangered	Yes	No	No	No
Loggerhead turtle, North Pacific Ocean DPS (*Caretta caretta*)	Endangered	Yes	No	NA	NA
Olive ridley (*Lepidochelys olivacea*)	Endangered/ Threatened	Yes	No	NA	NA
Green, East Pacific DPS (*Chelonia mydas*)	Threatened	Yes	No	NA	NA
Marine and Anadromous Fish					
Puget Sound (PS) Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No
PS steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Hood Canal summer-run (HCS) chum salmon (*O. keta*)	Threatened	Yes	No	No	No
Ozette Lake (OL) sockeye salmon (*O. nerka*)	Threatened	Yes	No	No	No
Upper Columbia River (UCR) spring-run Chinook salmon (*O. tshawytscha*)	Endangered	Yes	No	No	No
Upper Columbia River (UCR) steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Middle Columbia River (MCR) steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Snake River (SnkR) spring/summer-run (spr/sum) Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No
Snake River (SnkR) fall-run Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No
Snake River (SnkR) steelhead (*O. mykiss*)	Threatened	Yes	No	No	No

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?[1]	Is Action Likely to Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?[1,2]	Is Action Likely to Destroy or Adversely Modify Critical Habitat?[2]
Snake River (SnkR) sockeye salmon (*O. nerka*)	Endangered	Yes	No	No	No
Lower Columbia River (LCR) Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No
Lower Columbia River (LCR) coho salmon (*O. kisutch*)	Threatened	Yes	No	No	No
Lower Columbia River (LCR) steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Columbia River (CR) chum salmon (*O. keta*)	Threatened	Yes	No	No	No
Upper Willamette River (UWR) Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No
Upper Willamette River (UWR) steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Oregon Coast (OC) coho salmon (*O. kisutch*)	Threatened	Yes	No	No	No
Southern Oregon/Northern California Coast (SONCC) coho salmon (*O. kisutch*)	Threatened	Yes	No	No	No
Northern California (NC) steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
California Coastal (CC) Chinook salmon (*Oncorhynchus tshawytscha*)	Threatened	Yes	No	No	No
Sacramento River (SacR) winter-run Chinook salmon (*O. tshawytscha*)	Endangered	Yes	No	No	No
Central Valley spring-run (CVS) Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?[1]	Is Action Likely to Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?[1,2]	Is Action Likely to Destroy or Adversely Modify Critical Habitat?[2]
California Central Valley (CCV) steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Central California Coast (CCC) coho salmon (*O. kisutch*)	Endangered	Yes	No	No	No
Central California Coast (CCC) steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
South-Central California Coast (SCCC) Steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Southern California (SC) Steelhead (*O. mykiss*)	Endangered	No	No	No	No
Puget Sound/Georgia Basin (PS/GB) bocaccio (*Sebastes paucispinis*)	Endangered	Yes	No	No	No
PS/GB yelloweye rockfish (*S. ruberrimus*)	Threatened	Yes	No	No	No
Southern DPS (sDPS) eulachon (*Thaleichthys pacificus*)	Threatened	Yes	No	No	No
Southern DPS (sDPS) green sturgeon (*Acipenser medirostris*)	Threatened	Yes	No	No	No
Marine Invertebrates					
Sunflower Sea Star (*Pycnopodia helianthoides*)[4]	*Proposed - Threatened*	Yes	No	NA	NA

[1]Please refer to Section 2.12 of this document for analysis of species and critical habitats that are not likely to be adversely affected.
[2]Critical habitat has not been designated for species designated as 'NA' in these columns.
[3]The Eastern DPS of Steller sea lions were delisted on November 4, 2013 (78 FR 66140); however, critical habitat for Steller sea lions remains designated.
[4]The Sunflower sea star was proposed for listing under the ESA as threatened on March 16, 2023 (88 FR 21600).

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

Issued By: ____

Chris Yates
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West Coast Region
National Marine Fisheries Service

Date: *June 5, 2024*

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1. INTRODUCTION

This Introduction section provides information relevant to the other sections of this document and is incorporated by reference into Sections 2 and 3, below.

1.1 Background

The National Marine Fisheries Service (NMFS) prepared the Biological Opinion (Opinion) and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 U.S.C. 1531 et seq.), as amended, and implementing regulations at 50 CFR part 402. It constitutes a review of a proposed program of research to be conducted by the Northwest Fisheries Science Center and the associated authorizations the NMFS West Coast Region is proposing to issue under Sections 7 and 10(a)(1)(A) of the ESA. This Opinion is based on information provided by the NWFSC in a Biological Assessment, in the associated applications for authorization submitted by the NWFSC, past reporting data from previous NWFSC research activities, published and unpublished scientific information on the biology and ecology of listed species in the action areas, and other sources of information.

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (DQA) (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available within 2 weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. A complete record of this consultation is on file at the NMFS West Coast Region (WCR) Portland, Oregon office.

1.2 Consultation History

The Northwest Fisheries Science Center (NWFSC) first engaged the West Coast Region (WCR) Protected Resources Division (PRD) for pre-consultation guidance in April of 2022. During a series of virtual meetings and email exchanges from April 2022 through September 2022, WCR PRD staff described our information needs for consultation to the NWFSC, and provided potential sources of information (e.g., ESA listing status information, existing permit information in public research permitting databases, and information available from past WCR consultations) to the NWFSC and its contractor. On September 22, 2022, the NWFSC shared a draft Biological Assessment with the WCR PRD, and WCR PRD staff sent comments on the draft back to the NWFSC on October 14, 2022. WCR PRD comments included a request for additional information on the take of ESA-listed fish and fish species that are known to be prey for ESA-listed marine mammals that occurs as part of the NWFSC research activities considered in this Opinion. Between October 19, 2022, and February 17, 2023, the WCR PRD continued to communicate with NWFSC staff via email exchanges and virtual meetings to identify and collate the information requested.

On March 8, 2023, the NWFSC transmitted the final Biological Assessment (BA) and request for consultation to WCR PRD. After reviewing the BA and accompanying materials the WCR PRD agreed to accept the original transmittal as the consultation initiation date, but requested additional information from the NWFSC on April 18, 2023. The NWFSC responded with additional information and clarifications on May 2, 2023. Concurrently with these activities, on March 16, 2023, the WCR PRD issued a proposed rule to list the sunflower sea star as a threatened species under the ESA. In the April 18, 2023, request for additional information, the WCR PRD advised the NWFSC of the proposed listing and recommended a conference given the possibility of NWFSC research gear interacting with sunflower sea stars. The NWFSC acknowledged that their researchers had previously caught sunflower sea stars in their sampling gear and agreed with our recommendation that a conference was appropriate.

The WCR PRD proceeded to work on the consultation in anticipation of the publication of a proposed rule for the issuance of the requested Letter of Authorization (LOA) under the Marine Mammal Protection Act (MMPA) by the Office of Protected Resources (OPR) for research activities in the proposed action, which the NWFSC had applied for in August 2022. In September 2023, the consultation was temporarily put on hold pending the publication of a Proposed Rule to include this OPR action as part of the proposed action. However, given the need for the NWFSC to resume work in 2024 and the uncertainty around the timing of publication of the Proposed Rule, consultation work resumed on April 1, 2024. A Proposed Rule for the issuance of a new LOA under the MMPA is still expected to be published in 2024, although this consultation does not rely upon that Proposed or Final Rule being published by a particular date.

The affected species are:

Sea Turtles

- Leatherback turtle
- North Pacific Ocean Loggerhead turtle
- Olive ridley turtle
- East Pacific Green turtle

Marine and Anadromous Fish

- Chinook salmon
    - Puget Sound (PS)
    - Upper Columbia River (UCR) spring-run
    - Snake River (SnkR) spring/summer run
    - Snake River (SnkR) fall-run
    - Lower Columbia River (LCR)

  - Upper Willamette River (UWR)
  - Sacramento River winter-run (SacR)
  - Central Valley spring-run (CVS)
  - California Coastal (CC)
- Coho salmon
  - Lower Columbia River (LCR)
  - Oregon Coast (OC)
  - Southern Oregon/Northern California Coast (SONCC)
  - Central California Coast (CCC)
- Chum salmon
  - Hood Canal summer-run (HCS)
  - Columbia River (CR)
- Sockeye salmon
  - Ozette Lake (OL)
  - Snake River (SnkR)
- Steelhead
  - Puget Sound (PS)
  - Upper Columbia River (UCR)
  - Middle Columbia River (MCR)
  - Snake River Basin (SnkR)
  - Lower Columbia River (LCR)
  - Northern California (NC)
  - California Central Valley (CCV)
  - Central California Coast (CCC)
  - South-Central California Coast (SCCC)
- Southern DPS (sDPS) Green sturgeon
- Southern DPS (sDPS) Eulachon
- Puget Sound/Georgia Basin Boccacio (PS/GB)
- Puget Sound/Georgia Basin yelloweye rockfish (PS/GB)

Marine Invertebrates

- Sunflower sea star

The proposed action also has the potential to affect blue whales, fin whales, Mexico DPS and Central America DPS humpback whales, sei whales, sperm whales, Western North Pacific DPS gray whales, Guadalupe fur seals, and the Southern California steelhead DPS through interactions with research equipment or vessels. The proposed action also has the potential to affect Mexico DPS and Central America DPS humpback whales and Southern Resident killer whales and their critical habitat by diminishing the whales' prey base, and the potential to affect the designated critical habitats of Steller sea lions and leatherback sea turtles also by impacting available prey. We concluded that the proposed activities are not likely to adversely affect blue whales, fin whales, Mexico DPS and Central America DPS humpback whales, sei whales, sperm whales, Southern Resident killer whales, Western North Pacific DPS gray whales, Guadalupe fur seals, Southern California steelhead, or the designated critical habitats of Steller sea lions, leatherback sea turtles, Southern Resident killer whales, or Mexico DPS and Central America DPS humpback whales. The full analysis for that conclusion is found in the "Not Likely to Adversely Affect" Determinations section (2.12), and those species and habitats are therefore not discussed further in this consultation.

Updates to the regulations governing interagency consultation (50 CFR part 402) were effective on May 6, 2024 (89 FR 24268). We are applying the updated regulations to this consultation. The 2024 regulatory changes, like those from 2019, were intended to improve and clarify the consultation process, and, with one exception from 2024 (offsetting reasonable and prudent measures), were not intended to result in changes to the Services' existing practice in implementing section 7(a)(2) of the Act (89 FR at 24268; 84 FR at 45015). We have considered the prior rules and affirm that the substantive analysis and conclusions articulated in this Opinion and incidental take statement would not have been any different under the 2019 regulations or pre-2019 regulations.

1.3 Proposed Federal Action

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

The proposed action for this Opinion contains two distinct but related activities that may take[1] ESA-listed species:

1. The NWFSC proposes to continue to fund, administer, and conduct fisheries and ecosystem research activities (see Section 1.3.1) for the foreseeable future and, pursuant to those activities, to continue to seek and the necessary permits and authorizations under the ESA and MMPA to obtain appropriate coverage for the potential effects this research may have on protected species.
2. The WCR's PRD proposes to continue issuing (a) Section 10(a)(1)(A) research permits for the directed (intentional) take of ESA-listed fish and invertebrate species for these activities, and (b) Determination of Take Authorization (DTA) letters to cover studies that may cause take of ESA-listed fish and invertebrate species that is incidental to, but not the purpose of, these activities (Section 1.3.2).

[1] Take as defined in section 3 of the ESA means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect [a listed species], or to attempt to engage in any such conduct."

Each of these activities is described in further detail below, as well as continuing compliance efforts reasonably certain to occur as a result of these activities.

1.3.1 Northwest Fisheries Science Center Fisheries Research Activities

Fisheries Research Activities

As described in the Biological Assessment (BA) submitted to the WCR PRD on March 8, 2023 (NWFSC 2023a), the NWFSC conducts research and provides scientific information used to support fisheries management and conserve protected species. While work is conducted by NWFSC scientists throughout freshwater, estuarine, and marine ecosystems of the WCR, the scope of work proposed in the BA, as well as the Programmatic Environmental Assessment (PEA) and Supplemental PEA (SPEA), pertains to the program of fisheries and ecosystem research activities conducted throughout three research areas; the California Current Research Area (CCRA), Puget Sound Research Area (PSRA), and Lower Columbia River Research Area (LCRRA). See Figures 1-1, 1-2, and 1-3(f) in the BA (NWFSC 2023a) for maps of these research areas and Section 2.3 ("Action Area") for a description of the entire program's geographic extent. The NWFSC proposes to continue fisheries research activities throughout the CCRA, PSRA and LCRRA for the foreseeable future.

The NWFSC researchers propose to conduct fisheries and ecosystem research studies using a variety of approaches. These approaches use various equipment, gear types, and study designs. Gear types that may be used include those designed for land-based sampling in shallower nearshore and estuarine habitats (e.g., beach seines, small traps and pots, etc.) as well as many designed for deeper channel and offshore boat-based sampling and gear used in commercial and recreational fisheries. The researchers would use various biological sampling gear including beach seines, purse seines, gillnets, longlines, rods and reels, plankton and neuston nets, various traps and pots, and bottom, midwater, and surface trawls, and similar or modified gear (with equivalent effects) to conduct this research. The researchers would also deploy equipment for sampling the physical environment, such as conductivity, temperature, and density (CTD) profilers, collect water and sediment samples, and utilize equipment such as cameras, microphones, fish tag signal receivers (e.g., Passive Integrated Transponder (PIT) or acoustic/sonar tags), echosounders, and sonar for monitoring biota and habitat. The BA and associated appendices (NWFSC 2023a) provide detailed descriptions of the gear types and vessels expected to be used for this work. They also describe the current and future expected use of types of sampling gear, estimated number of projects, approximate annual number of days at sea (DAS), and estimated annual level of effort for each gear type in each research area. We incorporate by reference and adopt those descriptions here and apply them throughout this section covering the description of the proposed federal action (50 CFR 402.14(h)(3)).

Mitigation Measures

To avoid or minimize the potential for these activities to adversely affect protected species and their critical habitats, the NWFSC also proposes to implement several mitigation measures while conducting its research. These include measures to greatly reduce the likelihood of marine mammals or sea turtles interacting with research vessels or survey gear, and reduce the impact of anticipated interactions with ESA-listed fish and invertebrates to the greatest extent feasible. For all species, these measures include sufficient training and coordination among research personnel to ensure the best practices are consistently employed. To reduce the likelihood of marine mammals and turtles interacting with research equipment these mitigation measures generally include:

- Vessel speed reductions;
- Observers to monitor the area for the presence of these species before deploying gear;
- Protocols to move to other survey areas if species are sighted within certain distances of the research vessel (i.e., the "move-on" rule); and
- Limiting trawl durations and taking care to retrieve gear in ways that avoid or minimize potential harm.

For further discussion of the mitigation measures designed to avoid or minimize potential impacts to marine mammals see Section 2.12 ("Not Likely to Adversely Affect" Determinations).

For ESA-listed sea turtles anticipated to interact with survey gear, the mitigation measures also include procedures for handling and caring for incidentally captured turtles. It is possible that several species of sea turtles could be incidentally captured or entangled during NWFSC research activities. As described in Table 2-2 of the BA (NWFSC 2023a) the NWFSC will take appropriate measures to handle and release these individuals while minimizing injury to sea turtles and gear damage, consistent with the procedures set out in 50 CFR § 223.206(d)(1). If practicable, NWFSC crew and designated agents will measure, photograph, and apply flipper and passive integrated transponder (PIT) tags to any live sea turtle, and salvage any carcass or parts or collect any other scientifically relevant data from dead sea turtles, per authorization in 50 CFR § 222.310 (for endangered turtles) and § 223.206 (for threatened turtles). In addition, NWFSC crew may also collect skin tissue samples for genetic studies following procedures established by the Southwest Fisheries Science Center and Pacific Islands Regional Office (SWFSC-PIRO 2023).

For ESA-listed fish and invertebrate species that may be taken during proposed research activities, the mitigation measures generally include:

- Prioritizing handling and processing ESA-listed species and returning live animals to the water quickly;

- Using non-lethal sampling methods, wherever possible; and
- Using handling, sampling, tagging, and release procedures that minimize the potential for injury and post-release morbidity or mortality.

All of the proposed mitigation measures are described in detail in the SPEA (NWFSC 2023b) and Section 2.2 and Table 2-2 of the BA (NWFSC 2023a). Further, the procedures and requirements for handling these species are largely prescribed by the research permit and authorization regulations described in Section 1.3.2 (West Coast Region ESA Permits and Authorizations) below.

Program of Studies

The number of individual studies conducted in a given year is expected to fluctuate as new research needs are identified and ongoing surveys or their components are modified or discontinued to meet changing information needs. Other factors such as survey timing and locations are also expected to shift in response to research questions and environmental conditions. While the need for additional surveys could arise or some identified surveys could be discontinued or reduced in effort, any future modifications to the proposed research activities would use methods that are equivalent to, or less impactful than, the methods described here. As a result, their locations, scope, extent, and impacts would be commensurate with or lesser than the effects described here.

The extent of the research activities conducted by the NWFSC covered in this Opinion include those that:

- Contribute to NMFS's fishery management and ecosystem management responsibilities under U.S. law and international agreements.
- Take place in marine, estuarine, and lower river reach habitats accessible below impassable barriers in the Lower Columbia River Basin, in the Salish Sea south of the U.S.-Canadian border (including interior waters of Puget Sound), and waters of the Pacific Ocean as far north as offshore of British Columbia reaching to Dixon Entrance at the U.S.-Canadian border, including coastal marine and estuarine waters from that point south to the U.S.-Mexican border, and extending out beyond the Exclusive Economic Zone (EEZ) of the Pacific Coast of the United States (see description of the Action Area in Section 2.3).
- Involve transiting these waters in research vessels, observational surveys made from the decks of those vessels (e.g., marine mammal transects), the deployment of fishing gear and scientific instruments into the water in order to sample and monitor living marine resources and their environmental conditions, and/or use active acoustic devices for navigation and remote sensing purposes.
- Have the potential to interact adversely with marine mammals and protected fish, sea turtles, and invertebrates.

The “adverse interaction” noted in the last bullet above has the potential to occur in the form of incidentally taking ESA-listed marine mammals and sea turtles, or directly or incidentally taking ESA-listed fish and invertebrates.

This Opinion does NOT cover:

- Directed research on marine mammals or sea turtles that involves intentionally pursuing or capturing them for tagging, tissue sampling, or other intentional takes under the MMPA or ESA. Taking ESA-listed turtles or any marine mammals as part of a research activity that is considered direct, intentional take must be authorized through separate ESA Section 10 and/or MMPA Section 104 processes.
- The potential effects of research funded or carried out primarily by other NMFS Regions, state or federal agencies, tribes, or other collaborators with the help of the NWFSC scientists (i.e., with NWFSC staff who act as co-investigators in support of those studies) must be authorized through separate analyses for those actions.
- Other activities of the NWFSC that do not involve the deployment of vessels or gear in marine or estuarine waters, such as evaluations of socioeconomic impacts related to fisheries management decisions, taxonomic research in laboratories, fisheries enhancement activities (such as hatchery programs), educational outreach programs, and any activities conducted outside of the action area considered in this Opinion (see Section 2.3).

Ongoing Compliance and MMPA Mitigation Measures

The NWFSC proposes to continue their fisheries research activities for the foreseeable future, and to continue to seek the necessary permits and authorizations to continue conduct these activities. In order to conduct research activities as proposed above, the NWFSC intends to continue to seek the necessary permits and authorizations under the ESA and MMPA so long as the research program continues. This includes applying for a LOA for the program under the MMPA for the period 2023-2028 (which the NWFSC has already done), as well as for future LOAs as they are needed. It also includes NWFSC researchers continuing to apply for individual Section 10(a)(1)(A) permits and incidental take authorizations (DTA) letters for studies with the potential to impact ESA-listed species, as well as updating NEPA and other compliance documents, as needed.

The NWFSC has previously determined that they will supplement the PEA with a SPEA or other supplemental NEPA analysis each time they apply for a new MMPA Letter of Authorization (LOA). Individual LOAs under the MMPA for take of marine mammals may only be issued for a 5-year duration, and therefore, NEPA SPEAs and Finding of No Significant Impacts (FONSIs) for the proposed research activities have also thus far been developed on a 5-year timeframe, although they could consider longer timeframes in the future. The NWFSC is proposing to update NEPA documentation as frequently as necessary to maintain compliance, which includes summarizing any new information on impacts to the environment. As documented in the SPEA (NWFSC 2023b), the NWFSC research program has not changed substantially since the prior PEA was finalized (NWFSC 2018) and FONSI signed.

The NWFSC further proposes to continue to apply for MMPA coverage, and adhere to its own current or future proposed mitigation measures for minimizing the potential for harm to marine mammals, as well as the measures and requirements of any future LOA. On August 4, 2022, the NWFSC submitted an application to the OPR for a new LOA under the MMPA for continuation of its proposed research activities for the period 2023-2028 (NWFSC 2022a). In 2018, OPR issued a LOA to the NWFSC for their research program (83 FR 36370); the program has not changed substantially since that time in terms of anticipated impacts on marine mammals, as documented in the NWFSC's 2022 application.

Any future LOAs would rely on the NWFSC's adherence to planned mitigation, monitoring, and reporting measures described in the LOA application (e.g., NWFSC 2022a), and those incorporated by reference from the NWFSC's PEA (NWFSC 2018) and SPEA (NWFSC 2023b), with the intent of having the smallest practicable adverse impact of affect marine mammals. These measures will at a minimum include:

- Required monitoring of the sampling areas to detect the presence of marine mammals before deploying certain research gear.
- Required use of acoustic deterrent devices on surface trawl nets and marine mammal exclusion devices on midwater (Nordic) trawl nets.
- Required implementation of the mitigation strategy known as the ‘‘move-on rule mitigation protocol’’ which means that the researchers must use their best professional judgment to avoid marine mammal interactions during their research activities.

While the details of any future LOA may change, given (1) the requirements of Section 101(a)(5) of the MMPA, (2) the conditions of the NWFSC's prior LOA and proposed mitigation measures in its 2022 application, and (3) requirements of LOAs issued by OPR to other NMFS Science Centers for similar work, we anticipate that future LOAs will continue to require that the researchers have the smallest practicable adverse impact on the affected marine mammals.

The WCR PRD further proposes to review future NEPA documents and LOA applications prepared by the NWFSC to determine whether they remain consistent with the effects considered in this Opinion. The WCR PRD is also proposing to use these opportunities to meet with the NWFSC staff and discuss any new information and program changes. If the NWFSC were to complete additional NEPA analyses for activities or develop marine mammal mitigation measures for future MMPA LOA applications that are not substantially consistent with findings, restrictions, or mitigation measures considered in this Opinion (i.e., the activities do not meet the criteria for a FONSI under NEPA, the proposed mitigation measures would allow for more impacts to ESA-listed marine mammals beyond what has previously been authorized, or a future

MMPA LOA request is denied) those activities would be beyond the scope of what we consider in this Opinion.

1.3.2 West Coast Region ESA Permits and Authorizations

The WCR PRD is responsible for processing applications to take ESA-listed fish and invertebrates for research purposes, analyzing the proposed activities' possible effects, and issuing (or denying) the permits that authorize the work. As part of the proposed action, the WCR PRD proposes to continue to review, process, and issue (if appropriate) permits and authorizations for the NWFSC research program described in Section 1.3.1, above, for as long as it should continue.

The WCR PRD will be responsible for ensuring that the NWFSC's research activities are consistent with the requirements of applicable laws and regulations. WCR PRD's approval of any such proposed projects would continue to be based on a determination that the projects (1) meet the requirements described in Section 10(a)(1)(A) of the ESA (16 U.S.C. 1531 *et. seq.*) and regulations governing listed fish and wildlife permits (50 CFR 222–226), (2) fulfill additional considerations germane to research projects, (3) act to conserve the affected threatened species, and (4) meet the requirements of the proposed action as described below.

For the most part, the criteria WCR PRD uses to review and evaluate fisheries research activities are the same, regardless of whether the proposed research directly targets or only incidentally takes ESA-listed fish and invertebrates. However, the ESA authorities and (therefore) procedures for issuing those permits and authorizations differ. Below we describe the proposed process for issuing both Determination of Take (DTA) letters for studies involving incidental (unintentional) take of ESA-listed species and Section 10(a)(1)(A) research permits for studies involving directed (intentional) take of ESA-listed fish species.

Application Review

When the NWFSC proposes new studies for its research program or seeks to renew or expand the take coverage associated with its work, its researchers will continue to apply for new or additional ESA coverage through NMFS' online permitting system Authorizations and Permits for Protected Species (APPS) (https://apps.nmfs.noaa.gov/) or its equivalent successor platform. All such applications require detailed descriptions of the study purpose, design, methods, and mitigation measures that would be employed to avoid or minimize harm to ESA-listed species (for detailed information on types of information collected through applications see Chapter 3 of the APPS Online Application Instructions available on the website). Once received, WCR PRD will review applications for consistency with applicable ESA requirements.

Determination of Take Authorizations

Some studies conducted as part of the NWFSC fisheries research program do not target ESA-listed species, but may unintentionally capture or kill them (e.g., offshore surveys of hake abundance, studies of the California Current ecosystem, groundfish surveys, etc.). The potential effects on ESA-listed species for all studies that are part of the proposed NWFSC research program are considered in the scope of this Opinion. Because this take is incidental to, and not the purpose of, otherwise lawful fisheries research activities, we authorize that take through the Incidental Take Statement of this Opinion (Section 2.9). When the NWFSC applies for new studies or seeks to expand or change ongoing studies that do not target ESA-listed species, their researchers will apply for study-specific DTAs through the online permitting platform, and WCR PRD will review these applications to confirm whether they adhere to the established requirements and mitigation measures for the NWFSC research program (see Section 1.3.1 above) and evaluate whether the scope and extent of effects is consistent with those we analyze in this Opinion. If we find that the new or altered studies would both adhere to the requirements and be consistent with the scope and extent of the analyzed effects, we would then issue a DTA letter confirming those activities would be covered by this Opinion. For proposals that do not comport with these requirements, either the proposed activities would have to be revised to meet these requirements or the researchers would have to seek authorization through a separate consultation.

Section 10(a)(1)(A) Research Permits

Any application the NWFSC submits for individual studies under the proposed program whose purpose is to take ESA-listed species for research will also be reviewed for consistency with the requirements and assumptions of this Opinion. In addition, WCR PRD will also confirm that the applications are consistent with criteria found in Section 10(d) of the ESA (Permit and Exemption Policy) and those from NMFS's regulations for implementing Section 10(a)(1)(A) of the ESA [50 CFR 222.308]. These criteria require WCR PRD to evaluate:

1. Whether the project application was applied for in good faith;
2. Whether the project will operate to the disadvantage of the threatened or endangered species;
3. Whether the project would be consistent with the purposes and policy set forth in section 2 of the ESA;
4. Whether the project would further a bona fide and necessary or desirable scientific purpose, taking into account the benefits anticipated to be derived on behalf of the threatened species;
5. The status of the population of the requested species and the effect of the proposed actions on the population, both direct and indirect;

6. If a live animal is to be taken, transported, or held in captivity, the applicant's qualifications for the proper care and maintenance of the species and the adequacy of the applicant's facilities;
7. Whether alternative non-ESA listed species or population stocks can and should be used;
8. Whether the animal was born in captivity or was (or will be) taken from the wild;
9. Whether there are adequate provisions for disposition of the species if and when the project terminates;
10. How the applicant's needs, program, and facilities compare and relate to proposed and ongoing projects and programs; and
11. Whether the expertise, facilities, or other resources available to the applicant appear adequate to successfully accomplish the objectives stated in the application.

The first step in NMFS' review is to evaluate whether each scientific research project application was applied for in good faith, is consistent with the purposes and policies of the ESA, and would further a bona fide and necessary or desirable scientific purpose. In this step, NMFS evaluates whether the applicant provided fair, open, and honest information about the purpose of and need for their scientific research project. We also consider each activity's stated intent and gauge whether it would help answer genuine and relevant scientific questions relating to listed species status and/or management. The purposes of the NWFSC fisheries research program are well established, the data they provide are necessary for the effective management of fishery resources, and studies targeting ESA-listed species are commonly directly related to data needs identified by recovery plans or managers working to recover those species. Still, we will continue to verify individual NWFSC studies within the proposed research program meet the standards applied to all Section 10(a)(1)(A) research applications.

The WCR PRD would also, to the best of our ability, verify that these applications to take ESA-listed species are not unnecessarily redundant with other efforts, propose approaches and methods appropriate to answer the intended research questions, and are using the least impactful methods possible while still achieving the study's purpose and maintaining data integrity. The WCR PRD will also review and evaluate the NWFSC's descriptions of the facilities, equipment, and expertise it would employ in carrying out investigations that are a part of the proposed fisheries research program.

The phrase "will not operate to the disadvantage" [of listed species] is in the ESA Section 10(d) "Permit and Exemption Policy." The ESA does not define the phrase "will not operate to the disadvantage." Therefore, it is NMFS's responsibility to apply meaning to the phrase. In so doing, NMFS has interpreted this phrase to be a more conservative standard than the jeopardy standard[2] that is applied to federal agency actions and consultations under ESA section 7. The standard operating protocols, terms and conditions, and reporting requirements described elsewhere in this section (Section 1.3.2) are one way that NMFS ensures that individual projects, and the NWFSC research program as a whole, will not operate to the disadvantage of the listed species. Further, as described above, many of the NWFSC studies are needed to provide information for managing and recovering the ESA-listed species they will take and, per item 4 on the list above, we consider the benefits we anticipate a study may provide in terms of supporting species recovery.

Another factor that we look at is the requested level of lethal take across the program of research. Because the majority of the fish that would be captured for research purposes are expected to be released and recover with no long-term adverse physiological, behavioral, or reproductive effects, the true effects of the NWFSC research program on ESA-listed fish are best seen in the context of the fish that are likely to be killed.

To determine the potential effects of these losses, WCR PRD compares the combined requested levels of lethal take from the all the research conducted across the region to the estimated abundance of the various species, and looks for instances where requested take exceeds one half of one percent (0.5%) of the estimated annual abundance of any life stage of naturally produced listed species. We regard that 0.5% mortality rate as a signal indicating that extra caution is required. It is based on decades of analyzing research effects, and it does not constitute a bright line beyond which we believe a program would necessarily operate to listed species' disadvantage. Rather, it is simply the point at which we believe we must take a more in-depth look at the effects a program is having before we can determine that no disadvantage is occurring. Nonetheless, in our experience, we have found that when the standard operating protocols are followed and researchers utilize all means of collaboration to reduce take, research programs are generally able to stay well below this amount.

When WCR PRD receives an application for a Section 10 permit, we must publish a notice in the Federal Register asking for public comment on that application and giving the public 30 days to do so prior to permit issuance (ESA § 10(c)). Therefore, if the NWFSC applies for a new Section 10(a)(1)(A) permit or seeks to modify an existing permit, WCR PRD will publish a notice inviting public comments, and any comments received will be considered and recommendations incorporated into the final permits issued, as appropriate. We anticipate issuing one such notice annually for each batch of permit applications received in a given year, and subsequently issuing one batch of Section 10(a)(1)(A) permits for NWFSC research in a given year, but may do so more frequently if project start times require multiple issuance dates within a year.

[2] 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 a listed species in the wild by reducing the reproduction, numbers, or distribution of that species." 50 CFR 402.02.

Required Procedures, Conditions, and Reporting

The WCR PRD proposes to issue permits and authorizations that will contain conditions to avoid or minimize potential adverse effects on to ESA-listed fish and invertebrates and allow us to monitor take impacts. The following operating procedures, terms and conditions, and reporting requirements would apply to both DTAs and Section 10(a)(1)(A) research permits.

Standard Operating Protocols for Research Activities

As part of the application process, researchers are required to comply with a set of standard sampling practices. Researchers must follow the practices listed below:

- Fin clips from juveniles will be no greater than 1mm x 1mm for genetic samples and no greater than 2mm x 2mm for marking. No adipose fins will be clipped. Application supplemental information will describe which fin is to be clipped, explain why clipping is necessary, and state what happens to tissue samples.
- Passive Integrated Transponder (PIT) tags will be 9mm for juveniles 61mm to 69mm (fork length), and 12mm for juveniles >70mm (fork length). No PIT Tags may be implanted in fish smaller than 61mm. Researchers will use a sterilized needle for each individual fish when injecting PIT tags.
- To the greatest extent feasible, barbless hooks will be used when hook-and-line angling equipment is employed for sampling purposes.
- NMFS's electrofishing guidelines (NMFS 2000; or subsequent NMFS electrofishing guidelines) will be followed when electrofishing is employed.
- Electrofishing shall not be used to capture adult ESA-listed fish.
- Intentional sacrifice of naturally produced adult ESA-listed fish shall not be allowed.
- To the greatest extent possible, any fish that is unintentionally killed will be used in place of those approved to be intentionally sacrificed.
- Hatchery fish shall be used as test animals or surrogates for naturally produced listed fish whenever possible.
- When targeting non-listed species or using gear that captures a mix of species, ESA-listed species will be processed first.
- If anesthetics are used, the application will clearly indicate which one and, in all cases, FDA guidelines will be followed.
- NMFS's Weir Guidelines will be followed (Weir Operating Plan guidelines from September 2015, available on the APPS website, or applicable subsequent NMFS weir guidelines).

- No fish will be captured or handled if the instantaneous water temperature exceeds 70 degrees Fahrenheit at the capture site where any listed fish may be present.
- Each permit holder must review the purpose and methods of their study and affirm that eDNA is not currently a suitable or practical replacement for the take method(s) requested.
- Unintentional mortality should be no more than 3% for most activities. Unintentional mortality from tagging and tissue sampling effects may exceed 3% in some cases but should not exceed 5%.

The above standard operating protocols are based on the best available science, as well as the opinions of experts from state fishery agencies and NOAA Fisheries' science centers (i.e., Northwest Fisheries Science Center, Southwest Fisheries Science Center). The limits on unintentional mortality are founded in our analysis of annual report data from hundreds of permits and DTAs issued over the last 25 years.

Terms and Conditions for Research Permits and Authorizations

Research permits and authorizations lay out the conditions to be followed before, during, and after the research activities are conducted. These conditions are intended to minimize impacts on listed species, and ensure that NMFS receives information about the effects the permitted activities have on the species concerned. All research permits and authorizations the NMFS' WCR issues include the following conditions:

1. The permit holder must ensure that listed species are taken only at the levels, by the means, in the areas and for the purposes stated in the permit application, and according to the terms and conditions in the permit.

2. The permit holder must not intentionally kill or cause to be killed any listed species unless the permit specifically allows intentional lethal take.

3. The permit holder must handle listed fish with extreme care and keep them in cold water to the maximum extent possible during sampling and processing procedures. When fish are transferred or held, a healthy environment must be provided; e.g., the holding units must contain adequate amounts of well-circulated water. When using gear that captures a mix of species, the permit holder must process listed fish first to minimize handling stress.

4. The permit holder must stop handling listed juvenile fish if the water temperature exceeds 70 degrees Fahrenheit (^{o}F) at the capture site. Under these conditions, listed fish may only be visually identified and counted. In addition, electrofishing is not permitted if water temperature exceeds 64^{o}F.

5. If the permit holder anesthetizes listed fish to avoid injuring or killing them during handling, the fish must be allowed to recover before being released. Fish that are only counted must remain in water and not be anesthetized.

6. The permit holder must use a sterilized needle for each individual injection when passive integrated transponder tags (PIT-tags) are inserted into listed fish.

7. If the permit holder unintentionally captures any listed adult fish while sampling for juveniles, the adult fish must be released without further handling and such take must be reported.

8. The permit holder must exercise care during spawning ground surveys to avoid disturbing listed adult salmonids when they are spawning. Researchers must avoid walking in salmon streams whenever possible, especially where listed salmonids are likely to spawn. Visual observation must be used instead of intrusive sampling methods, especially when the only activity is determining fish presence.

9. The permit holder using backpack electrofishing equipment must comply with NMFS' Backpack Electrofishing Guidelines (NMFS 2000) or the most recent applicable NMFS guidelines for electrofishing.

10. The permit holder must obtain approval from NMFS before changing sampling locations or research protocols.

11. The permit holder must notify NMFS as soon as possible but no later than two days after any authorized level of take is exceeded or if such an event is likely. The permit holder must submit a written report detailing why the authorized take level was exceeded or is likely to be exceeded.

12. The permit holder is responsible for any biological samples collected from listed species as long as they are used for research purposes. The permit holder may not transfer biological samples to anyone not listed in the application without prior written approval from NMFS.

13. The person(s) actually doing the research must carry a copy of their research permit while conducting the authorized activities.

14. The permit holder must allow any NMFS employee or representative to accompany field personnel while they conduct the research activities.

15. The permit holder must allow any NMFS employee or representative to inspect any records or facilities related to the permit activities.

16. The permit holder may not transfer or assign their research permit to any other person as defined in section 3(12) of the ESA. The permit will cease to be in effect if transferred or assigned to any other person without NMFS' authorization.

17. NMFS may amend the provisions of the permit after giving the permit holder reasonable notice of the amendment.

18. The permit holder must obtain all other federal, state, and local permits/authorizations needed for the research activities.

19. On or before January 31st of every year, the permit holder must submit to NMFS a post-season report in the prescribed form describing the research activities, the number of listed fish taken and the location, the type of take, the number of fish intentionally killed and unintentionally killed, the take dates, and a brief summary of the research results. The report must be submitted electronically on the APPS permit website (apps.nmfs.noaa.gov) where downloadable forms can also be found. Falsifying annual reports or permit records is a violation of this permit.

20. If the permit holder violates any permit condition, they will be subject to any and all penalties provided by the ESA. NMFS may revoke the research permit if the authorized activities are not conducted in compliance with the permit and the requirements of the ESA or if NMFS determines that its ESA Section 10(d) findings are no longer valid.

"Permit holder" means the NWFSC or any employee, contractor, or agent of the NWFSC. Also, WCR PRD may include conditions specific to individual NWFSC studies in the individual permits issued in order to further minimize the potential for harm to protected species if appropriate for specific gear types, locations, or environmental conditions.

Annual Reports

For all research permits and authorizations, NWFSC researchers must provide an annual report of their results. This must include a report of the actual take resulting from the studies and a summary of their activities and outcomes. All reports must include at least the following:

- The project title, leader, and names of staff conducting the activities.
- A detailed description of activities, including: Dates when activities occurred; activity locations including stream name, reach (if possible), subbasin, and basin names; methods used; total number of listed fish taken by species; type of take; and life stages of the fish taken.
- A summary of major findings.
- A description of how all take calculations were made.

- Measures taken to minimize disturbances to listed species and the effectiveness of these measures.
- A description of any problems and/or unforeseen effects (e.g., fish injuries or deaths) that may have arisen during the research.

Additional reporting requirements may be added by WCR PRD to specific studies based on unique conditions or risks associated with that work, and in order to ensure the project effects would be consistent with those analyzed in this Opinion. WCR PRD will review these annual reports to monitor the actual number of listed fish taken annually in the scientific research activities as well as to verify the project is adhering to the procedures, conditions, and requirements listed above.

Incident Reports

In addition to annual reports, researchers may need to file an incident report. In the event that a researcher exceeds their authorized level of take or otherwise fails to adhere to the terms and conditions for research projects, the researcher must submit an incident report detailing the issue and any remedies they intend to take to avoid such issues in the future. WCR PRD will swiftly review incident reports and determine if the remedies are sufficient. WCR PRD will also review any incident reports to determine if the NWFSC program of studies as a whole has triggered any of the reevaluation factors below (Section 1.3.2 Annual Program Review and Reauthorization) or reinitiation triggers of this Opinion.

Issuance

As described above, the standard procedures, terms and conditions, and reporting requirements for all research activities are consistent whether they are conducted under Section 10(a)(1)(A) permits or DTA letters. However, because of differences between ESA section 7 and Section 10 and their associated implementing regulations, some of the procedures for issuing, modifying, reauthorizing and renewing these authorizations differ.

Duration

Historically the WCR PRD has issued Section 10(a)(1)(A) research permits for up to five years, although the ESA does not specify a duration limit on any permit. The same is true of DTA letters—there is no limit to the duration of such an authorization while the Biological Opinion is in effect. The proposed action we are analyzing in this Opinion proposes to issue ESA permits and authorizations for a longer period of time to reduce burdens on repeat applicants and streamline compliance processes. To meet the practical need to regularly ensure that (1) studies continue to be conducted in a manner consistent with the conditions of this Opinion, (2) coverage is still needed, and (3) impacts on listed species remain within the bounds of the effects analyzed in this Opinion, WCR PRD specifically proposes to issue most individual Section 10(a)(1)(A) research permits and DTA letters for up to 10 years from the date of issuance.

For studies of a limited duration, or those with potential impacts that are not well known (e.g., new studies) a shorter duration can help ensure the anticipated impacts of a study are not exceeded. WCR PRD will issue permits for such projects proposed within the NWFSC program of research for shorter periods, as appropriate. However, for long-standing programs of work for which we can analyze many years of reporting, it is more efficient and still adequately protective to issue coverage for longer periods of time. This is consistent with many other Section 10(a)(1)(A) permits issued by NMFS, and other Section 10 permits the WCR issues, that are good for up to 10 years. While individual studies conducted as part of the proposed program of work are expected to change over time, the program of NWFSC fisheries research as a whole has a very consistent record of impacts that reasonably predicts future impacts over longer time scales.

Amendments and Modifications

Sometimes researchers need to change key personnel or alter how a study is carried out. When that happens, the researchers can apply for an amendment or modification to their current permit or DTA letter (50 CFR 222.306). Some changes would not increase the amount or extent of take or otherwise increase the severity of effects that have already been analyzed. Some examples of this would be incorporating a commonly used method that wasn't previously included, modifying gear in ways that have equivalent or lesser impacts on listed species, or moving sampling locations to new areas that don't increase impacts on any particular population. In those instances, the WCR PRD would issue an amended permit or authorization documenting the change. Some changes that are administrative in nature (for example, key personnel changes) would also be made to permits or authorizations without issuing an amendment.

However, if the NWFSC seeks changes that could increase take or exacerbate an effect a study may have on listed species, then the NWFSC would apply for a modification of their Section 10(a)(1)(A) permit or DTA letter. WCR PRD would review such applications using the same approach we use when reviewing brand-new applications (See Section 1.3.2 Application Review) and, further, ensure that it is consistent with the conditions, requirements, and effects considered in this Opinion.

Reauthorizations

Each year, the WCR PRD will review the annual reports for permits and authorizations. Annual reports are due on January 31st of the year following the sampling activities. The WCR PRD will review the reports to ensure that researchers followed the standard operating protocols and terms and conditions, and review whether there were any exceedances of expected take amounts. If found sufficient and consistent with their authorized amount and extent of take, the WCR PRD will issue an annual reauthorization notification email through our APPS permitting system. In addition, WCR PRD will use annual reports to monitor the actual number of fish taken annually by each study and may further reduce the authorized take in subsequent years if those levels are deemed to be excessive (i.e., if the levels authorized are consistently in excess of what researchers have taken or might be expected to actually take in the course of their research).

If any issues, exceedances, or unanticipated incidents occurred, the WCR PRD will review the researchers' proposed remedies and, if it finds they would sufficiently reduce the chance of issues recurring, WCR PRD will also issue a reauthorization, along with any supplemental conditions or reporting requirements that may be appropriate. If proposed remedies for incidents are exceedances are not deemed sufficient to reduce the potential for recurrence, or the work is not expected to continue, WCR PRD will withdraw the individual permit or authorization.

Renewals

When permits or authorizations near their expiration, researchers may apply for a renewal. Until a renewal is issued, an existing permit or DTA letter may be extended if the applicant has submitted a new (and complete) application for work of a continuing nature (50 CFR 222.304). A Permit Holder operating under an extension may only continue such activities as were previously authorized by the permit until a decision has been made on the renewal application. The Permit Holder may also continue to possess biological samples of the target species acquired under the permit after its expiration without additional written authorization.

Applications for renewal may include substantial changes to a study, including increases in the requested take levels. The expiration of authorizations is an appropriate interval to verify (1) studies are still being conducted consistent with the conditions of this Opinion, (2) coverage is still needed, and (3) impacts on listed species are still within effects analyzed in this Opinion, so all applications for renewals will be evaluated in the same manner as new applications (See 1.3.2 Application Review) with additional review of their annual reports.

Annual Program Review and Reauthorization

In addition to reviewing annual reports for individual studies prior to reauthorizing them each year, WCR PRD will annually evaluate the impacts of the NWFSC proposed research program as a whole. These annual reviews will closely examine reported take of listed species in the context of shifting species abundance and previously approved research to ensure that the program's effects remain within the scope of what is considered in this Opinion. The WCR PRD will evaluate the total reported lethal take from all active studies in the NWFSC fisheries research program and determine if it is within the range of effects analyzed in this Opinion.

As described in more detail in Section 2.5 (Effects of the Action), the take of listed fish that has actually occurred as a result of NWFSC research studies in the action area over the past several years provide a basis for the levels of listed fish take we anticipate will occur as a result of the proposed action in the future. In addition, we recognize that the absolute numbers of fish taken by a particular sampling effort are likely to fluctuate as abundances of these species change over time. WCR PRD therefore proposes to compare the annual total of directed and incidental lethal take of listed fish species relative to our best estimates of abundances for the sampling year, and evaluate the proportional impact to each listed species component. For reasons explained further in Section 2.5 of this Opinion, WCR PRD would compare the reported take to thresholds of

(1) 0.5% mortality in any given year, and

(2) a 5-year running average of 0.25% mortality

of the abundance of any natural-origin ESU or DPS components of listed fish species. If levels of take exceeded these amounts then WCR PRD would need to consider whether the effects of NWFSC and WCR PRD's proposed activities had exceeded the range of what was analyzed in this Opinion.

In this annual evaluation, WCR PRD would document the reported take by species, life stage, and origin (hatchery vs. natural) for the program as a whole, including directed and incidental take of listed species. Thus, the annual program review acts as a yearly checkpoint for the proposed NWFSC research activities that would detect whether sustained increase in the relative (i.e., proportional) annual maximum mortality for natural-origin ESA-listed fish or invertebrates was occurring, which could trigger a reinitiation of consultation (see Section 2.11 Reinitiation of Consultation). In addition, if the cumulative take levels begin to approach reinitiation triggers established in this Opinion, the annual review will allow WCR PRD to notify the NWFSC, and the NWFSC compliance leads can work with researchers to adaptively manage their research program to ensure the program remains within the bounds of effect established in this Opinion.

2. ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. As required by section 7(a)(2) of the ESA, each federal agency must ensure that its actions are not likely to jeopardize the continued existence of endangered or threatened species or to adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, federal action agencies consult with NMFS, and section 7(b)(3) requires that, at the conclusion of consultation, NMFS provide an Opinion stating how the agency's actions would affect listed species and their critical habitats. If incidental take is reasonably certain to occur, section 7(b)(4) requires NMFS to provide an ITS that specifies the impact of any incidental taking and includes reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

This Opinion constitutes formal consultation and an analysis of effects solely for the evolutionarily significant units (ESUs) and distinct population segments (DPSs) that are the subject of this Opinion.[3] Herein, the NMFS determined that the proposed action, Consultation on Fisheries Research Conducted and Funded by the Northwest Fisheries Science Center, and Issuance of ESA Section 10(a)(1)(A) Scientific Research Permits in the West Coast Region Pursuant to those Research Activities:

- May adversely affect Puget Sound, Upper Columbia River, Snake River spring/summer-run, Snake River fall-run, Lower Columbia River, Upper Willamette River, Sacramento River winter-run, Central Valley spring-run, and California Coastal Chinook salmon; Lower Columbia River, Oregon Coast, Southern Oregon/Northern California Coast, and Central California Coast coho salmon; Hood Canal summer-run and Columbia River chum salmon; Ozette Lake and Snake River sockeye salmon; Puget Sound, Upper Columbia River, Middle Columbia River, Snake River, Lower Columbia River, Northern California, California Central Valley, Central California Coast, and South-Central California Coast steelhead; southern DPS green sturgeon; southern DPS eulachon; Puget Sound/Georgia Basin bocaccio; Puget Sound/Georgia Basin yelloweye rockfish, and sunflower sea stars, but would not jeopardize their continued existence and is not likely to adversely affect those species' designated critical habitats.
- Is not likely to adversely affect blue whales, fin whales, Mexico DPS and Central America DPS humpback whales, sei whales, sperm whales, Southern Resident killer whales, Western North Pacific DPS gray whales, Guadalupe fur seals, or Southern California steelhead, or their critical habitat. Our concurrence is documented in the "Not Likely to Adversely Affect" Determinations section (Section 2.12).

2.1 Analytical Approach

This biological opinion includes both a jeopardy analysis and an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "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 CFR 402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

Per 50 CFR § 402.10, we have also completed a conference opinion (ESA Section 7(a)(4)) evaluating the effects of the proposed program of activities on sunflower sea stars (*Pycnopodia helianthoides*),[4] as it is currently a species proposed for listing under the ESA. An opinion issued

[3] An ESU of Pacific salmon (Waples 1991) and a DPS of steelhead (71 FR 834), rockfish, eulachon, etc., are considered to be "species" as the word is defined in section 3 of the ESA.

[4] https://www.federalregister.gov/documents/2023/03/16/2023-05340/proposed-rule-to-list-the-sunflower-sea-star-as-threatened-under-the-endangered-species-act

at the conclusion of the conference may be adopted as the biological opinion when the species is listed or critical habitat is designated, but only if no significant new information is developed (including that developed during the rulemaking process on the proposed listing or critical habitat designation) and no significant changes to the federal action are made that would alter the content of the opinion. Hereafter, the combination of the biological opinion and conference opinion are referred to as a singular "Opinion."

This biological opinion also relies on the regulatory definition of "destruction or adverse modification," which "means a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species" (50 CFR 402.02).

The designations of critical habitat for some species considered in this Opinion use the term primary constituent element (PCE) or essential features. The 2016 final rule (81 FR 7414; February 11, 2016) that revised the critical habitat regulations (50 CFR 424.12) replaced this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

The ESA Section 7 implementing regulations define effects of the action using the term "consequences" (50 CFR 402.02). As explained in the preamble to the final rule revising the definition and adding this term (84 FR 44976, 44977; August 27, 2019), that revision does not change the scope of our analysis, and in this Opinion we use the terms "effects" and "consequences" interchangeably.

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

- Evaluate the rangewide status of the species and critical habitat expected to be adversely affected by the proposed action.
- Evaluate the environmental baseline of the species and critical habitat.
- Evaluate the effects of the proposed action on species and their critical habitat using an exposure–response approach.
- Evaluate cumulative effects.
- In the integration and synthesis, add the effects of the action and cumulative effects to the environmental baseline, and, in light of the status of the species and critical habitat, analyze whether the proposed action is likely to: (1) directly or indirectly reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species; or (2) directly or

indirectly result in an alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species.

- If necessary, suggest a reasonable and prudent alternative to the proposed action.

Supplemental Data Collected

As described in Consultation History (Section 1.2), during the pre-consultation phase we (WCR PRD) requested additional information about the proposed research activities, and worked directly with some NWFSC researchers and environmental compliance staff to gather information to support our analyses. Below is a description of information gathered in addition to what was provided in the BA and its appendices that was also relied upon in our analyses.

As part of WCR PRD's request for clarification and additional information in response to draft BA materials we also requested listed and non-listed fish take information to analyze ESA-listed fish take through all of the activities described in the proposed action and SPEA (i.e., directed take of ESA-listed fish under Section 10(a)(1)(A) permits) as well as removal of fish that are prey items for ESA-listed marine mammals (i.e., Chinook salmon for Southern Resident killer whales and several species of 'forage' fish which are prey for ESA-listed Humpback Whales). The NWFSC Compliance Coordinator relayed this request to researchers and the NWFSC permits coordinator, who worked directly with WCR PRD through email exchanges, phone calls, and virtual meetings to compile estimates of ESA-listed and relevant non-listed fish taken as a result of their research activities. Further, data on unlisted 'forage' fish species for large whales (i.e., smelt, anchovy, herring, sandlance, and some squids, as well as eulachon) and unlisted fish that may be prey items for ESA-listed marine mammals were gathered directly from researchers and from reporting data NWFSC researchers submitted to the Sustainable Fisheries Division's Scientific Research Permit program, which tracks the removal of commercially valuable species as well as some species incidentally caught as bycatch. Those data sources were combined to provide summary estimates of prey item removal.

ESA-listed fish and unlisted Chinook salmon

These data include ESA-listed fish take estimates as requested through the APPS permitting system (https://apps.nmfs.noaa.gov/) or estimated directly by researchers as though they were submitting an application for take coverage for future years of research. It's important to note that this is the summary of what the researchers have requested or estimate they will be requesting for ESA-fish take, which is always a greater amount than the take that actually occurs. While it serves as the theoretical upper limit of all of the take that could occur should all take we authorize for every study actually occur, not all studies occur in all years, and most of the take goes unused, particularly for adults. To evaluate potential for prey removal effects on Southern Resident killer whales, researchers taking ESA-listed fish as part of their research were asked to estimate the numbers of unlisted Chinook (adults and juveniles) that may also be taken as part of their work.

Non-listed 'forage' fish removal

The non-listed fish removal data (other than unlisted Chinook salmon) we were able to gather from self-reported data from researchers, and data provided from the WCR Sustainable Fisheries Division SRP permitting program, which was estimated as total metric tons of catch reported by species group across all NWFSC studies. WCR PRD considered the following species identified in this reporting to be potential prey sources for ESA-listed humpback whales; anchovy, herring, smelt, sandlance, squid, and eulachon. Estimates of sDPS eulachon removed were summarized as described above for ESA-listed fish species.

Evaluating an Adaptive Research Program

In this Opinion we analyze the effects of a program of research activities undertaken by the NWFSC, and authorized by the WCR PRD, as described in the proposed action (Section 1.3). We therefore considered the effects of the program as a whole, not limited to those specific studies which are currently proposed or continuing, but instead as a program of activities likely to employ a range of equipment, techniques, and sampling designs utilized in fisheries research. The specific approaches and methods are likely to change over time as new information informs the direction of future research and new experimental methods are developed and tested. We consider that research may be conducted using equipment or techniques not specifically described in the BA, SPEA, or proposed action. However, the impacts of fisheries research activities in the action area are well documented, so while individual methods and equipment used may vary over time, we expect the nature of effects to listed species to be consistent with those of past NWFSC research and general activity categories described in Section 2.5 (Effects of the Action).

Other factors such as survey timing and locations are also expected to shift in response to research questions, species distributions, and environmental conditions. We therefore consider that these activities may be conducted at any time throughout the year, and occur in any part of the action area, although gear types are constrained by the habitats (e.g., nearshore versus offshore, surface vs. at depth, etc.) in which they can be deployed.

Authorized Take and Likely Impacts for Listed Fish

As described in the proposed action (Section 1.3) individual NWFSC researchers will continue to apply for DTAs or Section 10(a)(1)(A) research permits to document ESA compliance for take of ESA-listed fish anticipated to occur as a result of their respective studies. When such applications are submitted researchers typically request authorization for all components (i.e., all life stages of all naturally or hatchery-produced fish) of all listed species which may be taken, and in sufficient number to account for unexpected events. For individual studies this nearly always results in a larger number of fish and more species, life stages, and origin types being authorized than are actually taken during a field season, as researchers don't end up needing all of the take they have requested. When compiled over the many research projects undertaken by the NWFSC, these differences result in a substantial gap between authorized take and how much actually occurs.

We consider the anticipated requests for take of ESA-listed fish presented in the BA and its appendices, although we know that because of this difference between what is authorized versus actually used, these amounts are deemed to be overestimates of likely program impacts. The reported take of ESA-listed fish as a result of previously implemented NWFSC research programs is a much more realistic estimate of the likely impacts to listed species as a result of the proposed research activities. Reporting data collected from our online permitting system (APPS, https://apps.nmfs.noaa.gov/) were used to evaluate the total take of ESA-listed fish that occurred as a result of NWFSC research activities over the past 5 years.

Analysis of ESA-listed fish species proportional effects

To analyze the effects of the proposed research activities on ESA-listed fish species, we compared the numbers of fish taken and killed during NWFSC research activities from the most recent 5 years of reporting data (2018-2022) to estimates of abundances for those species during each of those years. Species-specific status information, including current estimates of abundance, are provided in Section 2.2.2. Estimates of the abundances of ESA-listed fish species have been similarly generated for ESA consultations on research permitting actions for several years, and values from past Biological Opinions and 5-year reviews were used for analyses of 2018-2022 (Appendix A, Table A2). These numbers represent our best estimate of abundance during each reporting year, but should still be viewed with caution as they were generated using various assumptions about spawner ratios, fecundity, survival, and other parameters that may vary widely from year to year and among populations within a species. For these reasons we consider the estimates of potential proportional impacts on listed fish species used in our analyses (i.e., the proportion of an ESU or DPS component taken or killed) to be approximate, providing information about the likely magnitude of effects relative to species' abundance.

2.2 Rangewide Status of the Species and Critical Habitat

This Opinion examines the status of each species that is likely to be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' "reproduction, numbers, or distribution" for the jeopardy analysis. The Opinion also examines the condition of critical habitat, evaluates the value of the various watersheds and coastal and marine environments that make up the action area, and discusses the function of the PBFs that are essential for the conservation of the species.

2.2.1 Climate Change

Major ecological realignments are already occurring in response to climate change, which is likely to play an increasingly important role in determining the abundance and distribution of ESA-listed species and the conservation value of designated critical habitats in the West Coast Region (Crozier *et al.* 2019). Long-term trends in warming have continued at global, national, and regional scales (Siegel and Crozier 2020). It is almost certain that annual and seasonal surface temperatures over all of North America will continue to increase at a rate greater than the global average (Gutiérrez *et al.* 2021). As described in the Intergovernmental Panel on Climate Change Sixth Assessment Report (Gutiérrez *et al.* 2021), precipitation is also very likely to continue to increase over most of North America above 45°N, and likely to decrease in the southwestern U.S. (particularly in winter), and there is high certainty snow cover will decline over most regions of North America during the 21st century in terms of water equivalent, extent and annual duration (the only exception being high-latitude regions).

Evidence suggests that productivity in the North Pacific Ocean and California Current are being affected by climate change (Talonni-Alvarez *et al.* 2019, Crozier and Siegel 2023). Important ecological functions such as migration, feeding, and breeding locations for marine species may be influenced by factors such as ocean currents and water temperature. Any changes in these factors could render currently used habitat areas unsuitable and new use of previously unutilized or previously not existing habitats may be a necessity for displaced individuals. Changes to climate and oceanographic processes are also leading to different patterns of productivity and prey distribution and availability (Poloczanska *et al.* 2016, IPCC 2019). Such changes could affect individuals that are dependent on those affected prey.

These changes will not be spatially homogeneous across the action area landscape, and are therefore discussed in regionally-specific sections below.

Pacific Northwest

During the last century regional temperatures in the Pacific Northwest have increased substantially—nearly 2°F—and are projected to continue to increase during all seasons under all climate change prediction scenarios (Abatzoglou *et al.* 2014, Vose *et al.* 2017, Rupp *et al.* 2017). Temperatures have risen steadily, while precipitation remains highly variable, thus intensifying the hydrological cycle within the atmosphere and causing more intense storm events (Warner *et al.* 2015). Warming is likely to continue during the next century as average temperatures are projected to increase on average by another 3 to 5°F by the end of the 21st century, with the largest increases predicted to occur in the summer (Rupp *et al.* 2017). Decreases in summer precipitation of 4-10% by the end of the century are also consistently predicted across climate models, although much higher predictions for winter precipitation (8-14% increase) result in a predicted overall increase in annual precipitation (Rupp *et al.* 2017). Models consistently predict increases in the frequency of severe winter precipitation events (i.e., 20-year and 50-year events), in the western United States, with the largest increases in winter flood frequency and magnitude predicted for mixed rain-snow watersheds (Dominguez *et al.* 2012, Mote *et al.* 2014). Winter precipitation will also be more likely to fall as rain than snow, resulting in decreased snowpack and earlier snowmelt (Mote *et al.* 2014, Mote *et al.* 2016). Within snow-dominated watersheds, warmer winters and springs reduce snow accumulation and hasten snowmelt. Reduced snowpack causes an earlier and smaller freshet in spring. Reduced snowpack also can lead to lower minimum flows and higher stream temperatures in summer (May 2018). Decreased snowpack will increase risks of drought, lower instream flows, warmer water temperatures, and wildfires (Mote *et al.* 2014, McKenzie and Littell 2017).

Overall, about one-third of the current cold-water salmonid habitat in the Pacific Northwest is likely to exceed key water temperature thresholds by the end of this century (Mantua *et al.* 2009). Higher temperatures will reduce the quality of available salmonid habitat for most freshwater life stages (Mantua *et al.* 2010, Crozier *et al.* 2019). Temperature increases also shift timing of key life cycle events for salmonids and species forming the base of their aquatic food webs (Crozier *et al.* 2019, Tillmann and Siemann 2011, Winder and Schindler 2004). Higher stream temperatures will cause decreases in dissolved oxygen, and may also cause earlier onset of stratification and reduced mixing between layers in lakes and reservoirs, which can also result in reduced oxygen (Meyer *et al.* 1999, Winder and Schindler 2004, Raymondi *et al.* 2013). Higher temperatures are also likely to cause physiological stress that could result in decreased disease resistance and lower reproductive success for many salmon species (Beechie *et al.* 2013; Wainwright and Weitkamp 2013; Whitney *et al.* 2016).

Reduced streamflows will also likely reduce available suitable habitat for anadromous fish by making it more difficult for migrating fish to pass physical and thermal obstructions, limiting their access to available habitat (Mantua *et al.* 2010; Isaak *et al.* 2012, Tonina *et al.* 2022). As more basins become rain-dominated and prone to more severe winter storms, higher winter stream flows may also increase the risk that winter or spring floods in sensitive watersheds will damage spawning redds and wash away incubating eggs (Goode *et al.* 2013). Earlier peak stream flows will also alter migration timing for salmon smolts and may flush some young salmon and steelhead from rivers to estuaries before they are physically mature, increasing stress and reducing smolt survival (McMahon and Hartman 1989; Lawson *et al.* 2004). There is also evidence that changes in weather patterns and reductions in spring freshets have altered migration timing for eulachon, which may lead to earlier spawning and flushing of juveniles out of rivers (Moody 2008, Schweigert *et al.* 2007). Such changes in migration timing could result in a mismatch between juvenile outmigration and favorable marine upwelling conditions in the eastern Pacific (Gustafson *et al.* 2010, Sharma *et al.* 2016).

California

California has experienced continually below average precipitation and record high air temperatures in the last decade, a trend that models predict will continue (Alizedeh 2021). Heat waves are expected to occur more often, and heat wave temperatures are likely to be higher, with 2014-2018 being the five warmest years on record globally (NOAA NCEI 2022). Total precipitation in California may decline; critically dry years may increase (Alizedeh 2021, Sridhar *et al.* 2018). Events of both extreme precipitation and intense aridity are projected for California, increasing climactic volatility throughout the state (Swain *et al.* 2018). Snowpack is a major contributor to stored and distributed water and water temperature in the state (Yan *et al.* 2021), but this important water source is becoming increasingly threatened. The Sierra Nevada snowpack is likely to decrease by as much as 70 to 90 percent by the end of this century under the highest emission scenarios modeled (Luers and Moser 2006). California wildfires are expected to increase in frequency and magnitude, with 77% more area burned by 2099 under a high emission scenario model (Westerling 2018). Vegetative cover may also change, with decreases in evergreen conifer forest and increases in grasslands and mixed evergreen forests. The likely change in amount of rainfall in Northern and Central Coastal California streams under various warming scenarios is less certain, although as noted above, total rainfall across the state is expected to decline.

For the California North Coast, models show increased variability in interannual winter precipitation and increased summer evapotranspiration, showing that low summer flows are likely to become lower, less predictable and highly variable (Sridhar *et al.* 2018). Many of these changes are likely to further degrade salmonid habitat by, for example, reducing stream flows during the summer and raising summer water temperatures (Williams *et al.* 2016). Estuaries may also experience changes detrimental to salmonids and green sturgeon. Estuarine productivity is likely to change based on alterations to freshwater flows, prey availability, and altered run times (Chasco *et al.* 2021, Siegel and Crozier 2020).

Marine Habitats

Climate change impacts to marine environments are also likely to impact listed species on the West Coast. Changes in temperatures as well as chemistry, circulation patters, and food supply are likely to affect ecosystems and habitats important to subadult and adult green sturgeon and salmonids (Crozier *et al.* 2020, Crozier *et al.* 2021, Keefer *et al.* 2018, Barnett *et al.* 2020), which would be expected to negatively affect marine growth and survival of listed fish. The projections described above are for the mid- to late-21st Century. Over shorter periods, climate conditions not caused by the human addition of carbon dioxide to the atmosphere are more likely to predominate (Koontz *et al.* 2018, Yan *et al.* 2021).

Moreover, as atmospheric carbon emissions increase, increasing levels of carbon are absorbed by the oceans, changing the pH of the water. Acidification also affects sensitive estuary habitats, where organic matter and nutrient inputs further reduce pH and produce conditions more corrosive than those in offshore waters (Ou *et al.* 2015, Williams *et al.* 2019). Global sea levels are expected to continue rising throughout this century, reaching likely predicted increases of 10-32 inches by 2081-2100 (IPCC WGI 2021). These changes will likely result in increased erosion, more frequent and severe coastal flooding, increased temperature regimes, and shifts in the composition of nearshore habitats (Reeder *et al.* 2013, Crozier *et al.* 2019). Estuarine-dependent salmonids such as chum and Chinook salmon are predicted to be impacted by significant reductions in rearing habitat in some Pacific Northwest coastal areas (Osterback *et al.* 2018).

Historically, warm periods in the coastal Pacific Ocean have coincided with relatively low abundances of salmon and steelhead, while cooler ocean periods have coincided with relatively high abundances, and therefore these species are predicted to fare poorly in warming ocean conditions (Zabel *et al.* 2006; Siegel and Crozier 2020). This is supported by the recent observation that anomalously warm sea surface temperatures off the coast of Washington from 2013 to 2016 resulted in poor coho and Chinook salmon body condition for juveniles caught in those waters (NWFSC 2015). Pacific eulachon are also expected to be adversely affected by lower upwelling conditions and higher sea surface temperatures, which result in poorer ocean conditions for growth (Sharma *et al.* 2016). Changes to estuarine and coastal conditions, as well as the timing of seasonal shifts in these habitats, have the potential to affect a wide range of listed aquatic species (Stachura *et al.* 2014, Siegel and Crozier 2020, Chasco *et al.* 2021).

We consider the ongoing implications of climate change as part of the status of ESA-listed species. Where necessary or appropriate, we consider whether impacts to species resulting from the proposed action could potentially influence the resiliency or adaptability of those species to deal with climate change that we believe is likely over the foreseeable future.

2.2.2 Status of the Species

Information on the status and distribution of all the species considered here can be found in a number of documents, but the most pertinent are the status review updates and recovery plans listed in Table 1 and the specific species sections that follow. These documents and other relevant information may be found on the NOAA Fisheries West Coast Region website; the discussions they contain are summarized in the tables below. We incorporate the cited documents by reference, summarize their contents within this section, and consider the information contained therein in our analysis and conclusions in this Opinion.
For species we determined are not likely to be adversely affected by the proposed action (i.e., blue whales, fin whales, Mexico DPS and Central America DPS humpback whales, sei whales, sperm whales, Southern Resident killer whales, Western North Pacific DPS gray whales, and Guadalupe fur seals) their status is not discussed in this analysis. For further details on their occurrence and the rationale for those determinations see Section 2.12 ("Not Likely to Adversely Affect" Determinations).

Table 1. Listing classification and date, recovery plan reference, most recent status review, status summary, and limiting factors for each species considered in this Opinion.

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Sea Turtles					
Leatherback Sea Turtle	Endangered 06/02/1970 (35 FR 8491)	NMFS and FWS 1998a	NMFS and USFWS 2020b	The East Pacific and Malaysia leatherback populations have collapsed, yet Atlantic populations generally appear to be stable or increasing. Many explanations have been provided to explain the disparate population trends, including fecundity and foraging differences seen in the Pacific, Atlantic, and Indian Oceans. Since the last 5-year review, studies indicate that high reproductive output and consistent and high quality foraging areas in the Atlantic Ocean have contributed to the stable or recovering populations; whereas prey abundance and distribution may be more patchy in the Pacific Ocean, making it difficult for leatherbacks to meet their energetic demands and lowering their reproductive output	• Development, tourism, and destruction of nesting beaches • Harvest of eggs and nesting females, nest depredation • Climate change resulting in sea level rise (which eliminates nesting habitat), changing ocean temperatures affecting prey availability, and increasing air temperatures skewing sex ratios • Bycatch from global artisanal and commercial fishing • Boat strikes, the ingestion of and entanglement in marine debris, and exposure to heavy metals and other contaminants in the nesting and marine environments
North Pacific DPS Loggerhead Sea Turtle	Endangered 09/22/2011 (76 FR 58868)	NMFS and FWS 1998b	NMFS and USFWS 2020a	Loggerheads of the North Pacific Ocean DPS exhibit a complex life cycle that contains several life stages (i.e., hatchling, juvenile, and adult), occurring across wide-spread and diverse habitats. Abundance of this population is low, estimated to be 8,733 nesting females in 2015. The capacity to withstand stochastic disturbance is limited by the low abundance of the DPS. Recent trends in nesting suggest improvement; however, low remigration rates are of concern as population resilience is dependent upon females returning to nest on a regular basis. Resilience is limited because the major threats	• Fisheries bycatch • Climate change resulting in sea level rise and increasing storm frequency (which eliminates nesting habitat), changing ocean temperatures affecting prey availability, and increasing air increasing egg mortality • Habitat modification from erosion and coastal development • Harvest • Relocation and retention of eggs and hatchlings

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				caused by climate change are likely to affect all individuals, nesting beaches, and foraging areas.	• Predation
Olive Ridley Sea Turtle	Endangered/ Threatened 07/28/1978 (43 FR 32800)	NMFS and FWS 1998c	NMFS and USFWS 2014	The current abundance indicates the populations experienced steep declines compared to historic abundance. Nesting trends in Mexico, where known, at non-arribada beaches are stable or increasing in recent years. Recent at-sea estimates of density and abundance of the olive ridley show a yearly estimate of 1.39 million, which is consistent with the increases seen on the eastern Pacific nesting beaches as a result of protection programs that began in the 1990s. Although illegal harvest continues, the Endangered populations appear to have stabilized from the previous population collapse due to over exploitation. In the eastern Pacific, the large arribada nesting populations have declined since the 1970s. Nesting at some arribada beaches continues to decline (e.g., Nancite in Costa Rica) and is stable or increasing at others (e.g., Ostional in Costa Rica).	• Incidental take in fisheries • Vessel collisions • Effects from climate change such as skewed sex ratios and high egg mortality • Increased exposure to heavy metals and other contaminants in the marine environment • Habitat loss due to coastal development • Harvest of nesting turtles and eggs and illegal take in fisheries continues to be widespread outside the U.S. and poses a significant threat to the Threatened populations
East Pacific DPS of Green Sea Turtle	Threatened 07/28/1978 (43 FR 32800) and 04/06/2016 (81 FR 20057)	NMFS and FWS 1998d	NMFS 2015a	This DPS consists of at least five populations: two in Mexico, one in Costa Rica, one in the eastern Pacific and one in the Galapagos Islands. Those populations are represented by at least 39 nesting sites, with most of these sites concentrated in Mexico, Ecuador, and Costa Rica. Although trend information is lacking for the majority of nesting beaches, based on a 25-year trend for the nesting aggregation at Colola, Mexico, the abundance of East Pacific green turtles appears to have increased since the population's low point in the mid-1980s. The total for the entire East Pacific green turtle DPS	• Incidental take in fisheries • Vessel interactions • Current and historic levels of harvest of nesting turtles, eggs and juveniles • Effects of climate change due to rising sea level, increasing storm severity, and trophic level changes • Coastal development and associated lighting, foot traffic • Marine debris and marine and coastal pollution

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				is estimated at 20,062 nesting females (Seminoff *et al.* 2015). Similarly, data from the Galapagos Archipelago suggest that the abundance of nesting females in that population may be increasing.	
Marine and Anadromous Fish					
Puget Sound Chinook salmon	Threatened 06/28/2005 (70 FR 37160)	SSDC 2007 NMFS 2006a	Ford 2022*	This ESU comprises 22 populations distributed over five geographic areas. Most populations within the ESU have declined in abundance over the past 7 to 10 years, with widespread negative trends in natural-origin spawner abundance, and hatchery-origin spawners present in high fractions in most populations outside of the Skagit watershed. Escapement levels for all populations remain well below the Technical Recovery Team (TRT) planning ranges for recovery, and most populations are consistently below the spawner-recruit levels identified by the TRT as consistent with recovery.	• Degraded floodplain and in-river channel structure • Degraded estuarine conditions and loss of estuarine habitat • Degraded riparian areas and loss of in-river large woody debris • Excessive fine-grained sediment in spawning gravel • Degraded water quality and temperature • Degraded nearshore conditions • Impaired passage for migrating fish • Severely altered flow regime
Puget Sound steelhead	Threatened 05/11/2007 (72 FR 26722)	NMFS 2019a	Ford 2022*	This DPS comprises 32 populations. The DPS is currently at very low viability, with most of the 32 populations and all three population groups at low viability. Information considered during the most recent status review indicates that the biological risks faced by the Puget Sound Steelhead DPS have not substantively changed since the listing in 2007, or since the 2011 status review. Furthermore, the Puget Sound Steelhead TRT recently concluded that the DPS was at very low viability, as were all three of its constituent MPGs, and many of its 32	• Continued destruction and modification of habitat • Widespread declines in adult abundance despite significant reductions in harvest • Threats to diversity posed by use of two hatchery steelhead stocks • Declining diversity in the DPS, including the uncertain but weak status of summer-run fish • A reduction in spatial structure • Reduced habitat quality • Urbanization

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				populations. In the near term, the outlook for environmental conditions affecting Puget Sound steelhead is not optimistic. While harvest and hatchery production of steelhead in Puget Sound are currently at low levels and are not likely to increase substantially in the foreseeable future, some recent environmental trends not favorable to Puget Sound steelhead survival and production are expected to continue.	• Dikes, hardening of banks with riprap, and channelization
Puget Sound/ Georgia Basin DPS of Bocaccio	Endangered 04/28/2010 (75 FR 22276)	NMFS 2017a	NMFS 2016a	Though bocaccio were never a predominant segment of the multi-species rockfish population within the Puget Sound/Georgia Basin, their present-day abundance is likely a fraction of their pre-contemporary fishery abundance. Most bocaccio within the DPS may have been historically spatially limited to several basins within the DPS. They were apparently historically most abundant in the Central and South Sound with no documented occurrences in the San Juan Basin until 2008. The apparent reduction of populations of bocaccio in the Main Basin and South Sound represents a further reduction in the historically spatially limited distribution of bocaccio, and adds significant risk to the viability of the DPS.	• Over harvest • Water pollution • Climate-induced changes to rockfish habitat • Small population dynamics
Puget Sound/ Georgia Basin DPS of Yelloweye Rockfish	Threatened 04/28/2010 (75 FR 22276)	NMFS 2017a	NMFS 2016a	Yelloweye rockfish within the Puget Sound/Georgia Basin (in U.S. waters) are very likely the most abundant within the San Juan Basin of the DPS. Yelloweye rockfish spatial structure and connectivity is threatened by the apparent reduction of fish within each of the basins of the DPS. This reduction is probably most acute within the basins of Puget Sound proper. The severe reduction of fish in these	• Over harvest • Water pollution • Climate-induced changes to rockfish habitat • Small population dynamics

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				basins may eventually result in a contraction of the DPS' range.	
Hood Canal summer-run chum salmon	Threatened 06/28/2005 (70 FR 37160)	HCCC 2005 NMFS 2007	Ford 2022*	This ESU is made up of two independent populations in one major population group. Natural-origin spawner abundance has increased since ESA-listing and spawning abundance targets in both populations have been met in some years. Productivity was quite low at the time of the last review, though rates have increased in the last five years, and have been greater than replacement rates in the past two years for both populations. However, productivity of individual spawning aggregates shows only two of eight aggregates have viable performance. Spatial structure and diversity viability parameters for each population have increased and nearly meet the viability criteria. Despite substantive gains towards meeting viability criteria in the Hood Canal and Strait of Juan de Fuca summer chum salmon populations, the ESU still does not me*et al*l of the recovery criteria for population viability at this time.	• Reduced floodplain connectivity and function • Poor riparian condition • Loss of channel complexity Sediment accumulation • Altered flows and water quality
Ozette Lake sockeye salmon	Threatened 06/28/2005 (70 FR 37160)	NMFS 2009a	NMFS 2022a	This single population ESU's size remain very small compared to historical sizes. Additionally, population estimates remain highly variable and uncertain, making it impossible to detect changes in abundance trends or in productivity in recent years. Spatial structure and diversity are also difficult to appraise; there is currently no successfully quantitative program to monitor beach spawning or spawning at other tributaries. Assessment methods must improve to evaluate the status of this species and its responses to recovery actions. Abundance of	• Predation by harbor seals, river otters, and predaceous non-native and native species of fish • Reduced quality and quantity of beach spawning habitat in Lake Ozette • Increased competition for beach spawning sites due to reduced habitat availability • Stream channel simplification and increased sediment in tributary spawning areas

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				this ESU has not changed substantially from the last status review. The quality of data continues to hamper efforts to assess more recent trends and spatial structure and diversity although this situation is improving.	
Upper Columbia River spring-run Chinook salmon	Endangered 06/28/2005 (70 FR 37160)	UCSRB 2007	NMFS 2022b	This ESU comprises four independent populations. Three are at high risk and one is functionally extirpated. Current estimates of natural origin spawner abundance increased relative to the levels observed in the prior review for all three extant populations, and productivities were higher for the Wenatchee and Entiat populations and unchanged for the Methow population. However, abundance and productivity remained well below the viable thresholds called for in the Upper Columbia Recovery Plan for all three populations.	• Effects related to hydropower system in the mainstem Columbia River • Degraded freshwater habitat • Degraded estuarine and nearshore marine habitat • Hatchery-related effects • Persistence of non-native (exotic) fish species • Harvest in Columbia River fisheries
Upper Columbia River steelhead	Threatened 01/05/2006 (71 FR 834)	UCSRB 2007	NMFS 2022b	This DPS comprises four independent populations. Three populations are at high risk of extinction while 1 population is at moderate risk. Upper Columbia River steelhead populations have increased relative to the low levels observed in the 1990s, but natural origin abundance and productivity remain well below viability thresholds for three out of the four populations. The status of the Wenatchee River steelhead population continued to improve based on the additional year's information available for the most recent review. The abundance and productivity viability rating for the Wenatchee River exceeds the minimum threshold for 5% extinction risk. However, the overall DPS status remains unchanged from the prior review, remaining at high risk driven by	• Adverse effects related to the mainstem Columbia River hydropower system • Impaired tributary fish passage • Degraded floodplain connectivity and function, channel structure and complexity, riparian areas, large woody debris recruitment, stream flow, and water quality • Hatchery-related effects • Predation and competition • Harvest-related effects

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				low abundance and productivity relative to viability objectives and diversity concerns.	
Middle Columbia River steelhead	Threatened 01/05/2006 (71 FR 834)	NMFS 2009b	NMFS 2022c	This DPS comprises 17 extant populations. The DPS does not currently include steelhead that are designated as part of an experimental population above the Pelton Round Butte Hydroelectric Project. Returns to the Yakima River basin and to the Umatilla and Walla Walla Rivers have been higher over the most recent brood cycle, while natural origin returns to the John Day River have decreased. There have been improvements in the viability ratings for some of the component populations, but the DPS is not currently meeting the viability criteria in the MCR steelhead recovery plan. In general, the majority of population level viability ratings remained unchanged from prior reviews for each major population group within the DPS.	• Degraded freshwater habitat • Mainstem Columbia River hydropower-related impacts • Degraded estuarine and nearshore marine habitat • Hatchery-related effects • Harvest-related effects • Effects of predation, competition, and disease
Snake River spring/summer-run Chinook salmon	Threatened 06/28/2005 (70 FR 37160)	NMFS 2017b	NMFS 2022d	This ESU comprises 28 extant and four extirpated populations. All expect one extant population (Chamberlin Creek) are at high risk. Natural origin abundance has increased over the levels reported in the prior review for most populations in this ESU, although the increases were not substantial enough to change viability ratings. Relatively high ocean survivals in recent years were a major factor in recent abundance patterns. While there have been improvements in abundance and productivity in several populations relative to prior reviews, those changes have not been sufficient to warrant a change in ESU status.	• Degraded freshwater habitat • Effects related to the hydropower system in the mainstem Columbia River, • Altered flows and degraded water quality • Harvest-related effects • Predation
Snake River fall-run Chinook salmon	Threatened 06/28/2005	NMFS 2017c	NMFS 2022e	This ESU has one extant population. Historically, large populations of fall Chinook salmon	• Degraded floodplain connectivity and function

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
	(70 FR 37160)			spawned in the Snake River upstream of the Hells Canyon Dam complex. The extant population is at moderate risk for both diversity and spatial structure and abundance and productivity. The overall viability rating for this population is 'viable.' Overall, the status of Snake River fall Chinook salmon has clearly improved compared to the time of listing and compared to prior status reviews. The single extant population in the ESU is currently meeting the criteria for a rating of 'viable' developed by the ICTRT, but the ESU as a whole is not meeting the recovery goals described in the recovery plan for the species, which require the single population to be "highly viable with high certainty" and/or will require reintroduction of a viable population above the Hells Canyon Dam complex.	• Harvest-related effects • Loss of access to historical habitat above Hells Canyon and other Snake River dams • Impacts from mainstem Columbia River and Snake River hydropower systems • Hatchery-related effects • Degraded estuarine and nearshore habitat.
Snake River basin steelhead	Threatened 01/05/2006 (71 FR 834)	NMFS 2017b	NMFS 2022f	This DPS comprises 24 populations. Two populations are at high risk, 15 populations are rated as maintained, 3 populations are rated between high risk and maintained, 2 populations are at moderate risk, 1 population is viable, and 1 population is highly viable. Four out of the five MPGs are not meeting the specific objectives in the draft recovery plan based on the updated status information available for this review, and the status of many individual populations remains uncertain A great deal of uncertainty still remains regarding the relative proportion of hatchery fish in natural spawning areas near major hatchery release sites within individual populations.	• Adverse effects related to the mainstem Columbia River hydropower system • Impaired tributary fish passage • Degraded freshwater habitat • Increased water temperature • Harvest-related effects, particularly for B-run steelhead • Predation • Genetic diversity effects from out-of-population hatchery releases

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Snake River sockeye salmon	Endangered 06/28/2005 (70 FR 37160)	NMFS 2015b	NMFS 2022g	This single population ESU is at very high risk dues to small population size. There is high risk across all four basic risk measures. Although the captive brood program has been successful in providing substantial numbers of hatchery produced fish for use in supplementation efforts, substantial increases in survival rates across all life history stages must occur to re-establish sustainable natural production In terms of natural production, the Snake River Sockeye salmon ESU remains at extremely high risk although there has been substantial progress on the first phase of the proposed recovery approach – developing a hatchery based program to amplify and conserve the stock to facilitate reintroductions.	• Effects related to the hydropower system in the mainstem Columbia River • Reduced water quality and elevated temperatures in the Salmon River • Water quantity • Predation
Lower Columbia River Chinook salmon	Threatened 06/28/2005 (70 FR 37160)	NMFS 2013a	NMFS 2022h	This ESU comprises 32 independent populations. Twenty-seven populations are at very high risk, 2 populations are at high risk, one population is at moderate risk, and 2 populations are at very low risk Overall, there was little change since the last status review in the biological status of this ESU, although there are some positive trends. Increases in abundance were noted in about 70% of the fall-run populations and decreases in hatchery contribution were noted for several populations. Relative to baseline VSP levels identified in the recovery plan, there has been an overall improvement in the status of a number of fall-run populations, although most are still far from the recovery plan goals.	• Reduced access to spawning and rearing habitat • Hatchery-related effects • Harvest-related effects on fall Chinook salmon • An altered flow regime and Columbia River plume • Reduced access to off-channel rearing habitat • Reduced productivity resulting from sediment and nutrient-related changes in the estuary • Contaminant
Lower Columbia River coho salmon	Threatened 06/28/2005 (70 FR 37160)	NMFS 2013a	NMFS 2022h	Of the 24 populations that make up this ESU, 21 populations are at very high risk, 1 population is at high risk, and 2 populations are at moderate	• Degraded estuarine and near-shore marine habitat • Fish passage barriers

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				risk. Recent recovery efforts may have contributed to the observed natural production, but in the absence of longer term data sets it is not possible to parse out these effects. Populations with longer term data sets exhibit stable or slightly positive abundance trends. Some trap and haul programs appear to be operating at or near replacement, although other programs still are far from that threshold and require supplementation with additional hatchery-origin spawners .Initiation of or improvement in the downstream juvenile facilities at Cowlitz Falls, Merwin, and North Fork Dam are likely to further improve the status of the associated upstream populations. While these and other recovery efforts have likely improved the status of a number of coho salmon populations, abundances are still at low levels and the majority of the populations remain at moderate or high risk. For the Lower Columbia River region land development and increasing human population pressures will likely continue to degrade habitat, especially in lowland areas. Although populations in this ESU have generally improved, especially in the 2013/14 and 2014/15 return years, recent poor ocean conditions suggest that population declines might occur in the upcoming return years	• Degraded freshwater habitat: Hatchery-related effects • Harvest-related effects • An altered flow regime and Columbia River plume • Reduced access to off-channel rearing habitat in the lower Columbia River • Reduced productivity resulting from sediment and nutrient-related changes in the estuary • Juvenile fish wake strandings • Contaminants
Lower Columbia River steelhead	Threatened 01/05/2006 (71 FR 834)	NMFS 2013a	NMFS 2022h	This DPS comprises 23 historical populations, 17 winter-run populations and six summer-run populations. Nine populations are at very high risk, 7 populations are at high risk, 6 populations are at moderate risk, and 1 population is at low	• Degraded estuarine and nearshore marine habitat • Degraded freshwater habitat • Reduced access to spawning and rearing habitat

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				risk. The majority of winter-run steelhead populations in this DPS continue to persist at low abundances. Hatchery interactions remain a concern in select basins, but the overall situation is somewhat improved compared to prior reviews. Summer-run steelhead populations were similarly stable, but at low abundance levels. The decline in the Wind River summer-run population is a source of concern, given that this population has been considered one of the healthiest of the summer-runs; however, the most recent abundance estimates suggest that the decline was a single year aberration. Passage programs in the Cowlitz and Lewis basins have the potential to provide considerable improvements in abundance and spatial structure, but have not produced self-sustaining populations to date. Even with modest improvements in the status of several winter-run DIPs, none of the populations appear to be at fully viable status, and similarly none of the MPGs meet the criteria for viability.	• Avian and marine mammal predation • Hatchery-related effects • An altered flow regime and Columbia River plume • Reduced access to off-channel rearing habitat in the lower Columbia River • Reduced productivity resulting from sediment and nutrient-related changes in the estuary • Juvenile fish wake strandings • Contaminants
Columbia River chum salmon	Threatened 06/28/2005 (70 FR 37160)	NMFS 2013a	NMFS 2022h	Overall, the status of most chum salmon populations is unchanged from the baseline VSP scores estimated in the recovery plan. A total of 3 of 17 populations are at or near their recovery viability goals, although under the recovery plan scenario these populations have very low recovery goals of 0. The remaining populations generally require a higher level of viability and most require substantial improvements to reach their viability goals. Even with the improvements observed during the last five years, the majority of populations in this ESU	• Degraded estuarine and nearshore marine habitat • Degraded freshwater habitat • Degraded stream flow as a result of hydropower and water supply operations • Reduced water quality • Current or potential predation • An altered flow regime and Columbia River plume • Reduced access to off-channel rearing habitat in the lower Columbia River

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				remain at a high or very high risk category and considerable progress remains to be made to achieve the recovery goals.	• Reduced productivity resulting from sediment and nutrient-related changes in the estuary • Juvenile fish wake strandings • Contaminants
Upper Willamette River Chinook salmon	Threatened 06/28/2005 (70 FR 37160)	ODFW and NMFS 2011	Ford 2022*	This ESU comprises seven populations. Five populations are at very high risk, one population is at moderate risk (Clackamas River) and one population is at low risk (McKenzie River). Consideration of data collected since the last status review in 2010 indicates the fraction of hatchery origin fish in all populations remains high (even in Clackamas and McKenzie populations). The proportion of natural origin spawners improved in the North and South Santiam basins, but is still well below identified recovery goals. Abundance levels for five of the seven populations remain well below their recovery goals. Of these, the Calapooia River may be functionally extinct and the Molalla River remains critically low. Abundances in the North and South Santiam rivers have risen since the 2010 review, but still range only in the high hundreds of fish. The Clackamas and McKenzie populations have previously been viewed as natural population strongholds, but have both experienced declines in abundance despite having access to much of their historical spawning habitat. Overall, populations appear to be at either moderate or high risk, there has been likely little net change in the VSP score for the ESU since the last review, so the ESU remains at moderate risk.	• Degraded freshwater habitat • Degraded water quality • Increased disease incidence • Altered stream flows • Reduced access to spawning and rearing habitats • Altered food web due to reduced inputs of microdetritus • Predation by native and non-native species, including hatchery fish • Competition related to introduced salmon and steelhead • Altered population traits due to fisheries and bycatch

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Upper Willamette River steelhead	Threatened 01/05/2006 (71 FR 834)	ODFW and NMFS 2011	Ford 2022*	This DPS has four demographically independent populations. Three populations are at low risk and one population is at moderate risk. Declines in abundance noted in the last status review continued through the period from 2010-2015. While rates of decline appear moderate, the DPS continues to demonstrate the overall low abundance pattern that was of concern during the last status review. The causes of these declines are not well understood, although much accessible habitat is degraded and under continued development pressure. The elimination of winter-run hatchery release in the basin reduces hatchery threats, but non-native summer steelhead hatchery releases are still a concern for species diversity and a source of competition for the DPS. While the collective risk to the persistence of the DPS has not changed significantly in recent years, continued declines and potential negative impacts from climate change may cause increased risk in the near future.	• Degraded freshwater habitat • Degraded water quality • Increased disease incidence • Altered stream flows • Reduced access to spawning and rearing habitats due to impaired passage at dams • Altered food web due to changes in inputs of microdetritus • Predation by native and non-native species, including hatchery fish and pinnipeds • Competition related to introduced salmon and steelhead • Altered population traits due to interbreeding with hatchery origin fish
Oregon Coast coho salmon	Threatened 06/20/2011 (76 FR 35755)	NMFS 2016b	NMFS 2022i	This ESU comprises 56 populations including 21 independent and 35 dependent populations. The last status review indicated a moderate risk of extinction. Significant improvements in hatchery and harvest practices have been made for this ESU. Most recently, spatial structure conditions have improved in terms of spawner and juvenile distribution in watersheds; none of the geographic area or strata within the ESU appear to have considerably lower abundance or productivity. The ability of the ESU to survive	• Reduced amount and complexity of habitat including connected floodplain habitat • Degraded water quality • Blocked/impaired fish passage • Inadequate long-term habitat protection • Changes in ocean conditions

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				another prolonged period of poor marine survival remains in question.	
Southern Oregon/ Northern California Coast coho salmon	Threatened 06/28/2005 (70 FR 37160)	NMFS 2014a	SWFSC 2023*	This ESU comprises 31 independent, 9 independent, and 5 ephemeral populations all grouped into 7 diversity strata. Of the 31 independent populations, 24 are at high risk of extinction and 6 are at moderate risk of extinction. The extinction risk of an ESU depends upon the extinction risk of its constituent independent populations; because the population abundance of most independent populations are below their depensation threshold, the SONCC coho salmon ESU is at high risk of extinction and is not viable	• Lack of floodplain and channel structure • Impaired water quality • Altered hydrologic function • Impaired estuary/mainstem function • Degraded riparian forest conditions • Altered sediment supply • Increased disease/predation/competition • Barriers to migration • Fishery-related effects • Hatchery-related effects
Northern California steelhead	Threatened 6/7/2000 (65 FR 36074)	NMFS 2016c	SWFSC 2023*	This DPS historically comprised 42 independent populations of winter-run steelhead (19 functionally independent and 23 potentially independent), and up to 10 independent populations (all functionally independent) of summer-run steelhead, with more than 65 dependent populations of winter-run steelhead in small coastal watersheds, and Eel river tributaries. Many populations are considered to be extant. Significant gaps in information exist for the Lower Interior and North Mountain Interior diversity strata. All winter-run populations are currently well below viability targets, with most at 5-13% of these goals. Mixed population trends arise depending on time series length; thus, there is no strong evidence to indicate conditions for winter-run populations have worsened appreciably since the last status review. Summer-run populations are of concern. While one run is near the	• Dams and other barriers to migration • Logging • Agriculture • Ranching • Fishery-related effects • Hatchery-related effects

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				viability target, others are very small or there is a lack of data. Overall, available information for winter- and summer-run populations do not suggest an appreciable increase or decrease in extinction risk since the last status review.	
California Coastal Chinook salmon	Threatened 09/16/1999 (64 FR 50394)	NMFS 2016c	SWFSC 2023*	This ESU historically supported 16 Independent populations of fall-run Chinook salmon (11 Functionally Independent and five potentially Independent), six populations of spring-run Chinook salmon, and an unknown number of dependent populations. Based on the data available, eight of the 16 populations were classified as data deficient, one population was classified as being at a Moderate/High risk of extirpation, and six populations were classified as being at a High risk of extirpation. There has been a mix in population trends, with some population escapement numbers increasing and others decreasing. Overall, there is a lack of compelling evidence to suggest that the status of these populations has improved or deteriorated appreciably since the previous status review.	• Logging and road construction altering substrate composition, increasing sediment load, and reducing riparian cover • Estuarine alteration resulting in lost complexity and habitat from draining and diking • Dams and barriers diminishing downstream habitats through altered flow regimes and gravel recruitment • Climate change • Urbanization and agriculture degrading water quality from urban pollution and agricultural runoff • Gravel mining creating barriers to migration, stranding of adults, and promoting spawning in poor locations • Alien species (i.e. Sacramento Pikeminnow) • Small hatchery production without monitoring the effects of hatchery releases on wild spawners
Sacramento River winter-run Chinook salmon	Endangered 09/16/1999 (64 FR 50394)	NMFS 2014b	NMFS 2024a	This ESU historically supported 18 or 19 Independent populations, with some smaller dependent populations, and four diversity groups. Only three populations are extant (Mill, Deer, and Butte creeks on the upper Sacramento River) which only represent one diversity group (Northern Sierra Nevada). Spatial diversity is increasing with presence (at	• Dams block access to 90 percent of historic spawning and summer holding areas along with altering river flow regimes and temperatures. • Diversions • Urbanization and rural development • Logging • Grazing

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				low numbers in some cases) in all diversity groups. Recolonization of the Battle Creek population with increasing abundance of the Clear Creek population is benefiting ESU viability. The reappearance of phenotypic spring-run to the San Joaquin River tributaries may be the beginning of natural recolonization processes in once extirpated rivers. Active reintroduction efforts on the Yuba and San Joaquin rivers show promise. The ESU is trending positively towards achieving at least two populations in each of the four historical diversity groups necessary for recovery.	• Agriculture • Mining – historic hydraulic mining from the California Gold Rush era. • Estuarine modified and degraded, thus reducing developmental opportunities for juvenile salmon • Fisheries • Hatcheries • 'Natural' factors (e.g. ocean conditions)
Central Valley spring-run Chinook salmon	Threatened 09/16/1999 (64 FR 50394)	NMFS 2014b	SWFSC 2023*	This ESU historically supported 18 or 19 Independent populations, with some smaller dependent populations, and four diversity groups. Only three populations are extant (Mill, Deer, and Butte creeks on the upper Sacramento River) which only represent one diversity group (Northern Sierra Nevada). Spatial diversity is increasing with presence (at low numbers in some cases) in all diversity groups. Recolonization of the Battle Creek population with increasing abundance of the Clear Creek population is benefiting ESU viability. The reappearance of phenotypic spring-run to the San Joaquin River tributaries may be the beginning of natural recolonization processes in once extirpated rivers. Active reintroduction efforts on the Yuba and San Joaquin rivers show promise. The ESU is trending positively towards achieving at least two populations in each of the four historical diversity groups necessary for recovery.	• Dams block access to 90 percent of historic spawning and summer holding areas along with altering river flow regimes and temperatures. • Diversions • Urbanization and rural development • Logging • Grazing • Agriculture • Mining – historic hydraulic mining from the California Gold Rush era. • Estuarine modified and degraded, thus reducing developmental opportunities for juvenile salmon • Fisheries • Hatcheries • 'Natural' factors (e.g. ocean conditions)

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
California Central Valley steelhead	Threatened 3/19/1998 (63 FR 13347)	NMFS 2014b	SWFSC 2023*	Steelhead are present throughout most of the watersheds in the Central Valley, but often in low numbers, especially in the San Joaquin River tributaries. The status of this DPS appears to have changed little since the 2011 status review stating the DPS was in danger of extinction. There is still a paucity of data on the status of wild populations. There are some encouraging signs of increased returns over the last few years. However, the catch of unmarked (wild) steelhead at Chipps Island is still less than 5 percent of the total smolt catch, which indicates natural production of steelhead throughout the Central Valley remains at very low levels. Despite a positive trend on Clear Creek and encouraging signs from Mill Creek, all other concerns raised in the previous status review remain.	• Major dams • Water diversions • Barriers • Levees and bank protection • Dredging and sediment disposal • Mining • Contaminants • Alien species • Fishery-related effects • Hatchery-related effects
Central California Coast coho salmon	Endangered 04/02/2012 (77 FR 19552) 06/28/2005 (70 FR 37160) Threatened 10/31/1996 (61 FR 56138)	NMFS 2012a	NMFS 2023a	This ESU comprises approximately 76 populations that are mostly dependent populations. Historically, the ESU had 11 functionally independent populations and one potentially independent population organized into four stratum. Most independent populations remain at critically low levels, with those in the southern Santa Cruz Mountains strata likely extirpated. Data suggests some populations show a slight positive trend in annual escapement, but the improvement is not statistically significant. Overall, all populations remain, at best, a slight fraction of their recovery target levels, and, aside from the Santa Cruz Mountains strata, the continued extirpation of dependent populations continues	• Logging • Agriculture • Mining • Urbanization • Stream modifications - including altered stream bank and channel morphology, elevated water temperature, lost spawning and rearing habitat, habitat fragmentation, impaired gravel and wood recruitment from upstream sources, degraded water quality, lost riparian vegetation, and increased erosion into streams from upland areas • Dams • Wetland loss

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				to threaten the ESU's future survival and recovery.	• Water withdrawals (including unscreened diversions for irrigation)
Central California Coast steelhead	Threatened 8/18/1997 (62 FR 43937)	NMFS 2016c	SWFSC 2023*	Both adult and juvenile abundance data are limited for this DPS. It was historically comprised of 37 independent populations (11 functionally independent and 26 potentially independent) and perhaps 30 or more dependent populations of winter-run steelhead. Most of the coastal populations are assumed to be extant with other populations (Coastal San Francisco Bay and Interior San Francisco Bay) likely at high risk of extirpation. While data availability for this DPS remains poor, there is little new evidence to suggest that the extinction risk for this DPS has changed appreciably in either direction since the last status review.	• Dams and other barriers to migration • Stream habitat degradation • Estuarine habitat degradation • Hatchery-related effects
South-Central California Coast steelhead	Threatened 8/18/1997 (62 FR 43937)	NMFS 2013b	NMFS 2023b	Currently, nearly half of this DPS reside in the Carmel River. Most other streams and rivers have small populations that can be stochastically driven to extirpation. The ability to fully assess the status of individual populations and the DPS as whole has been limited. There is little new evidence to indicate that the status of the SCCC Steelhead DPS has changed appreciably since the last status review, though the Carmel River runs have shown a long term decline. Threats to the DPS identified during initial listing have remained largely unchanged, though some fish passage barriers have been removed. Threats to this DPS are likely to exacerbate the factors affecting the continued existence of the DPS. SCCC steelhead recovery will require reducing threats, maintaining interconnected populations across	• Hydrological modifications- dams, surface water diversions, groundwater extraction • Agricultural and urban development, roads, other passage barriers • Flood control, levees, channelization • Alien species • Estuarine habitat loss • Marine environment threats • Natural environmental variability • Pesticide contaminants

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				their native range, and preserving the diversity of life history strategies.	
Southern DPS of green sturgeon	Threatened 04/07/2006 (71 FR 17757)	NMFS 2018a	NMFS 2021a	The Sacramento River contains the only known green sturgeon spawning population in this DPS. The current estimate of spawning adult abundance is between 824-1,872 individuals. Telemetry data and genetic analyses suggest that Southern DPS green sturgeon generally occur from Graves Harbor, Alaska to Monterey Bay, California and, within this range, most frequently occur in coastal waters of Washington, Oregon, and Vancouver Island and near San Francisco and Monterey bays. Within the nearshore marine environment, tagging and fisheries data indicate that Northern and Southern DPS green sturgeon prefer marine waters of less than a depth of 110 meters.	• Reduction of its spawning area to a single known population • Lack of water quantity • Poor water quality • Poaching
Southern DPS of eulachon	Threatened 03/18/2010 (75 FR 13012)	NMFS 2017d	NMFS 2022j	The Southern DPS of eulachon includes all naturally-spawned populations that occur in rivers south of the Nass River in British Columbia to the Mad River in California. Sub populations for this species include the Fraser River, Columbia River, British Columbia and the Klamath River. In the early 1990s, there was an abrupt decline in the abundance of eulachon returning to the Columbia River. Despite a brief period of improved returns in 2001-2003, the returns and associated commercial landings eventually declined to the low levels observed in the mid-1990s. Although eulachon abundance in monitored rivers has generally improved, especially in the 2013-2015 return years, recent poor ocean conditions and the likelihood that these conditions will persist into the near future	• Changes in ocean conditions due to climate change, particularly in the southern portion of the species' range where ocean warming trends may be the most pronounced and may alter prey, spawning, and rearing success. • Climate-induced change to freshwater habitats • Bycatch of eulachon in commercial fisheries • Adverse effects related to dams and water diversions • Water quality • Shoreline construction • Over harvest • Predation

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				suggest that population declines may be widespread in the upcoming return years	
Marine Invertebrates					
Sunflower sea stars	Threatened *(Proposed)* 3/16/2023 (88 FR 16212)	NA	Lowry *et al.* 2022	The sunflower sea star is considered to be one panmictic population, ranging from the Northeastern Pacific Ocean from the Aleutian Islands to Baja California. Over 90 percent of the abundance of the species was lost from 2013 to 2017 due to sea star wasting syndrome (SSWS), and there are few positive signs of recovery. Likely linkages of SSWS with environmental parameters that are projected to worsen with ongoing climate change suggest that impacts on the species from SSWS will likely persist and potentially worsen over the foreseeable future throughout the range.	• Sea Star Wasting Syndrome (SSWS) • Climate change impacts likely to create ocean conditions exacerbating SSWS impacts

* Updated viability data are available from Ford 2022 and SWFSC 2023 although updated 5-year reviews have not been completed for these species

Sea Turtles

Leatherback Sea Turtles

A recovery plan for the U.S. Pacific populations of leatherbacks was completed over 20 years ago (NMFS and USFWS 1998b), and leatherbacks remain listed globally as an endangered species under the ESA. In 2012, NMFS revised critical habitat for leatherbacks to include additional areas within the Pacific Ocean (77 FR 4170). The revised designation includes approximately 17,000 square miles stretching along the California coast from Point Arena to Point Arguello east of the 3,000 meter depth contour and approximately 25,000 miles stretching from Cape Flattery, Washington, to Cape Blanco, Oregon east of the 2,000 meter depth contour. The principal biological feature identified as essential to leatherback conservation was prey, primarily *scyphomedusae*. The proposed action occurs within Pacific leatherback critical habitat, and we analyze potential effects to designated leatherback critical habitat in section 2.12 of this Opinion.

Leatherback sea turtles have been observed at sea between about 71° N to 47° S (Eckert *et al.* 2012). Globally, seven populations are currently recognized under the ESA: (1) Northwest Atlantic; (2) Southeast Atlantic; (3) Southwest Atlantic; (4) Northeast Indian; (5) Southwest Indian; (6) West Pacific; and (7) East Pacific (NMFS and USFWS 2020b).

Leatherback turtles lead a completely pelagic existence, foraging widely in temperate and tropical waters except during the nesting season, when gravid females return to tropical beaches to lay eggs. Leatherbacks are highly migratory, exploiting convergence zones and upwelling areas for foraging in the open ocean, along continental margins, and in archipelagic waters (Morreale *et al.* 1994; Eckert 1999; Benson *et al.* 2007, 2011). Leatherback sea turtles feed from near the surface to depths exceeding 1,000 m, including nocturnal feeding on tunicate colonies within the deep scattering layer (Spotila 2004).

In the Pacific, leatherback nesting aggregations are found in the eastern and western Pacific. Aerial surveys conducted between 2004 and 2007 identified Indonesia, Papua New Guinea, and Solomon Islands as the core nesting areas for the population (Benson *et al.* 2011). The majority of nesting occurs along the north coast of the Bird’s Head Peninsula, Papua Barat, Indonesia at Jamursba-Medi and Wermon beaches (Dutton *et al.* 2007). A recent discovery of a previously undocumented nesting area on Buru Island, Indonesia and relatively new sites in the Solomon Islands suggests that additional undocumented nesting habitats may exist on other remote or infrequently surveyed islands of the western Pacific Ocean (NMFS and USFWS 2020b). Low levels of nesting are also reported in Vanuatu (Petro *et al.* 2007).

Two life history strategies are documented in the West Pacific Ocean population: winter boreal nesters (December to March) and summer boreal nesters (June to September). Migration and foraging strategies vary based on these life history strategies, likely due to prevailing offshore currents and seasonal monsoon-related effects experienced as hatchlings (Benson *et al.* 2011; Gaspar *et al.* 2012). Summer nesting females forage in Northern Hemisphere habitats in Asia and the North Pacific Ocean, while winter nesting females migrate to tropical waters in the South Pacific Ocean (Benson *et al.* 2011; Harrison *et al.* 2018). Adult West Pacific leatherback sea turtles interacting with the proposed action are most likely summer nesters using the North Pacific transition zone (or Kuroshio extension), equatorial eastern Pacific, or the California Current Extension.

The most recent status review (NMFS and USFWS 2020b) defines the East Pacific subpopulation as leatherback turtles originating from the East Pacific Ocean, north of 47° S, south of 32.531° N, east of 117.124° W, and west of the Americas. The subpopulation generally occupies a distribution distinct from the West Pacific population and is considered to be located outside of the action area for the proposed action. Based on the genetic analyses of leatherbacks found off the U.S. West Coast, we consider the probability of the East Pacific leatherback sea turtles occurring in the action area, to be extremely low.

The IUCN Red List conducted its most recent assessment of the West Pacific Ocean subpopulation in 2013 and listed it as "Critically Endangered" due in part to its continual decline in nesting, the continued threat due to fishing, and the low number of estimated nesting females. Genetic samples from leatherback sea turtles interacting with the CA DGN fishery indicate that all of these individuals are from the West Pacific population (P. Dutton, personal communication, SWFSC, unpublished data).

<u>Population Status and Trends:</u> Leatherbacks occur throughout the world and populations and trends vary in different regions and nesting beaches. In 1980, the leatherback population was approximately 115,000 (adult females) globally (Pritchard 1982). By 1995, one estimate claimed this global population of adult females had declined to 34,500 (Spotila *et al.* 1996). In 2020, NMFS and USFWS published a global status review for leatherback sea turtles. Abundance and trend estimates of nesting females for five of the DPSs not located in the Pacific Ocean indicated that all were at risk of extinction. The Northwest Atlantic DPS has a total index of nesting female abundance of 20,659 females, with a moderate level of confidence. This DPS exhibits a decreasing nest trend at nesting beaches with the greatest known nesting female abundance. For the Southwest Atlantic DPS, NMFS and USFWS estimated only 27 females, with most nesting occurring in Brazil and exhibiting an increasing, although variable nest trend. The Southeast Atlantic DPS was estimated to have 9,198 nesting females, with most nesting in Gabon where a declining nest trend has been observed at this largest nesting aggregation. The Southwest Indian Ocean DPS was estimated to have 149 nesting females with an overall nesting trend to be slightly decreasing. Lastly, the Northeast Indian DPS total index of nesting female abundance was estimated to be 109 females with a declining trend, particularly with the extirpation of its largest nesting aggregation in Malaysia (NMFS and USWFS 2020b).

In the Pacific, leatherback populations are declining at all major Pacific basin nesting beaches, particularly in the last three decades (Spotila *et al.* 1996; Spotila *et al.* 2000; NMFS and USFWS 2020b).

East Pacific leatherbacks

Using the best available data for the East Pacific population, NMFS and USFWS (2020b) estimate that there are approximately 755 adult females in the East Pacific population with 76% of nesting occurring on beaches in Mexico (572 females), 22% (165 females) in Costa Rica and 2% (18 females) in Nicaragua. This estimate, 755 adult females, is based on index beaches that comprise approximately 75% of the total nesting for the population (NMFS and USFWS 2020b); therefore, we estimate a total of 1,007 adult females. Assuming a sex ratio of 79% female (Santidrian-Tomillo *et al.* 2014) suggests a total of 1,274 adults in 2020 inclusive of both males and females. We do not have data to assess the total population size; however, based on data in Table 2 of Jones *et al.* (2012), we expect that adults comprise a mean of 2.1% (CI: 1.3% to 3.7%) of the total population size, which would suggest a total population size of 60,611 (CI: 34,050 to 95,462) individuals in 2020. This population is declining, with a 97.4 % decline since the 1980s or 1990s (Wallace *et al.* 2013a). The declines have generally not been reversed despite intense conservation efforts (NMFS and USFWS 2020b).

Western Pacific leatherbacks

The Western Pacific leatherback metapopulation that nests in Indonesia, Papua New Guinea, Solomon Islands and Vanuatu harbors the last remaining nesting aggregation of significant size in the Pacific. The leatherback status review (NMFS and USFWS 2020b) conservatively estimated adult female abundance at 1,277 individuals in 2017. This value is based only on nesting at Jamursba-Medi and Wermon beaches in Papua Barat, Indonesia, as these are the only beaches with long-term monitoring. Despite a slight uptrend in the most recent data, NMFS and USFWS (2020b) estimated the long-term trend in annual nest counts for Jamursba Medi (data collected from 2001 to 2017) at -5.7 percent annually. These two beaches likely represent between 50% and 75% of all nesting for this population (NMFS and USFWS 2020b).

Results of a population viability analysis (PVA) model suggest that the adult female portion of the West Pacific leatherback sea turtle population is declining at a long-term rate of 6% per year (95% CI: -23.8% to 12.2%), and the population as indicated by the index beaches is at risk of falling to less than half of its current abundance in as few as five years (range 5-26 years, mean 12.7 years; Martin *et al.* 2020a). PVA modeled estimates suggest the population in 2017 from these two beaches consisted of about 790 adult female leatherback sea turtles (95% CI: 666-942) using the median values for nest counts. As trends at these beaches between 2017 and 2022 appear to be stable, we consider the 2017 abundance estimate to be the best estimate of current (2022) adult females for the index beaches. Approximately 50% to 75% of West Pacific leatherback nesting occurs at Jamursba Medi and Wermon beaches (Dutton *et al.* 2007; NMFS and USFWS 2020b). Applying the conservative estimate of 75% to the Martin *et al.* (2020a) estimate of 790 females in the West Pacific population would lead to an estimate of 1,053 females, with an overall 95% CI of 888 to 1,256 females.

Additional but lower levels of nesting have been documented elsewhere in Indonesia, including a new monitoring program established in 2017 on Buru Island (World Wildlife Fund (WWF) 2022), plus locations in Papua New Guinea, Solomon Islands, Vanuatu and the Philippines. Monitoring at most of these additional sites has not been going on long enough to establish trends or abundance; therefore, data from these nesting beaches cannot be used to reliably calculate those metrics at this time. An exception to this is the WWF program at Buru Island in Indonesia, where data have been consistently collected since 2017 (WWF 2022). While there is only 6 years of data available, this period does span almost two remigration intervals. These data indicate an increasing trend of 10.1% per year (CI: -26.1% to 46.3%) based on an exponential growth curve. Using the same method to calculate total adult females as Martin *et al.* (2020a; remigration interval multiplied by the average of the last 4 years of nesters, there are approximately 103 adult females nesting at Buru Island. This would constitute an addition to the modeled estimate of 790 annual nesting females at Jamursba Medi and Wermon in 2017 (Martin *et al.* 2020a). Assuming a 73% female sex ratio (Benson *et al.* 2011) and based on NMFS' PVA results for median nest counts, the total number of adult leatherback sea turtles in the West Pacific Ocean population would be 1,443 ([790/0.73]/0.75; 95% CI: 1,216-1,720) if the index beaches represent 75% of the population.

Based on the estimates presented in Jones *et al.* (2012) for all Pacific populations, NMFS inferred an estimated West Pacific leatherback total population size (i.e., juveniles and adults) of 250,000 (95 CI: 97,000-535,000) in 2004. Based on the relative change in the estimates derived from Jones *et al.* (2012) and the more recent Martin *et al.* (2020a), NMFS estimates the juvenile and adult population size of the West Pacific leatherback population is around 100,000 sea turtles (95 percent CI: 47,000-195,000). As nesting numbers have been stable since 2017, we assume these abundance estimates are representative of 2022 abundance estimates as well.

The Western Pacific population has been exhibiting low hatchling success and decreasing nesting population trends due to past and current threats (NMFS and USFWS 2020b). The low estimated nesting female abundance of the West Pacific population places it at elevated risk for environmental variation, genetic complications, demographic stochasticity, negative ecological feedback and catastrophes. These processes, working alone or in concert, place small populations at a greater extinction risk than large populations, which are better able to absorb impacts to habitat or losses in individuals. Low site fidelity, which is characteristic of the species, results in the dispersal of nests among various beaches. This may help to reduce population level impacts from threats which may disproportionately affect one area over another, but may also place nests in locations that are likely unmonitored and not protected from human poaching or predation, thereby increasing threats to the population. Due to its small size, this population has restricted capacity to buffer such losses (NMFS and USFWS 2020b).

Satellite tracking of post-nesting females and foraging males and females, as well as genetic analyses of leatherback turtles caught in U.S. Pacific fisheries or stranded on the west coast of the U.S., along with stable isotope analysis, all indicate that all of the leatherbacks found off the U.S. West Coast are from the western Pacific nesting populations, specifically boreal summer nesters. Approximately 38-57 percent of summer-nesting females from Papua Barat migrate to distant foraging grounds off the U.S. West Coast, including the neritic waters off central California. Researchers recently assessed the abundance and trend of leatherbacks foraging off central California using 28 years of aerial survey data from coast-wide and adaptive fine-scale surveys (Benson et al 2020). Results indicate that leatherback abundance has declined at an annual rate of -5.6% (95% credible interval of -9.8% to -1.5%) to less than 200 individuals.

Threats: Leatherback sea turtles are probably already beginning to be affected by impacts associated with climate change given low hatch success due to lethal beach temperatures and beach erosion (Tapilatu and Tiwari 2007; Bellagio Steering Committee 2008; NMFS and USFWS 2013). Over the long-term, climate change-related impacts will likely influence biological trajectories in the future on a century scale (Parmesan and Yohe 2003).

Natural factors, including the 2004 tsunami in the Indian Ocean (see detailed report by Hamann *et al.* 2006) and the tsunami that affected Japan in 2011, may have impacted leatherback nesting beach habitat through encroachment and erosion (2004 tsunami) or may have resulted in increased debris into leatherback marine habitat (e.g., impacting migratory routes and foraging hotspots). Shifting mudflats in the Guianas have also made nesting habitat unsuitable (Crossland 2003; Goverse and Hilterman 2003).

Predation on sea turtle hatchlings by birds and fish (see Vose and Shank 2003) has been commonly reported. Reported predation of leatherback hatchlings includes tarpons (Nellis and Henke 2000), gray snappers (Vose and Shank 2003), ghost crabs, great blue and yellow-crowned herons, and crested caracaras (Santidrian-Tomillo *et al.* 2010). Adult leatherbacks are preyed upon by large predators, such as jaguars, tigers, killer whales, sharks, and crocodiles (reviewed by Eckert *et al.* 2012).

Major anthropogenic threats to the species, are fisheries bycatch, direct harvest, alteration of nesting habitat, and predation (NMFS and USFWS 2020b). In addition, habitat changes attributed to changing environmental conditions (i.e., sand temperatures that result in mortality or changes in sex ratios, erosion), pollution and marine debris are also threats to this species (Tiwari *et al.* 2013). The drivers of these species decline - both anthropogenic (e.g., bycatch, egg harvest, exploitation of females) as well as environmental (e.g., lethal sand temperatures, predation, erosion) - have been described in detail (Eckert 1993; Bellagio Steering Committee 2008; Tapilatu and Tiwari 2007; Tapilatu *et al.* 2013). Egg harvest and exploitation of females have been minimized at the two most significant nesting beaches of Papua Barat, Indonesia, and the impact of environmental factors is being addressed through a science-based management and conservation programme. Fisheries bycatch is still considered the major obstacle to this population's recovery (Benson *et al.* 2011; Bailey *et al.* 2012; Tapilatu *et al.* 2013; Wallace *et al.* 2013b).

Conservation: Considerable effort has been made since the 1980s to document and address leatherback sea turtle bycatch in fisheries around the world. In the United States, observer programs have been implemented in most U.S. federally managed fisheries to collect bycatch data, and several strategies have been pursued to reduce both bycatch rates and post-interaction mortality. These include developing gear solutions to prevent or reduce capture (e.g., circle hooks in combination with fin-fish bait for longline fisheries) or to allow turtles to escape without harm (e.g., turtle exclusion devices in trawl fisheries), implementing seasonal time-area closures to prevent fishing when turtles are congregated, modifying existing gear (e.g., reducing mesh size of gillnets), and developing and promoting Sea Turtle Handling Guidelines. For example, switching to large circle hooks and mackerel-type bait in 2004 with complimentary fishery-based outreach and education resulted in an 84% reduction in the leatherback sea turtle interaction rate in the Hawai'i SSLL fishery (Swimmer at al. 2017).

NMFS developed a 5-year action plan (2016-2020), identifying the top five recovery actions to support this "Species in the Spotlight" (species listed under the ESA for which immediate, targeted efforts are vital for stabilizing their populations and preventing their extinction) over the next five years: (1) reduce fishery interactions; (2) improve nesting beach protection and increase reproductive output; (3) international cooperation; (4) monitoring and research; and (5) public engagement (NMFS 2016d). This initiative was recently renewed in 2021 for 2021-2025 (NMFS 2021d).

Community-based conservation projects in Wermon and Jamursba-Medi in Papua, Barat, Papua New Guinea, Solomon Islands, and Vanuatu in the West Pacific population and in Mexico, Costa Rica and Nicaragua in the East Pacific Population have been developed that monitor nesting and protect nests from harvest and predation, increasing the production of hatchlings from these nesting areas.

The conservation and recovery of leatherback sea turtles is facilitated by a number of regulatory mechanisms at international, regional, national and local levels, such as the FAO Technical Consultation on Sea Turtle-Fishery Interactions, the Inter-American Convention for the Protection and Conservation of Sea Turtles, CITES, and others. As a result of these designations and agreements, many intentional impacts on sea turtles have been reduced: harvest of eggs and adults have been reduced at several nesting areas through nesting beach conservation efforts (although significant more effort is needed to reduce harvest pressure), and a number of community-based initiatives have helped reduce the harvest of turtles in foraging areas.

North Pacific DPS Loggerhead Sea Turtles

Loggerheads are circumglobal, inhabiting continental shelves, bays, estuaries, and lagoons in temperate, subtropical, and tropical waters. Major nesting grounds are generally located in temperate and subtropical regions, with scattered nesting in the tropics. Until 2011, loggerheads were listed globally as a threatened species under the ESA. A recovery plan for the then threatened U.S. Pacific loggerhead populations was completed over 20 years ago (NMFS and USFWS 1998a). The most recent status review for the North Pacific DPS of loggerheads was completed in 2020, which reaffirmed the endangered status of this species (NMFS and USFWS 2020a). In 2011, a final rule was published describing ESA-listings for nine DPSs of loggerhead sea turtles worldwide (76 FR 58868). The North Pacific Ocean DPS, is the only species found in the *Action Area* of the proposed action listed as endangered under the ESA. Since the loggerhead listing was revised in 2011, a recovery plan for the North Pacific loggerhead DPS has not been completed.

North Pacific loggerhead sea turtles occur north of the equator in the Pacific Ocean. Like other sea turtle species, the North Pacific loggerhead exhibits a complex life cycle: egg, hatchling, juvenile, subadult, and adult. Juvenile and subadult life stages are also frequently distinguished according to whether they occur in neritic or pelagic waters.

North Pacific loggerheads nest exclusively in Japan, in three regions (or management units): mainland Japan, Yakushima, and Okinawa. After the turtles emerge as hatchlings on their natal beaches in Japan, they spend their developmental years foraging in the North Pacific, moving with the predominant ocean gyres for many years before returning to their neritic foraging habitats. Satellite tracking of juvenile loggerheads indicates the Kuroshio Extension Bifurcation Region in the central Pacific to be an important pelagic foraging area for juvenile loggerheads (Polovina *et al.* 2006; Howell *et al.* 2008). Researchers have identified other important juvenile turtle foraging areas off the coast of Baja California Sur, Mexico (Peckham *et al.* 2007; Conant *et al.* 2009). Resident times of juvenile North Pacific loggerheads foraging at a known hotspot off Baja California were recently estimated at over 20 years, with turtles ranging in age from 3 to 24 years old (Tomaszewicz *et al.* 2015). South of Point Eugenia on the Pacific coast of Baja California, pelagic red crabs (*Pleuroncodes planipes*) have been found in great numbers, attracting top predators such as tunas, whales and sea turtles, particularly loggerheads (Pitman 1990; Wingfield *et al.* 2011; Seminoff *et al.* 2014). After spending years foraging in the central and eastern Pacific, mature loggerheads migrate to forage in oceanic or neritic waters closer to Japan in between breeding seasons (Hatase *et al.* 2002; Hatase *et al.* 2010). Thus, adult loggerheads remain in the western Pacific for the remainder of their life cycle (Iwamoto *et al.* 1985; Kamezaki *et al.* 1997; Conant *et al.* 2009; Hatase *et al.* 2002).

Loggerheads documented off the U.S. west coast in the action area are primarily juveniles found south of Point Conception, California in the Southern California Bight.

Population Status and Trends: The North Pacific loggerhead DPS nests primarily in Japan (Kamezaki *et al.* 2003), although low level nesting may occur outside of Japan in areas surrounding the South China Sea (Chan *et al.* 2007; Conant *et al.* 2009). Along the Japanese coast, nine major nesting beaches (greater than 100 nests per season) and six “submajor” beaches (10–100 nests per season) exist, including Yakushima Island where over 50% percent of nesting occurs (Kamezaki *et al.* 2003; Jones *et al.* 2018). Census data from 12 of these 15 beaches provide composite information on longer term trends in the Japanese nesting assemblage. From this data, Kamezaki *et al.* (2003) concluded a substantial decline (50–90%) in the size of the annual loggerhead nesting population in Japan had occurred since the 1950s. As discussed in the 2011 final ESA listing determination, current nesting in Japan represents a fraction of historical nesting levels (Conant *et al.* 2009; 76 FR 58868). Nesting declined steeply from an initial peak of approximately 6,638 nests in 1990–1991, to a low of 2,064 nests in 1997. Since that time, nesting has been variable, increasing and decreasing over time as is typical of sea turtle nesting trends. Overall, since 2003/2004, an increasing trend of approximately 9 percent annual growth in the number of nests has been documented for the entire nesting assemblage, through 2015 (i.e., all nesting beaches combined) (Y. Matsuzawa, Sea Turtle Association of Japan, personal communication, 2017).

In terms of abundance, of North Pacific loggerheads, Van Houtan (2011) estimated the total number of adult nesting females in the population was 7,138 for the period 2008-2010. An abundance assessment using data available through 2013 as part of an IUCN Red List assessment that estimated 8,100 nesting females in the population. Jones *et al.* (2018) used a model estimate of 3,632 females nesting at Yakushima, assumed to represent 52% of all nesting females in the population, to estimate the total number of North Pacific loggerhead nesting females at 6,984 (NMFS 2019b).

Most recently, Martin *et al.* (2020a, 2020b) used a PVA model to estimate that the adult female portion of the North Pacific loggerhead sea turtle population is increasing at a rate of 2.3%/year (95% CI: −1.1% to 15.6%). PVA modeled estimates suggest that the modeled population presently consists of a minimum of 4,541 adult female loggerheads (95% CI: 4,074-5063) as the total nesters for the three index beaches in Japan. It is estimated that there are approximately 328,744 juvenile (year 1-25) North Pacific loggerhead sea turtles (T. Jones, NMFS, personal communication, 2019). Using the estimate of 4,541 females nesting in Yakushima, representing 52% of nesting females, the total number of North Pacific loggerhead nesting females is 8,733 (4,541*100/52). Using a sex ratio of 65% female suggests that the abundance of the North Pacific loggerhead DPS is approximately 13,435 (8,733*100/65) adults, or a total population size of 342,179 (328,744 juveniles + 13,435 adults).

As noted above, North Pacific loggerheads have been documented in high numbers off the central Pacific coast of Baja California, Mexico. Aerial surveys conducted from 2005 through 2007 in the Gulf of Ulloa, a known “hot spot,” provided an estimated foraging population of over 43,000 juvenile loggerheads (Seminoff *et al.* 2014). NMFS conducted aerial surveys of the SCB in 2015 (a year when the sea surface temperatures were anomalously warm, and an El Niño was occurring) and estimated more than 70,000 loggerheads throughout the area (Eguchi *et al.* 2018), likely feeding on pelagic red crabs and pyrosomes which are the turtle's preferred prey. Recent analysis of loggerhead sea turtle presence in the SCB suggests that loggerhead presence offshore of Southern California is tied not just to warm temperatures, but to persistently warm temperatures over a period of months such as what occurred during the recent large marine heatwave experienced by the Eastern North Pacific Ocean (Welch *et al.* 2019).

As summarized above, the North Pacific loggerhead nesting population has been generally increasing, considering the most recent trend analyses (using data from three index beaches from 1985 to 2015 (Martin et el. 2020a), which may be explained by conservation efforts on the nesting beaches, at the foraging grounds (e.g., Gulf of Ulloa, in Baja California, Mexico), and potentially realized reduction of threats from large-scale fisheries such as longlining.

<u>Threats:</u> A detailed account of natural and anthropogenic threats of loggerhead sea turtles around the world is provided in recent status reviews (Conant *et al.* 2009; NMFS and USFWS 2020a). Loggerhead nesting beaches are threatened by hurricanes and tropical storms as well as storm surges, sand accretion, and rainfall associated with hurricanes. Hatchlings are killed by predators such as herons, gulls, dogfish, and sharks. Juvenile and adult loggerheads are also killed by sharks and other large marine predators. Loggerheads are also killed by cold stunning and exposure to biotoxins.

The most significant threats facing loggerheads in the North Pacific include coastal development and bycatch in commercial fisheries. Destruction and alteration of loggerhead nesting habitats are occurring throughout the species' range, especially coastal development (including breakwaters that alter patterns of erosion and accretion on nesting beaches), beach armoring, beachfront lighting, and vehicular/ pedestrian traffic. As the size of the human population in coastal areas increases, that population brings with them secondary threats such as exotic fire ants, feral pigs, dogs and growth of populations that tolerate human presence (e.g., raccoons, armadillos and opossums) which feed on turtle eggs. Overall, the NMFS and USFWS have concluded that coastal development and coastal armoring on nesting beaches in Japan are significant threats to the persistence of this DPS (Conant *et al.* 2009; 76 FR 58868; NMFS and USFWS 2020a).

For both juvenile and adult individuals in the ocean, bycatch in commercial fisheries, both coastal and pelagic fisheries (including longline, drift gillnet, set-net, trawling, dredge, and pound net) throughout the species' range is a major threat (Conant *et al.* 2009). Specifically in the Pacific, bycatch continues to be reported in gillnet and longline fisheries operating in 'hotspot" areas where loggerheads are known to congregate (Peckham *et al.* 2007). Interactions and mortality with coastal and artisanal fisheries in Mexico and the Asian region likely represent the most serious threats to North Pacific loggerheads (Peckham *et al.* 2007; Ishihara 2009; Conant *et al.* 2009). In Mexico, loggerhead mortality has been significantly reduced, particularly in a previously identified hotspot, where thousands of loggerheads may forage for many years until reaching maturity. There are interactions between North Pacific loggerheads and domestic longline fishing for tuna and swordfish based out of Hawai'i.

Conservation: Considerable effort has been made since the 1980s to document and reduce loggerhead bycatch in Pacific Ocean fisheries, as this is the highest conservation priority for the species. NMFS has formalized conservation actions to protect foraging loggerheads in the North Pacific Ocean, which were implemented to reduce loggerhead bycatch in United States fisheries. Observer programs have been implemented in federally managed fisheries to collect bycatch data, and several strategies have been pursued to reduce both bycatch rates and post-hooking mortality. These include developing gear solutions to prevent or reduce capture (e.g., circle hooks) or to allow the turtle to escape without harm (e.g., turtle exclusion devices), implementing seasonal time-area closures to prevent fishing when turtles are congregated, modifying existing gear, and developing and promoting "Sea Turtle Handling Guidelines". For example, switching to large circle hooks and mackerel bait in 2004 reduced the interaction rate by approximately 90% in the Hawai'i shallow-set longline fishery (Gilman *et al.* 2007a, WPFMC 2009b) and more recent analyses showed a reduction of 95% in this fishery (Swimmer *et al.* 2017). NMFS has also developed a mapping product known as TurtleWatch that provides a near real time product that recommends areas where the deployment of pelagic longline shallow sets should be avoided to help reduce interactions between Hawai'i-based pelagic longline fishing vessels and loggerhead sea turtles (Howell *et al.* 2008, 2015).

Since loggerhead interactions and mortalities with coastal fisheries in Mexico and Japan are considered a major threat to North Pacific loggerhead recovery, NMFS and United States non-governmental organizations have worked with international entities to: (1) assess bycatch mortality through systematic stranding surveys in Baja California Sur, Mexico; (2) reduce interactions and mortalities in bottom-set fisheries in Mexico; (3) conduct gear mitigation trials to reduce bycatch in Japanese pound nets; and (4) convey information to fishers and other stakeholders through participatory activities, events and outreach.

Conservation efforts have also focused on protecting nesting beaches, nests, and hatchlings. Much of Japan's coastline is "armored" using concrete structures to prevent and minimize impacts to coastal communities from natural disasters. These structures have resulted in a number of nesting beaches losing sand suitable for sea turtle nesting, and nests often need relocating to protect them from erosion and inundation. Beach management activities include conducting nightly patrols during the summer nesting season to relocate nests from erosion prone areas, protecting nests from predators and people with mesh and fences, and cooling nests with water and shading to prevent overheating during incubation.

The conservation and recovery of loggerhead turtles is facilitated by a number of regulatory mechanisms at international, regional, national, and local levels, such as the Food and Agriculture Organization's (FAO) Technical Consultation on Sea Turtle-Fishery Interactions, the

Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC), the Convention on International Trade in Endangered Species (CITES), and others. As a result of these designations and agreements, many of the intentional impacts on sea turtles have been reduced: harvest of eggs and adults have been slowed at several nesting areas through nesting beach conservation efforts and an increasing number of community-based initiatives are in place to slow the take of turtles in foraging areas. Moreover, as shown by the above examples from Hawai'i, Japan, and Baja Mexico, international efforts are growing to reduce sea turtle interactions and mortality in artisanal and industrial fishing practices (Gilman *et al.* 2007b; Peckham *et al.* 2007; NMFS and USFWS 2007a; Ishihara et. al. 2014).

Olive Ridley Sea Turtles

Two populations of olive ridleys were listed under the ESA in 1978 (43 FR 32800; July 28, 1978): the breeding colony populations on the Pacific coast of Mexico was listed as endangered, and all other olive ridleys found other than on the Pacific coast of Mexico were listed as a threatened species. Since olive ridleys found off the U.S. West Coast are likely to originate from Pacific Mexican nesting beaches, we assume that any olive ridleys affected by the proposed action are endangered. A recovery plan for the U.S. Pacific populations of olive ridleys was completed nearly 20 years ago (NMFS and USFWS 1998c). A 5-year review of the status of olive ridley sea turtles was completed in 2014 (NMFS and USFWS 2014).

Olive ridley sea turtles occur throughout the world, primarily in tropical and sub-tropical waters. Nesting aggregations in the Pacific Ocean are found in the Marianas Islands, Australia, Indonesia, Malaysia, and Japan (western Pacific), and Mexico, Costa Rica, Guatemala, and South America (eastern Pacific). Like leatherback turtles, most olive ridley sea turtles lead a primarily pelagic existence (Plotkin *et al.* 1993), migrating throughout the Pacific, from their nesting grounds in Mexico and Central America to the deep waters of the Pacific that are used as foraging areas (Plotkin *et al.* 1994). While olive ridleys generally have a tropical to subtropical range, with a distribution from Baja California, Mexico to Chile (Silva-Batiz *et al.* 1996), individuals do occasionally venture north, some as far as the Gulf of Alaska (Hodge and Wing 2000). Olive ridleys live within two distinct oceanic regions including the subtropical gyre and oceanic currents in the Pacific. The gyre contains warm surface waters and a deep thermocline preferred by olive ridleys. The currents bordering the subtropical gyre, the Kuroshio Extension Current, North Equatorial Current and the Equatorial Counter Current, all provide for advantages in movement with zonal currents and location of prey species (Polovina *et al.* 2004). In the eastern Pacific, the post-reproductive migrations of olive ridleys are unique and complex. Their migratory pathways vary annually, there are no apparent migratory corridors, and there is no spatial and temporal overlap in migratory pathways among groups or cohorts of turtles (NMFS and USFWS 2014). Unlike other sea turtles that show site fidelity from a breeding ground to a single feeding area, where they reside until the next breeding season, olive ridleys are nomadic migrants that swim thousands of miles over vast oceanic areas. This nomadic behavior may be unique to olive ridleys in the eastern Pacific Ocean, as studies in other ocean basins indicate these species occupy neritic waters, not making extensive migrations observed in the eastern Pacific.

Individual olive ridleys experience three different reproductive strategies or behaviors: mass or *arribada* nesting, dispersed or solitary nesting, and a mixed strategy of both.

Population Status and Trends: It is estimated that there are over 1 million female olive ridley sea turtles nesting annually at one of the major beaches (arribada) in Mexico (La Escobilla) (NMFS and USFWS 2014). Unlike other sea turtle species, most female olive ridleys nest annually. According to the Marine Turtle Specialist Group of the IUCN, there has been a 50 percent decline in olive ridleys worldwide since the 1960s, although there have recently been substantial increases at some nesting sites (NMFS and USFWS 2007). A major nesting population exists in the eastern Pacific on the west coast of Mexico and Central America. Both of these populations use the north Pacific as foraging grounds (Polovina *et al.* 2004). As described above, because the proposed action is most likely to occur closer to eastern Pacific nesting and foraging sites, we assume that this population would be more likely (i.e., than the western Pacific population) to be affected by the proposed action, and that any affected turtles may have originated from the endangered Mexican breeding population. The eastern Pacific population is thought to be increasing, while there is inadequate information to suggest trends for other populations. Eastern Pacific olive ridleys nest primarily in large *arribadas* on the west coasts of Mexico and Costa Rica. Since reduction or cessation of egg and turtle harvest in both countries in the early 1990s, annual nest totals have increased substantially.

Based on the current number of olive ridleys nesting in Mexico, three *arribada* beaches appear to be stable (Mismaloya, Tlacoyunque, and Moro Ayuta), two are increasing (Ixtapilla, La Escobilla) and one is decreasing (Chacahua), but none of these populations have recovered to their pre-1960s abundance. At the major *arribada* nesting beach, La Escobilla, olive ridleys rebounded from approximately 50,000 nests in 1988 to over 700,000 nests in 1994, and more than a million nests by 2000. From 2001-2005, Abreu-Grobois and Plotkin (2008) estimated a mean annual estimate of over one million females nesting annually at Escobilla. Minor *arribada* nesting beaches in Mexico range from around 2,000 nests (Chacahua) to 10,000-100,000 nests (Moro Ayuta) (NMFS and USFWS 2014). Regarding non-*arribada* beaches, population trends for most indicate they are stable or increasing. Stable beaches include El Verde, Maruata-Colola, Puerto Arista, and Moro Ayuta. Increasing trends are reported for Platanitos and Cuyutlán (Abreu-Grobois and Plotkin 2008).

These increases observed on the nesting beaches are supported by at-sea estimates of density and abundance. Eguchi *et al.* (2007) analyzed sightings of olive ridleys at sea, leading to an estimate of 1,150,000 – 1,620,000 turtles in the eastern tropical Pacific in 1998-2006. In contrast, there are no known *arribadas* of any size in the western Pacific, and apparently only a few hundred nests scattered across Indonesia, Thailand, and Australia (Limpus and Miller 2008).

Threats: Threats to olive ridleys are described in the most recent five year status review (NMFS and USFWS 2014). Direct harvest and fishery bycatch are considered the two biggest threats. In the 1950s through the 1970s, it is estimated that millions of olive ridleys were killed for meat and leather and millions of eggs were collected at nesting beaches in Mexico, Costa Rica, and other locations in Central and South America. Harvest has been reduced in the 1980's and 1990's, although eggs are still harvested in parts of Costa Rica and there is an illegal harvest of eggs in parts of Central America and India (NMFS and UWFWS 2014).

Olive ridleys have been observed caught in a variety of fishing gear including longline, drift gillnet, set gillnet, bottom trawl, dredge and trap net. Fisheries operating in coastal waters near *arribadas* can kill tens of thousands of adults. This is evident on the east coast of India where thousands of carcasses wash ashore after drowning in coastal trawl and drift gillnets fishing near the huge arribada (NMFS and USFWS 2007a). Based upon available information, it is likely that olive ridley sea turtles are being affected by climate change through sea-level rise and rising sea surface temperatures as well as related changes in ice cover, salinity, oxygen levels and circulation. Impacts from climate change could include shifts in ranges and changes in algal, plankton and fish abundance, which could affect olive ridley prey distribution and abundance. However, olive ridleys are wide ranging and could shift from an unproductive habitat to more biologically productive waters. Sea level rise and other environmental and oceanographic changes such as the frequency and timing of storms may accelerate the loss of suitable nesting habitats could increase beach loss via erosion or inundation of nests (NMFS and USFWS 2014).

Conservation: The conservation and protection of olive ridleys is enhanced by a number of regional and local community conservation programs. Efforts to decrease or eliminate poaching of nesting females and eggs and protect their habitat have been implemented in many areas of Mexico. In 1986, Mexico established 17 reserve areas to protect sea turtles. In 1990, Mexico banned the harvest and trade of sea turtles. Mexico requires the use of turtle excluder devices in their shrimp fishery to reduce sea turtle bycatch. Local community efforts are numerous. For example, the nongovernmental organization, Grupo Tortuguero, established 30 community sites for monitoring beaches and in-water surveys along the Baja Peninsula and Gulf of California (Esliman *et al.* 2012). In the state of Nayarit, Mexico, there are seven centers for Sea Turtle Protection and Conservation and two Sea Turtle Protection Camps covering nearly 80 km of nesting beaches (Maldonado-Gasca and Hart 2012).

The U.S. implemented several fisheries regulations that remain in effect to reduce sea turtle bycatch including olive ridleys. For example, all commercial fishermen in the U.S. who incidentally take a sea turtle during fishing operations must handle the animals with due care to prevent injury to live sea turtles, resuscitate (if necessary), and return safely to the water. No sea turtles may be consumed, sold, landed, kept below deck, etc. The U.S. Hawai'i-based longline fishery operating in the central Pacific also incidentally takes olive ridleys from the endangered populations (NMFS 2008b). Olive ridley interaction and mortality rates have been reduced by requiring specific gear configurations and operational requirements that include use of circle hooks and non-squid bait; fishery closures based on maximum annual turtle interaction limits; area restrictions; proper handling of hooked and entangled turtles; use of disentangling and dehooking equipment such as dip nets, line cutters, and de-hookers; and reporting sea turtle interactions. Vessel owners and operators are also required to participate in protected species workshops to raise awareness of sea turtle ecology and ensure compliance with sea turtle protective regulations.

As a result of these international, national, and local efforts, many of the anthropogenic threats have been lessened. The ban on direct harvest resulted in stable or increasing nesting for the endangered breeding colony populations on the Pacific coast of Mexico, although the Chacahua *arribada* beach continues to decline. Conservation measures to reduce incidental bycatch have benefited the endangered populations; however, fisheries bycatch remain a concern.

East Pacific DPS of Green Sea Turtles

In 2016, NMFS finalized new listings for 11 green sea turtle DPSs, including listing the East Pacific DPS as threatened (81 FR 20057). The East Pacific DPS includes turtles that nest on the coast of Mexico which were historically listed under the ESA as endangered. All of the green turtles DPSs were listed as threatened, with the exception of the Central South Pacific DPS, Central West Pacific DPS, and the Mediterranean DPS which were listed as endangered (Seminoff *et al.* 2015).[5] Recently the IUCN assessed the East Pacific "regional management unit of green sea turtles as "vulnerable," which was downlisted from a previous "endangered" status (IUCN 2021). Currently, NMFS and USWFS are considering designating critical habitat for the East Pacific green sea turtle DPS as well as several other (five) DPSs within U.S. jurisdiction.

Throughout the Pacific Ocean, nesting assemblages group into two distinct regional areas: (1) western Pacific and South Pacific islands; and (2) eastern Pacific and central Pacific, including the rookery at French Frigate Shoals, Hawai'i. In the eastern Pacific, green sea turtles forage coastally from the U.S. West Coast (42°N) in the north, offshore in waters up to 1,000 miles from the coast, and south to central Chile (40°S). The boundaries of this DPS extend from the aforementioned locations in the U.S. and Chile, out to 143°W and 96°W, respectively (Seminoff *et al.* 2015). Green turtles found in the Gulf of California originate primarily from the Michoacán nesting stock. Green turtles foraging in southern California and along the Pacific coast of Baja California originate primarily from rookeries of the Islas Revillagigedos (Dutton 2003) and within the state of Michoacán (Dutton *et al.* 2019).

Green sea turtles in the eastern Pacific are migratory as adults, conducting reproductive migrations every three years on average between their natal nesting sites and foraging areas. Individuals show fidelity to foraging areas, often returning to the same areas after successive

[5] The 2015 biological status report that was used to support the recent listing activities (Seminoff *et al.* 2015) can be found at: http://www.nmfs.noaa.gov/pr/species/Status%20Reviews/green_turtle_sr_2015.pdf

nesting seasons. In neritic foraging areas, green turtles in the eastern Pacific are omnivorous, consuming marine algae, seagrass, mangrove parts and invertebrates. Green turtles in the wild are estimated to attain maturity at 15-50 years (Avens and Snover 2013), with East Pacific green turtles averaging 30 years to maturity.

The effects of climate change include, among other things, increases in sea surface temperature, the alteration of thermal sand characteristics of beaches (from warming temperatures), which could result in the reduction or cessation of male hatchling production (Hawkes *et al.* 2009) and a significant rise in sea level, which could significantly restrict green sea turtle nesting habitat. While sea turtles have survived past eras that have included significant temperature fluctuations, future climate change is expected to happen at unprecedented rates, and if sea turtles cannot adapt quickly, they may face local to widespread extirpations (Hawkes *et al.* 2009). Impacts from global climate change are likely to become more apparent in future years (IPCC 2018; 2021). However, in some areas like the primary nesting beach in Michoacán, Mexico (Colola), the beach slope aspect is very steep and the dune surface at which the vast majority of nests are laid is well elevated. This site is likely buffered against short-term sea level rise as a result of climate change. In addition, many nesting sites are along protected beach faces, out of tidal surge pathways. For example, multiple nesting sites in Costa Rica and in the Galapagos Islands are on beaches that are protected from major swells.

<u>Population Status and Trends:</u> A complete review of the most current information on green sea turtles is available in the 2015 Status Review (Seminoff *et al.* 2015). Based on genetic data, this DPS consists of at least five populations: two in Mexico, one in Costa Rica, one in the eastern Pacific and one in the Galapagos Islands. Those populations are represented by at least 39 nesting sites, with most of these sites concentrated in Mexico, Ecuador, and Costa Rica (Seminoff *et al.* 2015).

Although trend information is lacking for the majority of nesting beaches, based on a 25-year trend for the nesting aggregation at Colola, Mexico, the abundance of East Pacific green turtles appears to have increased since the population's low point in the mid-1980s. (which is the most important green turtle nesting area in the eastern Pacific). Based on nesting beach data, the current adult female nester population for Colola, Michoacan is 11,588 females, which makes this the largest nesting aggregation in the East Pacific green turtles, comprising nearly 58% of the total adult female population. The total for the entire East Pacific green turtle DPS is estimated at 20,062 nesting females (Seminoff *et al.* 2015). This observed increase may have resulted from the onset of nesting beach protection in 1979, as is suggested by the similarity in timing between the onset of beach conservation and the age-to-maturity for green turtles in Pacific Mexico. Similarly, data from the Galapagos Archipelago suggest that the abundance of nesting females in that population may be increasing. Given the likely increasing trend in this population, NMFS recently estimated a total mean population size of 3,580,207 animals in the East Pacific DPS (NMFS 2023c).

Most green turtles found off the U.S. West Coast and in the action area likely originate from the Revillagigedos Archepelago, a secondary nesting site, and the coast of Michoacán, Mexico (Dutton *et al.* 2019). The most recent survey (2008) from Revillagigedos estimated that as many as 500 nests were laid over a 4-week period, which the most recent status review (Seminoff *et al.* 2015) used to estimate nester abundance at 500 females. Two foraging populations of green turtles are found in U.S. waters adjacent to the proposed action area. South San Diego Bay serves as important habitat for a resident population of up to about 60 juvenile and adult green turtles in this area (Eguchi *et al.* 2010). There is also an aggregation of green sea turtles that is persistent in the San Gabriel River and surrounding coastal areas in the vicinity of Long Beach and Seal Beach, California (Lawson *et al.* 2011; Crear *et al.* 2016; Crear *et al.* 2017). Seasonal shifts in movement and distribution of green turtles in the Long Beach/Seal Beach area show that green turtles in the San Gabriel River use warm effluent from two power plants as a thermal refuge, although the river sustains juveniles and adults year-round (Crear *et al.* 2016).

<u>Threats:</u> A thorough discussion of threats to green turtles worldwide can be found in the most recent status review (Seminoff *et al.* 2015). Major threats include: coastal development (including heavy armament and subsequent erosion) and loss of nesting and foraging habitat; incidental capture by fisheries; and the harvest of eggs, sub-adults and adults. Climate change is also emerging as a critical issue. Destruction, alteration, and/or degradation of nesting and near shore foraging habitat is occurring throughout the range of green turtles. These problems are particularly acute in areas with substantial or growing coastal development, beach armoring, beachfront lighting, and recreational use of beaches. In addition to damage to the nesting beaches, pollution and impacts to foraging habitat are a concern. Pollution run-off can degrade sea grass beds that are the primary forage of green turtles. The majority of turtles in coastal areas spend their time at depths less than 5 m below the surface (Schofield *et al.* 2007; Hazel *et al.* 2009) and hence collisions with boats are known to cause significant numbers of mortality every year (NMFS and USFWS 2007b; Seminoff *et al.* 2015). Marine debris is also a source of concern for green sea turtles especially given their presence in nearshore coastal and estuarine habitats.

The bycatch of green sea turtles, especially in coastal fisheries, is a serious problem because in the Pacific, many of the small-scale artisanal gillnet, setnet, and longline coastal fisheries are not well regulated. These are the fisheries that are active in areas with the highest densities of green turtles (NMFS and USFWS 2007b). In the northern portions of the East Pacific DPS, bycatch in fisheries has been less well-documented. However, along the Baja California Peninsula, Mexico, green turtles were reported stranded (suspected bycatch) in the hundreds in Bahia Magdalena (Koch *et al.* 2006). In Baja California Sur, Mexico, from 2006-2009, small-scale gillnet fisheries caused massive green sea turtle mortality at Laguna San Ignacio, where an estimated 1,000 turtle were killed each year in a fishery targeting guitar fish (Mancini *et al.* 2012). Bycatch of green turtles has also been reported in Peru and Chile, and while the problem persists, innovated bycatch reduction techniques and monitoring approaches have likely reduced bycatch of all sea turtle species.

The meat and eggs of green turtles has long been favored throughout much of the world that has interacted with this species. As late as the mid-1970s, upwards of 80,000 eggs were harvested every night during nesting season in Michoacán (Clifton *et al.* 1982). Even though Mexico has implemented bans on the harvest of all turtle species in its waters and on the beaches, poaching of eggs, females on the beach, and animals in coastal water continues to happen. In some places throughout Mexico and the whole of the eastern Pacific, consumption of green sea turtles remain a part of the cultural fabric and tradition (NMFS and USFWS 2007b; IUCN 2021).

Like other sea turtle species, increasing temperatures have the potential to skew sex ratios of hatchling and many rookeries are already showing a strong female bias as warmer temperatures in the nest chamber leads to more female hatchlings (Kaska *et al.* 2006; Chan and Liew 1995). Increased temperatures also lead to higher levels of embryonic mortality (Matsuzawa *et al.* 2002). An increase in typhoon frequency and severity, a predicted consequence of climate change (Webster el al. 2005), can cause erosion which leads to high nest failure (Van Houtan and Bass 2007). Rising sea levels can cause repeated inundation of nests and abrupt disruption of ocean currents used for natural dispersion during the green turtle life cycle. Green sea turtles feeding may also be affected by climate change. Seagrasses are a major food source for green sea turtles and may be affected by changing water temperature and salinity (Short and Neckles 1999; Duarte 2002).

<u>Conservation</u>: There have been important conservation initiatives and advances that have benefited East Pacific green turtles. There are indications that wildlife enforcement branches of local and national governments are stepping up their efforts to enforce existing laws, although successes in stemming sea turtle exploitation through legal channels are infrequent. In addition, there are a multitude of non-profit organizations and conservation networks whose efforts are raising awareness about sea turtle conservation. When assessing conservation efforts, we assumed that all conservation efforts would remain in place at their current levels or improve. Among the notable regional and/or multinational conservation groups and initiatives are the Central American Regional Network for the Conservation of Sea Turtles, Grupo Tortuguero de las Californias (GTC), Permanent Commission of the South Pacific (CPPS), and IAC. The Central American Regional Network resulted in the creation of a national sea turtle network in each country of the Central American region, as well as the development of firsthand tools, such as a regional diagnosis, a 10-year strategic plan, a manual of best practices, and regional training and information workshops for people in the region. The GTC is a regional network in Mexico that brings together scientists, conservation practitioners, fishers, and local peoples to address sea turtle conservation issues. Perhaps the greatest achievement of this group was the large decrease in green turtle hunting and local consumption throughout Northwestern Mexico. The Permanent Commission of the South Pacific is a regional body that includes Panama, Colombia, Ecuador, Peru and Chile, that has conducted many regional workshops on sea turtle conservation, but most importantly has developed a regional management plan for sea turtles. The IAC is the world's only binding international treaty for sea turtle conservation. Signatory nations in the Eastern

Pacific include Chile, Peru, Ecuador, Panama, Costa Rica, Honduras, Guatemala, Mexico, and the United States. This treaty endeavors to reduce fisheries bycatch and habitat destruction through a series of binding conservation agreements across these nations. All three of these initiatives work under the principle that benefits and achievements from working in alliance are much higher than those from working alone.

In Southern California, NMFS has increased its outreach and education efforts to improve public awareness of the presence of green turtles and to reduce threats to foraging populations, particularly in San Diego Bay, the San Gabriel River and adjacent watershed, as well as estuaries such as Agua Hedionda and Mission Bay. Local threats to green turtles primarily include recreational fishing and vessel strikes, and NMFS has worked with partners to develop educational materials and signs to specifically address those threats.

Marine and Anadromous Fish

Salmon and Steelhead

For Pacific salmon and steelhead, NMFS commonly uses four parameters to assess the viability of the populations that, together, constitute the species: spatial structure, diversity, abundance, and productivity (McElhany *et al.* 2000). These “viable salmonid population” (VSP) criteria therefore encompass the species’ “reproduction, numbers, or distribution” as described in 50 CFR 402.02. We apply the same criteria for other species as well, but in those instances, they are not referred to as “salmonid” population criteria. When any animal population or species has sufficient spatial structure, diversity, abundance, and productivity, it will generally be able to maintain its capacity to adapt to various environmental conditions and sustain itself in the natural environment.

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

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

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

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

In addition, it should be noted that for many species in this biological opinion, hatchery populations make up part of the listed unit and may be tied to the four VSP parameters defined above. As a result, this Opinion often analyzes effects on hatchery components, and when it does, the terms "artificially propagated" and "hatchery" are used interchangeably, as are the terms "naturally propagated" and "natural."

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

A species' status is thus a function of how well its biological requirements are being met: the greater the degree to which the requirements are fulfilled, the better the species' status. Information on the status and distribution of all the species considered here can be found in a number of documents, but the most pertinent are the status review updates and recovery plans listed in Table 1 and the specific species sections that follow. These documents and other relevant information may be found on the NOAA Fisheries West Coast Region website; the discussions they contain are summarized in the tables below. For the purposes of our later analysis, all the species considered here require functioning habitat and adequate spatial structure, abundance, productivity, and diversity to ensure their survival and recovery in the wild.

Puget Sound Chinook Salmon

Abundance and Productivity

The current abundance for PS Chinook salmon populations is displayed in Table 2, below. To estimate the abundance of adult spawners, we took the geometric means of the last five years of adult returns—as estimated by dam counts, radio-tag studies, PIT-stag studies, redd counts, and other methods (Ford 2022). Natural-origin juvenile PS Chinook salmon abundance estimates come from applying estimates of the percentage of females in the population and average fecundity to escapement data. Fecundity estimates for the ESU range from 2,000 to 5,500 eggs per female, and the proportion of female spawners in most populations is approximately 40% of escapement. By applying a conservative fecundity estimate (2,000 eggs/female) to the expected female escapement (both natural-origin and hatchery-origin spawners – 18,641 females), the ESU is estimated to produce approximately 37.3 million eggs annually. Smolt trap studies have researched egg to migrant juvenile Chinook salmon survival rates in the following Puget Sound tributaries: Skagit River, North Fork Stillaguamish River, South Fork Stillaguamish River, Bear Creek, Cedar River, and Green River (Beamer *et al.* 2000; Seiler *et al.* 2002, 2004, 2005; Volkhardt *et al.* 2005; Griffith *et al.* 2004). The average survival rate in these studies was 10%, which corresponds with those reported by Healey (1991). With an estimated survival rate of 10%, the ESU should produce roughly 3.7 million natural-origin outmigrants annually.

Juvenile listed hatchery PS Chinook salmon abundance estimates come from the annual hatchery production goals. Hatchery production varies annually due to several factors including funding, equipment failures, human error, disease, and adult spawner availability. Funding uncertainties and the inability to predict equipment failures, human error, and disease suggest that production averages from previous years is not a reliable indication of future production. For these reasons, abundance is assumed to equal production goals. The combined hatchery production goal for listed PS Chinook salmon is roughly 34 million juvenile Chinook salmon annually.

Table 2. Recent Five-Year Geometric Means for Estimated PS Chinook Juvenile Outmigrations and Adult Returns (Ford 2022) (LHIA=Listed hatchery, intact adipose (fin); LHAC= listed hatchery, adipose-clipped).

Life Stage	Origin	Outmigration/Return
Adult	Natural	23,371
Adult	Hatchery	23,232
Juvenile	Natural	3,728,240
Juvenile	LHIA	8,680,000
Juvenile	LHAC	25,624,500

Total abundance in the ESU over the entire time series shows that individual populations have varied in increasing or decreasing abundance. Several populations (North Fork and South Fork Nooksack, Sammamish, Green, White, Puyallup, Nisqually, Skokomish, Dungeness and Elwha) are dominated by hatchery returns. Abundance across the ESU has generally increased since the last viability assessment, with only 2 of the 22 populations (Cascade and North Fork and South Fork Stillaguamish) showing a negative change in the 5-year geometric mean for natural-origin spawner abundances (Ford 2022). Fifteen of the remaining 20 populations showed positive change in the 5-year geometric mean natural-origin spawner abundances. These same 15 populations have relatively low natural spawning abundances of less than 1000 fish, so some of these increases represent small changes in total abundance.

Across the Puget Sound ESU, 10 of 22 Puget Sound populations show natural productivity below replacement in nearly all years since the mid-1980s. In recent years, only five populations have had productivities above zero. These are Lower Skagit, Upper Skagit, Lower Sauk, Upper Sauk, and Suiattle, all Skagit River populations are in the Whidbey Basin MPG. The overall pattern continues the decline reported in the Northwest Fishery Science Center’s 2015 viability assessment (Ford 2022).

None of the 22 Puget Sound populations meets minimum viability abundance targets. The populations closest to meeting the planning targets (Upper Skagit, Upper Sauk, and Suiattle) need to increase substantially just to meet the minimum viability abundance target. The Lower Skagit population is the second most abundant population, but its natural-origin spawner abundance is only 10% of the minimum viability abundance target.

Spatial Structure and Diversity

The PS Chinook salmon ESU is made up of naturally spawned Chinook salmon originating from rivers flowing into Puget Sound from the Elwha River (inclusive) eastward, including rivers in Hood Canal, South Sound, North Sound, and the Strait of Georgia. The PS Chinook salmon ESU is composed of 31 historically quasi-independent populations, 22 of which are extant. The populations are distributed in five geographic regions, or major population groups, identified by the Puget Sound Technical Recovery Team (PSTRT) based on similarities in hydrographic, biogeographic, and geologic characteristics of the Puget Sound basin (PSTRT 2002). The ESU also includes Chinook salmon from twenty-five artificial propagation programs (85 FR 81822).

Spatial structure and diversity can be evaluated by assessing the proportion of natural-origin spawners versus hatchery-origin spawners on the spawning grounds. From approximately 1990 to 2018, the proportion of PS Chinook salmon natural-origin spawners showed a declining trend. Considering populations by their MPGs, the Whidbey Basin is the only MPG with consistently high-fraction natural-origin spawner abundance: six out of 10 populations. All other MPGs have either variable or declining spawning populations that have high proportions of hatchery-origin spawners.

All PS Chinook salmon populations continue to remain well below the TRT planning ranges for recovery escapement levels. Most populations also remain consistently below the spawner-recruit levels identified by the TRT as necessary for recovery. Across the ESU, most populations have increased somewhat in abundance since the last 5-year review in 2016, but have small negative trends over the past five years (Ford 2022). Productivity remains low in most populations. Hatchery-origin spawners are present in high fractions in most populations outside the Skagit watershed, and in many watersheds, the fraction of spawner abundances that are natural-origin have declined over time. Habitat protection, restoration, and rebuilding programs in all watersheds have improved stream and estuary conditions despite record numbers of humans moving into the Puget Sound region in the past two decades.

Puget Sound Steelhead

Abundance and Productivity

To estimate the abundance of adult spawners, we took the geometric means of the last five years of adult returns—as estimated by dam counts, radio-tag studies, PIT-stag studies, redd counts, and other methods (Ford 2022). Natural-origin juvenile PS steelhead abundance estimates are calculated from the estimated abundance of adult spawners and estimates of fecundity. For this species, fecundity estimates range from 3,500 to 12,000 eggs per female; and the male to female ratio averages 1:1 (Pauley *et al.* 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (9,728 females), 34.05 million eggs are expected to be produced annually. With an estimated survival rate of 6.5% (Ward and Slaney 1993), the DPS should produce roughly 2.21 million natural-origin outmigrants annually.

Juvenile listed hatchery PS steelhead abundance estimates come from the annual hatchery production goals (WDFW 2022). The combined hatchery production goal for listed PS steelhead is roughly 279 thousand juveniles annually (Table 3).

Table 3. Recent Five-Year Geometric Means for Estimated PS Steelhead Juvenile Outmigrations and Adult Returns (Ford 2022).

Life Stage	Origin	Outmigration/Return
Adult	Natural	18,196
Adult	Hatchery	1,618
Juvenile	Natural	2,253,842
Juvenile	LHIA	53,000
Juvenile	LHAC	226,000

No abundance information is available for approximately one-third of the populations, and this is disproportionately true for summer-run populations. In most cases where no information is available, we assume that abundances are very low. While increases in spawner abundance were observed in a number of populations over the last five years (Ford 2022), these improvements were disproportionately found in the South and Central Puget Sound, Strait of Juan de Fuca, and Hood Canal MPGs, and primarily among smaller populations. The apparent reversal of strongly negative trends among winter run populations in the White, Nisqually, and Skokomish rivers decreased (to some degree) the demographic risks those populations face. Certainly, improvement in the status of the Elwha River steelhead (winter and summer run) following the removal of the Elwha dams reduced the demographic risk for the population and major population group to which it belongs. Improvements in abundance were not as widely observed in the Northern Puget Sound MPG. Foremost among the declines were summer- and winter-run populations in the Snohomish Basin. In particular, the only summer-run population with a long-term dataset, declined 63% during the 2015-2019 period with a negative 4% trend since 2005 (Ford 2022).

Spatial Structure and Diversity

The PS steelhead DPS is composed of naturally spawned anadromous *Oncorhynchus mykiss* (steelhead) originating below natural and manmade impassable barriers from rivers flowing into Puget Sound from the Elwha River (inclusive) eastward, including rivers in Hood Canal, South Sound, North Sound, and the Strait of Georgia. Steelhead are found in most of the larger accessible tributaries to Puget Sound, Hood Canal, and the eastern Strait of Juan de Fuca. Surveys of the Puget Sound (not including the Hood Canal) in 1929 and 1930 identified steelhead in every major basin except the Deschutes River (Hard *et al.* 2007). This DPS also includes hatchery steelhead from five artificial propagation programs (85 FR 81822).

Although PS steelhead populations include both summer- and winter-run life-history types, winter-run populations predominate. For the PS steelhead DPS, Myers *et al.* (2015) identified three MPGs with 27 populations of winter-run steelhead and nine populations of summer-run steelhead. Summer-run stock statuses are mostly unknown; however, most appear to be small, averaging less than 200 spawners annually (Hard *et al.* 2007). Summer-run stocks are primarily concentrated in the northern Puget Sound and the Dungeness River (Myers *et al.* 2015).

A number of fish passage actions have improved access to historical habitat in the past 10 years. The removal of dams on the Elwha, Middle Fork Nooksack, and Pilchuck rivers, as well as the fish passage programs recently started on the North Fork Skokomish and White rivers will provide access to important spawning and rearing habitat. While there have been some significant improvements in spatial structure, it is recognized that land development, loss of riparian and forest habitat, loss of wetlands, and demands on water allocation all continue to degrade the quantity and quality of available fish habitat.

The recovery plan for PS steelhead (NMFS 2019a) recognizes that production of hatchery fish of both run types—winter run and summer run—has posed a considerable risk to diversity in natural steelhead in the Puget Sound DPS. Overall, the risk posed by hatchery programs to naturally spawning populations has decreased during the last five years with reductions in production (especially with non-local programs) and the establishment of locally-sourced broodstock. Unfortunately, while competition and predation by hatchery-origin fish can swiftly be diminished, it is unclear how long the processes of natural selection will take to reverse the legacy of genetic introgression by hatchery fish.

The Northwest Fisheries Science Center (NWFSC) found that the PS steelhead DPS viability has improved since Hard *et al.* (2015) concluded it was at very low viability (Ford 2022). Perhaps more importantly, improvements were noted in all three of the DPS's MPGs and many of its 32 demographically independent populations (DIPs) (Ford 2022). However, in spite of improvements, where monitoring data exists, most populations remain at low abundance levels.

Hood Canal Summer-run Chum Salmon

Abundance and Productivity

Managers have been estimating total spawner and natural spawner returns for this ESU since 1974. The estimates are based on spawning ground surveys and genetic stock identification (Ford 2022). Fifteen-year trends in log natural-origin spawner abundance over two time periods (1990–2005 and 2004–2019) show strongly positive trends in the two populations in the first time period, but abundance trends for both populations have decreased to close to zero in the most recent 15-year period (Ford 2022). Since 2016, abundances for both populations have sharply decreased. This began in 2017 for the Strait of Juan de Fuca population and in 2018 for the Hood Canal population. Despite substantive gains towards meeting viability criteria in the Hood Canal and Strait of Juan de Fuca summer chum salmon populations, the ESU still does not meet all of the recovery criteria for population viability at this time (Ford 2022). Abundance estimates for the ESU components are listed below.

Table 4. Recent 5-Year Geometric Means for Estimated HCS Chum Juvenile Outmigrations and Adult Returns (Ford 2022).

Life Stage	Origin	Outmigration/Return
Adult	Natural	28,117
Adult	Hatchery	881
Juvenile	Natural	4,240,958

Productivity for this ESU had increased at the time of the last review (NWFSC 2015) but has been down for the last 3 years for the Hood Canal population, and for the last four years for the Strait of Juan de Fuca population (Ford 2022). Productivity rates have varied above and below replacement rates over since at least 1975 and have averaged very close to zero (1:1 replacement) over the last 15 years.

Spatial Structure and Diversity

The species comprises all naturally spawned populations of summer-run chum salmon in Hood Canal and its tributaries as well as populations in Olympic Peninsula rivers between Hood Canal and Dungeness Bay, Washington. Four artificial propagation programs were initially listed as part of the ESU (79 FR 20802). Spatial structure and diversity measures for the Hood Canal summer chum recovery program include the reintroduction and sustaining of natural-origin spawning in multiple small streams where summer chum spawning aggregates had been extirpated.

Hatchery contribution varies greatly among the spawning aggregations within each population. It is generally highest in the Strait of Juan de Fuca population, ranging from 8.4% to 62.8% in the Strait of Juan de Fuca population, and 5.8% to 40.2% in the Hood Canal population. The hatchery contribution also generally decreased over the last several years as supplementation programs were terminated as planned (Ford 2022). All were ended by 2011 in the Strait of Juan de Fuca population, and by 2017 in the Hood Canal population.

Recent analyses suggested the Hood Canal population would be considered to be at negligible risk of extinction considering current biological performance, provided that the exploitation rate remains very low (Ford 2022). The Strait of Juan de Fuca population had a much higher risk of extinction, even with a zero exploitation rate. As noted above, since 2017, both populations have experienced much lower returns, and a 2020 analysis showed considerably reduced population performance under a changing ocean climate (Ford 2022).

Overall, natural-origin spawner abundance has increased since ESA-listing and spawning abundance targets in both populations have been met in some years. Productivity had increased at the time of the last review (NWFSC 2015) but has been down for the last 3 years for the Hood Canal population, and for the last four years for the Strait of Juan de Fuca population. Productivity of individual spawning aggregates shows only two of eight aggregates have viable performance. Spatial structure and diversity viability parameters, as originally determined by the TRT have improved and nearly meet the viability criteria for both populations. Despite substantive gains towards meeting viability criteria in the Hood Canal and Strait of Juan de Fuca summer chum salmon populations, the ESU still does not meet all of the recovery criteria for population viability at this time, however. Overall, the Hood Canal summer chum salmon ESU therefore remains at moderate risk of extinction, with viability largely unchanged from the 2015 status review.

Ozette Lake Sockeye Salmon

Abundance and Productivity

To estimate abundance for this ESU, we used weir counts, DIDSON sonar, spawning surveys, data from the Umbrella Creek Hatchery, and other methods. Over the last seven years (2013-2019), it was frequently the case that portions of the run were not enumerated in due to in-river conditions and technical problems. To account for this, expansion estimates and detection rate estimates were used when they could be reasonably ascertained (Ford 20220). In addition, natural spawners were calculated by subtracting the effective catch from the total run size. The effective catch is the number of fish that were removed from the natural spawning population due broodstock take (1983–present). Until 2000, all broodstock was taken from beaches. From 2000 on, the broodstock was taken from Umbrella Creek (Ford 2022).

Table 5. Recent Five-Year Geometric Means for Estimated OL Sockeye Juvenile Outmigrations and Adult Returns (Ford 2022).

Life Stage	Origin	Outmigration/Return
Adult	Natural	5,876
Adult	Hatchery	309
Juvenile	Natural	1,273,337
Juvenile	LHIA	259,250
Juvenile	LHAC	45,750

The geometric mean of abundance from 2015 to 2019 was higher than the previous five-year geometric mean, and the trend over the last 15 years has been positive. Still, there are sufficient data to determine that the total Ozette Lake abundance is well below the desired lower bound for recovery (NMFS 2009a), although the population has increased since the last review and over the past 15 years. Over the last few decades, productivity for the total Ozette Lake population has exhibited a 10–20-year cyclical pattern alternating between negative and positive values. Average rates over the last five- and 15-year periods have been slightly positive, but a negative phase could be starting.

Structure and Diversity

Ozette Lake sockeye salmon ESU comprise one historical population, with substantial sub-structuring of individuals into multiple spawning aggregations. The primary existing spawning aggregations occur in two beach locations, Allen's and Olsen's Beaches, and in two tributaries, Umbrella Creek and Big River (Ford 2022). Defining a historical baseline and assessing the current state of the spatial structure and diversity of the population is difficult due to a paucity of data. In particular, without estimates of abundance for the beach spawning aggregates, it is difficult to assess the degree to which the existing spatial structure is robust to demographic variability. This is especially important because both the abundance and distribution of the beach spawners has declined to a small percentage of historical levels. While no abundance estimates for beach spawners are available, there is relatively strong evidence for a substantial decline during the mid-to-late 2000s, when very few spawners were observed with moderate levels of survey effort. There is also some indication that run timing may have changed since the 1970s.

Currently, it appears that the Umbrella Creek hatchery program has successfully introduced a tributary spawning aggregate. This has increased the spatial and possibly genetic structure of the population while maintaining a genetic reservoir initially established with beach-spawning fish. The addition of the tributary aggregate may have increased or stabilized overall abundance, although this is not yet confirmed by the abundance trends.

Based on an evolving understanding of both the status and the uncertainty in the status of the Ozette Lake sockeye salmon beach-spawning aggregates, believe the biological risk for Ozette Lake sockeye salmon appears to have increased somewhat compared to prior reviews. Extinction risk is determined by our best prediction of the demographic probability of extinction and the uncertainty in that prediction—and more uncertainty results in higher risk. In the case of Ozette Lake sockeye salmon, the uncertainty is high enough that it is not possible to rule out further decline in the VSP parameters over the next couple of decades, which would increase overall risk.

Overall, the Ozette Lake sockeye salmon ESU therefore has mixed viability trends, and is likely at "moderate-to-high" risk of extinction.

Upper Columbia River Spring-run Chinook Salmon

Abundance and Productivity

To estimate abundance of juvenile natural and hatchery UCR spring-run Chinook salmon, we calculate the geometric means for outmigrating smolts over the past five years by using annual abundance estimates provided by the NWFSC (Zabel 2017, 2018, 2020, 2021, and Hecht 2022). To estimate the abundance figures for adult returns, we used the geometric means of the last five years of adult returns as reported by the NWFSC (Ford 2022). The figures for adults are broken down by natural and hatchery fish, but not into individual hatchery components (i.e., LHAC and LHIA). Abundance estimates for the ESU components are listed below.

Table 6. Recent 5-Year Geometric Means for Estimated UCR Chinook Juvenile Outmigrations and Adult Returns (Ford 2022; Zabel 2017, 2018, 2020, 2021; Hecht 2022).

Life Stage	Origin	Outmigration/Return
Adult	Natural	813
Adult	Hatchery	1,140
Juvenile	Natural	488,401
Juvenile	LHIA	470,744
Juvenile	LHAC	682,958

These adult return numbers represent substantial reductions from levels seen in the last status review (NWSFC 2015). Since that time, all three populations have seen approximately 50% reductions in natural spawners. All populations in the ESU have low (< 1.0) R/S (recruit/spawner) values, indicating that the natural replacement rate is not keeping up with all sources of mortality across the animals' life cycle. In addition, the 15-year (2004-2019) linear regressions for natural spawner abundances are negative for all three populations in the ESU (Ford 2022). Thus, both abundance and productivity have been decreasing for all UCR Chinook populations for the last several years and the populations all remain well below the Interior Columbia Basin Technical Recovery Team's (ICTRT's) minimum viability thresholds for natural abundance (ICTRT 2007). All three populations are considered to be at high risk of extinction stemming from factors related to abundance and productivity.

Structure and Diversity

Excluding one extirpated population, the UCR Chinook ESU is made up of three extant populations (Methow, Wenatchee, and Entiat), all of which have some hatchery spawner component, though the Entiat population is not currently being directly supplemented. The natural spawner components for all three populations had been increasing since approximately 2009, but the trend has been downward for the last two years in all cases. Currently, the natural component of the Methow population is 37% (an increase since the last status review), the Wenatchee population natural component is 43% (also an increase), and the Entiat is 70% natural spawners (a decrease since the last review) (Ford 2022). The spatial structure risk ratings for the populations range from low to moderate, but due to the high levels of hatchery fish on the populations' spawning grounds, the diversity risk is still rated as high for all three populations.

Because the risks ratings for abundance and productivity also remain high, the integrated overall risk ratings covering all VSP parameters remain high for all three populations and overall viability has not markedly changed since the last status review.

Upper Columbia River Steelhead

Abundance and Productivity

To estimate abundance of juvenile natural and hatchery UCR steelhead, we calculate the geometric means for outmigrating smolts over the past five years by using annual abundance estimates provided by the NWFSC (Zabel 2017, 2018, 2020, 2021, and Hecht 2022). To calculate the abundance figures for adult returns, we took the geometric means of the last five years of adult returns—as estimated by expanded redd surveys, carcass counts, dam counts, and run-at-large PIT tag detections (Ford 2022). The figures for adults are broken down by natural and hatchery fish, but not into individual hatchery components (i.e., LHAC and LHIA) (Table 7).

Table 7. Recent Five-Year Geometric Means for Estimated UCR Steelhead Juvenile Outmigrations and Adult Returns (Ford 2022; Zabel 2017 2018, 2020, 2021; Hecht 2022).

Life Stage	Origin	Outmigration/Return
Adult	Natural	1,465
Adult	Hatchery	2,893
Juvenile	Natural	150,459
Juvenile	LHIA	139,810
Juvenile	LHAC	765,850

These adult return numbers represent substantial reductions from levels seen in the last status review (NWSFC 2015). Since that time, all four populations have seen reductions in natural spawners—these reductions range from 28% (Methow R.) to 63% (Wenatchee R.). All populations in the DPS have low (< 1.0) R/S (recruit/spawner) values, indicating that the natural replacement rate is not keeping up with all sources of mortality across the animals' life cycle. In addition, the 15-year (2004-2019) linear regressions for natural spawner abundances are negative for all four populations in the DPS (Ford 2022). Thus, both abundance and productivity have been decreasing for all four UCR steelhead populations for the last several years and they all remain well below the ICTRT's minimum viability criteria (ICTRT 2007). The Methow, Entiat, and Okanogan populations are considered to be at high risk of extinction stemming from factors related to abundance and productivity; the Wenatchee population is considered to be at moderate risk relative to these factors.

Structure and Diversity

The UCR steelhead DPS is made up of four populations (Methow, Wenatchee, Entiat, and Okanogan) all of which have some hatchery spawner component, though the Entiat population is not currently being directly supplemented. The natural spawner components for all four populations have been increasing since approximately 2000, but the trend has been downward for the Wenatchee R. population in recent years. Currently, the natural components of the populations range from 24% (Okanogan) to 50% (Wenatchee) (Ford 2022).

The integrated spatial structure and diversity risk ratings for the populations are high for all four populations. Because the risks ratings for abundance and productivity are also high for all but the Wenatchee population, the integrated overall risk ratings covering all VSP parameters remain high for all populations in the DPS and viability concerns remain acute.

Middle Columbia River Steelhead

Abundance and Productivity

To estimate abundance of juvenile natural and hatchery MCR steelhead, we calculate the geometric means for outmigrating smolts over the past five years by using annual abundance estimates provided by the NWFSC (Zabel 2017, 2018, 2020, 2021, and Hecht 2022). To estimate the abundance figures for adult returns, we used the geometric means of the last five years of adult returns as reported by the NWFSC (Ford 2022). The figures for adults are broken down by natural and hatchery fish, but not into individual hatchery components (i.e., LHAC and LHIA). Abundance estimates for the DPS components are listed below (Table 8).

Table 8. Recent 5-Year Geometric Means for Estimated MCR Steelhead Juvenile Outmigrations and Adult Returns (Ford 2022; Zabel 2017, 2018, 2020, 2021; Hecht 2022).

Life Stage	Origin	Outmigration/Return
Adult	Natural	13,598
Adult	Hatchery	713
Juvenile	Natural	351,481
Juvenile	LHIA	113,302
Juvenile	LHAC	372,581

In all but one population (Klickitat R.), these adult return numbers represent substantial reductions from levels seen in the last status review (NWSFC 2015). Since that time, 16 out of the DPS's 17 extant populations have seen reductions in natural spawners that range from 15% (upper Yakima) R.) to 70% (eastside Deschutes R.). In addition, only four populations show productivity increases over the last 14 years, and all populations in the DPS have demonstrated decreases in productivity during the most recent 3-five years for which we have data (Ford 2022). Thus, both abundance and productivity have been decreasing for essentially all MCR steelhead populations for the last several years; however, five populations remain above the

ICTRT's minimum viability thresholds for natural abundance (ICTRT 2007) and several more are near their thresholds. In addition, freshwater productivity indices (FWPIs) are above 1.0 for all populations except the Umatilla—indicating that poor marine survival could be driving most of the downturns. The result is that most of the populations are considered to be at moderate extinction risk with regard to abundance and productivity criteria, but three (Deschutes R. westside, Rock Cr., and Touchet R.) are considered to be at high risk (Ford 2022).

Structure and Diversity

The MCR steelhead DPS comprises two extirpated and 17 extant populations from four major population groups. Thirteen of the populations are made up of 96% (or more) natural spawners. Of the remaining four, only the Touchet R. (at 76%) comprises less than 85% natural fish (Ford 2022). This DPS also includes steelhead from the four artificial propagation programs (FR 85 81822), but does not currently include steelhead that are designated as part of an experimental population. The integrated extinction risks associated with spatial structure and diversity are rated as moderate for 14 populations, low for two populations, and high for only one—the upper Yakima R., due to its high diversity-related risk. These ratings represent little change from the last status review.

General viability ratings for all the populations range from "high risk" to "highly viable," with most populations falling in the "maintained" category. As a result, overall, the MCR steelhead DPS remains at moderate risk of extinction, with viability essentially unchanged from the last review.

Snake River Spring/Summer-run Chinook Salmon

Abundance and Productivity

To estimate abundance of juvenile natural and hatchery SnkR spr/sum Chinook, we calculate the geometric means for outmigrating smolts over the past five years by using annual abundance estimates provided by the NWFSC (Zabel 2017, 2018, 2020, 2021, and Hecht 2022). To estimate the abundance figures for adult returns, we used the geometric means of the last five years of adult returns as reported by the NWFSC (Ford 2022). The figures for adults are broken down by natural and hatchery fish, but not into individual hatchery components (i.e., LHAC and LHIA). Abundance estimates for the ESU components are listed below.

Table 9. Recent 5-Year Geometric Means for Estimated SnkR spr/sum Chinook Juvenile Outmigrations and Adult Returns (Ford 2022; Zabel 2017, 2018, 2020, 2021; Hecht 2022).

Life Stage	Origin	Outmigration/Return
Adult	Natural	4,419
Adult	Hatchery	2,822
Juvenile	Natural	682,600

Life Stage	Origin	Outmigration/Return
Juvenile	LHIA	695,385
Juvenile	LHAC	4,743,977

The most recent 5-year geometric mean abundance estimates for 26 out of the ESU's 27 populations show a consistent and marked pattern of declining population size (one showed a slight increase from previously very low levels), with natural spawner abundance levels for the 27 populations declining by an average of 55% (Ford 2022). In five cases, the natural spawner reductions are greater than 70% and, for total spawners, the reductions are 80% or more in four populations. Similarly, all 27 populations have shown declines in productivity over the last three to five years for which we have information; however, FWPIs remain above 1.0 for 17 out of the 22 populations for which we have data—indicating that marine survival may largely be driving the productivity declines. As a result of all these negative trends, the integrated abundance and productivity extinction risks for this ESU are rated as high for all but three populations rated as moderate and two for which there is insufficient data to assign a risk rating. None of the 27 populations meets or exceeds its ICTRT minimum viability abundance threshold (ICTRT 2007).

Structure and Diversity

The SnkR spr/sum Chinook salmon ESU comprises 27 extant populations from among five MPGs. The fraction of natural fish on the spawning grounds ranges from 24% (Grand Ronde R. upper mainstem) to 100% (14 populations); as a result, the hatchery fraction for each population is somewhat variable, but well over half of the populations are made up of more than 90% natural fish. Further, since the mid-1990s, there has been a concerted effort to decrease out-of-basin hatchery supplementation for this ESU and increase the use of local broodstock—so in many cases the hatchery fraction is derived from local stock. Nonetheless, The ESU also includes spring/summer-run Chinook salmon from thirteen artificial propagation programs (85 FR 81822). Because the populations commonly remain well distributed, the integrated structure/diversity risk ratings for this ESU are generally low to moderate, but four populations are rated as being at high risk for these factors.

Overall viability ratings for this ESU's populations are given as high risk for all but three populations that are considered maintained. As a result, the ESU as a whole is considered to be at moderate to high risk, with viability largely unchanged from the last review.

Snake River Fall-run Chinook Salmon

Abundance and Productivity

To estimate abundance of juvenile natural and hatchery SnkR fall-run Chinook, we calculate the geometric means for outmigrating smolts over the past five years by using annual abundance estimates provided by the NWFSC (Zabel 2017, 2018, 2020, 2021, and Hecht 2022). To calculate the abundance figures for adult returns, we took the geometric means of the last five years of adult returns—as estimated by dam counts, PIT-stag studies, parental-based-tagging, redd counts, and other methods (Ford 2022). The figures for adults are broken down by natural and hatchery fish, but not into individual hatchery components (i.e., LHAC and LHIA).

Table 10. Recent Five-Year Geometric Means for Estimated SnkR Fall Chinook Juvenile Outmigrations and Adult Returns (Ford 2022; Zabel 2017, 2018, 2020, 2021; Hecht 2022).

Life Stage	Origin	Outmigration/Return
Adult	Natural	7,262
Adult	Hatchery	14,879
Juvenile	Natural	799,765
Juvenile	LHIA	2,966,190
Juvenile	LHAC	2,608,733

The geometric mean natural adult abundance for the most recent 10 years (2010-2019) is 8,920. This is higher than the 10-year geomean reported in the most recent status review (NWFSC 2015), but it includes a 34% reduction in natural spawners over the last five years. Nonetheless, while the population has not been able to maintain the higher returns it achieved in some years between 2010 and 2015, it has continued to remain above the ICTRT defined minimum abundance threshold of 3,000 natural adults (ICTRT 2007). Productivity has remained below replacement since 2010 (Ford 2022), but because the ESU has remained above the ICTRT abundance threshold, it is considered to be at low risk of extinction with regard to abundance and productivity factors.

Structure and Diversity

The SnkR fall-run Chinook salmon ESU is made up of one extant population spread out over five spatially complex spawning areas in the Snake River and lower mainstems of the Clearwater, Imnaha, Grande Ronde, Salmon and Tucannon rivers (ICTRT 2007). The ESU also includes fall-run Chinook salmon from four artificial propagation programs (85 FR 81822). The single population consists of 33% natural spawners—a 2% increase since the last status review (NMFS 2015). Because the ESU contains only one population that is made up largely of hatchery spawners, the integrated extinction risk for factors relating to structure and diversity is considered to be moderate. And while the one population is currently considered viable, the ESU is not meeting the recovery goals described in the recovery plan for the species—that would require the single population to be “highly viable with high certainty” and/or reintroduction of a viable population above the Hells Canyon Dam complex (NMFS 2017b).

The SnkR fall-run Chinook salmon ESU is therefore considered to be at moderate-to-low risk of extinction, with viability largely unchanged from the last review.

Snake River Basin Steelhead

Abundance and Productivity

To estimate abundance of juvenile natural and hatchery SnkR steelhead, we calculate the geometric means for outmigrating smolts over the past five years by using annual abundance estimates provided by the NWFSC (Zabel 2017, 2018, 2020, 2021, and Hecht 2022). To calculate the abundance figures for adult returns, we took the geometric means of the last five years of adult returns—as estimated by dam counts, PIT-stag studies, genetics sampling, redd counts, and other methods (Ford 2022). The figures for adults are broken down by natural and hatchery fish, but not into individual hatchery components (i.e., LHAC and LHIA).

Table 11. Recent Five-Year Geometric Means for Estimated SnkR Steelhead Juvenile Outmigrations and Adult Returns (Ford 2022; Zabel 2017, 2018, 2020, 2021; Hecht 2022).

Life Stage	Origin	Outmigration/Return
Adult	Natural	9,965
Adult	Hatchery	3,285
Juvenile	Natural	573,245
Juvenile	LHIA	528,903
Juvenile	LHAC	3,058,720

The five-year geometric mean abundance estimates for all the populations in this DPS show significant declines in the recent past (Ford 2022). The population decreases ranged from 15% (Lochsa/Selway) to over 70% (Little Salmon/Rapid R.), with most declines somewhere in the 50% range.

These declines, following years of general increase, resulted in nearly zero population change over the past five years for the three populations with sufficiently long data time series to measure. Overall productivity among every population in the DPS has also declined over the last five years for which we have data. However, the freshwater component of productivity, as measured by FWPIs, has remained above 1.0 for every MPG in the DPS (Ford 2022)—which may indicate low marine survival rates are driving much of the recent declines. Given the abundance and productivity downturns in recent years, the DPS is now generally rated as being at moderate extinction risk for factors relating to abundance and productivity, though three populations are at very low risk and three are at high risk.

Structure and Diversity

The SnkR steelhead DPS comprises 23 extant populations from among five MPGs. The fraction of natural fish on the spawning grounds ranges from 14% (Little Salmon/Rapid R.) to 100% (Asotin Cr.), so the hatchery fraction is somewhat variable, but 11 of the populations are made up of more than 95% natural fish. The DPS also includes steelhead from six artificial propagation programs (85 FR 81822). In the most recent status review, spatial structure risk ratings for all but one of the Snake Basin steelhead populations were considered to be low or very low because natural production is well distributed within those populations. (The single exception was Panther Creek, which was given a high risk rating.) The diversity risk ratings ranged from low (10 populations) to moderate (16 populations). As a result, all populations except Panther Cr. are considered to be at low to moderate extinction risk from factors relating to structure and diversity.

General viability ratings for all the populations range from "high risk" to "highly viable," with most populations falling in the "maintained" category. As a result, overall, the SnkR steelhead DPS remains at moderate risk of extinction, with viability essentially unchanged from the last review.

Snake River Sockeye Salmon

Abundance and Productivity

To estimate abundance of juvenile natural and hatchery SnkR sockeye, we calculate the geometric means for outmigrating smolts over the past five years (2016-2020) by using annual abundance estimates provided by the NWFSC (Zabel 2017a, 2017b, 2018, 2020, 2021 and Hecht 2022). To estimate the abundance figures for adult returns, we used the geometric means of the last five years of adult returns as reported by the NWFSC (Ford 2022). The figures for adults are broken down by natural and hatchery fish, but not into individual hatchery components (i.e., LHAC and LHIA). In addition, there are no LHIA juvenile fish in this ESU because all hatchery fish have their adipose fins clipped. Abundance estimates for the ESU components are listed below.

Table 12. Recent 5-Year Geometric Means for Estimated SnkR Sockeye Juvenile Outmigrations and Adult Returns (Ford 2022; Zabel 2017, 2018, 2020, 2021; Hecht 2022).

Life Stage	Origin	Outmigration/Return
Adult	Natural	16
Adult	Hatchery	97
Juvenile	Natural	18,000
Juvenile	LHAC*	298,464

*All listed hatchery fish in this ESU have had their adipose fins clipped.

After a number of years of small but steady increases, adult sockeye salmon returns to the Sawtooth Basin crashed in 2015 and natural returns have remained low since then (Ford 2022). The low returns of fish collected at the Redfish Lake and Sawtooth weirs have limited anadromous releases into Redfish Lake to a high of 311 hatchery fish in 2016, and no natural anadromous fish have been released since 2014 because they are required to be spawned in the captive broodstock program. Captive adult releases continue to support spawning in Redfish

Lake, but productivity for this ESU is almost entirely due to the captive spawning efforts. Given the low returns in recent years, the production occurring almost entirely in hatchery environments, and the persistence of poor climatic conditions during times when the adult sockeye are migrating, the species' extinction risk remains high for factors relating to abundance and productivity.

Structure and Diversity

The SnkR sockeye salmon ESU is made up of one extant population that persists only in portions of the upper Salmon River in the Stanley basin. It is dominated by hatchery production in the form of captive broodstock supplementation efforts. Given the ESU's limited spatial structure and largely hatchery-driven constituency, the species remains at high extinction risk with regard to both the structure and diversity factors.

Thus, the Snake River Sockeye ESU remains at extremely high overall risk. Though there has been substantial progress in developing a hatchery-based program to amplify and conserve the stock to facilitate reintroductions, these measures have yet to take full effect. In addition, current climate change modeling supports the extremely high-risk rating and highlights the potential for extirpation in the near future (Ford 2022). The viability of the SnkR sockeye ESU therefore has likely declined since the time of the last review, and the extinction risk remains very high.

Lower Columbia River Chinook Salmon

Abundance and Productivity

To estimate abundance of juvenile natural and hatchery LCR Chinook, we calculate the geometric means for outmigrating smolts over the past five years by using annual abundance estimates provided by the NWFSC (Zabel 2017, 2018, 2020, 2021, and Hecht 2022). To calculate the abundance figures for adult returns, we took the geometric means of the last five years of adult returns—as estimated by index reach redd counts, tributary weir counts, mark/recapture surveys, and hatchery trap, dam trap, and dam ladder counts (Ford 2022). The figures for adults are broken down by natural and hatchery fish, but not into individual hatchery components (i.e., LHAC and LHIA).

Table 13. Recent Five-Year Geometric Means for Estimated LCR Chinook Juvenile Outmigrations and Adult Returns (Ford 2022; Zabel 2017, 2018, 2020, 2021; Hecht 2022).

Life Stage	Origin	Outmigration/Return
Adult	Natural	29,298
Adult	Hatchery	18,814
Juvenile	Natural	11,135,315
Juvenile	LHIA	942,328
Juvenile	LHAC	30,923,844

The most recent five-year geometric mean abundance estimates for the ESU's 32 demographically independent populations (DIPs) are highly variable. We only have recent natural and hatchery fish abundance data for 23 of the DIPS, and about half of them have seen decreases in natural spawners and about half have seen increases. However, all but two DIPs (Sandy R. spring-run and Lower Gorge tributaries fall-run) have shown decreases in productivity for the most recent years for which we have data. Of the 32 DIPs, only seven are at or near their recovery viability goals (Dornbusch 2013)—and six of those seven are from the same stratum (Cascade). All of the Coastal and Gorge MPG fall-run populations (except the Lower Gorge DIP) likely fell within the high to very-high risk categories for abundance and productivity. Similarly, with the exception of the Sandy River spring-run DIP, all of the spring-run DIPs in the Cascade and Gorge MPGs are at high to very high risk, with a number of populations at or near zero and others largely persisting through hatchery supplementation (Ford 2022).

Structure and Diversity

The LCR Chinook salmon ESU comprises 32 historic DIPs from among six MPGs (though we do not have VSP data for all of them). The ESU also includes Chinook salmon from eighteen artificial propagation programs (85 FR 81822). The fraction of natural fish on the spawning grounds ranges from 0.04% (Big Creek fall-run) to 100% in two DIPs (Lewis R. late-fall-run, Kalama R. spring-run). As a result, the hatchery fraction for each population is somewhat variable, but approximately 2/3 of the DIPs for which have data are made up of more than 50% natural fish. Further, while overall hatchery production for the ESU has been reduced slightly in recent years, hatchery fish still represent the majority of fish returning to the ESU (Ford 2022). In terms of structure, there have been a number of large-scale efforts to improve accessibility in this ESU (one of the primary metrics for spatial structure): Cowlitz R., Toutle R., Hood R. White Salmon R., etc. These efforts are showing some positive results and many are likely to support sustainable populations in previously inaccessible habitat sometime in the near future (5-10 years). As a result, the structure VSP criterion is improving for a number of LCR Chinook populations.

Overall, there has been modest change since the last status review in the biological status of Chinook salmon populations in the Lower Columbia River ESU (NWFSC 2015), although some populations do exhibit marked improvements. Increases in abundance were noted in about half of the fall-run populations and 75% of the spring-run population for which data were available. Decreases in hatchery contribution were also noted for several populations. Relative to baseline VSP levels identified in the Recovery Plan (NMFS 2013a), there has been an overall improvement in the status of a number of fall-run populations, although most are still far from the recovery plan goals. In summation, LCR Chinook viability has increased somewhat since the last status review, but the ESU remains at moderate risk of extinction.

Lower Columbia River Coho Salmon

Abundance and Productivity

To estimate current abundance of juvenile natural and hatchery LCR coho salmon, we calculate the geometric means for outmigrating smolts over the past five years by using annual abundance estimates provided by the NWFSC (Zabel 2017, 2018, 2020, 2021; Hecht 2022). To estimate the abundance of adult spawners, we took the geometric means of the last five years of adult returns—as estimated by dam counts, radio-tag studies, PIT-stag studies, redd counts, and other methods (Ford 2022).

Table 14. Recent Five-Year Geometric Means for Estimated LCR Coho Juvenile Outmigrations and Adult Returns (Ford 2022; Zabel 2017, 2018, 2020, 2021; Hecht 2022).

Life Stage	Origin	Outmigration/Return
Adult	Natural	18,714
Adult	Hatchery	15,949
Juvenile	Natural	827,007
Juvenile	LHIA	324,130
Juvenile	LHAC	7,941,886

The 2015 status review update (NWFSC 2015) occurred at a time of near-record returns for several LCR coho populations, but conditions have worsened substantially since them, so the ESU abundance has declined markedly during the last five years. Natural spawner and total abundances have decreased in almost all populations, and Coastal and Gorge Strata populations are all at low levels with significant numbers of hatchery-origin coho salmon on the spawning grounds. Only six of the 23 populations for which we have data appear to be above their recovery goals (Ford 2022). This includes the Youngs Bay DIP and Big Creek DIP, which have very low recovery goals, and the Salmon Creek DIP and Tilton River DIP, which were not assigned goals but have relatively high abundances. Of the remaining DIPs in the ESU, 3 DIPs are at 50-99% of their recovery goals, seven DIPs are at 10-50% of their recovery goals, and seven populations are at less than 10% of their recovery goals (this includes the Lower Gorge DIP for which there are no data, but it is assumed that the abundance is low).

Spatial Structure and Diversity

The LCR coho salmon ESU is composed of all naturally spawned populations of coho salmon in the Columbia River and its tributaries in Washington and Oregon, from the mouth of the Columbia River up to and including the Big White Salmon and Hood Rivers, and including the Willamette River to Willamette Falls, Oregon. The ESU also includes twenty-one artificial propagation programs are part of the ESU (85 FR 81822). Before they were listed under the ESA, the coho salmon in the Columbia River were managed primarily as a hatchery stock. Coho were present in all lower Columbia River tributaries, but the run now consists of very few wild fish. It is possible that some native coho populations are now extinct, but the presence of naturally spawning hatchery fish makes it difficult to ascertain. The strongest remaining populations occur in Oregon and include the Clackamas River and Scappoose Creek.

There have been a number of large-scale efforts to improve accessibility, one of the primary metrics for spatial structure, in this ESU. Dams were removed over ten years ago on the Hood and White Salmon rivers. Fish passage operations (trap and haul) are ongoing on the Lewis and Cowlitz, and Toutle rivers. Hatchery production has been relatively stable and the proportion of hatchery-origin fish on the spawning grounds has increased for some populations and decreased for others. The transition from segregated hatchery programs to integrated local broodstock programs should reduce the risks from domestication and non-native introgression.

There have likely been incremental improvements in spatial structure during the last five years, but poor ocean and freshwater conditions have masked any benefits from these changes. Similarly, improvements in fish passage at culverts has improved, with 132 km (79 miles) of stream habitat being opened up in Washington State alone since 2015 (LCFRB 2020), but there are a large number of small-scale fish barriers that remain to be upgraded or removed.

Overall abundance trends for the ESU are generally negative. In light of the poor ocean and freshwater conditions that occurred during much of this recent review period, it should be noted that some of the populations exhibited resilience and only experienced relatively small declines in abundance (Ford 2022). Some populations were exhibiting positive productivity trends during the last year of review, representing the return of the progeny from the 2016 adult return (Ford 2022). Improvements in diversity and spatial structure have been slight and overshadowed by declines in abundances and productivity. For individual populations, the risk of extinction spans the full range from low to very high. Overall, the LCR coho ESU remains at moderate risk, and viability is largely unchanged from the last status review.

Lower Columbia River Steelhead

Abundance and Productivity

To estimate abundance of juvenile natural and hatchery LCR steelhead, we calculate the geometric means for outmigrating smolts over the past five years by using annual abundance estimates provided by the NWFSC (Zabel 2017, 2018, 2020, 2021, and Hecht 2022). To calculate the abundance figures for adult returns, we took the geometric means of the last five years of adult returns—as estimated by expanded redd surveys, index and census surveys, dam and weir counts, and adult mark-resight studies during prespawn holding (Ford 2022).

Table 15. Recent Five-Year Geometric Means for Estimated LCR Steelhead Juvenile Outmigrations and Adult Returns (Ford 2022; Zabel 2017 2018, 2020, 2021; Hecht 2022).

Life Stage	Origin	Outmigration/Return
Adult	Natural	8,152
Adult	Hatchery	6,382
Juvenile	Natural	375,208
Juvenile	LHIA	14,801
Juvenile	LHAC	1,183,963

Total spawner counts are available for 17 (of 21) DIPs, but the wild spawner fraction is known for only six of those populations. Total spawners have increased in nine of the DIPs since the most recent review (NWFSC 2015), and of the six DIPs with known wild spawner fractions, three have increased, two have decreased, and one remains essentially unchanged. However, productivity has decreased for all six of those DIPs. We do not have any productivity data for the rest of the LCR steelhead DIPs because we do not know how many wild fish are returning to them. For most winter-run populations, the trend in the 2015 to 2019 period is strongly negative as expressed in annual productivity estimates. There is some concern that this downward trend may be indicative of something more systemic than short-term freshwater or oceanic conditions. For most summer-run DIPS, the changes in 5-year abundances have been not substantial, however recent negative trends are of concern here as well (Ford 2022).

Structure and Diversity

The LCR steelhead DPS comprises 23 DIPs that come from four MPGs—two winter-run and two summer-run. This DPS also includes steelhead from eight artificial propagation programs (FR 85 81822), so all of the DIPs experience some hatchery influence, though hatchery production has decreased from 3 million smolts to 2.75 million since the last review (Ford 2022). Among the DIPs for which we know the numbers of wild spawners, the range is from 49% natural fish (upper Cowlitz R. winter-run) to 94% natural fish (Sandy R. winter-run). In terms of structure, there have been a number of large-scale efforts to improve accessibility for this DPS—e.g., upper Cowlitz, Cispus, and Tilton Rivers. However, structure remains a concern, especially for those populations that rely on adult trap-and-haul programs and juvenile downstream passage structures for sustainability (Ford 2022).

Of the 23 DIPs in the LCR steelhead DPS, 10 are putatively at or above the goals set in the recovery plan (Dornbusch 2013); however, many of these abundance estimates do not distinguish between natural and hatchery-origin spawners. Although a number of DIPs exhibited increases in their 5-year geometric mean, others remain depressed, and neither the winter- nor summer-run MPGs are near viability in the Columbia River Gorge. Overall, the LCR steelhead are therefore considered to be at moderate risk, and their viability is largely unchanged from the most recent review (Ford 2022).

Columbia River Chum Salmon

Abundance and Productivity

To estimate current abundance of juvenile natural and hatchery CR chum salmon, we calculate the geometric means for outmigrating smolts over the past five years by using annual abundance estimates provided by the NWFSC (Zabel 2017, 2018, 2020, 2021, and Hecht 2022). To estimate the abundance of adult spawners, we took the geometric means of the last five years of adult returns—as estimated by dam and weir counts, tributary surveys, mark-recaptures studies, radio-tag studies, PIT-stag studies, redd counts, and other methods (Ford 2022).

Table 16. Recent Five-Year Geometric Means for Estimated CR Chum Juvenile Outmigrations and Adult Returns (Ford 2022; Zabel 2017, 2018, 2020, 2021; Hecht 2022).

Life Stage	Origin	Outmigration/Return
Adult	Natural	17,305
Adult	Hatchery	1,145
Juvenile	Natural	7,777,554
Juvenile	LHIA*	554,973

*There are no listed adipose-fin-clipped fish in this ESU.

Of the 17 historical populations identified, only three currently exceed the abundance targets in the recovery plan (NMFS 2013a). The remaining populations have unknown abundances, although it is reasonable to assume that the abundances are very low and unlikely to be more that 10% of the established recovery goals. Even with the improvements observed in three populations over the last five years, the majority of populations in this ESU remain at a very high risk for abundance and productivity factors.

Spatial Structure and Diversity

The Willamette/Lower Columbia River Technical Recovery Team (WLC-TRT) identified 17 historical populations divided into three major population groups. Three artificial propagation programs are also considered to be part of the ESU (85 FR 81822). Currently, spawning populations of CR chum salmon are limited to tributaries below Bonneville Dam, with most spawning occurring in the Grays River, near the mouth of the Columbia River, and Hardy and Hamilton Creeks, approximately three miles below Bonneville Dam. In contrast to other species, mainstem dams have less of an effect on chum salmon distribution. Rather, it is smaller, stream-scale blockages that limit chum access to spawning habitat. Upland development can also affect the quality of spawning habitat by disrupting the groundwater upwelling that chum prefer. In addition, juvenile habitat has been curtailed through dikes and revetments that block access to riparian areas that are normally inundated in the spring. Loss of lower river and estuary habitat probably limits the species' ability of to expand and recolonize historical habitat. Presently, detectable numbers of chum salmon persist in only four of the 17 demographically independent populations—a fraction of their historical range.

It is notable that during this most recent review period, the three populations (Grays River, Washougal, and Lower Gorge) improved markedly in abundance. In contrast, the other populations in this ESU have not exhibited any detectable improvement in status. Abundances for these populations are assumed to be at or near zero, and straying from nearby healthy populations do not seem sufficient to reestablish self-sustaining populations. The viability of this ESU is relatively unchanged since the last review, and the improvements in some populations do not warrant a change in risk category, especially given the uncertainty regarding climatic effects in the near future (Ford 2022). The CR chum salmon ESU therefore remains at moderate risk of extinction, and its viability is largely unchanged from the most recent review.

Upper Willamette River Chinook Salmon

Abundance and Productivity

To estimate current abundance of juvenile natural and hatchery UWR Chinook salmon, we calculate the geometric means for outmigrating smolts over the past five years by using annual abundance estimates provided by the NWFSC (Zabel 2017, 2018, 2020, 2021, and Hecht 2022). To estimate the abundance of adult spawners, we used the geometric means of the last five years of adult returns as reported by the NWFSC (Ford 2022). Abundance estimates for the ESU components are listed below.

Table 17. Recent 5-Year Geometric Means for Estimated UWR Chinook Salmon Juvenile Outmigrations and Adult Returns (Ford 2022; Zabel 2017, 2018, 2020, 2021; Hecht 2022).

Life Stage	Origin	Outmigration/Return
Adult	Natural	10,531
Adult	Hatchery	25,380
Juvenile	Natural	1,159,334
Juvenile	LHIA	0
Juvenile	LHAC*	4,361,832

*All hatchery fish in this ESU have had their adipose fins clipped.

Abundance levels for all but one of this ESU's seven populations remain well below their recovery goals. The Clackamas River currently exceeds its abundance recovery goal. In addition, the Calapooia River population may be functionally extinct and the Molalla River remains critically low (there is considerable uncertainty regarding the level of natural production in the Molalla River). Abundances in the North and South Santiam rivers have declined since the 2015 status review update (NWFSC 2015), with natural-origin abundances in the low hundreds of fish.

The Middle Fork Willamette River is at a very low abundance, even with the inclusion of natural origin spring-run Chinook salmon spawning in Fall Creek. While returns to Fall Creek Dam number in the low hundreds, prespawn mortality rates are very high in the basin; however, the Fall Creek program does provide valuable information on juvenile fish passage through operational drawdown. With the exception of the Clackamas River, the proportion of natural origin spawners in the remainder of the ESU are well below those identified in the recovery goals (ODFW and NMFS 2011). While the Clackamas River appears to be able to sustain above recovery goal abundances, even during relatively poor ocean and freshwater conditions, the remainder of the ESU is well short of its recovery goals.

Spatial Structure and Diversity

The Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead (ODFW and NMFS 2011) identifies seven demographically independent populations of spring Chinook salmon: Clackamas, Molalla, North Santiam, South Santiam, Calapooia, McKenzie, and the Middle Fork Willamette. The ESU also contains spring-run Chinook salmon from six artificial propagation programs (85 FR 81822). The recovery plan identifies the Clackamas, North Santiam, McKenzie and Middle Fork Willamette populations as "core populations" and the McKenzie as a "genetic legacy population." Core populations are those that were historically the most productive populations. The McKenzie population is also important for meeting genetic diversity goals. Spatial structure—particularly access to historical spawning habitat—continues to be a concern.

In the absence of effective passage programs, spawners in the North Santiam, Middle Fork Willamette, and to a lesser extent South Santiam and McKenzie rivers will continue to be confined to more lowland reaches where land development, water temperatures, and water quality may be limiting. A second spatial structure concern is the availability of juvenile rearing habitat in side channel or off-channel habitat. River channelization and shoreline development have constrained habitat in the lower tributary reaches and Willamette river mainstem and this, is turn, has limited the potential for fry and subyearling "movers" emigrating to the estuary (Schroeder *et al.* 2016).

Overall, there has likely been a declining trend in the viability of the Upper Willamette Chinook salmon ESU since the 2015 status review. The magnitude of this change is not sufficient to suggest a change in risk category, however, so the Upper Willamette Chinook salmon ESU remains at moderate risk of extinction.

Upper Willamette River Steelhead

Abundance and Productivity

To estimate current abundance of juvenile natural and hatchery UWR Chinook salmon, we calculate the geometric means for outmigrating smolts over the past five years by using annual abundance estimates provided by the NWFSC (Zabel 2017, 2018, 2020, 2021, and Hecht 2022). To estimate the abundance of adult spawners, we took the geometric means of the last five years of adult returns—as estimated by Willamette Falls adult bypass counts, PIT-stag studies, redd counts, and other methods (Ford 2022).

Table 18. Recent Five-Year Geometric Means for Estimated UWR Steelhead Juvenile Outmigrations and Adult Returns (Ford 2022; Zabel 2017, 2018, 2020, 2021; Hecht 2022).

Life Stage	Origin	Outmigration/Return
Adult	Natural	2,628
Adult	Hatchery	*
Juvenile	Natural	135,303

*This DPS contains no hatchery fish.

Populations in this DPS have experienced long-term declines in spawner abundance. The underlying causes of these declines are not well understood. Returning adult winter steelhead do not experience the same deleterious water temperatures as the spring-run Chinook salmon and prespawn mortalities are not likely to be significant. Although the recent magnitude of these declines is relatively moderate, the continued declines are a cause for concern (Ford 2022).

Spatial Structure and Diversity

The recovery plan for this DPS (ODFW and NMFS 2011) identifies four demographically independent populations of steelhead: Molalla, North Santiam, South Santiam, and Calapooia. No artificially propagated steelhead stocks are considered part of the listed species. The hatchery summer-run steelhead in the basin are an out-of-basin stock and not considered part of the DPS. Winter steelhead have been reported spawning in the west-side tributaries to the Willamette River, but these tributaries were not considered to have constituted an independent population historically. The west-side tributaries may serve as a population sink for the DPS (Myers *et al.* 2006).

Improvements to fish passage and operational temperature control at the dams on the North and South Santiam rivers continue to be a concern. It is unclear if sufficient high-quality habitat is available below Detroit Dam to support the population reaching its VSP recovery goal, or if some form of access to the upper watershed is necessary to sustain a “recovered” population. Similarly, the South Santiam Basin may not be able to achieve its recovery goal status without access to historical spawning and rearing habitat above Green Peter Dam (Quartzville Creek and Middle Santiam River) and/or improved juvenile downstream passage at Foster Dam.

While the diversity goals are partially achieved through the closure of winter-run steelhead hatchery programs in the Upper Willamette River, there is some concern that the summer-run steelhead releases in the North and South Santiam rivers may be influencing the viability of native steelhead.

Overall, the UWR steelhead DPS continued to decline in abundance since the previous status review in 2015. While the viability of the ESU appears to be declining, the recent uptick in abundance may provide a short-term demographic buffer. Although the most recent counts at Willamette Falls and the Bennett dams in 2019 and 2020 suggest a rebound from the record 2017 lows, it should be noted that current “highs” are equivalent to past lows. Introgression by non-native summer-run steelhead continues to be a concern. Genetic analysis suggests that there is introgression among native late-winter steelhead and summer-run steelhead (Van Doornik *et al.* 2015, Johnson *et al.* 2018, Johnson *et al.* 2021). Accessibility to historical spawning habitat is still limited, especially in the North Santiam River. Efforts to provide juvenile downstream passage at Detroit are well behind the prescribed timetable (NMFS 2008c), and passage at Green Peter Dam has not yet entered the planning stage. Much of the accessible habitat in the Molalla, Calapooia, and lower reaches of North and South Santiam rivers is degraded and under continued development pressure. Although habitat restoration efforts are underway, the time scale for restoring functional habitat is considerable. Overall, the Upper Willamette steelhead DPS therefore is at moderate-to-high risk, with a declining viability trend (Ford 2022).

Oregon Coast Coho Salmon

Abundance and Productivity

To estimate the abundance of adult spawners, we used the geometric means of the last five years of adult returns as reported by the NWFSC (Ford 2022). While we currently lack data on how many natural juvenile coho salmon this ESU produces, it is possible to make rough estimates of juvenile abundance from adult return data. By applying a very conservative value of 2,000 eggs per female to an estimated 30,631 females returning (half of 61,262) to this ESU, one may expect approximately 61.3 million eggs to be produced annually. Nickelson (1998) found survival of coho from egg to parr in Oregon coastal streams to be around 7%. Thus, we can estimate that roughly 4.3 million natural-origin juvenile coho salmon are produced annually by the Oregon Coast ESU. In addition, the Cow Creek OC coho salmon artificial propagation program has an annual release target of 60,000 juveniles in the Umpqua River (ODFW 2017). Abundance estimates for the ESU components are listed below.

Table 19. Recent 5-Year Geometric Means for Estimated OC Coho Juvenile Outmigrations and Adult Returns (Ford 2022).

Life Stage	Origin	Outmigration/Return
Adult	Natural	60,624
Adult	Hatchery	638
Juvenile	Natural	4,288,340
Juvenile	LHAC	60,000

The spawner abundance of coho salmon in the Oregon Coast ESU varies by time and population. The large populations (abundances > 6,000 spawners since 2015) include the Coos, Coquille, Nehalem, Tillamook, Alsea, Siuslaw, and Lower Umpqua Rivers (Ford 2022). The total abundance of spawners in the ESU generally increased between 1999 and 2014, before dropping in 2015 and remaining low. The 2014 OC coho return (355,600 wild and hatchery spawners) was the highest since at least the 1950s (2011 was the second highest with 352,200), while the 2015 return (56,000 fish) was the lowest since the late 1990s. Most independent and dependent populations show synchronously high abundances in 2002-2003, 2009-2011 and 2014, and low abundances in 2007, 2012-2013, and now 2015-2019—this indicates the overriding importance of marine survival to returns of OC coho (Ford 2022).

Spatial Structure and Diversity

The geographic area occupied by the OC coho salmon ESU is physically diverse, and includes numerous rocky headlands and an extensive area with sand dunes. Most rivers the ESU's range drain the west slope of the Coast Range, with the exception the Umpqua River, which extends through the Coast Range to drain the Cascade Mountains (Weitkamp *et al.* 1995). While most coho salmon populations in the ESU use stream and riverine habitats, there is extensive winter lake rearing by juvenile coho salmon in several large lake systems. The Oregon and Northern California Coasts Technical Recovery Team identified 56 populations, including 21 independent and 36 dependent populations in five biogeographic strata (Lawson *et al.* 2007). The ESU also includes the Cow Creek hatchery coho stock, produced at the Rock Creek Hatchery. Independent populations are populations that historically would have had a high likelihood of persisting in isolation from neighboring populations for 100 years. Dependent populations tend to be smaller and may not have be able to maintain themselves continuously for periods as long as hundreds of years without strays from adjacent populations.

The spatial structure of coho salmon populations within the ESU can also be inferred from population-specific spawner abundances and productivity (Ford 2022). In particular, there is no geographic area or stratum within the ESU that appears to have considerably lower abundances or be less productive than other areas or strata and therefore might serve as a "population sink." Furthermore, if the factors driving abundances in independent populations apply equally to dependent populations, then it is unlikely that small populations are being lost at unusually high rates, which is a concern for spatial structure (McElhany *et al.* 2000). Abundance and productivity trends for dependent populations in the North and Mid Coast strata show the same patterns and trends as independent populations, consistent with this premise.

The biological status of the ESU has likely degraded slightly since the 2015 status review (NWFSC 2015), which covered a period of favorable ocean conditions and high marine survival rates. However, the ESU's status has improved relative to the 2012 assessment (NMFS 2012). This improvement occurred despite similar or better abundances and marine survival rates during the earlier period, suggesting that management decisions to reduce both harvest and hatchery releases continue to benefit the species. A recent assessment of the vulnerability of ESA-listed salmonid "species" to climate change indicated that OC coho had high overall vulnerability, had high biological sensitivity and climate exposure, but only moderate adaptive capacity (Crozier *et al.* 2019). Overall, the OC coho ESU is therefore at moderate-to-low risk of extinction, with viability largely unchanged from the most recent review.

Southern Oregon/Northern California Coast Coho Salmon

Abundance and Productivity

To estimate the abundance of adult spawners, we took the geometric means of the last five years of adult returns—as estimated by dam counts, radio-tag studies, PIT-stag studies, redd counts, and other methods (SWFSC 2023). While we currently lack data on how many natural juvenile coho salmon this ESU produces, it is possible to make rough estimates of juvenile abundance from adult return data. Sandercock (1991) published fecundity estimates for several coho salmon stocks; average fecundity ranged from 1,983 to 5,000 eggs per female. By applying a very conservative value of 2,000 eggs per female to an estimated 1,154 females returning (50 percent of the run) to this ESU, one may expect approximately 12.6 million eggs to be produced annually. Nickelson (1998) found survival of coho salmon from egg to parr in Oregon coastal streams to be around 7 percent. Thus, we can estimate that roughly the Southern Oregon/Northern California Coast ESU produces 884,870 natural-origin juvenile coho salmon annually. Combined hatchery releases for the Cole Rivers, Trinity River, and Iron Gate hatchery programs result in an estimate of 650 thousand hatchery-origin outmigrants per year (A. Cranford pers comm., ODFW 2020)

Table 20. Recent Five-Year Geometric Means for Estimated SONCC coho Juvenile Outmigrations and Adult Returns (SWFSC 2023[a]).

Life Stage	Origin	Outmigration/Return
Adult	Natural and Hatchery	12,641
Juvenile	Natural	884,870
Juvenile	LHIA	75,000
Juvenile	LHAC	575,000

[a] Data are provisional and subject to change

We only have population-level estimates of abundance for seven of the 26 independent populations in this ESU. The available data indicate that the six independent populations remain below recovery targets and, in two cases (Shasta River and Mattole River), are below the high-risk thresholds established by the TRT and adopted in the recovery plan (NMFS 2014). Although they are well below recovery thresholds, positive abundance trends were observed in the Elk and Scott rivers populations. The remaining five populations had negative abundance trends. All independent populations that are included in this assessment and were included in the previous assessment from five years ago had a lower average annual abundance in this most recent assessment, including the Scott River.

Spatial Structure and Diversity

Williams *et al.* (2006) identified 36 independent and nine dependent populations of coho salmon in the SONCC coho salmon ESU. The ESU also includes coho salmon from three hatchery programs in Oregon and California (85 FR 81822). Independent populations are populations that historically would have had a high likelihood of persisting in isolation from neighboring populations for 100 years and are rated as functionally independent or potentially independent. Dependent populations historically would not have had a high likelihood of persisting in isolation for 100 years. These populations were further grouped into seven diversity strata based on the geographical arrangement of the populations and basin-scale genetic, environmental, and ecological characteristics.

The primary factors affecting the genetic and life history diversity of SONCC coho salmon appear to be low population abundance and the influence of hatcheries and out-of-basin introductions. Although the operation of a hatchery tends to increase the abundance of returning adults, the reproductive success of hatchery-born salmonids spawning in the wild can be less than that of naturally produced fish (Araki *et al.* 2007). As a result, the higher the proportion of hatchery-born spawners, the lower the overall productivity of the population, as demonstrated by Chilcote (2003). Because the main stocks in the SONCC coho salmon ESU (i.e., Rogue River, Klamath River, and Trinity River) remain heavily influenced by hatcheries and have little natural production in mainstem rivers (Weitkamp *et al.* 1995; Good *et al.* 2005), some of these populations are at high risk of extinction with respect to the genetic diversity parameter.

In addition, some populations are extirpated or nearly extirpated (i.e., Middle Fork Eel, Bear River, Upper Mainstem Eel) and some brood years have low abundance or may even be absent in some areas (e.g., Shasta River, Scott River, Mattole River, Mainstem Eel River), which further affects the spatial structure and diversity of the ESU. The ESU's current genetic variability and variation in life history likely contribute significantly to long-term risk of extinction. Given the recent trends in abundance across the ESU, the genetic and life history diversity of populations are probably very low and inadequately contributing to a viable ESU.

In summary, data availability for this ESU remains generally poor, new information available since Williams *et al.* (2016) suggests there has been little improvement over the five years since the last viability assessment (SWFSC 2023). For the seven independent populations with appropriate data to assess population viability, all are at or above a moderate risk based on population viability criteria (Williams *et al.* 2008). Five of the seven populations have negative trends in abundance including two (Shasta and Mattole rivers) that are at high-risk based on viability criteria (Williams *et al.* 2008). Of the two populations with positive abundance trends (Elk and Scott rivers), only one has a significant positive abundance trend (Elk River). The Scott River's 12-year average of 670 fish is well below the recovery target of 6,500 (NMFS 2014); both the Elk River and Scott River are at moderate-risk of extinction based on the spawner density criterion (Williams *et al.* 2008). Based on the available data, the extinction risk of the SONCC Coho Salmon ESU has increased since the last assessment.

Northern California Steelhead

Abundance and Productivity

Adult abundance and redd surveys are frequently conducted throughout many of the populations in this DPS. However, the record is inconsistent with either no fish observed or no surveys conducted in some years. Due to the inconsistency of the record we have used a 5-year average as an estimate for abundance (2014-2015 to 2018-2019 sampling seasons) for population data were available (CDFW 2020). While we currently lack data on naturally produced juvenile NC steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. Juvenile NC steelhead abundance estimates come from the escapement data displayed in the table below (Table 21). For this species, fecundity estimates range from 3,500 to 12,000 eggs per female, and the male to female ratio averages 1:1 (Pauley *et al.* 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (half of the escapement of spawners –4,178 females), 14.6 million eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce roughly 950,495 natural-origin outmigrants annually. No hatchery NC steelhead are listed as part of this DPS.

Table 21. Recent Five-Year Means for Estimated NC Steelhead Adult Returns and Estimated Juvenile Outmigrations (CDFW 2020, Pauley *et al.* 1986, Ward and Slaney 1993).

Life Stage	Origin	Outmigration/Return
Adult	Natural	8,356
Juvenile	Natural	950,495

The SWFSC (2023) reported that winter-run populations remain well below recovery targets. Trends in abundance for larger populations have been mixed, with the majority showing slight (non-significant) increases. Moreover, there appears to be a downward (but non-significant) trend in abundance for smaller populations.

Summer-run populations remain a significant concern. The Middle Fork Eel River population has remained remarkably stable for nearly five decades and is closer to its recovery target (~80%) than any other population in the DPS. However, the other summer-run populations in the DPS are either well below recovery targets or there is not enough information to evaluate abundance and productivity.

Spatial Structure and Diversity

The NC steelhead DPS comprises both winter- and summer-run steelhead populations and does not include any hatchery stocks. Extant summer-run populations are found in Redwood Creek, Mad River, Eel River (Middle Fork), and the Mattole River. Two artificial propagation programs were originally listed as part of the DPS, but both programs were terminated in the mid-2000s (NMFS 2007). Bjorkstedt *et al.* (2005) concluded that the NC steelhead DPS historically comprised 42 populations of winter-run steelhead and as many as 10 populations of summer-run steelhead. Winter-run steelhead were also likely found in numerous smaller coastal watersheds that were dependent on immigration from the larger independent populations.

NC steelhead remain broadly distributed throughout their range, with the exception of habitat upstream of dams on both the Mad River and Eel River that have reduced the extent of available habitat. The distribution and abundance of summer-run steelhead continues to be a significant concern for the diversity of the DPS (Williams *et al.* 2021). Summer-run steelhead persist in the Middle Fork Eel, Mad, Mattole, and Van Duzen rivers, as well as Redwood Creek. However, the numbers of summer-run steelhead in most of these systems is believed to be well below viability targets. Hatchery practices expose natural populations to genetic introgression and the potential for deleterious interactions between native stock and introduced steelhead. At the time of listing, the artificial propagation programs identified as potential threats to diversity were Yager Creek/Van Duzen, Van Arsdale Fish Station, Mad River, Noyo River and the North Fork Gualala hatcheries. The Yager Creek/Van Duzen, Van Arsdale Fish Station, Noyo and the North Fork Gualala hatchery programs have since been terminated. Although the steelhead produced at the Mad River Hatchery are not considered part of the DPS, CDFW continues to operate the hatchery.

Although most populations for which there are population estimates available remain well below viability targets, trends have been relatively flat, suggesting that this DPS is not at immediate risk of extinction.

California Coastal Chinook Salmon

Abundance and Productivity

Adult Chinook salmon abundance estimates come from (1) sonar-based estimates on Redwood Creek and the Mad and Eel rivers, (2) weir counts at Freshwater Creek (one tributary of the Humboldt Bay population), (3) trap counts at Van Arsdale Station (representing a small portion of the upper Eel River population), (4) adult abundance estimates based on spawner surveys for six populations on the Mendocino Coast, and (5) video counts of adult Chinook salmon at Mirabel on the Russian River (SWFSC 2023). Previous status reviews have included maximum live/dead counts in three index reaches in the Eel River (Sproul and Tomki creeks) and Mad River (Cannon Creek); however, these efforts have been discontinued and replaced with the more rigorous efforts to monitor populations in the Eel and Mad rivers using sonar methods. Nonetheless, and despite the recent improvements, population-level abundance data are still limited. Abundance estimates for the ESU components are listed below.

Table 22. Recent 5-Year Means for Estimated CC Chinook Adult Returns and Estimated Juvenile Outmigrations (SWFSC 2023).

Life Stage	Origin	Outmigration/Return
Adult	Natural	13,169
Juvenile	Natural	2,392,807

While we currently lack data on naturally produced juvenile CC Chinook salmon production, it is possible to make rough estimates of juvenile abundance from adult return data. Juvenile CC Chinook salmon population abundance estimates come from applying estimate of the percentage of females in the population, fecundity, and survival rates to escapement data. We have no precise specific data on average fecundity for female CC Chinook salmon, however, Healey and Heard (1984) indicates that average fecundity for Chinook salmon in the nearby Klamath River is 3,634 eggs for female. By applying that rate to the estimated 6,584 females returning (half of the average total number of spawners), and applying an estimated survival rate from egg to smolt of 10 percent, the ESU could produce roughly 2.4 million natural outmigrants annually.

Structure and Diversity

Relatively new sonar-based monitoring programs in the Mad and Eel Rivers, which have replaced index-reach surveys in a limited number of tributaries, indicate that populations in these watersheds are doing better than believed in previous assessments, with the Mad River population currently at levels above recovery targets. Likewise, sonar-based estimates for Redwood Creek suggest that the Redwood Creek population, while somewhat variable, is approaching its recovery target in favorable years. Trends in the longer time series are mixed, with the Freshwater Creek population showing a significant decline and the Van Arsdale population showing no significant trend over the in either the long (23-year) or short (12-year) time series.

Data from populations in the more southerly diversity strata indicate that most populations (all except the Russian River) have exhibited mixed trends but remain far from recovery targets. In all Mendocino Coast populations (Ten Mile, Noyo, Big, Navarro, and Garcia rivers), surveys have failed to detect Chinook salmon in 3–10 of the 11 or 12 years of monitoring, suggesting only sporadic occurrence in these watersheds. Thus, concerns remain not only about the small population sizes, but the maintenance of connectivity across the ESU. Only the Russian River population has consistently numbered in the low thousands of fish in most years, making it the largest population south of the Eel River. The ESU therefore continues to be at risk of reduced spatial structure and diversity throughout its range (SWFSC 2023).

Sacramento River Winter-run Chinook Salmon

Abundance and Productivity

To estimate the abundance of adult spawners in this ESU we took the means of the last three years of adult returns—as estimated by mark-recaptures studies, redd counts, and carcass surveys (SWFSC 2023). The average of the estimated run size of in-river spawners from the most recent three years (2017-2019) was 3,702 adults. Over the most recent three years 68% of in-river spawners on average were hatchery-origin (SWFSC 2023), and therefore we estimate there would be 1,185 natural-origin and 2,517 hatchery-origin in-river spawners in a given year. When added to the average of 180 adults spawned per year at the Livingston Stone National Fish Hatchery (LSNFH) over the most recent three years, the total abundance of hatchery-origin adults is estimated to be 2,697 annually.

To estimate the abundance of juvenile SacR Chinook we utilize estimates developed pursuant to the biological opinion for the long-term operations of the Central Valley Project and State Water Project. Each year, a technical team from the Interagency Ecological Program uses adult escapement estimates from carcass surveys in the prior year, genetic data, the estimated number of fry-equivalents passing Red Bluff Diversion Dam, and survival rates of fry and smolts as they migrate downstream, to estimate the number of juvenile winter-run Chinook salmon to enter the Sacramento-San Joaquin Delta. We use these projections as our estimates of the number of hatchery-origin and naturally produced juveniles expected to be present in the system, as summarized in the table below.

Table 23. Recent 5-Year Means for Estimated SacR Chinook Adult Returns and Estimated Juvenile Outmigrations (SWFSC 2023).

Life Stage	Origin	Outmigration/Return
Adult	Natural	1,185
Adult	Hatchery	2,697
Juvenile	Natural	125,038
Juvenile	LHAC	158,855

As with many Central Valley Chinook salmon populations, the abundance of Sacramento River winter-run Chinook salmon has declined during recent periods of unfavorable ocean conditions and droughts (SWFSC 2023). These conditions likely contributed to the low numbers of natural-origin adults observed in 2017 and 2018. However, recent improvements in adult returns in 2018 and 2019 have resulted in current population sizes that satisfy the low-risk criterion for abundance of this population. Still, the 10-year trend in run size, is not significantly different from zero (SWFSC 2023), and therefore does not indicate long-term improvements.

Structure and Diversity

The SacR Chinook population continues to be considered at high extinction risk because of the lack of population redundancy within the ESU, which has long consisted of a single spawning population spawning in the mainstem Sacramento River (SWFSC 2023). Reintroduction efforts in Battle Creek initiated in 2017 have begun the process of establishing a second winter-run Chinook salmon population, though it is not sufficient to mitigate the risk to the primary population in this ESU (SWFSC 2023).

In addition to limited spatial structure, this ESU is also highly dependent on the hatchery-origin fish produced by the LSNFH (SWFSC 2023). The primary role of this conservation hatchery is to prevent extinction of this ESU, so in response to drought conditions from 2013-2015 the number of hatchery adults spawned and juveniles released was greatly increased. This resulted in a significant increase in the proportion of hatchery-origin adult spawners in 2017 and 2018 (>80%), continuing a worsening trend of increasing hatchery influence that has reached levels placing this ESU at a high risk of extinction (SWFSC 2023).

Central Valley Spring-run Chinook Salmon

Abundance and Productivity

To estimate annual abundance of natural adult spawners (natural- and hatchery-origin), we calculate the average of the most recent three years of adult spawner counts (2017 through 2019) from surveys conducted by CDFW (SWFSC 2023). The Feather River Hatchery (FRH) is the only hatchery that produces CVS Chinook (with the exception of the San Joaquin Salmon Conservation and Research Facility). The majority of spring-run Chinook salmon adults returning to spawn in the Feather River are therefore of hatchery origin; coded-wire tag data collected by CDFW from 2015-2019 spawning surveys indicates that on average 96% of adults spawning in the Feather River over the past five years have been of hatchery origin (Palmer-Zwahlen *et al.* 2019 and 2020, Letvin *et al.* 2020, 2021a, and 2021b). We therefore multiplied this fraction by the total population of spawners reported for the Feather River to estimate 2,083 hatchery-origin adults in this ESU, and the remainder of the Feather River adults in addition to all other populations estimated for this ESU resulted in the estimate of 6,756 natural-origin adults annually, based on the three-year averages (SWFSC 2023, Table 24).

While we currently lack data on naturally produced juvenile CVS Chinook salmon production, it is possible to make rough estimates of juvenile abundance from adult return data. The abundance of natural-origin CVS Chinook salmon juveniles was generated by applying estimates of the percentage of females in the population, fecundity, and survival rates to escapement data. Assuming half of the returning adults are females (4,420 females), and applying an average fecundity of 4,161 eggs per female and a 10% survival rate from egg to juvenile outmigrant (CDFG 1998), over 1.8 million natural-origin juvenile CVS Chinook salmon could be produced annually. The annual release target for hatchery juvenile spring-run Chinook salmon from the Feather River Hatchery is 2 million. Abundance estimates for the ESU components are listed below.

Table 24. Recent Three-Year Means for Estimated CVS Chinook Adult Returns and Estimated Juvenile Outmigrations (SWFSC 2023).

Life Stage	Origin	Outmigration/Return
Adult	Natural	6,756
Adult	Hatchery	2,083
Juvenile	Natural	1,838,954
Juvenile	LHAC	2,000,000

All populations of CVS Chinook salmon continue to decline in abundance, with the exception of two dependent populations (SWFSC 2023). The total abundance (hatchery- and natural-origin spawners) of CVS Chinook in the Sacramento River basin in 2019 was approximately half of the population size in 2014 and close to the decadal lows that occurred as recently as the last two years (Azat 2020). The Butte Creek spring-run population has become the backbone of this ESU, in part due to extensive habitat restoration and the accessibility of floodplain habitat in the Butte Sink and the Sutter Bypass for juvenile rearing in the majority of years. Butte Creek remains at low risk, yet all viability metrics for the ESU have been trending in a negative direction in recent years (SWFSC 2023). Most dependent spring-run populations have been experiencing continued and, in some cases, drastic declines (SWFSC 2023).

Structure and Diversity

The Central Valley Technical Review Team estimated that historically there were 18 independent populations of CVS Chinook salmon, along with a number of dependent populations, in four distinct or diversity groups (Lindley *et al.* 2004). Of these 18 populations, only three remain (Mill, Deer, and Butte creeks, which are tributary to the upper Sacramento River) and they represent only the northern Sierra Nevada diversity group (SWFSC 2023). However, spatial diversity in the ESU is increasing and spring-run Chinook salmon are present (albeit at low numbers in some cases) in all diversity groups. The reestablishment of a population in Battle Creek and increasing abundance in Clear Creek observed in some years appears to be increasing the species' viability (SWFSC 2023). Similarly, the reappearance of early migrating Chinook salmon to the San Joaquin River tributaries may be the beginning of natural dispersal processes into rivers where they were once extirpated. Active reintroduction efforts on the Yuba River, above Shasta and Don Pedro dams, and below Friant Dam, if successful, would further improve the viability of this ESU.

Current introgression between fall- and spring-run Chinook salmon in the FRH breeding program and straying of FRH spring-run Chinook salmon to other spring-run populations where genetic introgression would be possible is having an adverse effect on the diversity of this ESU (SWFSC 2023). Off-site releases of FRH spring-run Chinook salmon have caused hatchery fish to increasingly stray into other spring-run populations and, if continued, could result in a moderate risk of extinction to other spring-run Chinook salmon populations. However, in 2014, the FRH started releasing spring-run production into the Feather River rather than the San Francisco Bay and it is hypothesized that this will reduce straying (Palmer-Zwahlen *et al.* 2019; Sturrock *et al.* 2019.

California Central Valley Steelhead

Abundance and Productivity

To estimate annual abundance for adult spawners (natural- and hatchery-origin) we use the average of the estimated run sizes for the most recent three years (2017-2019) from populations with available survey data (SWFSC 2023). It is important to note that these estimates do not include data from a number of watersheds where steelhead are known to be present, and therefore likely represent an underestimate of adult abundance for the DPS. In addition, while we know that the large average numbers of adults returning to the Mokelumne River, Feather River, and Coleman hatcheries (9,325 of the 11,494 returning adults) are predominantly of hatchery origin, we do not have sufficient population-level data to estimate the proportion of hatchery-origin spawners across the DPS. Abundance estimates for the DPS components are listed below.

Table 25. Recent Three-Year Means for Estimated CCV Steelhead Adult Returns and Estimated Juvenile Outmigrations (SWFSC 2023).

Life Stage	Origin	Outmigration/Return
Adult	Natural and Hatchery	11,494
Juvenile	Natural	1,307,443
Juvenile	LHAC	1,050,000

While we currently lack data on naturally produced juvenile CCV steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. Fecundity estimates for steelhead range from 3,500 to 12,000 eggs per female; and the male to female ratio averages 1:1 (Pauley *et al.* 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (half of the adult total, or 5,747 females), over 20 million eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce roughly 1.3 million natural-origin outmigrants annually. The sum of expected annual releases from all of the hatchery programs is used to estimate the abundance of outmigrating hatchery-origin juvenile CCV steelhead (CDFW 2020, unpublished).

Steelhead are present throughout most of the watersheds in the Central Valley, but often in low numbers, especially in the San Joaquin River tributaries, and population abundance data remain extremely limited for this DPS. While the total hatchery populations have continued to increase in abundance in recent years, the state of natural-origin fish remains poor and largely unknown (SWFSC 2023). Recent expansions in monitoring, such as in the Yuba, Stanislaus, and

Tuolumne rivers and the San Joaquin River tributaries, have recently allowed several populations to be evaluated using viability criteria for the first time, and many show recent declines. Data collected through 2019 from the Chipps Island midwater trawl, which provides information on the trends in abundance for the DPS as a whole, indicate that the production of natural-origin steelhead remains very low relative to the abundance of hatchery-origin steelhead (SFWSC 2022).

Structure and Diversity

Recent modest improvements in the abundance of this DPS is driven by the increase in adult returns to hatcheries from previous lows, but improvements to the sizes of the largely hatchery populations does not warrant a downgrading of the DPS extinction risk. As described above, the lack of improved natural production as estimated by exit at Chipps Island, and low abundances coupled with large hatchery influence in the Southern Sierra Nevada diversity group, are cause for concern (SWFSC 2023). In addition to the major populations being reliant on hatchery supplementation, the influence of hatchery-origin steelhead that are not part of the DPS also threaten the genetic diversity of this species. Nimbus Hatchery steelhead were founded from coastal steelhead populations, and continued introgression of strays from this program with natural-origin American River steelhead poses a risk to the CV steelhead DPS (SWFSC 2023).

Central California Coast Coho Salmon

Abundance and Productivity

To estimate annual abundance of adult spawners (natural- and hatchery-origin), we calculate the geometric mean of the most recent years of adult spawner estimates, as reported in SWFSC (2023). Population estimates are based on redd counts from surveys of stream reaches selected according to a Generalized Randomized Tessellation Survey (GRTS) design. Redd counts are then expanded to adult estimates based on spawner:redd ratios estimated at a network of life cycle monitoring (LCM) stations (SFWSC 2023). Abundance estimates for the ESU components are listed below (Table 26).

Table 26. Geometric Means for Estimated CCC Coho Adult Returns, Estimated Juvenile Outmigrations, and Target Annual Hatchery Releases (SWFSC 2023, CDFW 2020).

Life Stage	Origin	Outmigration/Return
Adult	Natural and hatchery	2,308
Juvenile	Natural	161,560
Juvenile	LHIA	140,000

While we currently lack data on how many natural juvenile coho salmon this ESU produces, it is possible to make rough estimates of juvenile abundance from adult return data. Sandercock

(1991) published fecundity estimates for several coho salmon stocks; average fecundity ranged from 1,983 to 5,000 eggs per female. By applying a very conservative value of 2,000 eggs per female to an estimated 1,154 females returning (50 percent of the run, including the Russian River hatchery returns which are allowed to spawn in the wild) to this ESU, one may expect approximately 2.3 million eggs to be produced annually. Nickelson (1998) found survival of coho salmon from egg to parr in Oregon coastal streams to be around 7 percent. Thus, we can estimate that roughly the Central California Coast ESU produces 161,560 juvenile coho salmon annually (Table 26). The CCC coho salmon ESU includes three artificial propagation programs (79 FR 20802), and the combined minimum annual target for hatchery releases for CCC coho salmon is 140,000 LHIA juveniles.

Available data for CCC coho salmon populations indicate that all remain far below recovery targets for abundance (SWFSC 2023). In recent years there have been slight improvements in the abundance of populations in the Lost Coast—Navarro Point and Navarro Point—Gualala Point strata at the northern end of the species' range. However, in the Coastal diversity stratum there has been little change in abundance since the last 5-year status review, and is possibly declining in the Santa Cruz Mountain stratum, although assessment of both of these strata is difficult due to the scarcity of reliable data and how rarely CCC coho salmon are observed in these areas (SWFSC 2023).

Structure and Diversity

The current viability of populations is progressively worse moving north to south in the ESU (SWFSC 2023). While abundance trends appear to be increasing in the Lost Coast diversity stratum and remained stable in the Navarro Point diversity stratum, the already-small population sizes have not improved in the Coastal stratum since 2016. In the Santa Cruz Mountain stratum, natural production of coho salmon is extremely low. In this stratum observations of adult coho salmon are rare in the two historically independent populations, and all dependent populations are either extirpated or at critically low levels. Population persistence in this stratum is also highly dependent on the ongoing captive rearing program, and there has been a loss of genetic diversity in the hatchery broodstock, which necessitated the incorporation of out-of-stratum broodstock into the program. The loss of genetic diversity in this stratum and risk of very low abundance population in this stratum being lost to the ESU negatively affect the diversity and spatial structure of this ESU.

Central California Coast Steelhead

Abundance and Productivity

Data for both adult and juvenile abundance are limited for this DPS. Moreover, the record is inconsistent with either no fish being observed or no surveys being conducted in some years. Due to the inconsistency of the record, we have used a 5-year average as an estimate for abundance (2015-2019)(CDFW 2020, unpubl., SWFSC 2022). While we currently lack data on naturally produced juvenile CCC steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. For steelhead, fecundity estimates range from 3,500 to 12,000; and the male to female ratio averages 1:1 (Pauley *et al.* 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (half of the escapement of spawners – 953 females), roughly 3.3 million eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce over 216 thousand natural outmigrants annually. In addition, hatchery managers could produce 520,000 listed hatchery juvenile CCC steelhead each year given hatchery release targets. Abundance estimates for the DPS components are listed below (Table 27).

Table 27. Recent 5-Year Means for Estimated CCC Steelhead Adult Returns and Estimated Juvenile Outmigrations (SWFSC 2023).

Life Stage	Origin	Outmigration/Return
Adult	Natural and hatchery	1,906
Juvenile	Natural	216,808
Juvenile	LHAC	520,000

The scarcity of information on steelhead abundance in the CCC Steelhead DPS continues to make it difficult to assess trends in abundance and productivity (SWFSC 2023). Population-level estimates of adult abundance are entirely lacking for the 25 independent populations in the North Coastal, Interior, Coastal San Francisco Bay, and Interior San Francisco Bay diversity strata identified as essential or supporting in the DPS. A few survey efforts that are targeting coho salmon do collect data on steelhead as well, but generally, surveys do not encompass the entire spawning space of season for steelhead. The implementation of the Coastal Monitoring Plan (CMP) in the Russian River basin has improved our understanding of the overall abundance of steelhead in the watershed, providing basin-wide estimates of abundance of steelhead (combined natural and hatchery-origin) that have ranged from about 800–2,000 over three years, but as population estimates are not produced for individual populations within the basin, direct comparison with recovery targets is not yet possible. Spawner surveys and rotary screw trapping in recent years in selected portions of the Napa River watershed confirm the continued occurrence of steelhead in this watershed, however, there is insufficient data to determine if the population has increased or decreased since the previous status review. Likewise, limited spawner surveys in selected tributaries of the Petaluma River confirmed steelhead presence very small numbers in the watershed, but do not allow conclusions to be drawn about current viability.

Implementation of the CMP in the Santa Cruz Mountain stratum has been intermittent, and difficulties in assigning redds to species (steelhead versus coho) confound interpretation of these data. Scott Creek remains the only population for which robust estimates are available for more than a few years, and while the population appeared to be declining, a sizable return in 2018-2019 indicates that the population is somewhat resilient (SWFSC 2023). Populations in the San

Lorenzo River and Pescadero Creek appear to typically number in the low hundreds of fish, while other independent populations appear to number in the tens of fish. Two dependent populations (Gazos and San Vicente creeks) likewise appear to number in the tens of fish in most years, with considerable variation in numbers among years. Though uncertainty remains high for nearly all of these populations, it is clear that they are well below recovery targets.

Structure and Diversity

All steelhead in the CCC steelhead DPS are winter-run fish. Bjorkstedt *et al.* (2005) described the CCC steelhead DPS as historically comprising 37 independent populations and perhaps 30 or more smaller dependent populations of winter-run steelhead. These populations were placed in five geographically based diversity strata (Bjorkstedt *et al.* 2005; modified in Spence *et al.* 2008). Most of the coastal populations are assumed to be extant, however many of the Coastal San Francisco Bay and Interior San Francisco Bay populations are likely at high risk of extirpation due to the loss of historical spawning habitat and the heavily urbanized nature of these watersheds (Williams *et al.* 2011).

Hatchery programs can provide short-term demographic benefits, such as increases in abundance, during periods of low natural abundance. They also can help preserve genetic resources until limiting factors can be addressed. However, the long-term use of artificial propagation can pose a risk to natural productivity and diversity. The Russian River monitoring program has provided quantitative evidence that hatchery-origin steelhead constitute roughly 50% of all fish on natural spawning grounds and that these hatchery fish are being observed throughout the basin. Thus, concerns expressed in the recent status review update about potential genetic consequences of interbreeding between hatchery and wild fish appear well-founded (SWFSC 2023).

Importantly, this monitoring program has provided quantitative evidence that hatchery-origin steelhead constitute roughly 50% of all fish on natural spawning grounds and that these hatchery fish are being observed throughout the basin. Thus, concerns expressed in prior status reviews about potential genetic consequences of interbreeding between hatchery and wild fish (Williams *et al.* 2011) appear well founded. Population-level estimates of abundance are non-existent for any populations in the Interior and Coastal San Francisco Bay stratum, thus, the status remains highly uncertain, though it is likely that many populations where historical habitat is now inaccessible due to dams and other passage barriers are likely at high risk of extinction.

South-Central California Coast Steelhead

Abundance and Productivity

Data for both adult and juvenile abundance are limited for this DPS. In addition, the record is inconsistent with either no fish observed or no surveys conducted in some years. Due to the inconsistency of the record, we have used a 5-year average as an estimate for abundance (2015-

2019) (CDFW 2020, unpubl.). While we currently lack data on naturally produced juvenile SCCC steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. For steelhead, fecundity estimates range from 3,500 to 12,000; and the male to female ratio averages 1:1 (Pauley *et al.* 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (half of the escapement of natural-origin spawners – 98 females), roughly 340 thousand eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce roughly 22,295 natural outmigrants annually. There are no hatchery components of this DPS. Abundance estimates for the DPS components are listed below (Table 28).

Table 28. Recent 5-Year Geometric Means for Estimated SCCC Steelhead Juvenile Outmigrations and Adult Returns SWFSC 2023).

Life Stage	Origin	Outmigration/Return
Adult	Natural	196
Juvenile	Natural	22,295

Data on abundance of adult steelhead and fish density indicate that the recent drought had very large negative impacts on this DPS, with generally negative trends observed in all indicators, most with statistical significance (SWFSC 2023). However, since the end of the drought in 2017 all indicators of abundance have improved, suggesting that *O. mykiss* populations have persisted in drought refugia (e.g., lower Pajaro River tributaries, the upper Carmel River, the Big Sur Coast) and are now recovering from the drought. Yet the size of steelhead runs is still extremely low, and the mean fish densities for the past four years are still below the provisional viability criterion of 0.3 fish/m2 (SWFSC 2023). While monitoring of status and trends continues to be insufficient in this DPS, a draft plan to update the monitoring strategy is in progress.

Spatial Structure and Diversity

The SCCC steelhead DPS consists of 12 discrete sub-populations representing localized groups of interbreeding individuals. Most of these sub-populations are characterized by low population abundance, variable or negative population growth rates, and reduced spatial structure and diversity. In 2002, NMFS surveyed 36 watersheds and found that between 86 and 94 percent of the historic watersheds were still occupied. Also, occupancy was determined for 18 watershed basins with no historical record of steelhead (NMFS 2012b).

Although steelhead are present in most of the streams in the SCCC DPS (Good *et al.* 2005), their populations remain small, fragmented, and unstable (more subject to stochastic events) (Boughton *et al.* 2006). In addition, severe habitat degradation and the compromised genetic integrity of some populations pose a serious risk to the survival and recovery of the SCCC steelhead DPS (Good *et al.* 2005). The sub-populations in the Pajaro River and Salinas River watersheds are in particularly poor condition (relative to watershed size) and exhibit a greater lack of viability than many of the coastal populations.

Puget Sound/Georgia Basin Rockfish

The VSP criteria described by McElhaney *et al.* (2000) identified spatial structure, diversity, abundance, and productivity as criteria to assess the viability of salmonid species because these criteria encompass a species' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. These viability criteria reflect concepts that are well founded in conservation biology and are generally applicable to a wide variety of species because they describe demographic factors that individually and collectively provide strong indicators of extinction risk for a given species (Drake *et al.* 2010), and are therefore applied here for PS/GB bocaccio.

Life history traits of yelloweye rockfish and PS/GB bocaccio suggest generally low levels of inherent productivity because they are long-lived, mature slowly, and have sporadic episodes of successful reproduction (Musick 1999; Tolimieri and Levin 2005). Using several available, but spatiotemporally patchy, data series on rockfish occurrence and abundance in Puget Sound Tolimieri *et al.* (2017) determined that total rockfish declined at a rate of 3.1 to 3.8 percent per year from 1977 to 2014, or a 69 to 76 percent total decline over that period. The two listed DPSs declined over-proportional compared to the total rockfish assemblage. Therefore, long-term population growth rate for the listed species was likely even lower (more negative) than that for total rockfish. While there is little to no evidence of recent recovery of total groundfish abundance in response to protective measures enacted over the last 2five years (Essington *et al.* 2021), increases in the prevalence of several life stages of the more common rockfish species have been observed (Pacunski *et al.* 2020; LeClair *et al.* 2018). Given the slow maturation rate, episodic recruitment success, and rarity of yelloweye and bocaccio, combined with targeted fisheries being closed for over a decade, insufficient data exist to assess the recent recovery trajectory of these species.

Factors currently limiting recovery for PS/GB DPS yelloweye and bocaccio include (NMFS 2017a):

- Fishery mortality (commercial and recreational bycatch)
- Derelict fishing gear in nearshore and deep-water environments
- Degraded water quality (chemical contamination, hypoxia, nutrients)
- Climate change (ocean warming and acidification)
- Habitat degradation (rocky habitat loss of eelgrass and kelp, nearshore development disrupting juvenile rearing and food production)

Puget Sound/Georgia Basin DPS Bocaccio

The PS/GB bocaccio DPS was listed as endangered on April 28, 2010 (75 FR 22276). In April 2016, we completed a 5-year status review that recommended the DPS retain its endangered classification (Tonnes *et al.* 2016), and we released a recovery plan in October 2017 (NMFS 2017a).

Abundance and Productivity

In 2013, the Washington Department of Fish and Wildlife (WDFW) published abundance estimates from a remotely operated vehicle (ROV) survey conducted in 2008 in the San Juan Island area (Pacunski *et al.* 2013). This survey was conducted exclusively within rocky habitats and represents the best available abundance estimates to date for one basin of the DPS. The survey produced an estimate of 4,606 (100 percent variance) PS/GB bocaccio in the San Juan area (Tonnes *et al.* 2016). We currently lack the necessary information to make an informed estimate of the abundance of other age classes. Though the WDFW has produced other ROV-based estimates of rockfish biomass in Washington waters of the DPSs, none have both covered the entirety of the DPSs and had sufficient sample size to accurately estimate population size for rare species such as bocaccio.

Table 29. Estimated Adult Boccacio Abundance (Pacunski *et al.* 2013).

Life Stage	Origin	Abundance
Adult	Natural	4,606

The PS/GB bocaccio DPS exists at very low abundance and observations are relatively rare. No reliable range-wide historical or contemporary population estimates are available for the PS/GB bocaccio DPS. It is believed that prior to contemporary fishery removals, each of the major PS/GB basins likely hosted relatively large, though unevenly distributed, populations of PS/GB bocaccio. They were likely most common within the South Sound and Main Basin, but were never a predominant segment of the total rockfish abundance within the region (Drake *et al.* 2010). The best available information indicates that between 1965 and 2007, total rockfish populations have declined by about 70 percent in the Puget Sound region, and that PS/GB bocaccio have declined by an even greater extent (Drake *et al.* 2010; Tonnes *et al.* 2016; NMFS 2017a).

Structure and Diversity

The PS/GB bocaccio DPS includes all bocaccio from inland marine waters east of the central Strait of Juan de Fuca and south of the northern Strait of Georgia, collectively known as the Salish Sea. The waters of Puget Sound and Straits of Georgia can be divided into five interconnected basins that are largely hydrologically isolated from each other by relatively shallow sills. The basins within US waters are: (1) San Juan, (2) Main, (3) South Sound, and (4)

Hood Canal. The fifth basin consists of Canadian waters east and north of the San Juan Basin into the Straits of Georgia. Although most individuals of the PS/GB bocaccio DPS are believed to remain within the basin of their origin, including larvae and pelagic juveniles, some movement between basins occurs, and the DPS is currently considered a single population (Tonnes *et al.* 2016). Research intended to assess this assumption using genetic techniques was unable to collect sufficient samples for analysis (Andrews *et al.* 2018), but is ongoing.

Puget Sound/Georgia Basin DPS Yelloweye Rockfish

The PS/GB yelloweye DPS was listed as threatened on April 28, 2010 (75 FR 22276). In April 2016, we completed a 5-year status review that recommended the DPS retain its threatened classification (Tonnes *et al.* 2016), and we released a recovery plan in October 2017 (NMFS 2017a).

Abundance and Productivity

In 2013, WDFW published abundance estimates from a remotely operated vehicle (ROV) survey conducted in 2008 in the San Juan Island area (Pacunski *et al.* 2013). This survey was conducted exclusively within rocky habitats and represents the best available abundance estimates to date for one basin of the DPS. The survey produced an estimate of 47,407 (25 percent variance) adult yelloweye rockfish (Tonnes *et al.* 2016). We currently lack the necessary information to make an informed estimate of the abundance of other age classes. Though the WDFW has produced other ROV-based estimates of rockfish biomass in Washington waters of the DPSs, none have both covered the entirety of the DPSs and had sufficient sample size to accurately estimate population size for rare species such as yelloweye.

Table 30. Estimated Adult Yelloweye Rockfish Abundance (Pacunski *et al.* 2020).

Life Stage	Origin	Abundance
Adult	Natural	114,494

Yelloweye rockfish within U.S. waters of the PS/GB are very likely the most abundant within the San Juan and Hood Canal Basins. In Puget Sound, catches of PS/GB yelloweye rockfish have declined as a proportion of the overall rockfish catch in the decades preceding listing (Drake *et al.* 2010). Adult PS/GB yelloweye rockfish also typically occupy relatively small ranges (Love *et al.* 2002), and the extent to which they may move to find suitable mates is unknown. Yelloweye rockfish productivity is therefore potentially vulnerable to an Allee effect, where at small population sizes the decreased probability of adults encountering potential mates leads to continual decline of productivity and population density, and ultimately extinction. However, there is insufficient information to determine that this is currently occurring for yelloweye rockfish, and this question warrants further research (Hutchings and Reynolds 2004).

Structure and Diversity

The PS/GB bocaccio DPS includes all yelloweye rockfish found in waters of Puget Sound, the Strait of Juan de Fuca east of Victoria Sill, the Strait of Georgia, and Johnstone Strait. Recent collection and analysis of PS/GB yelloweye rockfish tissue samples revealed significant genetic differentiation between the inland (DPS) and coastal yelloweye samples (Andrews *et al.* 2018). These new data are consistent with and further support the existence of a population of PS/GB yelloweye rockfish that is discrete from coastal populations, an assumption that was made at the time of listing based on proxy species including quillback and copper rockfish (Ford 2015; Tonnes *et al.* 2016).

In addition, yelloweye rockfish from Hood Canal were genetically differentiated from other PS/GB yelloweye, indicating a previously unknown degree of population differentiation within the DPS (Ford 2015; Tonnes *et al.* 2016; Andrews *et al.* 2018). Other genetic analysis has found that yelloweye rockfish in the Georgia Basin had the lowest molecular genetic diversity of a collection of samples along the coast (Siegle *et al.* 2013). Although the adaptive significance of such microsatellite diversity is unclear, it may suggest low effective population size, increased drift, and thus lower genetic diversity in the PS/GB yelloweye DPS. Yelloweye rockfish spatial structure and connectivity is threatened by the apparent reduction of fish within each of the basins of the DPS, as they were once prized fishery targets. This reduction is probably most acute within the basins of Puget Sound proper. The severe reduction of fish in these basins may eventually result in a contraction of the DPS' range.

Southern DPS Eulachon

Abundance and Productivity

There are no reliable fishery-independent, historical abundance estimates for Southern eulachon. Beginning in 2011, Oregon Department of Fish and Wildlife (ODFW) and Washington Department of Fish and Wildlife (WDFW) began instituting annual eulachon monitoring surveys in the Columbia River where spawning stock biomass (SSB) is used to estimate spawner abundance (NMFS 2017b). In addition, WDFW has retrospectively estimated historical SSB in the Columbia River for 2000–2010 using pre-2011 expansions of eulachon larval densities (Gustafson *et al.* 2016). Spawning stock biomass estimates have also been collected for the Fraser River since 1995 (DFO 2022). There are currently no additional data available for abundance trends in other watersheds, and at this time, there are not sufficient data to develop viability criteria or assess the productivity of this DPS (NMFS 2017b).

In recent years, abundance estimates of Southern eulachon in the Columbia River have fluctuated from a low of just over 4 million in 2018 to over 96 million in 2021. The geometric mean spawner abundance over the past five years is just over 23.5 million, though this is almost certainly an underestimate as surveys were cut short in 2020. These estimated abundance levels are an improvement over estimated abundance at the time of listing (Gustafson *et al.* 2010), but a decline from the average abundances at the time of the last status review (Gustafson *et al.* 2016). Since 2018 annual abundance has been increasing, although the mean abundance estimated in 2021 was only about half of the peak annual estimate from the past 20 years (i.e., 185,965,200 in 2014). The situation in the Klamath River is also more positive than it was at the time of the 2010 status review with adult eulachon presence being documented in the Klamath River in the spawning seasons of 2011–2014, although it has not been possible to calculate estimates of SSB in the Klamath River (Gustafson *et al.* 2016). The Fraser River population has been at low levels most years since 2004 although recent years have shown higher spawning numbers, which may signal a positive trend (DFO 2022). SSB estimations of eulachon in the Fraser River from the years 2018 through 2022 have ranged from a low of an estimated 248,496 fish in 2022 to a high of 15,352,621 fish in 2020 (DFO 2023, estimate based on report weight assuming 11.16 fish per pound and 2,204.62 pounds per metric tonne). Abundance estimates for the DPS components are listed below.

Table 31. SDPS eulachon spawning stock biomass survey estimates (NMFS 2022j, DFO 2023).

Year	Columbia River Spawning Stock Estimate (mean)	Fraser River Spawning Stock Estimate (mean)
2017	18,307,100	
2018	4,100,000	10,038,252
2019	46,684,765	2,657,184
2020[a]	21,280,000	15,352,621
2021	96,395,712	3,469,102
2022		248,496
5-Year geomean[b]	**23,513,733**	**3,232,658**

[a] Abbreviated estimate; sampling stopped mid-March of 2020
[b] 5-year geometric mean of most recent years of mean eulachon biomass estimates

Structure and Diversity

The southern DPS of eulachon is comprised of fish that spawn in rivers south of the Nass River in British Columbia to, and including, the Mad River in California. There are many subpopulations of eulachon within the range of the species. At the time the species was evaluated for listing, the Biological Review Team (BRT) partitioned the southern DPS of eulachon into geographic areas for their threat assessment, which did not include all known or possible eulachon spawning areas (Gustafson *et al.* 2010). We now know eulachon from these excluded areas (e.g., Elwha River, Naselle River, Umpqua River, and Smith River) may have (or had) some important contribution to the overall productivity, spatial distribution, and genetic and life history diversity of the species (NMFS 2017b). We currently do not have the data necessary to determine whether eulachon are one large metapopulation, or comprised of multiple demographically independent populations. Therefore, we consider the four subpopulations identified by the BRT (i.e., Klamath River, Columbia River, Fraser River, and British Columbia coastal rivers) as the minimum set of populations comprising the DPS. Large, consistent spawning runs of eulachon have not been documented in Puget Sound river systems, and therefore eulachon spawning in these watersheds are not considered part of an independent subpopulation. However, eulachon have been observed regularly in many Washington rivers and streams, as well as Puget Sound (Monaco *et al.* 1990, Willson *et al.* 2006; as cited in Gustafson *et al.* 2010).

Genetic analyses of population structure indicate there is divergence among basins; however, it is less than typically observed in most salmon species. The genetic differentiation among some river basins is also similar to the levels of year-to-year genetic variation within a single river, suggesting that patterns among rivers may not be temporally stable (Beacham *et al.* 2005). Eulachon in both Alaska and the Columbia basin show little genetic divergence within those regions, which is also the case among some British Columbia tributaries. However, there is greater divergence between regions, with a clear genetic break that appears to occur in southern British Columbia north of the Fraser River (Gustafson *et al.* 2016, NMFS 2017b). A 2015 genetic study of single nucleotide polymorphism (SNP) markers in eulachon from several geographic regions concluded there might be three main groups of subpopulations; a Gulf of Alaska group, a British Columbia to SE Alaska group, and a southern Columbia to Fraser group (Candy *et al.* 2015; as cited in NMFS 2017b).

Threats and Limiting Factors

The greatest threat identified to the persistence of SDPS eulachon was climate change impacts on ocean conditions (Gustafson *et al.* 2016, NMFS 2017b). Poor conditions in the Northeast Pacific Ocean in 2013-2015 are likely linked to the sharp declines in eulachon abundance in monitored rivers in 2016 and 2017 (NMFS 2017b). The likelihood that these poor ocean conditions will persist into the near future suggest that subpopulation declines may again be widespread in the upcoming return years (NMFS 2017b), although returns in 2021 do not appear to have been as dramatically impacted by the 2019 Northeast Pacific marine heatwave as prior years were by the 2013-2015 event. Climate change impacts on freshwater habitat were also identified as a moderate threat to all subpopulations due to increasing water temperatures and changes in flow quantity and timing (Gustafson *et al.* 2016, NMFS 2017b).

Eulachon bycatch in offshore shrimp fisheries was also ranked in the top four threats in all subpopulations of the DPS. Dams and water diversions in the Klamath and Columbia rivers and predation in the Fraser and British Columbia coastal rivers filled out the last of the top four threats for this DPS (Gustafson *et al.* 2010; as cited in NMFS 2017b). Predation by pinnipeds and degraded water quality (due to increased temperatures and toxic contaminants) were identified as moderate threats to all or most subpopulations. All other threats were ranked as either low or very low severity to some or all subpopulations in the DPS (NMFS 2017b). The risk these threats pose to the persistence of eulachon remained largely unchanged compared to the time of listing, as of the most recent status review (Gustafson *et al.* 2016). No limiting factors were identified for SDPS eulachon (NMFS 2017b).

Southern DPS Green Sturgeon

Green sturgeon comprise two DPSs with two geographically distinct spawning locations. The northern DPS spawn in rivers north of and including the Eel River in Northern California, with known spawning occurring in the Eel, Klamath, and Trinity rivers in California and the Rogue and Umpqua rivers in Oregon. The southern DPS adults spawn in rivers south of the Eel River, which is currently restricted to the Sacramento River.

Abundance and Productivity

Since 2010, Dual Frequency Identification Sonar (DIDSON) surveys of aggregating sites in the upper Sacramento River for S green sturgeon have been conducted. Previous reports based on data from 2010 to 2015 estimated the total population size to be 17,548 individuals, and abundance estimates were derived for each age class by applying a conceptual demographic structure from prior modeling (Mora *et al.* 2018). The Southwest Fisheries Science Center (SWFSC) continued Mora *et al.* (2018)'s work and conducted DIDSON surveys at aggregation sites in the upper Sacramento River from 2016-2020. The total population estimate has recently been updated to 17,723 individuals based on data from 2016 to 2018 (Dudley 2021, as cited in Ford 2022). Applying the same demographic proportions as prior previous estimates (Beamesderfer *et al.* 2007 as cited in Mora *et al.* 2018) to this total, we calculated abundance estimates of adults, juveniles, and sub-adults that would be expected as portions of this updated total (Table 32).

Table 32. SDPS green sturgeon estimated total population size based on data from 2016 to 2018 (Dudley 2021), and life stage-specific abundance estimates derived from the total (Beamesderfer *et al.* 2007 as cited in Mora *et al.* 2018).

Life stage	Abundance Estimate	Range	
		25th Percentile	75th Percentile
Total DPS	17,723[a]	6,761	37,891
Juvenile	4,431		
Sub-adult	11,165		
Adult	2,127		

[a]Median value for 2018 was selected as the revised population estimate in Dudley 2021.

The DIDSON surveys and associated modeling will eventually provide population trend data, but we currently do not have enough data to provide information on long-term trends, and demographic features or trends needed to evaluate the recovery of SDPS green sturgeon. Annual spawner count estimates in the upper Sacramento River from 2010 to 2019 found that the DPS only met the spawner demographic recovery criterion (i.e., spawning population size of at least 500 individuals in any given year) in one of those years (Dudley 2020, as cited in Ford 2022). There are currently no studies that address juvenile and subadult abundance of S green sturgeon to evaluate whether the recovery criterion for increasing trends of these life stages is being met (NMFS 2021a).

Structure and Diversity

Telemetry data and genetic analyses suggest that SDPS green sturgeon generally occur from Graves Harbor, Alaska to Monterey Bay, California and, within this range, most frequently occur in coastal waters of Washington, Oregon, and Vancouver Island and near San Francisco and Monterey bays (NMFS 2021a). Adult and subadult SDPS green sturgeon have been observed in large concentrations in the summer and fall within coastal bays and estuaries along the west coast of the United States, and telemetry studies performed by the WDFW and NMFS-Northwest Fisheries Science Center (NWFSC) have shown a great amount of seasonal movement between the coastal bays and estuaries and the nearshore marine environment (NMFS 2021a). Green sturgeon also move extensively within an individual estuary and between different estuaries during the same season (WDFW and ODFW 2014, as cited in NMFS 2021a). In California, Miller *et al.* (2020) recorded adult and subadult SDPS green sturgeon presence year-round in the Sacramento-San Joaquin Delta, Suisun Bay, San Pablo Bay, and Central San Francisco Bay, although spawning Southern DPS adults often use the area as a migration corridor, passing through within a few days of entering. These adults migrate into the Sacramento River to spawn, although small numbers of adults have also been observed in the Yuba and Feather Rivers and San Joaquin River Basin (NMFS 2021a).

Sustained spawning of S green sturgeon adults is currently restricted to the Sacramento River, and the spawning population congregates in a limited area of the river compared to potentially available habitat. The reason for this is unknown, and it is concerning given that a catastrophic or targeted poaching event impacting just a few holding areas could affect a significant portion of the adult population (NMFS 2021a). Removal of the Red Bluff Diversion Dam (RBDD) barrier did allow SDPS green sturgeon to freely access a larger area of the river, so the Southern DPS likely now holds in a larger area of the river compared to when RBDD was operating in 2011 (NMFS 2021a). New research documents spawning by S green sturgeon in the Feather and Yuba rivers multiple years, although it is periodic, and not continuous as required to meet the recovery criterion for continuous spawning for populations in these rivers (NMFS 2021a). Given the limited number of occurrences and lack of consistent successful spawning events in additional spawning locations, the limited spatial distribution of spawning continues to make this DPS vulnerable.

Marine Invertebrates

Sunflower Sea Star (proposed)

The sunflower sea star (*Pycnopodia helianthoides*) occupies nearshore intertidal and subtidal marine waters shallower than 450 m (~1400 ft) deep from Adak Island, AK, to Bahia Asunción, Baja California Sur, MX. They are occasionally found in the deep parts of tide pools. The species is a habitat generalist, occurring over sand, mud, and rock bottoms both with and without appreciable vegetation. Critical habitat is currently indeterminable because information does not exist to clearly define primary biological features. Prey include a variety of epibenthic and infaunal invertebrates, and the species also digs in soft substrate to excavate clams. It is a well-known urchin predator and plays a key ecological role in control of these kelp consumers. More information about sea star biology, ecology, and their life history cycle is found in the proposed listing (88 FR 16212).

From 2013 to 2017, the sunflower sea star experienced a range-wide epidemic of sea star wasting syndrome (SSWS) (Gravem *et al.* 2021; Hamilton *et al.* 2021; Lowry *et al.* 2022). While the cause of this disease remains unknown, prevalence of the outbreak has been linked to a variety of environmental factors, including temperature change, sustained elevated temperature, low dissolved oxygen, and decreased pH (Hewson *et al.* 2018; Aquino *et al.* 2021; Heady *et al.* 2022; Oulhen *et al.* 2022). As noted above, changes in physiochemical attributes of nearshore waters are expected to change in coming decades as a consequence of anthropogenic climate change, but the specific consequences of such changes on SSWS prevalence and severity are currently impossible to accurately predict.

2.2.3 Status of the Species' Critical Habitat

This section describes the status of designated critical habitat affected by the proposed action by examining the condition and trends of the essential physical and biological features of that habitat throughout the designated areas. These features are essential to the conservation of the ESA-listed species because they support one or more of the species' life stages (*e.g.*, sites with conditions that support spawning, rearing, migration and foraging).

For most salmon and steelhead, NMFS's critical habitat analytical review teams (CHARTs) ranked watersheds within designated critical habitat at the scale of the fifth-field hydrologic unit code (HUC5) in terms of the conservation value they provide to each ESA-listed species that they support (NMFS 2005). The conservation rankings were high, medium, or low. To determine the conservation value of each watershed to species viability, the CHARTs evaluated the quantity and quality of habitat features, the relationship of the area compared to other areas within the species' range, and the significance to the species of the population occupying that area. Even if a location had poor habitat quality, it could be ranked with a high conservation value if it were essential due to factors such as limited availability, a unique contribution of the population it served, or is serving another important role.

A summary of the status of critical habitats, considered in this Opinion, is provided in Table 33, below. Note that critical habitat has not been designated for several species considered in this Opinion (i.e., blue whale, fin whale, sei whale, sperm whale, western North Pacific Gray whale, Guadalupe fur seal, North Pacific DPS Loggerhead sea turtle, Olive ridley sea turtle, East Pacific DPS Green sea turtle, or sunflower sea star), which is why they are not listed in the table below. For species with designated critical habitat, we determined their critical habitats are not likely to be adversely affected by the proposed action, and therefore the status of these habitats is not described beyond the table below. For further details on the rationale for those determinations see Section 2.12 ("Not Likely to Adversely Affect" Determinations).

Table 33. Critical habitat, designation date, federal register citation, and status summary for critical habitat considered in this Opinion.

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
Marine Mammals		
Southern resident killer whale	11/29/2006 71 FR 69054 08/02/2021 86 FR 41668	Critical habitat consists of three specific marine areas of inland waters of Washington: 1) the Summer Core Area in Haro Strait and waters around the San Juan Islands; 2) Puget Sound; and 3) the Strait of Juan de Fuca. These areas comprise approximately 2,560 square miles of marine habitat. Based on the natural history of the Southern Residents and their habitat needs, NMFS identified three PBFs, or physical or biological features, essential for the conservation of Southern Residents: 1) Water quality to support growth and development; 2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction and development, as well as overall population growth; and 3) passage conditions to allow for migration, resting, and foraging Water quality in Puget Sound, in general, is degraded. On September 19, 2019 NMFS proposed to revise the critical habitat designation for the SRKW DPS under the ESA by designating six new areas along the U.S. West Coast (84 FR 49214). Specific new areas proposed along the U.S. West Coast include 15,626.6 square miles (mi\2\) (40,472.7 square kilometers (km\2\)) of marine waters between the 6.1-meter (m) (20 feet (ft)) depth contour and the 200-m (656.2 ft) depth contour from the U.S. international border with Canada south to Point Sur, California. The proposed rule to revise critical habitat designation was based on new information about the SRKW's habitat use along the coast. In 2021, NMFS published a final rule (86 FR 41668, August 2, 2021) to revise SRKW critical habitat to designate six additional coastal critical habitat areas (approximately 15,910 sq. miles), in addition to the 2,560 square miles previously designated in 2006 in inland waters of Washington (71 FR 69054; November 29, 2006). Each coastal area contains all three physical or biological essential features identified in the 2006 designation: (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality and availability to support individual growth, reproduction and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging.
Humpback whale, Mexico DPS	04/21/2021 86 FR 21082	Designated critical habitat along the west coast of the U.S. includes 116,098 nmi2 for the Mexico DPS. The Mexico DPS critical habitat is designated in the eastern Bering Sea, Gulf of Alaska, and the California Current Ecosystem. The designation includes a prey biological feature including primarily euphausiids (*Thysanoessa*, *Euphausia*, *Nyctiphanes*, and *Nematoscelis*) and small pelagic schooling fishes, such as Pacific sardine (*Sardinops sagax*), northern anchovy (*Engraulis mordax*), and Pacific herring (*Clupea pallasii*) of sufficient quality, abundance, and accessibility within humpback whale feeding areas to support feeding and population growth. The prey biological feature for the Mexico DPS also includes capelin (*Mallotus villosus*), juvenile walleye pollock (*Gadus chalcogrammus*), and Pacific sand lance (*Ammodytes personatus*).
Humpback whale, Central America DPS	04/21/2021 86 FR 21082	Designated critical habitat along the west coast of the U.S. includes 48,521 nmi2 for the Central American DPS and is located entirely along the U.S. West Coast. The designation includes a prey biological feature including primarily euphausiids (*Thysanoessa*, *Euphausia*, *Nyctiphanes*, and *Nematoscelis*) and small pelagic schooling fishes, such as Pacific sardine (*Sardinops sagax*), northern anchovy (*Engraulis mordax*), and Pacific herring (*Clupea pallasii*) of sufficient quality, abundance, and accessibility within humpback whale feeding areas to support feeding and population growth.

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
Steller Sea Lion, Eastern DPS	09/27/1993 58 FR 45269	Despite the delisting of the eastern DPS of Steller sea lions, critical habitat is still designated for this previously listed species. Critical habitat includes all Steller sea lion rookeries and major haulouts (i.e., haulouts supporting > 200 Steller sea lions) located within state and federally managed waters off Alaska, a terrestrial zone that extends 3,000 feet (0.9 km) landward from the baseline or base point of each major rookery and major haulout in Alaska, an air zone that extends 3,000 feet (0.9 km) above the terrestrial zone of each major rookery and major haulout in Alaska, measured vertically from sea level, an aquatic zone that extends 3,000 feet (0.9 km) seaward in state and federally managed waters from the baseline or basepoint of each major rookery and major haulout in Alaska east of 144° W. longitude, an aquatic zone that extends 20 nm (37 km) seaward in State and federally managed waters from the baseline or basepoint of each major rookery and major haulout in Alaska that is west of 144° W. longitude, and three special aquatic foraging areas in Alaska, including the Shelikof Strait area, the Bogoslof area, and the Seguam Pass area.
Sea Turtles		
Leatherback sea turtle	01/26/2012 77 FR 4170	Within the Pacific Ocean this designation includes approximately 16,910 square miles (43,798 square km) stretching along the California coast from Point Arena to Point Arguello east of the 3,000 meter depth contour; and 25,004 square miles (64,760 square km) stretching from Cape Flattery, Washington to Cape Blanco, Oregon east of the 2,000 meter depth contour. The designated areas comprise approximately 41,914 square miles (108,558 square km) of marine habitat and include waters from the ocean surface down to a maximum depth of 262 feet (80 m). The one PCE essential for the conservation of leatherbacks in marine waters off the U.S. West Coast is the occurrence of prey species, primarily scyphomedusae of the order Semaeostomeae (e.g., *Chrysaora*, *Aurelia*, *Phacellophora*, and *Cyanea*), of sufficient condition, distribution, diversity, abundance and density necessary to support individual as well as population growth, reproduction, and development of leatherbacks.
Marine and Anadromous Fish		
Puget Sound Chinook salmon	09/02/2005 70 FR 52630	Critical habitat for Puget Sound Chinook salmon includes 1,683 miles of streams, 41 square mile of lakes, and 2,182 miles of nearshore marine habitat in Puget Sounds. The Puget Sound Chinook salmon ESU has 61 freshwater and 19 marine areas within its range. Of the freshwater watersheds, 41 are rated high conservation value, 12 low conservation value, and eight received a medium rating. Of the marine areas, all 19 are ranked with high conservation value. Primary constitute elements relevant for this consultation include: 1) Estuarine areas free of obstruction with water quality and aquatic vegetation to support juvenile transition and rearing; 2) Nearshore marine areas free of obstruction with water quality conditions, forage, submerged and overhanging large wood, and aquatic vegetation to support growth and maturation; 3) Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.
Puget Sound steelhead	02/24/2016 81 FR 9252	Critical habitat for Puget Sound steelhead includes 2,031 stream miles. Nearshore and offshore marine waters were not designated for this species. There are 66 watersheds within the range of this DPS. Nine watersheds received a low conservation value rating, 16 received a medium rating, and 41 received a high rating to the DPS.
Puget Sound/Georgia	11/13/2014 79 FR 68042	Critical habitat for bocaccio includes 590.4 square miles of nearshore habitat and 414.1 square miles of deepwater habitat. Critical habitat is not designated in areas outside of United States jurisdiction; therefore, although waters in Canada are part of the DPSs' ranges for all three species, critical habitat was not designated in that area. Based on the natural history of bocaccio

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
Basin DPS of bocaccio		and their habitat needs, NMFS identified two physical or biological features, essential for their conservation: 1) Deepwater sites (>30 meters) that support growth, survival, reproduction, and feeding opportunities; 2) Nearshore juvenile rearing sites with sand, rock and/or cobbles to support forage and refuge. Habitat threats include degradation of rocky habitat, loss of eelgrass and kelp, introduction of non-native species that modify habitat, and degradation of water quality as specific threats to rockfish habitat in the Georgia Basin.
Puget Sound/Georgia Basin DPS of yelloweye rockfish	11/13/2014 79 FR 68042	Critical habitat for yelloweye rockfish includes 414.1 square miles of deepwater marine habitat in Puget Sound, all of which overlaps with areas designated for canary rockfish and bocaccio. No nearshore component was included in the CH listing for juvenile yelloweye rockfish as they, different from bocaccio and canary rockfish, typically are not found in intertidal waters (Love *et al.* 1991). Yelloweye rockfish are most frequently observed in waters deeper than 30 meters (98 ft) near the upper depth range of adults (Yamanaka *et al.* 2006). Habitat threats include degradation of rocky habitat, loss of eelgrass and kelp, introduction of non-native species that modify habitat, and degradation of water quality as specific threats to rockfish habitat in the Georgia Basin.
Hood Canal summer-run chum salmon	09/02/2005 70 FR 52630	Critical habitat for Hood Canal summer-run chum salmon includes 79 miles and 377 miles of nearshore marine habitat in HC. Primary constituent elements relevant for this consultation include: 1) Estuarine areas free of obstruction with water quality and aquatic vegetation to support juvenile transition and rearing; 2) Nearshore marine areas free of obstruction with water quality conditions, forage, submerged and overhanging large wood, and aquatic vegetation to support growth and maturation; 3) Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.
Ozette Lake sockeye salmon	09/02/2005 70 FR 52630	Critical habitat is comprised of a single subbasin containing a single watershed, Ozette Lake Subbasin located in Clallam County, Washington. It encompasses approximately 101 mi^2 and approximately 317 miles of streams; Ozette Lake, the dominant feature of the watershed, is entirely located within the Olympic National Park. The known beach spawning areas, and three tributaries used by sockeye salmon for spawning, incubation, and migration, are encompassed as part of critical habitat for the listed species. Beach spawning is degraded by historical sediment loading, disrupted hydrology, and encroachment of riparian vegetation. Streams supporting spawning, rearing, and migration are impaired by lack of large wood, excessive fine sediment levels (Big River), and mammalian predation.
Upper Columbia River spring-run Chinook salmon	09/02/2005 70 FR 52630	Critical habitat encompasses four subbasins in Washington containing 15 occupied watersheds, as well as the Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition. However, most of these watersheds have some, or high, potential for improvement. We rated conservation value of HUC5 watersheds as high for 10 watersheds, and medium for five watersheds. Migratory habitat quality in this area has been severely affected by the development and operation of the dams and reservoirs of the Federal Columbia River Power System.
Upper Columbia River steelhead	09/02/2005 70 FR 52630	Critical habitat encompasses 10 subbasins in Washington containing 31 occupied watersheds, as well as the Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. We rated conservation value of HUC5 watersheds as high for 20 watersheds, medium for eight watersheds, and low for three watersheds.

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
Middle Columbia River steelhead	09/02/2005 70 FR 52630	Critical habitat encompasses 15 subbasins in Oregon and Washington containing 111 occupied watersheds, as well as the Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. We rated conservation value of occupied HUC5 watersheds as high for 80 watersheds, medium for 24 watersheds, and low for 9 watersheds.
Snake River spring/summer-run Chinook salmon	10/25/1999 64 FR 57399	Critical habitat consists of river reaches of the Columbia, Snake, and Salmon rivers, and all tributaries of the Snake and Salmon rivers (except the Clearwater River) presently or historically accessible to this ESU (except reaches above impassable natural falls and Hells Canyon Dam). Habitat quality in tributary streams varies from excellent in wilderness and roadless areas, to poor in areas subject to heavy agricultural and urban development (Wissmar *et al.* 1994). Reduced summer stream flows, impaired water quality, and reduced habitat complexity are common problems. Migratory habitat quality in this area has been severely affected by the development and operation of the dams and reservoirs of the Federal Columbia River Power System.
Snake River fall-run Chinook salmon	10/25/1999 64 FR 57399	Critical habitat consists of river reaches of the Columbia, Snake, and Salmon rivers, and all tributaries of the Snake and Salmon rivers presently or historically accessible to this ESU (except reaches above impassable natural falls, and Dworshak and Hells Canyon dams). Habitat quality in tributary streams varies from excellent in wilderness and roadless areas, to poor in areas subject to heavy agricultural and urban development (Wissmar *et al.* 1994). Reduced summer stream flows, impaired water quality, and reduced habitat complexity are common problems. Migratory habitat quality in this area has been severely affected by the development and operation of the dams and reservoirs of the Federal Columbia River Power System.
Snake River basin steelhead	09/02/2005 70 FR 52630	Critical habitat encompasses 25 subbasins in Oregon, Washington, and Idaho. Habitat quality in tributary streams varies from excellent in wilderness and roadless areas, to poor in areas subject to heavy agricultural and urban development (Wissmar *et al.* 1994). Reduced summer stream flows, impaired water quality, and reduced habitat complexity are common problems. Migratory habitat quality in this area has been severely affected by the development and operation of the dams and reservoirs of the Federal Columbia River Power System.
Snake River sockeye salmon	10/25/1999 64 FR 57399	Critical habitat consists of river reaches of the Columbia, Snake, and Salmon rivers; Alturas Lake Creek; Valley Creek; and Stanley, Redfish, Yellow Belly, Pettit and Alturas lakes (including their inlet and outlet creeks). Water quality in all five lakes generally is adequate for juvenile sockeye salmon, although zooplankton numbers vary considerably. Some reaches of the Salmon River and tributaries exhibit temporary elevated water temperatures and sediment loads that could restrict sockeye salmon production and survival (NMFS 2015). Migratory habitat quality in this area has been severely affected by the development and operation of the dams and reservoirs of the Federal Columbia River Power System.
Lower Columbia River Chinook salmon	09/02/2005 70 FR 52630	Critical habitat encompasses 10 subbasins in Oregon and Washington containing 47 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some, or high potential for improvement. We rated conservation value of HUC5 watersheds as high for 30 watersheds, medium for 13 watersheds, and low for four watersheds.
Lower Columbia River coho salmon	02/24/2016 81 FR 9252	Critical habitat encompasses 10 subbasins in Oregon and Washington containing 55 occupied watersheds, as well as the lower Columbia River and estuary rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
		good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. We rated conservation value of HUC5 watersheds as high for 34 watersheds, medium for 18 watersheds, and low for three watersheds.
Lower Columbia River steelhead	09/02/2005 70 FR 52630	Critical habitat encompasses nine subbasins in Oregon and Washington containing 41 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. We rated conservation value of HUC5 watersheds as high for 28 watersheds, medium for 11 watersheds, and low for two watersheds.
Columbia River chum salmon	09/02/2005 70 FR 52630	Critical habitat encompasses six subbasins in Oregon and Washington containing 19 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. We rated conservation value of HUC5 watersheds as high for 16 watersheds, and medium for three watersheds.
Upper Willamette River Chinook salmon	09/02/2005 70 FR 52630	Critical habitat encompasses 10 subbasins in Oregon containing 56 occupied watersheds, as well as the lower Willamette/Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition. However, most of these watersheds have some, or high, potential for improvement. Watersheds are in good to excellent condition with no potential for improvement only in the upper McKenzie River and its tributaries (NMFS 2005). We rated conservation value of HUC5 watersheds as high for 22 watersheds, medium for 16 watersheds, and low for 18 watersheds.
Upper Willamette River steelhead	09/02/2005 70 FR 52630	Critical habitat encompasses seven subbasins in Oregon containing 34 occupied watersheds, as well as the lower Willamette/Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. Watersheds are in good to excellent condition with no potential for improvement only in the upper McKenzie River and its tributaries (NMFS 2005). We rated conservation value of HUC5 watersheds as high for 25 watersheds, medium for 6 watersheds, and low for 3 watersheds.
Oregon Coast coho salmon	02/11/2008 73 FR 7816	Critical habitat encompasses 13 subbasins in Oregon. The long-term decline in Oregon Coast coho salmon productivity reflects deteriorating conditions in freshwater habitat as well as extensive loss of access to habitats in estuaries and tidal freshwater. Many of the habitat changes resulting from land use practices over the last 150 years that contributed to the ESA-listing of Oregon Coast coho salmon continue to hinder recovery of the populations; changes in the watersheds due to land use practices have weakened natural watershed processes and functions, including loss of connectivity to historical floodplains, wetlands and side channels; reduced riparian area functions (stream temperature regulation, wood recruitment, sediment and nutrient retention); and altered flow and sediment regimes (NMFS 2016b). Several historical and ongoing land uses have reduced stream capacity and complexity in Oregon coastal streams and lakes through disturbance, road building, splash damming, stream cleaning, and other activities. Beaver removal, combined with loss of large wood in streams, has also led to degraded stream habitat conditions for coho salmon (Stout *et al.* 2012)
Southern Oregon/Northern	05/05/1999 64 FR 24049	Critical habitat includes all areas accessible to any life-stage up to long-standing, natural barriers and adjacent riparian zones. SONCC coho salmon critical habitat within this geographic area has been degraded from historical conditions by ongoing land management activities. Habitat impairments recognized as factors leading to decline of the species that were included in the

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
California Coast coho salmon		original listing notice for SONCC coho salmon include: 1) Channel morphology changes; 2) substrate changes; 3) loss of in-stream roughness; 4) loss of estuarine habitat; 5) loss of wetlands; 6) loss/degradation of riparian areas; 7) declines in water quality; 8) altered stream flows; 9) fish passage impediments; and 10) elimination of habitat
Northern California steelhead	9/2/2005 70 FR 52488	There are approximately 3,028 miles of stream habitats and 25 square miles of estuary habitats designated as critical habitat for NC steelhead. NMFS determined that marine areas did not warrant consideration as critical habitat for this DPS. NC steelhead PBFs are sites and habitat components which support one or more life stages. There are 50 watersheds within the range of this DPS. Nine watersheds received a low rating, 14 received a medium rating, and 27 received a high rating of conservation value to the DPS. Two estuarine habitats, Humboldt Bay and the Eel River estuary, have high conservation value ratings. Since designation, critical habitat for this species has continued to be degraded somewhat by the factors listed above in the status section. Nonetheless, a number of restoration efforts have been undertaken by local, state, and federal entities resulting in slightly improved conditions in some areas and a slowing of the negative trend.
California Coastal Chinook salmon	09/02/2005 70 FR 52488	Critical habitat includes approximately 1,475 miles of stream habitats and 25 square miles of estuary habitats. There are 45 watersheds within the range of this ESU. Eight watersheds received a low rating, 10 received a medium rating, and 27 received a high rating of conservation value to the ESU. Two estuarine habitat areas used for rearing and migration (Humboldt Bay and the Eel River Estuary) also received a high conservation value rating. PBFs include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and nearshore marine areas. Since designation, critical habitat for this species has continued to be. Nonetheless, a number of restoration efforts have been undertaken by local, state, and federal entities resulting in slightly improved conditions in some areas and a slowing of the negative trend.
Sacramento River winter-run Chinook salmon	06/16/1993 58 FR 33212 Modified 03/23/1999 64 FR 14067	Critical habitat includes the following waterways, bottom and water of the waterways and adjacent riparian zones: The Sacramento River from Keswick Dam, Shasta County (RK 486) to Chipps Island (RK 0) at the westward margin of the Sacramento-San Joaquin Delta, all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait, all waters of San Pablo Bay westward of the Carquinez Bridge, and all waters of San Francisco Bay (north of the San Francisco/Oakland Bay Bridge) from San Pablo Bay to the Golden Gate Bridge. The critical habitat for this species was designated before the CHART team process, thus watersheds have not yet been evaluated for conservation value. Since designation, critical habitat for this species has continued to be degraded. Nonetheless, a number of restoration efforts have been undertaken by local, state, and federal entities resulting in slightly improved conditions in some areas and a slowing of the negative trend.
Central Valley spring-run Chinook salmon	09/02/2005 70 FR 52488	Critical habitat includes approximately 1,373 miles of stream habitats and 427 square miles of estuary habitats in 37 watersheds. The CHART rated seven watersheds as having low, three as having medium, and 27 as having high conservation value to the ESU. Four of these watersheds comprise portions of the San Francisco-San Pablo-Suisun Bay estuarine complex, which provides rearing and migratory habitat for the ESU. PBFs include freshwater spawning sites, freshwater rearing sites, and freshwater migration corridors. Since designation, critical habitat for this species has continued to be degraded somewhat by the factors listed above in the status section. Nonetheless, a number of restoration efforts have been undertaken by local, state, and federal entities resulting in slightly improved conditions in some areas and a slowing of the negative trend.

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
California Central Valley steelhead	9/2/2005 70 FR 52488	There are approximately 2,308 miles of stream habitats and 254 square miles of estuary habitats designated as critical habitat for CCV steelhead. NMFS determined that marine areas did not warrant consideration as critical habitat for this DPS. CCV steelhead PBFs are those sites and habitat components which support one or more life stages. There are 67 watersheds within the range of this DPS. Twelve watersheds received a low rating, 18 received a medium rating, and 37 received a high rating of conservation value to the DPS. Since designation, critical habitat for this species has continued to be degraded somewhat by the factors listed above in the status section. Nonetheless, a number of restoration efforts have been undertaken by local, state, and federal entities resulting in slightly improved conditions in some areas and a slowing of the negative trend.
Central California Coast coho salmon	05/05/1999 64 FR 24049	Critical habitat encompasses accessible reaches of all rivers (including estuarine areas and tributaries) between Punta Gorda and the San Lorenzo River (inclusive) in California, including two streams entering San Francisco Bay: Arroyo Corte Madera Del Presidio and Corte Madera Creek. Critical habitat includes all waterways, substrate, and adjacent riparian zones below longstanding, naturally impassable barriers (i.e., natural waterfalls in existence for at least several hundred years). NMFS has identified several dams in the CCC coho salmon critical habitat range that currently block access to habitats historically occupied by coho salmon. However, NMFS has not designated these inaccessible areas as critical habitat because the downstream areas are believed to provide sufficient habitat for conserving the ESUs. The critical habitat for this species was designated before the CHART team process, thus watersheds have not yet been evaluated for conservation value. Since designation, critical habitat for this species has continued to be degraded. Nonetheless, a number of restoration efforts have been undertaken by local, state, and federal entities resulting in slightly improved conditions in some areas and a slowing of the negative trend.
Central California Coast steelhead	9/2/2005 70 FR 52488	There are approximately 1,465 miles of stream habitats and 386 square miles of estuary habitats designated as critical habitat for CCC steelhead. NMFS determined that marine areas did not warrant consideration as critical habitat for this DPS. CCC steelhead PBFs are sites and habitat components which support one or more life stages including freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and nearshore marine areas. There are 46 watersheds within the range of this DPS. For conservation value to the DPS, fourteen watersheds received a low rating, 13 received a medium rating, and 19 received a high rating. Since designation, critical habitat for this species continues to be degraded by several factors listed in the status section. Nonetheless, a number of restoration efforts have been undertaken by local, state, and federal entities to improve conditions in some areas and slow the negative trend.
South-Central California Coast steelhead	9/2/2005 70 FR 52488	There are approximately 1,249 miles of stream habitats and three square miles of estuary habitats designated as critical habitat for SCCC steelhead. NMFS determined that marine areas did not warrant consideration as critical habitat for this DPS. SCCC steelhead PBFs are sites and habitat components which support one or more life stages including freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and nearshore marine areas. There are 30 watersheds within the range of this DPS. For conservation value to the DPS, six watersheds received a low rating, 11 received a medium rating, and 13 received a rated high. Morro Bay, an estuarine habitat, is used as rearing and migratory habitat for spawning and rearing steelhead. SCCC steelhead inhabit coastal river basins from the Pajaro River south to, but not including, the Santa Maria River. Major watersheds include Pajaro River, Salinas River, Carmel River, and numerous smaller rivers and streams along the Big Sur

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
		coast and southward. Only winter-run steelhead are found in this DPS. The climate is drier and warmer than in the north that is reflected in vegetation changes from coniferous forests to chaparral and coastal scrub. The mouths of many rivers and streams in this DPS are seasonally closed by sand berms that form during the low stream flows of summer. Since designation, critical habitat for this species continues to be degraded by several factors listed in the status section Nonetheless, a number of restoration efforts have been undertaken by local, state, and federal entities to improve conditions in some areas and slow the negative trend.
Southern California steelhead	9/2/2005 70 FR 52488	Critical habitat consists of 708 miles of stream habitat from 32 watersheds, with almost all occupied habitat from southern San Luis Obispo at the Santa Maria River to northern San Diego County at the San Mateo Creek designated. Within occupied habitat all military lands are excluded. There are also portions excluded due to economic considerations. Most watersheds south of Malibu Creek were not designated, though San Juan Creek and San Mateo Creek were designated. There are two general types of watersheds within the range of this DPS: those with short coastal streams that drain mountain ranges directly adjacent to the coast, and watersheds that contain larger river systems that continue inland through gaps in the coastal ranges. The rivers and streams in this area often have interrupted base flow patterns due to geologic formations and precipitation patterns that have strong seasonality. Restoration efforts are driven by two primary strategies. The first is working toward solutions that address fundamental causes of degradation. The second is based on resilience against climate change and harmony between human communities and this DPS.
Southern DPS of eulachon	10/20/2011 76 FR 65324	Critical habitat for eulachon includes portions of 16 rivers and streams in California, Oregon, and Washington. All of these areas are designated as migration and spawning habitat for this species. In Oregon, we designated 24.2 miles of the lower Umpqua River, 12.4 miles of the lower Sandy River, and 0.2 miles of Tenmile Creek. We also designated the mainstem Columbia River from the mouth to the base of Bonneville Dam, a distance of 143.2 miles. Dams and water diversions are moderate threats to eulachon in the Columbia and Klamath rivers where hydropower generation and flood control are major activities. Degraded water quality is common in some areas occupied by southern DPS eulachon. In the Columbia and Klamath river basins, large-scale impoundment of water has increased winter water temperatures, potentially altering the water temperature during eulachon spawning periods. Numerous chemical contaminants are also present in spawning rivers, but the exact effect these compounds have on spawning and egg development is unknown. Dredging is a low to moderate threat to eulachon in the Columbia River. Dredging during eulachon spawning would be particularly detrimental.
Southern DPS of green sturgeon	10/09/2009 74 FR 52300	Critical habitat has been designated in coastal U.S. marine waters within 60 fathoms depth from Monterey Bay, California (including Monterey Bay), north to Cape Flattery, Washington, including the Strait of Juan de Fuca, Washington, to its United States boundary; the Sacramento River, lower Feather River, and lower Yuba River in California; the Sacramento-San Joaquin Delta and Suisun, San Pablo, and San Francisco bays in California; tidally influenced areas of the Columbia River estuary from the mouth upstream to river mile 46; and certain coastal bays and estuaries in California (Humboldt Bay), Oregon (Coos Bay, Winchester Bay, Yaquina Bay, and Nehalem Bay), and Washington (Willapa Bay and Grays Harbor), including, but not limited to, areas upstream to the head of tide in various streams that drain into the bays, as listed in Table 1 in USDC (2009). The CHART identified several activities that threaten the PBFs in coastal bays and estuaries and necessitate the need for special management

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
		considerations or protection. The application of pesticides is likely to adversely affect prey resources and water quality within the bays and estuaries, as well as the growth and reproductive health of Southern DPS green sturgeon through bioaccumulation. Other activities of concern include those that disturb bottom substrates, adversely affect prey resources, or degrade water quality through re-suspension of contaminated sediments. Of particular concern are activities that affect prey resources. Prey resources are affected by: commercial shipping and activities generating point source pollution and non-point source pollution that discharge contaminants and result in bioaccumulation of contaminants in green sturgeon; disposal of dredged materials that bury prey resources; and bottom trawl fisheries that disturb the bottom (but result in beneficial or adverse effects on prey resources for green sturgeon).

2.3 Action Area

"Action area" means all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR 402.02).

The action area for the proposed action includes the three geographic regions the NWFSC designates for research surveys:

- The Puget Sound Research Area (PSRA), which includes the inland waters of Puget Sound, the Strait of Georgia, and the Strait of Juan de Fuca;
- The Lower Columbia River Research Area (LCRRA), which extends offshore beyond the Columbia River Plume and inland through the Lower Columbia River and tributaries up to Bonneville Dam; and
- The California Current Research Area (CCRA), which includes waters off of California, Oregon, Washington, and southeast Alaska.

Detailed descriptions and maps of these areas and studies currently associated with each are provided in Appendix C "Geographic Areas of Research" of the final SPEA (NWFSC 2023b)

In all, these research areas encompass coastal marine and estuarine waters of the Pacific Ocean as far north as waters off the coast of British Columbia reaching to Dixon Entrance at the United States (U.S.)-Canadian border, south to the U.S.-Mexican border, and extending out beyond the Exclusive Economic Zone (EEZ) of the Pacific Coast of the United States. For the purposes of analyzing potential impacts on ESA-listed species and designated critical habitats, we assume the fisheries survey research activities could take place anywhere within the contiguous action area formed by these three research areas.

2.4 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 consultations, and the impact of state or private actions which are contemporaneous with the consultation in process. The impacts to listed species or designated critical habitat from agency activities or existing federal agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

The environmental baseline for this Opinion is the result of the impacts that a great many activities (summarized below) have had on the various listed species' survival and recovery, and in many cases these actions have taken place upstream from where the currently proposed research actions would occur. Because the action area under consideration covers individual animals from the anywhere in the various listed species' entire ranges (see Section 1.3), the effects of these past activities on the species themselves (effects on abundance, productivity, etc.) are displayed in more detail in the species status sections that precede this section (see Section 2.2). That is, for all of the work being contemplated here, the physical results of activities in the action area *are indistinguishable from those effects described in the previous section on the species' rangewide status that falls within the action area*. Thus, and again, for much of the work being contemplated here, the impacts that previous federal, state, and private activities in the action area have had on the species cannot be segregated from those effects summarized in the sections on the species' rangewide status. The same is true with respect to the species' habitat: for much of the contemplated work, the environmental baseline is the result of these activities' rangewide effects on the PBFs that are essential to the conservation of the species.

2.4.1 Sea Turtles

As described above in the status section, leatherback, loggerhead, olive ridley, and green sea turtles have been and continue to be affected by numerous activities within the proposed action area. The proposed action area encompasses a vast portion of the ocean stretching from the coastal and offshore waters of the CCE in the north Pacific where activities that affect sea turtles such as commercial and recreational fishing are conducted. Other impacts on ESA-listed sea turtles that may occur while present along the U.S. West Coast include vessel collisions, scientific research, and entrainment in coastal power plants, and exposure to environmental changes or hazards. Because impacts on all four turtle species are similar, we look at the environmental baseline on all turtle species together, calling out differences among species where appropriate.

Fisheries Interactions

Along the west coast of the U.S., in the California Current Ecosystem, the four sea turtle species considered in this biological opinion are occasionally reported and/or observed interacting with fishing gear, including pot/trap gear, recreational hook and line gear, and gillnets. All four species have been taken in the California swordfish drift gillnet fishery, however, sea turtle interactions are now considered rare events in this fishery since the Pacific Sea Turtle Conservation Areas have been put in place (Carretta 2022a). In other commercial fisheries along the U.S. West Coast, sea turtle bycatch has only rarely been documented. In 2008, one leatherback was found entangled (dead) in sablefish trap gear fishing offshore of Fort Bragg (NMFS 2012c). No leatherbacks have been observed entangled in this gear since 2008, through 2022 (data from 2002-2022; Benson *et al.* 2021; NMFS-WCR groundfish observer program, unpublished data). Over the most recent 5-year period analyzed for this fishery, Benson *et al.* (2021) estimated that zero leatherbacks had been caught by the fleet. One leatherback was found dead entangled in unidentified pot/trap gear in 2015 off central California, and one leatherback was found entangled in Dungeness crab pot gear and released alive in 2016 (NMFS WCR stranding database, unpublished). More recently, in 2018, a dead leatherback was found floating offshore in Ventura County entangled in lines attached to two buoys (unknown fishery), which was subsequently identified as rock crab gear (NMFS WCR unpublished stranding data, 2022).

As shown in Figure 1, in over 40 years (1975-mid-2016), only four loggerheads, 10 leatherbacks, and 14 green turtles, were documented stranded with fishing gear in California. Note that this may include recreational fishing gear and does not include information reported from observer programs, including the DGN observer program.

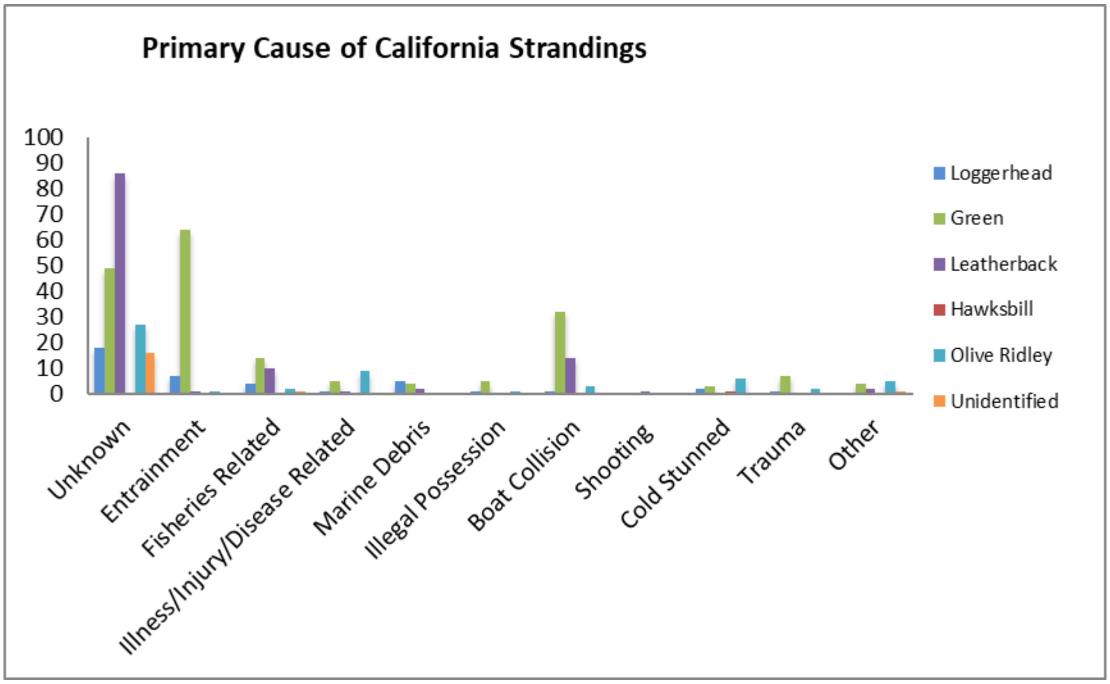

Figure 1. Known cause of sea turtle strandings in California, 1975-2016 (R. LeRoux, NMFS-SWFSC, unpublished data).

A review of the most recent stranding records (2017-2021) reveal two reports of loggerhead interactions with fishing gear, one off Oxnard in Ventura County (unidentified netting reported) and one entangled off Warrenton, Oregon with unidentified netting and fishing line in its mouth (NMFS WCR unpublished stranding data).

Green turtles have been found entangled and hooked in fishing gear; but most, if not all, have been documented interacting with recreational fishing gear. Of 116 green turtles that stranded off California between 2017 and 2021, 15 animals were found hooked (including ingested hooks) or entangled (or ingested) in fishing gear, all of it appearing to be recreational fishing gear (NMFS WCR unpublished stranding data). All were found within bays and estuaries or in the nearshore coastal areas, which further suggest that the likely interactions were with hook and line (recreational) gear. Most (n=9) were found alive, and most were able to be released either following the removal of gear, or following rehabilitation. No olive ridley turtles were found interacting with fishing gear, either commercial or recreation, during the same most recent time period (2017-2021).

When considering the impact of U.S. West Coast federal fisheries on ESA-listed species of turtles, recent biological opinions have found no jeopardy to any of these species (NMFS 2012c, 2013c, 2016e). There are two state gillnet fisheries in California that may interact with sea turtles: the set gillnet fishery targeting halibut and white seabass; and the small mesh drift gillnet fishery targeting yellowtail, barracuda, and white seabass. No sea turtle interactions have been documented historically or recently, although observer coverage of these fisheries has been limited and irregular.

Highly Migratory Species Experimental Fisheries Permits

In 2018 and 2019, NMFS WCR Sustainable Fisheries Division (SFD) consulted upon and/or issued 4 Experimental Fishing Permits (EFPs) for Highly Migratory Species (HMS) recommended by the PFMC that may occur within the proposed action area. These EFPs include: DSBG [deep-set buoy gear] issued in 2018 (NMFS 2018b); DSLBG [deep-set linked buoy gear] issued in 2018 (NMFS 2018b); Longline Gear (LL), including DSLL [deep-set longline] and SSLL [shallow-set longline], issued in 2019 (NMFS 2018b); and Deep-Set Shortline (DSSL) consulted on in 2019 (NMFS 2019c). Through consultation NMFS ultimately determined that ESA-listed species, including all ESA-listed species considered in this Opinion, would not be adversely affected by 3 of these EFPs: DSBG, DSLBG, and DSLL. In 2023, NMFS WCR SFD amended the HMS Fishery Management Plan to authorize DSBG and DSLBG as legal gear types for commercial fishing, precluding the need for future EFPs for these gear types. WCR PRDs consultation on this amendment (Amendment 6) again concluded no take of ESA-listed species was expected to occur as a result of authorizing these gear types (NMFS 2023e).

Through formal consultation, NMFS determined that the LL EFP was likely to result in the take of ESA-listed sea turtles, including North Pacific DPS loggerhead, leatherback, and olive ridley sea turtles. Specifically, over the course of 2 years the LL EFP was expected to result in: as many as 2 loggerhead sea turtle entanglements, with 1 mortality; as many as 2 leatherback sea turtle entanglements, with 1 mortality; and no more than 1 olive ridley sea turtle entanglement and mortality (NMFS 2018d). The LL EFP was issued in April, 2019, and was set to expire after two years. Two fishermen fished DSLL and SSLL for around three months in 2019 with no interactions with sea turtles (100% observer coverage). On December 20, 2019, a federal court vacated the EFP, final EA, and biological opinion as a result of litigation on the issuance of the LL EFP. In addition, SFD consulted upon and issued two EFPs for HMS in the U.S. West Coast EEZ off California and Oregon, one in 2022 (for one vessel to fish between 2022 through 2023, NMFS 2022k) and one in 2024 (for up to 5 vessels to fish between 2024 through 2025, NMFS 2024b), to fish with night-set buoy gear (NSBG). Similar to other consultations above, NMFS determined that ESA-listed species, including all ESA-listed species considered in this Opinion, would not be adversely affected by these two EFPs for NSBG. Apart from these two EFPs for NSBG from 2022 through 2025, no other longline fishing activity has occurred within the U.S. West Coast EEZ under the EFP since the court’s ruling in 2019. NMFS is currently evaluating EFP permits submitted by applicants and is in consultation on a proposed action to issue some EFP permits that may lead to the incidental take of a small number of leatherback and loggerhead sea turtles over a five-year period, including the potential for some mortalities.

Entrainment in Power Plants

In 2006, a biological opinion was completed and analyzed the effects of sea turtle entrainment in the two federally regulated nuclear power plants located in California, the Diablo Canyon Power Plant found in San Luis Obispo County and the San Onofre Nuclear Generating Station found near San Clemente California (NMFS 2006b). While historically loggerheads, leatherbacks and olive ridleys were observed entrained in the power plants in very low numbers, since 2006, there have been only two reported entrainments, both in the San Onofre Nuclear Generating Station, one olive ridley (alive) in 2009, and one loggerhead (alive) in 2010. In addition, the San Onofre station began de-commissioning in 2014, although some cooling water is still drawn in to cool the reactors. The incidental take statement covering both power plants estimates up to 6 loggerheads taken, 6 leatherbacks taken, and 6 olive ridleys taken (with two serious injuries each and two mortalities each for all three species) over a one-year period (NMFS 2006b).

There are other coastal power plants in California (non-nuclear and state-managed) where sea turtle entrainment has occurred (typically green sea turtles). Although these facilities have all been required to install large organism excluder devices by the State of California (CASWRB 2010), occasional instances of green turtle entrainments (typically alive) continue to be reported. As shown in Figure 1, only seven loggerheads were entrained in power plants over the last 40 years (1975-late-2016), and a review of the records from 2017-2021 showed no reports of entrained loggerheads. During that same time period (1975 through late-2016), 64 green turtles were entrained (most released alive). Since then, only three green turtles have been entrained in power plants, all released alive (2017-2021; NMFS-WCR unpublished stranding records). Over that same earlier time period, only one leatherback was entrained and no leatherbacks have been entrained in power plants based on stranding data from 2017-2021 (NMFS-WCR unpublished stranding data).

Scientific Research

NMFS issues scientific research permits to allow research actions that involve take of sea turtles within the action area. Currently there are 2 permits that allow directed research on sea turtles, typically involving either targeted capture or sampling of individuals that may have stranded or incidentally taken in some other manner. These permits allow the Southwest Fisheries Science Center (SWFSC) to conduct a suite of activities that include tagging, tracking, and collection of biological data and samples. These activities are intended to be non-injurious, with only minimal short-term effects. But the risks of a sea turtle incurring an injury or mortality cannot be discounted as a result of directed research. Prior to completing a section 7 ESA consultation on the SWFSC programmatic research program, one leatherback was found during a scientific trawl net survey in 2011 and was released alive. The most recent biological opinion that analyzed the effects of proposed SWFSC research surveys and estimated that one ESA-listed sea turtle found within the action area (any species of leatherback, North Pacific loggerhead, olive ridley and East Pacific green turtle) may be captured in California Current Ecosystem trawl surveys and one ESA-listed sea turtle may be captured/entangled in longline surveys, with both released alive (NMFS 2020b).

Vessel Collisions

Vessel collisions are occasionally a source of injury and mortality to sea turtles along the west coast. A review of the strandings database for the U.S. West Coast maintained by NMFS indicates that green sea turtles and leatherbacks are reported most often as stranded due to the impact by vessels strikes (Figure 1), although only approximately 15 leatherbacks were reportedly struck by vessels between 1975 and late 2016 (around 1 every 3 years), and many of these collisions occur off central California, when they are foraging in or near the approach to the ports of San Francisco and Oakland. A review of the stranding records from 2017-2021 indicated no reported vessel strikes off California and Oregon. As shown in Figure 1, one loggerhead was reportedly struck by a vessel in the last 40 years (1975-late 2016), although a review of the records from 2017-2021 revealed that two loggerheads were reportedly struck by vessels off Los Angeles (Long Beach) and San Diego County (Pacific Beach; NMFS WCR unpublished stranding data). In southern California (and including the state of California), green turtles are by far the most frequent species of sea turtles struck by vessels (including jet skis, small power boats, etc.). As shown in Figure 1, from 1975 through late 2016, 32 green turtles were suspected to be struck by vessels, with most resulting in mortality. In a review of the stranding records from 2017-2021, of 116 reported strandings of green turtles in California and Oregon, 29 of them were reported (suspected) struck by vessels, with almost all of them dead (28 animals; NMFS WCR unpublished stranding data). Most were in moderate to advanced decomposition, which often makes it difficult to determine a cause of death, although a cracked carapace or deep lacerations are usually a good indicator of blunt force trauma with a vessel's hull or propeller.

El Niño/Changing Climate

El Niño events occur with irregularity off the U.S. west coast and are associated with anomalously warm water incursions. Sea turtles may be affected by El Niño event through a change in distribution or abundance of their preferred prey, which may result in a change in sea turtle distribution or behavior. These warm water events often bring more tropical marine species into normally temperate waters and therefore may affect the local ecosystem and normal predator-prey relationships. For example, North Pacific loggerheads have been encountered off the U.S. west coast in large numbers during an El Niño. Loggerhead presence in the SCB was first documented in the CA drift gillnet fishery during the 1990s, when they were taken by the fishery during years associated with El Niño events (1992-93 and 1997-98). Anomalously warm waters bring pelagic red crabs, a preferred prey item of loggerheads and may have brought loggerheads into the area, although they have also been documented associating with pyrosomes during the 2014 incursion of warm water into the waters off California.

We considered the effect of climate change on sea turtles foraging in the action area and/or migrating to and from their nesting beaches or other areas of the Pacific Ocean. While climate change effects have been documented extensively on sea turtle nesting beaches, there is less information available on the effects of climate change on sea turtles specifically within in the action area. Generally we suspect that some sea turtle species may shift their distribution north as sea surface temperatures increase, which could bring them into more contact with human activities that occur off the U.S. West Coast. The recent research described in Section 2.2.4 above suggest that the presence of loggerhead sea turtles should be expected to increase if warmer sea surface temperatures in the SCB occur and persist in the future (Eguchi *et al.* 2018; Welch *et al.* 2019).

Other Threats and Strandings

Strandings of sea turtles along the U.S. west coast reflect in part the nature of interactions between sea turtles and human activities, as many strandings are associated with human causes. Sea turtles have been documented stranded off California (and Oregon and Washington, though in less frequent numbers) through their encounters with marine debris, either through ingesting debris or becoming entangled in the debris. Concentrations of plastic debris have been documented widely in the last decade, with the North Pacific Ocean showing similar patterns in other oceans, with plastics concentrating in the convergence zone of all five of the large subtropical gyres. Since the 1970s, the production of plastic has increased five-fold, with around 50% of it buoyant (summarized in Cózar *et al.* 2014). Studies documenting marine debris ingestion by sea turtles indicate impaired digestive capability, “floating syndrome,” or reduced ability to swim, in addition to death (Casale *et al.* 2016). In addition, studies of marine debris ingestion in green turtles (Santos *et al.* 2015) and loggerheads (Casale *et al.* 2016) indicated that the potential for death is likely underestimated, as is the magnitude of the threat worldwide, particularly for highly migratory species.

A study assessed the health of leatherbacks foraging off California and measured hematologic and plasma chemistry values. When these values were compared to nesting female leatherbacks in French Guiana and St. Croix, the foraging turtles were found to have elevated levels of Cadmium but Harris *et al.* (2011) note that biomagnification of trace elements via trophic transfer might be limited in this species due to their preference for cnidarian zooplankton. The authors note that hard-shelled turtles such as loggerheads, which have a more varied diet such as crustaceans and bivalves, have shown high levels of PCBs and DDE, when compared to more herbivorous consumers, such as green turtles. Domoic acid, which is a potent marine algal toxin that has been shown to cause neurologic disease in marine mammals and sea turtles was found in a stranded dead leatherback in 2008 (Harris *et al.* 2011). Other documented threats to sea turtles found off the U.S. west coast include illness, gunshot wounds, and unknown illnesses (usually cold-stunning, particularly for olive ridleys). Because not all dead stranded sea turtles are necropsied, the stranding database does not provide full documentation of the source of many threats to sea turtles, and the causes of a majority of strandings are unknown. This is especially true for leatherbacks, since they are often difficult to access and transport to a laboratory, given their size and rate of decomposition (Harris *et al.* 2011).

Figures 2 and 3 show the historical data on sea turtle strandings off the U.S. West Coast since 1958, including information on trends, species, and area along the coast. There are fewer strandings of sea turtles in the Pacific Northwest (Figure 3), although they do occur and are documented. A review of the most recent stranding information (2017-2021) for leatherbacks revealed four stranded turtles (one fishery-related stranding, described above). One juvenile leatherback stranded dead in Orange County, California in 2017 with evidence of trauma, but this may have been post-mortem. In 2020, a leatherback was found in San Francisco Bay but cause of death could not be determined as the animal was never recovered. Finally, in 2021 an adult leatherback stranded dead in Douglas County, Oregon with unknown cause of death, but the animal had markings indicative of a predation event and also had a puncture wounds and pieces of plastic in stomach/intestines (NMFS WCR unpublished stranding data, 2022).

A review of the most recent stranding information (2017-2021) for loggerheads, revealed 14 strandings off California and Oregon. All but one were identified as juveniles (one was unknown age class but likely a juvenile). Five loggerheads stranded in Oregon during the winter months (February/March) over this five-year period, mostly cold-stunned, although one showed signs of trauma/predation. One loggerhead stranded in northern California in February, so was likely also cold-stunned. One loggerhead stranded in Oregon and another in the SCB with signs of fishery interactions (described above), while two loggerheads stranded in southern California with signs of a vessel strike (described above). One loggerhead stranded with a string around its neck, was disentangled and released alive. Lastly, three loggerhead turtles stranded in San Diego County where cause of death could not be determined (NMFS WCR unpublished stranding data).

Strandings of olive ridleys increased in northern California and the Pacific Northwest since late 2014 (NMFS WCR stranding data, unpublished), with most of them cold-stunned (n=6 from 1975-late-2016), likely following the warm water incursion associated with a strong El Niño, which occurred during that time period through the fall of 2016. No olive ridleys were reported stranded in 2017-2021.

Many green turtles have reported stranded off California and Oregon where the cause of injury/death cannot be determined, especially when some are found with moderate to advanced decomposition. From 2017-2021, 66 green sea turtles stranded alive, injured and/or dead off California and Oregon, with the cause of death undetermined. In most cases, NMFS experts could not determine whether human interaction played a factor in the stranding, either because of the lack of details or the moderate to advanced decomposition of the animal.

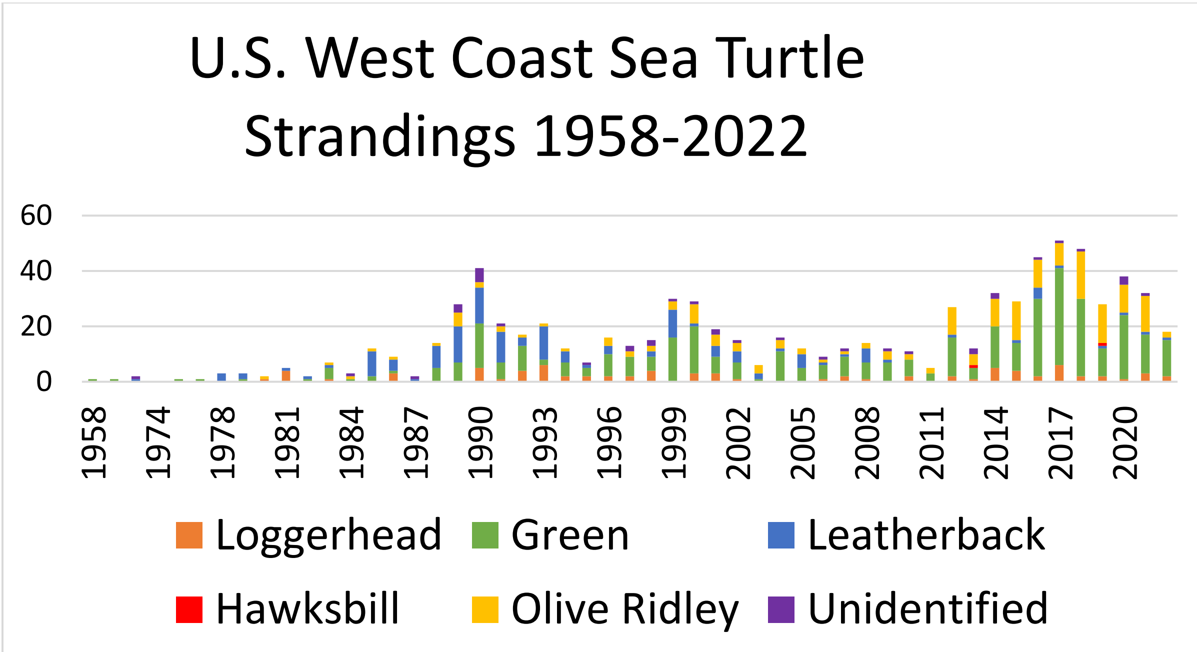

Figure 2. U.S. West Coast Sea Turtle Strandings, 1958 through mid-2022 (R. LeRoux, NMFS, unpublished data, 2022).

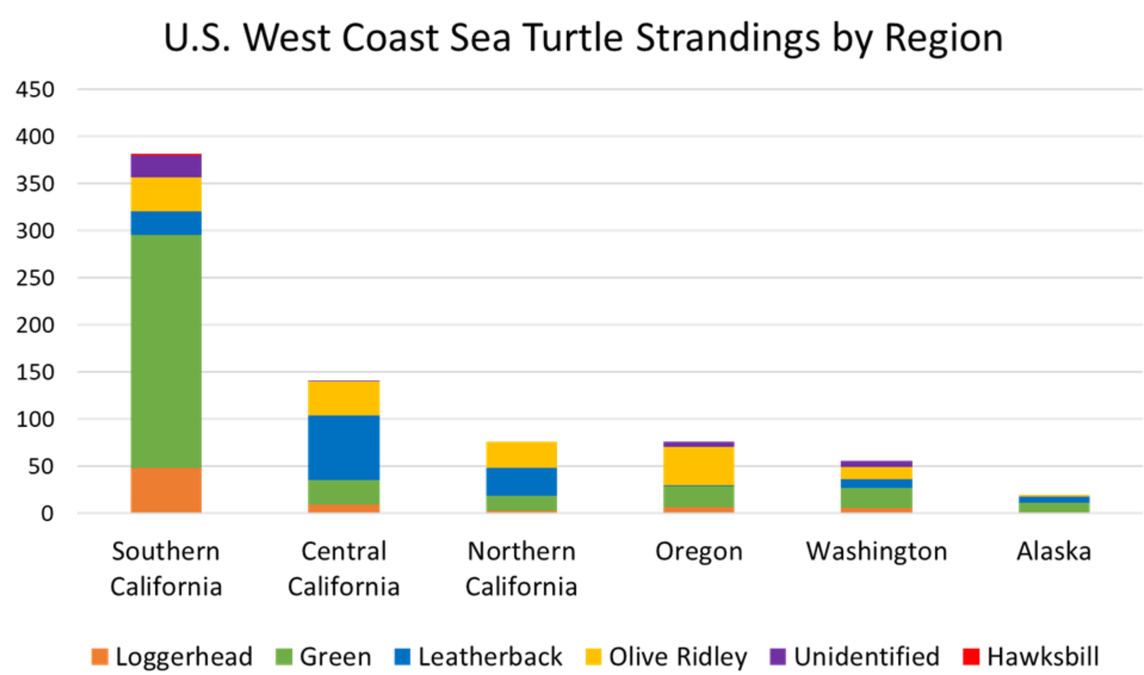

Figure 3. U.S. West Coast sea turtle strandings by region and species, 1958-2021 (R.LeRoux, NMFS, unpublished data, 2022).

2.4.2 Marine and Anadromous Fish

Factors Limiting Recovery

The best scientific information presently available demonstrates that a multitude of factors, past and present, have contributed to the decline of west coast salmonids, sturgeon, eulachon, and rockfish. NMFS' status reviews, Technical Recovery Team publications, and recovery plans for the listed species considered in this Opinion identify several factors that have caused them to decline, as well as those that prevent them from recovering (many of which are the same). Very generally, these include harvest and hatchery practices and habitat degradation and curtailment caused by human development and resource extraction. NMFS' decisions to list the species identified a variety of factors that were limiting their recovery. None of these documents identifies scientific research as either a cause for decline or a factor preventing their recovery. See Tables 1 and 33 for summaries of the major factors limiting recovery of the listed species and how various factors have degraded PBFs and harmed listed species considered in this Opinion. Also, please see section 2.2 for information regarding how climate change has affected and is affecting species and habitat in the action areas. Climate change was not generally considered a relevant factor when the species were listed and the critical habitat designated, but it is now.

In general, though, and with respect to the species' habitat, the environmental baseline is the culmination of these effects on the PBFs that are essential to the conservation of the species. The PBFs for listed species in the action area are best expressed in terms of the sites essential to supporting one or more of the species' life stages. These sites, in turn, contain physical and biological features essential to conserving the species (70 FR 52630). The specific PBFs/PCEs include (for most species):

1. Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development.

2. Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.

3. Freshwater migration corridors free of obstruction with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival.

4. Estuarine areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic

vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.

5. Nearshore marine areas free of obstruction with water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels.

6. Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.

The best scientific information presently available demonstrates that a multitude of factors, past and present, have contributed to the decline of west coast salmonids, eulachon, rockfish, and green sturgeon by adversely affecting these essential habitat features. These factors are well known and documented in hundreds of scientific papers, policy documents, news articles, books, and other media. It is therefore unnecessary to exhaustively detail in this Opinion the many ways in which human activities and natural factors have affected the species' PBFs. In short, nearly every widespread human activity in the West has adversely affected some or all of the habitat features listed above. And by disrupting those habitat features, these activities—coupled with hatchery and fishery effects and occasional natural disturbances such as drought and fire—have had detrimental impacts on all the species' health, physiology, numbers, and distribution in nearly every subpopulation and at every life stage. More detailed information on how the various human activities have affected the species' critical habitat is found in each of the species' status discussions (Section 2.2). These status descriptions are supported by the species' recovery plans, and subsequent viability analyses and 5-year reviews (listed in Table 1), which are available through NOAA's institutional repository (https://repository.library.noaa.gov/) and are here incorporated by reference.

Catch and Bycatch in Commercial Fisheries

Salmon and Steelhead

Since 1977, salmon fisheries in the exclusive economic zone (EEZ) (three to 200 miles offshore) off Washington, Oregon, and California have been managed under the salmon FMP. The take of ESA-listed salmon ESUs in the ocean and in-river salmon fisheries has been analyzed by the NMFS in a number of biological opinions and in each of these, NMFS has either found that salmon-directed fisheries would not jeopardize the continued existence of ESA-listed salmon or provided reasonable and prudent alternatives to avoid jeopardy. The salmon fisheries, both ocean harvest and in-river harvest, are managed to meet escapement objectives intended to support sustainable non-ESA-listed populations and reduce negative impacts to ESA-listed populations.

Large numbers of salmon are caught incidentally in other commercial fisheries off the U.S. West Coast; these include: the bottom trawl and whiting components of the groundfish fishery off the coasts of Washington, Oregon, and California, and the purse seine fisheries that target coastal pelagic species (CPS) such as sardines and squid. A number of section 7 consultations have been conducted to determine effects of these fisheries ESA-listed salmon. In each of the consultations, NMFS has determined that the incidental take of salmon in the fishery would not likely jeopardize the continued existence of the ESUs (mostly Chinook) under consideration (NMFS 2010a; NMFS 2017e). More recently, the West Coast fisheries observer programs for groundfish, hake, and PSFMC electronic and catch share monitoring programs estimated that in 2020 the total bycatch of salmon included 3,295 Chinook, 14 chum, and 91 coho salmon (NWFSC 2022b).

Rockfish

In 2010, the Washington State Fish and Wildlife Commission formally adopted regulations that ended the retention of rockfish by recreational anglers in Puget Sound and closed fishing for bottom fish in all waters deeper than 120 feet. In 2010 WDFW enacted a package of regulations by emergency rule for several non-tribal commercial fisheries in Puget Sound in order to protect dwindling rockfish populations. Fisheries management in British Columbia, Canada (also partially overlapping with the DPSs' boundary) has also been altered to better conserve rockfish populations. In response to declining rockfish stocks, the government of Canada initiated comprehensive changes to fishery policies beginning in the 1990s (Yamanaka and Logan 2010).

Recreational fishers targeting bottom fish and the shrimp trawl fishery in Puget Sound can incidentally catch listed rockfish. In 2012 NMFS issued an incidental take permit to the WDFW for listed rockfish caught in these two fisheries. The permit was in effect for 5 years and authorized the total incidental take of up to 152 yelloweye rockfish and 43 bocaccio annually (all of these fish would have been released). Some released fish are expected to survive; thus, of the total takes, we authorized a subset of lethal take of up to 75 yelloweye rockfish and 25 bocaccio annually (consultation number F/NWR/2012/1984). Based on reporting through 2017, in a given year up to 111 yelloweye rockfish were actually taken (43 lethally), but no bocaccio were caught during that 5-year period (APPS database). This fishery continues to be managed by WDFW, although we do not have information on incidental take of rockfish since 2017. WDFW is currently working with NMFS WCR PRD to re-authorize this fishery, and regulations promulgated by WDFW continue to advance the use of depth-descending devices expected to lower the mortality rates of released incidentally caught rockfish. Recreational and commercial halibut fishermen can incidentally catch listed rockfish. In 2014 we assessed the bycatch associated with the halibut fishery in Puget Sound. NMFS estimated that up to 270 yelloweye rockfish and 40 bocaccio would be caught and killed annually (NMFS 2023d).

Green sturgeon

The operation of the federal groundfish fishery and the state-managed California halibut bottom trawl fishery both incidentally catch green sturgeon. Although retention of green sturgeon is prohibited, some portion of the green sturgeon incidentally caught dies immediately or after being released back into the water. Because sDPS green sturgeon are not morphologically distinguishable from Northern DPS green sturgeon, the effects of these fisheries described below are not specific to Southern DPS green sturgeon.

The number of green sturgeon caught in the Limited Entry (LE) groundfish bottom trawl sector and the at-sea Pacific hake/whiting sector (at-sea hake sector) of the Pacific Coast Groundfish Fishery (PCGF) has varied over the years. The LE groundfish bottom trawl sector encountered an estimated 0 to 43 green sturgeon per year from 2002 through 2010 (Al-Humaidhi *et al.* 2012). Almost all the fish were released alive. In the at-sea hake sector, only three green sturgeon were encountered in the period from 1991 through 2011 and all of them died (Al-Humaidhi *et al.* 2012;). Data are not available to determine if the fish belonged to the Southern DPS or Northern DPS.

Green sturgeon are encountered in the state-regulated California halibut bottom trawl fishery conducted in coastal marine waters. Changes in state fishing regulations were implemented in 2006 to reduce access to the California halibut fishery (California Fish and Game Code Section 8494) and appear to have decreased total California halibut landings and the number of encounters with green sturgeon per year. The estimated encounters with Southern DPS green sturgeon ranged from 86 to 289 per year from 2007 through 2010, compared to 152 to 786 per year from 2002 through 2006 (Al-Humaidhi *et al.* 2012). Thus, the level of encounters has been reduced compared to historical levels. Based on the 2007 through 2010 bycatch data, we estimate that the California halibut bottom trawl fishery encounters 86 to 289 Southern DPS green sturgeon per year. Applying a bycatch mortality rate of 5.2 percent, we estimate that encounters in the California halibut bottom trawl fishery kills 5 to 15 Southern DPS green sturgeon per year.

Eulachon

Eulachon are taken as bycatch in shrimp trawl fisheries off the coasts of Washington, Oregon, and California. Offshore trawl fisheries for ocean shrimp (*Pandalus jordani*) extend from the west coast of Vancouver Island to the U.S. West Coast off Cape Mendocino, California. Al-Humaidhi *et al.* (2012) provide estimates of the number of individual eulachon caught in the Oregon and California ocean shrimp trawl fishery as bycatch from 2004 to 2010 (except for 2006 when these fisheries were not observed). The total estimated bycatch of eulachon in the Oregon and California ocean shrimp fisheries ranged from 217,841 fish in 2004 to a high of 1,008,259 fish in 2010 (Al-Humaidhi *et al.* 2012). For all years observed, fleet-wide eulachon bycatch estimates in the Oregon ocean shrimp fishery were much higher than in the California fishery. In 2010, estimated eulachon bycatch in the Washington ocean shrimp fishery was 66,820 fish; and the total 2010 estimated eulachon bycatch for all three states combined was 1,075,081 (Al-Humaidhi *et al.* 2012). Total coastwide ocean shrimp landings have ranged from a low of 1,888 mt in 1957 to a high of 41,418 mt in 2014 (Gustafson *et al.* 2016). Eulachon encountered as bycatch in these fisheries come from a wide range of age classes but are all assumed to be part of the southern DPS.

Research Effects

Although not identified as a factor for decline or a threat preventing recovery, scientific research and monitoring activities have the potential to affect the species' survival and recovery by killing listed salmonids—whether intentionally or not. For the year 2024, NMFS has issued numerous research Section 10(a)(1)(A) scientific research permits allowing listed species to be taken and sometimes killed. NMFS has also issued numerous authorizations for state and tribal scientific research programs under ESA section 4(d). Table 34 displays the total take for the ongoing research currently authorized under ESA sections 4(d) and 10(a)(1)(A).

Table 34. Total take for research currently authorized in the West Coast Region under ESA sections 4(d) and 10(a)(1)(A).

Species	Life Stage	Origin*	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Puget Sound Chinook salmon	Adult	Natural	1,480	68	6.333	0.291
		LHIA	756	26	11.833	0.783
		LHAC	1,993	156		
	Juvenile	Natural	742,072	13,104	19.904	0.351
		LHIA	225,225	5,129	2.595	0.059
		LHAC	188,676	8,651	0.736	0.034
Puget Sound steelhead	Adult	Natural	5,072	93	27.874	0.511
		LHIA	427	12	28.677	1.236
		LHAC	37	8		
	Juvenile	Natural	106,776	2,001	4.738	0.089
		LHIA	3,048	49	5.751	0.092
		LHAC	11,515	200	5.095	0.088
Puget Sound/Georgia Basin DPS bocaccio	Adult	Natural	26	15	1.802	0.934
	Juvenile	Natural	57	28		
Puget Sound/Georgia Basin DPS yelloweye rockfish	Adult	Natural	32	20	0.079	0.046
	Juvenile	Natural	58	33		
Hood Canal summer-run chum salmon	Adult	Natural	2,136	37	7.597	0.132
		LHAC	1	0	0.114	0.000
	Juvenile	Natural	1,083,787	4,720	25.555	0.111
		LHIA	1,445	45	-	-
		LHAC	95	19		
	Adult	Natural	194	7	23.862	0.861

Species	Life Stage	Origin*	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Upper Columbia River spring-run Chinook salmon		LHIA	157	5	29.386	1.228
		LHAC	178	9		
	Juvenile	Natural	12,956	350	2.653	0.072
		LHIA	1,804	74	0.383	0.016
		LHAC	1,544	234	0.226	0.034
Upper Columbia River steelhead	Adult	Natural	199	4	13.584	0.273
		LHIA	90	2	10.301	0.277
		LHAC	208	6		
	Juvenile	Natural	11,377	66	7.562	0.044
		LHIA	2,211	51	1.581	0.036
		LHAC	10,017	226	1.308	0.030
Middle Columbia River steelhead	Adult	Natural	2,219	34	16.319	0.250
		LHIA	200	7	261.431	3.787
		LHAC	1,664	20		
	Juvenile	Natural	181,832	4,105	51.733	1.168
		LHIA	8,743	120	7.717	0.106
		LHAC	852	40	0.229	0.011
Snake River spring/summer-run Chinook salmon	Adult	Natural	1,259	22	28.491	0.498
		LHIA	724	9	32.140	0.744
		LHAC	183	12		
	Juvenile	Natural	567,671	7,300	83.163	1.069
		LHIA	74,639	643	10.733	0.092
		LHAC	86,388	1,076	1.821	0.023
Snake River fall-run Chinook salmon	Adult	Natural	85	11	1.170	0.151
		LHIA	37	2	0.786	0.128
		LHAC	80	17		
	Juvenile	Natural	5,071	295	0.634	0.037
		LHIA	2,027	159	0.068	0.005
		LHAC	2,536	311	0.097	0.012
Snake River Basin steelhead	Adult	Natural	10,314	123	103.502	1.234
		LHIA	2,540	38	178.569	2.740
		LHAC	3,326	52		
	Juvenile	Natural	406,581	5,496	70.926	0.959
		LHIA	51,854	528	9.804	0.100
		LHAC	55,154	642	1.803	0.021

<table>
<tr><th>Species</th><th>Life Stage</th><th>Origin*</th><th>Requested Take</th><th>Lethal Take</th><th>Percent of ESU/DPS taken</th><th>Percent of ESU/DPS killed</th></tr>
<tr><td rowspan="5">Snake River sockeye salmon</td><td rowspan="3">Adult</td><td>Natural</td><td>113</td><td>6</td><td>706.250</td><td>37.500</td></tr>
<tr><td>LHIA</td><td>1</td><td>0</td><td rowspan="2">2.062</td><td rowspan="2">0.000</td></tr>
<tr><td>LHAC</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Juvenile</td><td>Natural</td><td>8,325</td><td>297</td><td>46.250</td><td>1.650</td></tr>
<tr><td>LHAC</td><td>206</td><td>62</td><td>0.069</td><td>0.021</td></tr>
<tr><td rowspan="6">Lower Columbia River Chinook salmon</td><td rowspan="3">Adult</td><td>Natural</td><td>468</td><td>49</td><td>1.597</td><td>0.167</td></tr>
<tr><td>LHIA</td><td>4</td><td>3</td><td rowspan="2">2.413</td><td rowspan="2">0.340</td></tr>
<tr><td>LHAC</td><td>450</td><td>61</td></tr>
<tr><td rowspan="3">Juvenile</td><td>Natural</td><td>416,213</td><td>5,933</td><td>3.738</td><td>0.053</td></tr>
<tr><td>LHIA</td><td>429</td><td>70</td><td>0.046</td><td>0.007</td></tr>
<tr><td>LHAC</td><td>3,340</td><td>1,211</td><td>0.011</td><td>0.004</td></tr>
<tr><td rowspan="6">Lower Columbia River coho salmon</td><td rowspan="3">Adult</td><td>Natural</td><td>1,096</td><td>25</td><td>5.857</td><td>0.134</td></tr>
<tr><td>LHIA</td><td>3</td><td>2</td><td rowspan="2">2.658</td><td rowspan="2">0.339</td></tr>
<tr><td>LHAC</td><td>421</td><td>52</td></tr>
<tr><td rowspan="3">Juvenile</td><td>Natural</td><td>247,151</td><td>3,125</td><td>29.885</td><td>0.378</td></tr>
<tr><td>LHIA</td><td>965</td><td>206</td><td>0.298</td><td>0.064</td></tr>
<tr><td>LHAC</td><td>17,286</td><td>1,150</td><td>0.218</td><td>0.014</td></tr>
<tr><td rowspan="5">Lower Columbia River steelhead</td><td rowspan="2">Adult</td><td>Natural</td><td>3,120</td><td>33</td><td>38.273</td><td>0.405</td></tr>
<tr><td>LHAC</td><td>75</td><td>4</td><td>1.175</td><td>0.063</td></tr>
<tr><td rowspan="3">Juvenile</td><td>Natural</td><td>55,442</td><td>954</td><td>14.776</td><td>0.254</td></tr>
<tr><td>LHIA</td><td>3</td><td>0</td><td>0.020</td><td>0.000</td></tr>
<tr><td>LHAC</td><td>3,541</td><td>87</td><td>0.299</td><td>0.007</td></tr>
<tr><td rowspan="6">Columbia River chum salmon</td><td rowspan="3">Adult</td><td>Natural</td><td>91</td><td>11</td><td>0.526</td><td>0.064</td></tr>
<tr><td>LHIA</td><td>3</td><td>1</td><td>0.524</td><td>0.175</td></tr>
<tr><td>LHAC</td><td>3</td><td>1</td><td></td><td></td></tr>
<tr><td rowspan="3">Juvenile</td><td>Natural</td><td>69,034</td><td>865</td><td>0.888</td><td>0.011</td></tr>
<tr><td>LHIA</td><td>562</td><td>18</td><td>0.101</td><td>0.003</td></tr>
<tr><td>LHAC</td><td>16</td><td>1</td><td>-</td><td>-</td></tr>
<tr><td rowspan="6">Upper Willamette River Chinook salmon</td><td rowspan="3">Adult</td><td>Natural</td><td>273</td><td>12</td><td>2.592</td><td>0.114</td></tr>
<tr><td>LHIA</td><td>2</td><td>1</td><td rowspan="2">0.650</td><td rowspan="2">0.067</td></tr>
<tr><td>LHAC</td><td>163</td><td>16</td></tr>
<tr><td rowspan="3">Juvenile</td><td>Natural</td><td>86,167</td><td>3,079</td><td>7.432</td><td>0.266</td></tr>
<tr><td>LHIA</td><td>891</td><td>28</td><td>-</td><td>-</td></tr>
<tr><td>LHAC</td><td>15,140</td><td>436</td><td>0.347</td><td>0.010</td></tr>
</table>

Species	Life Stage	Origin*	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Upper Willamette River steelhead	Adult	Natural	381	6	14.498	0.228
	Juvenile	Natural	33,307	689	24.617	0.509
Oregon Coast coho salmon	Adult	Natural	15,215	185	25.097	0.305
		LHAC	35	19	5.486	2.978
	Juvenile	Natural	698,540	15,849	16.289	0.370
		LHAC	505	259	0.842	0.432
Southern Oregon/Northern California Coast coho salmon	Adult	Natural	4,496	44	71.062	0.728
		LHIA	3,422	29		
		LHAC	1,065	19		
	Juvenile	Natural	281,563	4,921	31.820	0.556
		LHIA	18,618	1,004	24.824	1.339
		LHAC	20,481	565	3.562	0.098
Northern California steelhead	Adult	Natural	1,720	26	20.584	0.311
	Juvenile	Natural	144,077	2,649	15.158	0.279
California Coastal Chinook salmon	Adult	Natural	520	23	3.949	0.175
	Juvenile	Natural	109,295	1,925	4.568	0.080
Sacramento River winter-run Chinook salmon	Adult	Natural	1,425	18	120.253	1.519
		LHAC	1,423	50	52.762	1.854
	Juvenile	Natural	425,680	11,404	340.441	9.120
		LHAC	203,331	7,234	127.998	4.554
Central Valley spring-run Chinook salmon	Adult	Natural	1,807	30	26.747	0.444
		LHAC	895	82	42.967	3.937
	Juvenile	Natural	1,005,374	20,417	54.671	1.110
		LHIA	2,600	6	-	-
		LHAC	60,665	4,641	3.033	0.232
California Central Valley steelhead	Adult	Natural	4,376	138	55.925	2.697
		LHIA	100	2		
		LHAC	1,952	170		
	Juvenile	Natural	87,696	2,235	6.707	0.171
		LHIA	90	3	-	-
		LHAC	29,323	1,580	2.793	0.150
Southern DPS eulachon	Adult	Natural	39,024	31,037	0.156	0.125
	Subadult	Natural	1,210	1,036		
	Juvenile	Natural	1,525	1,368		

Species	Life Stage	Origin*	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Southern DPS green sturgeon	Adult	Natural	660	16	31.030	0.752
	Subadult	Natural	529	25	4.738	0.224
	Juvenile	Natural	6,648	193	150.034	4.356
	Larvae	Natural	11,348	1,124	-	-
	Egg	Natural	3,870	3,870		

[a] Abundances for adult hatchery salmonids are LHAC (Listed Hatchery Adipose Clip) and LHIA (Listed Hatchery Intact Adipose) combined.

[b] Abundances for all adult components are combined.

Actual take levels associated with these activities are almost certain to be a substantially lower than the permitted levels. There are three reasons for this. First, most researchers do not handle the full number of juveniles or adults they are allowed. That is, for the vast majority of scientific research permits, history has shown that researchers generally take far fewer than the allotted number of fish every year. Over the past five years, researchers in the Section 10(a)(1)(A) program have reported taking approximately 24% and killing approximately 11% of the juveniles that were authorized, and only taking roughly 15% and killing roughly 8% of the adults that were authorized across all species. This is discussed further for NWFSC studies specifically in Section 2.5. Second, we purposefully increase our take and mortality estimates for each proposed study by a small amount to account for uncertainty and the effects of potential accidental deaths from unforeseen events. Therefore, it is very likely that far fewer fish—especially juveniles—would be killed under any given research project than the researchers are permitted. Third, for salmonids, many of the fish that may be affected would be in the smolt stage, but others would be yearlings, parr, or even fry. These are all simply be described as "juveniles," and treated as if they were smolts even though a great many of them would be from life stages represented by multiple spawning years and containing more individuals than reach the smolt stage—perhaps as much as an order of magnitude more. Therefore, the estimates of percentages of ESUs/DPSs taken were derived by (a) conservatively estimating the actual number of juveniles, (b) overestimating the number of fish likely to be killed, and (c) treating each dead juvenile fish as part of the same year class. Thus, the actual numbers of juvenile salmonids the research is likely to kill are undoubtedly smaller than the authorized totals.

Other factors

Salmon and Steelhead

Beyond the impacts of fisheries described above, at-sea survival of salmon can be affected by a number of manmade and natural factors once they reach the marine environment. Juvenile salmon are prey for marine seabirds, marine mammals, and larger fish. Adult salmon are prey to pinnipeds such as sea lions, harbor seals (Chasco *et al.* 2017) and killer whales in the Pacific

Northwest (Osborne 1999; Hilborn *et al.* 2012). In certain areas where salmon and predators are in close proximity in relatively high concentrations, predation has been identified as a significantly limiting factor for certain ESUs (e.g., sea lions at Bonneville Dam (NMFS 2008c).

There is evidence to suggest that salmon abundance is linked to variation in climate effects on the marine environment. It is widely understood that variations in marine survival of salmon correspond with periods of cold and warm ocean conditions, with cold regimes being generally favorable for salmon survival and warm ones unfavorable (Behrenfeld *et al.* 2006; Wells *et al.* 2006). Both short term El Nino Southern Oscillation (ENSO) and longer term climate variability, (PDO), appear to play a part in salmon survival and abundance. The environmental conditions at the time of ocean entry and near the point of ocean entry are likely to be especially important in determining the survival of juvenile Chinook (Lindley *et al.* 2009). If ocean productivity and feeding conditions are good, growth will be high and starvation or the effects of size-dependent predation may be lower. Studies have provided evidence that growth and survival rates of salmon in the California Current off the Pacific Northwest can be linked to fluctuations in ocean conditions (Peterson *et al.* 2006; Wells *et al.* 2008). The correlation between various environmental indices that track ocean conditions and salmon productivity in the Pacific Ocean, both on a broad and local scale, provides an indication of the role they play in salmon survival in the ocean.

In the parts of the action area that include nearshore habitat within Puget Sound and the Columbia River Estuary, nearshore areas have been modified by human activity, disrupting the physical, biological, and chemical interactions that are vital for creating and sustaining diverse ecosystems. Effects of shoreline modification on nearshore and estuarine habitat function include diminished sediment supply, diminished organic material (e.g., woody debris and beach wrack) deposition, diminished over-water (riparian) and nearshore in-water vegetation (SAV), diminished prey availability, diminished aquatic habitat availability, diminished invertebrate colonization, and diminished forage fish population. Shoreline modification, including armoring, often results in increased beach erosion waterward of the armoring, which, in turn, leads to beach lowering, increases in sediment temperature, and reductions in invertebrate density. The reductions to shallow water habitat, as well as reduced forage potential resulting from shoreline modification may cause juvenile salmonids to temporarily utilize deeper habitat, thereby exposing them to increased piscivorous predation. Typical piscivorous juvenile salmonid predators, such as flatfish, sculpin, and larger salmonids, being larger than their prey, generally avoid the shallowest nearshore waters that out-migrant juvenile salmonids prefer. When juvenile salmonids temporarily leave the relative safety of the shallow water, their risk of being preyed upon by other fish increases.

Water quality degradation from agricultural and urban stormwater has also been identified as a threat to many salmon and steelhead species in the action area. Stormwater runoff is the primary way that non-point source pollution is conveyed to waterways, where it may affect salmonids and their habitat. Pollutants in stormwater are reflective of their source areas and land use. Urbanized areas contribute general-use pesticides sold in stores and legacy pesticides from their former (often agricultural) land uses, nutrients from lawn and garden care, and elevated levels of suspended sediment and turbidity from land-disturbing activities. Roads and streets contribute additional stormwater contaminants such as Polycyclic Aromatic Hydrocarbons (PAHs), oils and greases, various heavy metals such as copper and zinc, and other toxic substances such as tire particles (containing 6PPD-quinone). Fish embryos and larvae exposed to PAHs have been documented to experience adverse changes in heart physiology and morphology, even with only temporary exposure to low concentrations (Incardona and Sholz 2017). Heavy metals such as copper and zinc are also well-documented contaminants in storm water from roadways (Caltrans 2003) and have been shown to detrimentally affect salmonids and their habitat at very low, environmentally realistic levels. These low levels are noted to impact the resistance of fishes to disease, cause hyperactivity, impair respiration, disrupt osmoregulation and calcium levels and/or impact olfactory performance leading to disruption in critical fish behaviors at concentrations that are at, or just slightly above, ambient concentrations. The tire particle associated 6PPD-quinone has only recently been identified as a source of mortality for salmon and steelhead, and tire-derived products used by agencies and municipalities, such as asphalt rubber paving, fill for overpass construction or surface area covers for porous walkways, paths and bike trails, may also contribute harmful chemicals to waterways. The highest concentration of chemicals harmful to instream habitats are expected to be associated with the point of discharge during and shortly after rainfall, particularly "first-flush" rain events after long antecedent dry periods. However, when road densities are high enough many contaminants exhibit transport-limited, rather than mass-limited, characteristics. This means the source of contaminants within the system is large enough that additional precipitation continues to mobilize the pollutants either by transporting that which was newly deposited on the roadway or that which was less mobile or more distant from the discharge point (Johannessen *et al.* 2022, Feist *et al.* 2018). In these cases, designated critical habitat has the potential to experience a temporary or permanent reduction in function and value as a result of exposure to untreated stormwater runoff, particularly near urban areas.

Rockfish, Green Sturgeon, and Eulachon

For species associated with bottom substrates in estuaries such as eulachon and green sturgeon, dredging actions have damaged available habitat. Ocean dredged material disposal sites have been designated within the action area, such as off the mouth of the Columbia River (NMFS 2012d). The disposal of dredged materials at these disposal sites has the potential to entrain and bury small (i.e., ≤ 2 feet in length) subadult green sturgeon that, unlike adults and larger subadults, may not be able to move quickly enough to avoid descending sediments. This may result in injury to small subadult green sturgeon, but the number affected was expected to be low given the location of the disposal sites and the migratory patterns of green sturgeon in marine waters (e.g., green sturgeon are likely to spend limited time in one area as they move from estuary to estuary). Such actions may also displace or bury eulachon, or more likely their eggs, during the spawning months.

The degradation of some rocky habitat, loss of eelgrass and kelp, introduction of non-natural-origin species that modify habitat, and degradation of water quality are threats to marine habitat in Puget Sound (Drake *et al.* 2010b; Palsson *et al.* 2009). Benthic habitats in nearshore areas and within Puget Sound have been influenced by abandoned fishing gear that has the potential to impact rockfish as well as other species. Some benthic habitats have been impacted by derelict fishing gear that include lost fishing nets, and shrimp and crab pots (Good *et al.* 2010). Derelict fishing gear can continue “ghost” fishing and is known to kill rockfish, salmon, and marine mammals as well as degrade rocky habitat by altering bottom composition and killing numerous species of marine fish and invertebrates that are eaten by rockfish (Good *et al.* 2010). Thousands of nets have been documented within Puget Sound and most have been found in the San Juan Basin and the Main Basin. The removal of over 5,800 nets and over 6,000 derelict pots have restored over 860 acres of benthic habitat (Northwest Straits Foundation 2024), though many derelict nets and crab and shrimp pots remain in the marine environment and are known to cause rockfish bycatch (Antonelis *et al.* 2018).Therefore, there is an unknown but potentially significant impact from derelict gear on rockfish habitats within Puget Sound.

In offshore habitats, renewable ocean energy installations may affect green sturgeon behavior and migration because of potential impacts from anthropogenic noise and electromagnetic fields, as well as the addition of structures to the water column and seafloor. NMFS consulted on the effects of renewable ocean energy installations off the Oregon coast (off Reedsport and off Newport) and concluded that the proposed actions were likely to adversely affect but not likely to jeopardize the continued existence of the Southern DPS green sturgeon (NMFS 2012e and 2012f). Electromagnetic fields generated by the installations may either attract or deter green sturgeon in the area. In addition, the installation structures themselves could pose a migration barrier for green sturgeon. For both projects, the degree of exposure and responses of green sturgeon to the potential effects was uncertain, but expected to most likely be small. The consultations included measures to implement study plans and adaptive management frameworks to identify unanticipated negative effects of the installations on green sturgeon and the development of appropriate actions to avoid and minimize those effects in the future.

Several activities occur within the action area that may affect prey resources for Southern DPS green sturgeon. The feeding habits and diet of green sturgeon in the ocean is poorly known, but they may prey upon demersal fish (sand lance are a known diet item) captured in bottom trawl fisheries. Disturbance of benthic habitats by bottom trawl fisheries may also affect prey species and alter the abundance, distribution, and composition of benthic communities. How these changes may affect Southern DPS green sturgeon and designated critical habitat is unclear, however, because some of these benthic communities are in high energy environments characterized by frequent disturbance and rapid recolonization. In addition, it is unclear whether disturbance of benthic habitats by bottom trawls may reduce or enhance feeding opportunities for green sturgeon. Also, green sturgeon feeding while in marine waters and the prey resources they may feed on have not yet been confirmed or identified. Thus, effects of fishing activities on prey availability in designated green sturgeon critical habitat and feeding opportunities for green sturgeon are difficult to evaluate until more definitive information is known about the marine habitat use and diets of green sturgeon.

2.4.3 Marine Invertebrates

The sunflower sea star occupies nearshore subtidal marine waters off the West Coast of the United States in waters shallower than 450 m from Alaska to Mexico, which overlaps with many past and ongoing activities in marine waters, although only those interacting with the bottom substrate are expected to significantly impact this species. The current regional population declined by more than 95% in some areas occurred from 2013-17 as a result of sea star wasting syndrome (SSWS), and signs of recovery have been patchy and slow to progress. While the cause of this disease remains unknown, prevalence of the outbreak has been linked to a variety of environmental factors, including temperature change, sustained elevated temperature, low dissolved oxygen, and decreased pH (Hewson *et al.* 2018; Aquino *et al.* 2021; Heady *et al.* 2022; Oulhen *et al.* 2022). As noted above in Section 2.2, physiochemical attributes of nearshore waters are expected to change in coming decades as a consequence of anthropogenic climate change, but the specific consequences of such changes on SSWS prevalence and severity are currently impossible to accurately predict.

As habitat generalists that can feed on a variety of benthic prey species, and given the broad dispersal of currently small numbers of animals, habitat conditions are not currently thought to be degraded to the point they would limit recovery. However, past and ongoing commercial fishing operations employing bottom trawling gear over large areas have likely impacted several square miles of substrate by removing benthic prey organisms, reducing available prey for sunflower sea stars that will not repopulate for some time. Such operations also incidentally catch sunflower sea stars; while this species can be removed from the water for short periods and returned with minimal negative impacts, the nets and gear associated with fishing operations may cause lacerations or crushing that injures or kills the sunflower sea stars when nets are brought on board.

Stormwater runoff from urban watershed carries a wide variety of toxic contaminants known to affect organismal health and vitality in marine systems. While studies have not been conducted with sunflower sea stars, bioaccumulation of chemicals, with both sublethal and lethal effects, has been documented in various life stages of other mesopredators with planktonic larvae (e.g., herring, rockfish). Using these species as proxies, both sublethal and lethal effects to sunflower sea stars can be presumed, with the greatest impact likely occurring at the larval stage.

2.5 Effects of the Action

Under the ESA, “effects of the action” are 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 but that are not part of the 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 CFR 402.02)

2.5.1 Effects on Critical Habitat

Full descriptions of effects of the proposed research activities on listed species are given in Section 2.5.2.

Sea Turtles

Leatherback sea turtles are the only listed sea turtle in the action area with designated critical habitat. The one PCE associated with this critical habitat, essential for the conservation of leatherbacks in marine waters off the U.S. West Coast, is the occurrence of jellyfish prey species of sufficient condition, distribution, diversity, abundance and density necessary to support individual as well as population growth, reproduction, and development of leatherbacks. Information about the total biomass removed during NWFSC surveys, which included estimates of jellyfish and salps by weight, indicated that the total amount of these species taken in research surveys is very small (i.e., less than a quarter of a metric ton of jellyfish, pyrosomes, and salps annually) relative to their overall biomass in the action area. In addition to the small magnitude of prey reductions that are expected to result from the proposed action, surveys that remove jellyfish are spread out systematically over large areas such that prey removals are not concentrated during any place or time in a manner that is expected to affect foraging for any leatherback turtles in a discernible manner. As a result, we anticipate that the proposed action is only expected to have very minor and transitory impacts on prey used by the ESA-listed turtles in the action area, and the risks of local depletions that could have an impact on the overall health and fitness of leatherback turtles are minimal.

Marine and Anadromous Fish

The critical habitat that overlaps with the NWFSC research areas include eulachon critical habitat in the Columbia River and select tributaries; Green sturgeon critical habitat in marine waters of the West Coast from Cape Flattery to Monterey Bay, sections of Puget Sound, and the Columbia River estuary; rockfish critical habitat in many parts of Puget Sound; and salmonid critical habitat in lower reaches and estuaries of rivers along the West Coast including the Columbia River estuary, as well of sections of Puget Sound including nearshore marine areas.

In general, the activities described above would be (1) capturing fish with angling equipment and nets of various types, (2) collecting biological samples from live fish, and (3) collecting fish (non-lethally or lethally) for biological sampling. All of these techniques have minimally intrusive effects on habitat because they would involve very little, if any, disturbance of streambeds or adjacent riparian zones. Moreover, the proposed activities are all of short duration, and any temporary impacts to sediments, water quality, or physical disturbance are expected to be ephemeral.

Some fish collection activities involve bottom trawls in marine or estuarine environments which may temporarily disturb substrate, displace benthic invertebrate prey, and increase turbidity just above the water surface. The total amount of prey species taken in the research surveys is very small relative to their overall commercial and recreational catches and biomass. It is not clear exactly how much NWFSC research and overall prey removal occurs within the designated critical habitat for ESA-listed fishes, but any removals of potential prey are likely to be limited to very small localized totals that are scattered across a very large survey area. The overall density of prey items in any area should not be affected to a degree that would be detectable by individuals. Thus, the removal of fish and invertebrate species by NWFSC survey trawls is not expected to significantly reduce the quality or quantity of prey resources within designated critical habitat. Therefore none of the activities analyzed in this Opinion will measurably affect any habitat PBF function or value described earlier for listed fish species (see section 2.2.2).

2.5.2 Effects on the Species

As discussed above, the proposed research activities would not measurably affect any of the listed species' habitat. The actions are therefore not likely to measurably affect any of the listed species by reducing that habitat's ability to contribute to their survival and recovery.

The primary effect that the proposed research (and its authorization) would have on the listed species would come in the form of capturing and handling the fish. Harassment caused by capturing, handling, and releasing fish generally leads to stress and other sub-lethal effects that are difficult to assess in terms of their impact on individuals, let alone entire species.

The following subsections describe the types of activities being proposed. Each is described in terms broad enough to apply to all the studies. The activities would be carried out by trained professionals using established protocols. The effects of the activities are well documented and discussed in detail below. No researcher would receive authorization for a specific study unless the activities incorporate NMFS' uniform, pre-established set of mitigation measures. These measures are described in Section 1.3 of this Opinion. They are incorporated (where relevant) into every permit or authorization as part of the conditions to which a researcher must adhere.

Sea Turtles

Capture or Entanglement

Given the broad scope of NWFSC research activities occurring throughout the CCRA, there is substantial general overlap between NWFSC research and ESA-listed species of sea turtles discussed in this Opinion. Because hard shelled species of sea turtles are generally more densely populated in warmer ocean waters, much of the proposed action area where NWFSC surveys occur in the northern portion of the CCRA north of Point Conception is outside of areas where high densities of any hard shelled turtles may be expected. However, the sea turtle stranding record does indicate that loggerhead, green, and olive ridley turtles do periodically occur in coastal waters all along the U.S. West Coast (NMFS stranding data), and it is possible that sea turtles could be incidentally captured or entangled in NWFSC surveys in the CCRA at any time, especially during summer/fall when water temperatures would be expected to be warmest throughout the U.S. West Coast. Leatherback turtles may be found foraging in coastal upwelling areas all along the U.S. West Coast in the summer and fall, although most likely in central and northern portions of the U.S. West Coast. Given the historic strandings and fisheries bycatch known to have occurred and the available information on sea turtle migrations in ocean waters throughout the Pacific, it is clear that NWFSC research occurring in the southern CCRA overlaps with areas where all four of these species would be expected to occur, in varying densities.

As described in the proposed action, the distribution of NWFSC research using active capture survey gear in the CCRA ranges across a wide swath of the U.S. EEZ with varying intensity throughout the year. Despite the regular potential exposure of sea turtles to active fishing survey gear used by the NWFSC in the CCRA, there have been no documented interactions with sea turtles. In addition, there have been only two incidental capture/entanglement of a sea turtle recorded throughout the history of the similar research programs conducted by the SWFSC. During the 2011 SWFSC Juvenile Salmon Survey, a leatherback sea turtle (likely a sub-adult) was incidentally caught in a Nordic 264 surface trawl fishing due west of Pigeon Point, San Mateo County, California. Once the net was pulled onto the deck of the research vessel, it became apparent that the leatherback sea turtle had been caught, along with a large haul of jellyfish. The crew immediately loosened the net around the turtle’s head to allow it to breathe, and the crew opened the net and extracted the turtle within three minutes. Once out of the net, the turtle showed no signs of severe injuries, and was released alive. The turtle was subsequently observed swimming and breathing normally at the surface behind the vessel. Mitigation measures in use at the time of the sea turtle interaction included a sea turtle watch (3-4 observers) before and during the trawl.

In September, 2016, one green sea turtle was discovered to be tangled and hooked near Point Conception in Southern California at 34.4433°N, 120.35°W during an HMS pelagic longline survey targeting thresher shark. The monofilament mainline 2 miles in length with a 1000lb test and the 200 monofilament gangions were each 4 meters long. The longline was set at a depth of about 6 meters and sardine and mackerel were used as bait. The sea turtle was pulled out of the water alive using the shark cradle. The leader was found to be wrapped once around the turtle’s front left flipper and the barb of the 13/0 offset circle hook was partially embedded into the flipper. When the barb and leader line were removed from the turtle no blood was visible. During the recovery and sampling, the turtle was very active and swam away vigorously after being released into the water. All required mitigation measures were followed during this set.

Although the Juvenile Salmon Survey is the only trawl survey by a NMFS Science Center on the West Coast of the U.S. where a sea turtle has been taken, other trawl surveys are also conducted in the CCRA in areas where any of these sea turtle species considered in this Opinion may occur. Therefore, we conclude the one SWFSC trawl bycatch event reflects the general risk of capture for sea turtles in all survey trawls in the CCRA, which is to say a rare event is possible at any time. Similarly, we conclude the one recent sea turtle interaction with pelagic longline gear reflects the general risk of capture for sea turtles with any hook and line gear used in NWFSC research is a rare event possible at any time.

To date, no interactions between NWFSC gears/surveys and sea turtles has occurred. Even though there is overlap between sea turtles and NWFSC research in the CCRA, the interaction rate between sea turtles and research gear in the CCRA has been, and is expected to be very small in the CCRA based on the historical performance of NWFSC and other fisheries research. Given the known overlap and generally accepted vulnerability of sea turtles to trawl and longline/hook and line gear, it is likely that the gear configuration and survey protocols that have been used for deployment have been effective to some degree at reducing the exposure of sea turtles to NWFSC research gear to a point where capture or entanglement in trawl or longline gear can be classified as simply a rare event that cannot be completely discounted.

Trawls

During surface trawling operations, nets are fished at or very near the surface, minimizing the extent of the water column that is exposed to the trawl net. Turtles are air breathers and do require time at the surface, but also spend time diving in the water column searching for prey. While pelagic trawls are not free from sea turtle bycatch potential, traditionally much more attention has been placed on the significance of turtle bycatch in bottom trawl fisheries that occurs in near shore coastal waters. During trawling operations, the NWFSC employs monitoring procedures prior to setting gear and institutes a “move-on” rule if sea turtles are present to avoid the risk of capture. Additionally, survey tow times are relatively short, typically no longer than 45 minutes. In recent years, pelagic trawls involving the Nordic 264 have been using a marine mammal excluder device with a 5” bar spacing to prevent marine mammals from being captured and trapped in the back end (codend) of the trawl net (Figure 5 of Appendix B in Final SPEA, NWFSC 2023b). Similar in concept to turtle excluder devices (TEDs) that have been used for decades to reduce turtle bycatch of many species in trawl fisheries around the world, this device may well be effective at minimizing the chance of a sea turtle being captured and trapped in the codend as well. All of these measures appear to have worked together to help minimize the risk of sea turtle bycatch in survey trawl gear, as only one event has happened during SWFSC research activities. These same survey protocols are expected to continue in the future under this proposed action.

Given the one documented interaction of the SWFSC with a sea turtle (a leatherback), we assume it is still possible that a sea turtle could encounter NWFSC survey trawls in the CCRA, despite the efforts to avoid interaction and move away after observing any turtles present. NMFS also assumes that while MMEDs are likely very effective at preventing turtles from being captured in survey trawls, they are not 100% effective as entanglement in the netting with a flipper or in the MMED grid/opening is possible. In addition, some survey trawls are executed without MMEDs. While activity that occurs in certain areas like central California in the summer and fall may be more likely to encounter leatherback sea turtles, other activities in southern California are more likely to encounter green, loggerheads, or olive ridley sea turtles.

Effectively, any of these four species may be captured/entangled in trawl gear, and there isn't enough information to distinguish relative risk among these species from only one historical incident. Although multiple interactions of sea turtles over any period of time are possible, the historical record does not support this as a likely outcome within a survey year, especially given the efforts to minimize the risks to sea turtles described above.

Any sea turtle that is subject to forced submergence in a trawl net is at risk of drowning and death. The protocols for NWFSC survey trawls typically employ a short tow time (45 minutes) which is expected to minimize the risk of drowning. In shrimp fisheries in the Atlantic, restriction of tow times to 55 minutes or less is considered a mitigation measure that reduces the risks of drowning for sea turtles captured in that fishery to an extent where TED use is not required, because of the known ability of sea turtles to normally hold their breath for this period of time, even under duress of capture in fishing gear (50 CFR 22.3.206(d)(3)(i)). While it is not impossible for a sea turtle to drown forcibly submerged for 30 minutes or less, we infer it is unlikely. As a result, we expect that any sea turtle that may be captured in a NWFSC survey trawl net will survive.

Longline and Hook and Line Angling

During longline/hook and line operations, the NWFSC also employs monitoring and "move-on" protocols during operations. During pelagic longlines, gear configurations such as circle hooks and use of mackerel bait that have been demonstrated to reduce the interaction and mortality rates of sea turtles caught in pelagic longline gear are used during some surveys, although sometimes J hooks and/or market squid are still used for some surveys. Soak times are relatively short for most surveys (~3 hours for all pelagic longline surveys), compared to standard commercial longline fishery operations where soak times may be 8-12 hours or more. Given that only one sea turtle interaction with SWFSC longline gear has been documented, and no interactions have been documented for any longline/hook and line gear used by NWFSC, the possibility of encounter and subsequent hooking or entanglement remains very small. The fact that the SWFSC did take only one sea turtle during the last 5 years of research surveys provides some evidence that we cannot discount the possibility that NWFSC longline/hook and line surveys in the CCRA could result in the take a sea turtle. We do not expect regular interactions each survey year, but expect that a rare event similar to what was described above for survey trawls, could occur any year where the NWFSC conducts longline/hook and line surveys.

The relative chances that any particular capture or entanglement would involve any particular species of sea turtle is difficult to characterize given the limited amount of information that is available on the specific location of future NWFSC research and the vast proposed action area. In Hawaii fisheries, interaction with loggerheads and leatherbacks are more likely than olive ridleys or greens, although in the CCRA green turtles are known to be residents in the Southern California Bight and the most common sea turtle species that is documented stranded in coastal waters.

Incidental capture or entanglement in longline/hook and line gear can lead directly to mortality, typically associated with drowning, or to subsequent mortality resulting from injuries sustained (see Ryder *et al.* 2006 for information of post-hooking mortality estimates). For the hard shelled turtles and leatherbacks, expected mortality rates are relatively low (19% and 22% respectively) in shallow-set longline gear. This is due largely to the ability of sea turtles to reach the surface after most hooking/entangling events in shallow-set gear. Recent gear modifications including use of circle hooks and increased awareness of proper handling and release also contribute to minimizing the extent of injuries for turtles caught in Hawaii longline fisheries. In deep-set gear, mortality rates are typically expected to be much higher for hard shelled turtles (70%-95%), mostly because the gear (and specifically the hook/gangion) is set too deep to allow for turtles to reach the surface if hooked or entangled. Leatherback mortality rates in deep-set gear are expected to only be slightly higher than in shallow-set gear (36%). Leatherback turtles are more commonly observed entangled in various other portions of the gear such as floatlines, branchlines, and main lines, and not necessarily hooked at deep depths. Also, leatherback turtles have the strength necessary to carry substantial segments of attached gear to the surface where they can breathe until the gear can be retrieved or removed, which significantly increases the chance for survival.

As discussed previously, the distinctions between NWFSC research longline/hook and line gear and commercial gear are also important to consider in terms of assessing potential response of sea turtles captured/entangled in NWFSC longline gear. Although deep-set longlines are part of the proposed action, shallow-set longlines are the most likely source of turtle interactions during NWFSC research activities. Instead of extended soak times of 8 or more hours that are associated with commercial longline fisheries, soak times are expected to be only ~3 hours in shallow-set longline surveys. This should reduce the potential for drowning or other significant injuries to some degree by ensuring more rapid response to a captured/entangled sea turtle than in normal commercial fishing settings. Due to the limited historical sea turtle bycatch in NWFSC longline/hook and line surveys, it is not possible to quantify the potential difference in mortality rates for sea turtles caught in survey gear compared to commercial fisheries, considering all these factors. However, we conclude that direct mortality rates are likely to be reduced due to minimized soak times and the nature of survey operations.

We note that the one green turtle that was captured was released alive in a SWFSC survey with very minimal apparent injuries. However, there is still a chance that any sea turtle could sustain injuries that would make it likely to die, based on the Ryder *et al.* (2006) criteria (injury classified as 50% or more likely to lead to mortality). While some NWFSC research surveys incorporate circle hooks, which have been shown to minimize the extent of injuries such as ingestion of hooks for some species (see Read 2007 for review), not all NWFSC surveys do so because of target catch performance. Given the available information and the difficulty in relating NWFSC research operations specifically to commercial fishing, we cannot quantify the likelihood of a significant injury for any single turtle capture/entanglement event in NWFSC longline/hook and line research, which is already difficult to predict given the limited previous interactions between sea turtles and NWFSC longline/hook and line gear. However, during NWFSC research, we expect any sea turtle (or marine mammal) interaction to receive full attention and priority handling to minimize the extent of injuries or gear that may remain attached to animals released at all times. Based on the general expectations of relatively low mortality rates for sea turtles captured in shallow-set longline gear, which is far more likely to interact with sea turtles than deep-set gear, it is most likely that any turtle captured/entangled would not be killed or receive significant injuries. As a result, we expect that any sea turtle that may be captured in NWFSC longline/hook and line survey gear will survive.

Handling and Sampling

As described in section 1.3.4.2, the handling of any live sea turtles once captured, includes the standard methods consistent with the protocol required for safe sea turtle handling in 50 CFR 223.206(d)(1). If practicable, the NWFSC intends to conduct basic biological data collection and sampling. NMFS routinely authorizes biological sampling of sea turtles captured in directed research that includes tissue sampling, as well as more invasive sampling techniques. Based on the described methods of cleansing and disinfection, infection of the tissue biopsy site would not be expected. At most, we expect turtles would experience brief, minimal discomfort during the process. It is not expected that individual turtles would experience more than short-term stress during tissue sampling. Researchers who examined turtles caught two to three weeks after sample collection noted the sample collection site was almost completely healed. During a more than 5-year period of tissue biopsying using sterile techniques, NMFS researchers encountered no infections or mortality resulting from this procedure (NMFS 2006c). Bjorndal *et al.* (2010) investigated the effects of repeated skin, blood and scute sampling on juvenile loggerhead growth. Turtles were sampled for each tissue type three times over a 120-day period. The researchers found that repeated sampling had no effect on growth rates; growth rates of sampled turtles were not significantly different from control animals. Turtles exhibited rapid healing at the sampling site with no infection or scarring. Further, all turtles increased in body mass during the study indicating that sampling did not have a negative impact on growth or weight gain. The researchers concluded that the sampling did not adversely impact turtle physiology or health (Bjorndal *et al.* 2010). Consequently, we believe the impact of collecting tissue samples is minor and will not have any significant effect on any species of sea turtle that may be captured or entangled in NWFSC research gear. The wounds caused by biological sampling (skin, tissue plug and/or subcutaneous fat) would be expected to heal in a few days. In the unlikely event that any sea turtle is killed, we expect the NWFSC will be able to salvage the dead animal or collect parts for return to the SWFSC for further investigation under authorities provided in sections 50 CFR 222.310 and 50 CFR 223.206.

Capture or Entanglement Summary

Given the vast project action area and the wide distribution of all these sea turtles throughout the area, and the limited information that reliably predicts sea turtle interaction rates by species in NWFSC research surveys, we conclude that the probability of any turtle interaction with NWFSC longline research is relatively equal, and that the very rare occurrence of one sea turtle capture during the course of any year could be any of the four species discussed in this Opinion.

In summary, we expect that: (1) up to one sea turtle may be captured by or entangled in NWFSC research gear during any year; (2) this turtle will be released alive and is expected to survive; and (3) this turtle may be from any of the four species discussed in this Opinion.

Vessel Collision

Collisions of ships and marine animals can cause major wounds, which may lead to the death of the animal. An animal at the surface could be struck directly by a vessel, a surfacing animal could hit the bottom of a vessel, or an animal just below the surface could be cut by a vessel's propeller. The severity of injuries typically depends on the size and speed of the vessel (Knowlton and Kraus 2001; Laist *et al.* 2001; Vanderlaan and Taggart 2007).

Collisions between NWFSC research vessels and sea turtles are possible since turtles must come to the surface to breathe, and may spend time resting or foraging near the surface. Along the U.S. West Coast, strandings believed to be associated with vessel strikes are one of the most common sources of sea turtle strandings (R. LeRoux, NMFS SWFSC, unpublished data; Figure 1). Whether these strikes are associated more commonly with larger vessels more similar to NWFSC research vessels, or smaller vessels used for recreation or other purposes, is unknown. To date, the NWFSC has not reported any incidents of sea turtle vessel strikes during their research cruises, although it is possible that vessel strikes with sea turtles could occur undetected. During all research cruises, the NWFSC maintains constant watch and will slow down or take evasive maneuvers to avoid collisions with marine species such as sea turtles and marine mammals (see section 2.12 for analysis of marine mammal collisions). The officer on watch, Chief Scientist (or other designated member of the Scientific Party), and crew standing watch on the bridge visually scan for marine mammals, sea turtles, and other ESA-listed species (protected species) during all daytime operations. Bridge binoculars (7X) are used as necessary to survey the area as far as environmental conditions (lighting, sea state, precipitation, fog, etc.) will allow. NWFSC research vessels operational speed is typically relatively slow; 4 knots or less during operations and approximately 10 knots while cruising under transit. At any time during a survey or in transit, any crew member that sights any protected species that may intersect with the vessel course immediately communicates their presence to the bridge for appropriate course alteration or speed reduction as possible to avoid incidental collisions. Consequently, if a sea turtle is observed, NWFSC research vessels will slow down or otherwise take evasive action to avoid collisions. Given the lack of any historical information suggesting NWFSC research vessels present any particular risk of sea turtle strikes and efforts to avoid turtles while conducting research or in transit, the risks of vessel collisions for sea turtles during NWFSC research activities are remote.

Acoustic Disturbance

Unlike for marine mammals, NMFS has yet to establish specific noise criteria for sea turtles exposure to underwater sound relative to potential injury or temporary loss of hearing. While the number of published studies on the impacts of sound on sea turtles is small, the available data does suggest that sea turtles have better hearing at low frequencies (≤ 1000 Hz) (Ridgeway *et al.* 1969; Lenhardt 1994; Bartol and Ketten 2003; Martin *et al.* 2012). As a result, active acoustic sources used by the NWFSC during research activity are not expected to be detectable by any species of sea turtles, and no effects from high frequency sound use are anticipated (see Section 10 of Appendix A of the Final SPEA (NWFSC 2023b) for details on the frequencies of NWFSC active acoustics, which are in generally in excess of 20 kHz). Given the relative low frequencies of vessel noise, it is likely that sea turtles can detect the presence of passing vessels, which produce low frequency sounds (see section 2.12 for more information). However, we do not expect any discernable effects from a short duration exposure to a vessel in transit or temporarily located in an area for only a matter of hours at most.

Prey Reduction

The specific diets of sea turtles do vary by species and life stage, although jellyfish and other invertebrates may be significant sources of food during pelagic life stages, especially for leatherbacks. The potential for impacts due to removal of these prey items is discussed in detail in the Section 2.5.1 analysis of leatherback critical habitat, for which the occurrence of jellyfish prey species of sufficient condition, distribution, diversity, abundance and density is a PCE. While the other turtle species do not have a similar critical habitat prey element, the potential for impacts due to prey removal are anticipated to be similar for all turtle species in the action area. That is, the total amount of these prey species taken in research surveys is very small relative to their overall biomass in the action area, and surveys that remove jellyfish are spread out systematically over large areas, such that prey removals are not concentrated during any place or time in a manner that is expected to affect foraging for any listed turtles in a discernible manner.

Species-Level Effects

We expect adverse effects on ESA-listed turtles from incidental capture or entanglement in research survey gear as a result of NWFSC research activities. Given the spatial extent of proposed activities, it is possible that multiple populations of a given species may be adversely affected.

For completeness, here we consider the specific populations that are likely impacted by the proposed action. For leatherback sea turtles, any turtle that may be captured or entangled in the CCRA would most likely belong to the western Pacific population, particularly leatherbacks from Jamursba-Medi, based on the known migratory patterns discussed in section 2.2. For loggerhead sea turtles, any individual that may be captured or entangled in the CCRA is expected to be from the North Pacific DPS originating from Japan, based on tracking information discussed in section 2.2. For olive ridley sea turtles, any individual that may be captured or entangled in NWFSC research gear in the CCRA will be from the eastern Pacific population, and may well be from the endangered Mexico nesting beach origin. For green sea turtles, any individual that may be captured or entangled in NWFSC research gear is expected be from the East Pacific DPS. There is not enough information available to assess exactly which individuals from these populations are at most risk to interactions with NWFSC research gear, so we assume that any turtle could be an adult or juvenile, and a male or female. Generally, we assume that adult females are the most important members of sea turtle populations for the purposes of assessing reproductive output potential.

While capture or entanglement during NWFSC research is considered "take" under the definition and regulatory standards of the ESA, even for animals that ultimately survive the encounter, the nature of incidents where no mortality or other significant effect to potential successful reproduction occurs poses no risks to populations or species. In this Opinion, we want to acknowledge concern about risks of post-release mortality for any turtle that is released alive, particularly after being injured in longline gear. Following the Ryder *et al.* (2006) criteria, we have considered only the likelihood of post-release mortality following any single capture/entanglement event. If the NWFSC were to demonstrate a pattern of multiple sea turtle captures/entanglements over any 5-year rolling period, we will evaluate the relative likelihood that a post-release mortality has occurred over all the interactions. If we determine it is likely that over time there has been at least one mortality that can be attributed to NWFSC research interactions, then we will conclude that the NWFSC research has exceeded the take anticipated in this Opinion.

Marine and Anadromous Fish

Capture, Handling, and Sampling

The most common pathway by which research activities will impact ESA-listed fish species is through common fishery research activities such as collecting, handling, anesthetizing, marking, sampling, and tagging fish. The effects of anticipated research activities are described further below. However, we expect that the NWFSC research program may also include studies that use similar, modified, or new equipment, techniques, or procedures, which we expect to fall within the analysis of this Opinion as long as the impacts of those methods have equivalent or lesser effects on ESA-listed species as those described in this Opinion.

The specific oceanic distributions of salmonid ESUs listed under the ESA are not well understood outside the bounds of ocean fisheries catch and coded wire tag data. Generally, Chinook, coho, chum, sockeye, and steelhead salmon are known to be widely distributed throughout the northern Pacific. Based on the general life cycle of all salmon, it can be inferred that the likelihood of encountering any specific ESU increases in nearshore coastal waters during the time of year when adult fish are maturing and preparing to return to those origins of spawning, typically distinguished by run timing (e.g., spring or fall), or when juveniles have just recently entered the ocean to begin their maturation process.

Handling and Anesthesia

The primary effect of the proposed research on the listed species would be in the form of capturing and handling fish. Harassment caused by capturing, handling, and releasing fish generally leads to stress and other sub-lethal effects that are difficult to assess in terms of their impact on individuals, populations, and species (Sharpe *et al.* 1998). Handling of fish may cause stress, injury, or death, which typically are due to overdoses of anesthetic, differences in water temperatures between the river and holding buckets, depleted dissolved oxygen in holding buckets, holding fish out of the water, and physical trauma. Excessive air exposure causes gill lamellae to collapse, ceasing aerobic respiration and causing hypoxia. High water temperature can contribute to high mortality following air exposure (Patterson *et al.* 2017). Loss of protective mucus is a common injury during capture and handling which increases susceptibility to disease (Cook *et al.* 2019). Mucus contains antibacterial proteins, and its loss makes fish vulnerable to pathogens that may cause infections and latent mortality. Fish held at higher water temperature have a higher risk of infection post-sampling (Patterson *et al.* 2017). Stress on salmonids increases rapidly from handling if the water temperature exceeds 18ºC or dissolved oxygen is below saturation. Exhaustion from excess physical activity can result in death through acidosis or latent mortality due to the inability to recover from exhaustion. Fish that survive physiological imbalances caused during handling can lose equilibrium and have impaired swimming abilities, increasing their susceptibility to predation (Cook *et al.* 2019). Fish transferred to holding buckets can experience trauma if care is not taken in the transfer process, and fish can experience stress and injury from overcrowding in traps, nets, and buckets. Capture and handling stressors can combine to cause cumulative effects that greatly increase the likelihood of fish mortality. The permit conditions identified in Section 1.3 contain measures that mitigate factors that commonly lead to stress and trauma from handling, and thus minimize the harmful effects of capturing and handling fish. When these measures are followed, fish typically recover rapidly from handling.

Anesthetics are crucial for minimizing stress and immobilizing fish during handling, transport, blood sampling, PIT tagging, and tissue sampling. Commonly used fish anesthetics include Tricaine Methanesulfonate (MS-222), Clove oil, Benzocaine, and 2-Phyenoxyethanol. These are typically administered through immersion, where fish absorb the anesthetic through their gills. Anesthetics depress the central and peripheral nervous system, resulting in a state of sedation during which the fish is rendered unconscious, minimizing changes to biochemical stress indicators including plasma cortisol, glucose, and lactate (Martins *et al.* 2018). Stress responses in fish need to be minimized since they have negative physiological effects that can compromise growth, reproduction, and immunity (Souza *et al.* 2019). Immersion anesthetics typically have higher efficacy in warmer water temperatures and lower efficacy in water with low pH value (Neiffer & Stamper 2009, Priborski & Velisek 2018). Higher doses are associated with quicker induction and longer recovery. Fish anesthetics can alter fish plasma biochemical indices, hematological profile, oxidative stress biomarkers, and antioxidant enzymes (Priborski & Velisek 2018). When chemical anesthetics are first administered, fish can experience a phase of intense excitement and agitation as their inhibitory neurons become depressed before full anesthesia is achieved (Young *et al.* 2019, Souza *et al.* 2019). Exposure to high levels of anesthetics can thus induce stress (Young *et al.* 2019), and anesthetic overdoses can be fatal.

Tricaine Methanesulfonate (MS-222) is a widely used anesthetic in fish research, and the only fish anesthetic approved by the FDA for use in fish that people may consume —this includes

ESA-listed fish that may be harvested. MS-222 requires personal protective equipment during handling and must be mixed with a buffering agent since it reduces water pH (Neiffer & Stamper 2009, Martins *et al.* 2018). During surgery an anesthetic maintenance dose is required to maintain stage 4 anesthesia (Carter *et al.* 2010). MS-222 can cause several side effects, including compromising a fish's antioxidant defenses, increasing cortisol (which reduces oxygen uptake), and reducing blood flow through the gills (Teles *et al.* 2019). Long-term effects of MS-222 exposure are not adequately known, and ease of accidental overdose from MS-222 is a concern (Carter *et al.* 2010).

Capture via Seines, Traps, and Hand/Dip Nets

Seines, traps, and hand or dip net methods are generally used to obtain information on fish distribution and abundance, habitat use, life history, and outmigration timing, and are often used to capture fish for further data collection procedures such as tagging, sampling, or gastric lavage. Beach seines and small traps (such as minnow traps, or similar) are used to collect juvenile fish in shallow-water habitats. Boat seines (such as purse seines) and large traps (such as fyke traps, or similar) are used to collect or observe adults. Nets can injure fish by removing protective mucus and tearing gills (Patterson *et al.* 2017). Wearing gloves during handling and using soft rubber or knotless nets minimizes damage to fish gills, scales, and mucus. In general, handling should be conducted with soft, smooth, and pre-wetted gear. Based on years of sampling at hundreds of locations under hundreds of scientific research authorizations, we would expect the mortality rates for fish captured by seines, traps, or hand/dip nets to be three percent or less.

Electrofishing

Electrofishing is a process by which an electrical current is passed through water containing fish to stun them, which makes them easy to capture. High voltage current is passed between an anode and a cathode, which induces muscular convulsions (galvanotaxis) in fish when they encounter a high enough voltage gradient between the electrodes. Electrofishing can have several short-term effects, including stress, fatigue, reduced feeding, and susceptibility to predation (NMFS 2000). Electrofishing can also cause physical injuries such as internal hemorrhaging and spinal injuries, which are caused by galvanotaxis. Mortality from electrofishing is typically due to respiratory failure or asphyxiation (Snyder 2003). The extent to which sampled fish are affected depends on the electrofishing waveform, pulse frequency, fish age and size, number of exposures, and operator skill (Panek & Densmore 2011, Simpson *et al.* 2016, Chiaramonte 2020, Pottier & Marchand 2020). Research indicates that using continuous direct current (DC) or low-frequency (30 Hz) pulsed DC waveforms (PDC) produce lower spinal injury rates, particularly for salmonids (Holliman *et al.* 2010, Pottier & Marchand 2020, Clancy *et al.* 2021). Higher frequencies generally result in better catch efficiency albeit with higher rates of injury (Chiaramonte *et al.* 2020).

Adult salmonids are particularly susceptible to spinal injuries, as longer fish (> 300mm) are subjected to strong voltage gradients by the electrofishing anode (Pottier & Marchand 2020).

Spinal injuries to salmonids become increasingly detectable over time and are often not immediately apparent (Holliman *et al.* 2010). To avoid causing such injuries, we do not allow electrofishing to be used as a method for capturing adult salmonids. Though electrofishing crews do sometimes inadvertently encounter adults during their work, they must immediately turn off their equipment and allow the fish to swim away. Smaller, juvenile fish are subjected to lesser voltage gradients, but there is conflicting evidence about whether this results in lower rates of injury (Snyder 2003). Spawning female salmonids are also vulnerable, since electrofishing can reduce survival rates for eggs spawned from previously electroshocked females (Cho *et al.* 2002, Huysman *et al.* 2018). Salmon in early developmental stages, including embryos and alevin, are another vulnerable group for whom electrofishing should be avoided (Simpson *et al.* 2016). Electrofishing can also inflict harm on non-target species, particularly during multiple pass depletion surveys, during which non-target fish can be exposed to multiple electroshocks (Panek & Densmore 2011). Incidence of injuries for target fish and non-target bycatch alike increases with multiple exposures (Panek & Densmore 2013).

When using appropriate electrofishing protocols and equipment settings, shocked fish normally revive quickly. When done carefully, electrofishing of individual fish has been shown to not affect wild salmonid abundance (Clancy *et al.* 2021), and individual long-term survival is not usually compromised (Snyder 2003). However, individual growth may be stunted by electroshock exposure, resulting in abnormally low weight and small size (Thompson *et al.* 1997, Dwyer *et al.* 2001). The latent, sublethal, and population level impacts of electrofishing are areas that are not well understood, and in which further research is recommended.

Permit conditions would require that all researchers follow NMFS' electrofishing guidelines (NMFS 2000). The guidelines require that field crews:

- Use electrofishing only when other survey methods are not feasible.

- Be trained by qualified personnel in equipment handling, settings, maintenance to ensure proper operating condition, and safety.

- Conduct visual searches prior to electrofishing on each date and avoid electrofishing near adults or redds. If an adult or a redd is detected, researchers must stop electrofishing at the research site and conduct careful reconnaissance surveys prior to electrofishing at additional sites.

- Test water conductivity and keep voltage, pulse width, and rate at minimal effective levels. Use only DC waveforms.

- Work in teams of two or more technicians to increase both the number of fish seen at one time and the ability to identify larger fish without having to net them. Working in teams allows netter(s) to remove fish quickly from the electrical field and to net fish farther from the anode, where the risk of injury is lower.

- Observe fish for signs of stress and adjust electrofishing equipment to minimize stress.

- Provide immediate and adequate care to any fish that does not revive immediately upon removal from the electrical current.

The preceding discussion focused on the effects backpack electrofishing and the ways those effects would be mitigated. In larger streams and rivers, electrofishing units are sometimes mounted on boats or rafts. These units often use more current than backpack electrofishing equipment because they need to cover larger and deeper areas. The environmental conditions in larger, more turbid streams can limit researchers' ability to minimize impacts on fish. As a result, boat electrofishing can have a greater impact on fish. Researchers conducting boat electrofishing must follow NMFS' electrofishing guidelines.

Gastric Lavage

Knowledge of the food and feeding habits of fish are important in the study of aquatic ecosystems. However, in the past, food habit studies required researchers to kill fish for stomach removal and examination. Consequently, several methods have been developed to remove stomach contents without injuring the fish. Most techniques use a rigid or semi-rigid tube to inject water into the stomach to flush out the contents.

Few assessments have been conducted regarding the mortality rates associated with nonlethal methods of examining fish stomach contents (Kamler and Pope 2001). However, Strange and Kennedy (1981) assessed the survival of salmonids subjected to stomach flushing and found no difference between stomach-flushed fish and control fish that were held for three to five days. In addition, when Light *et al.* (1983) flushed the stomachs of electrofished and anesthetized brook trout, survival was 100 percent for the entire observation period. In contrast, Meehan and Miller (1978) determined the survival rate of electrofished, anesthetized, and stomach-flushed wild and hatchery coho salmon over a 30-day period to be 87 percent and 84 percent respectively.

Hook and Line/Angling

Fish caught with hook and line and released alive may still die due to injuries and stress they experience during capture and handling. Angling-related mortality rates vary depending on the type of hook (barbed vs barbless), the type of bait (natural vs artificial), water temperature, anatomical hooking location, species, and the care with which fish are handled and released (level of air exposure and length of time for hook removal).

The available information assessing hook and release mortality of adult steelhead suggests that hook and release mortality with barbless hooks and artificial bait is low. Nelson *et al.* (2005) reported an average mortality of 3.6% for adult steelhead that were captured using barbless hooks and radio tagged in the Chilliwack River, BC. The authors also note that there was likely some tag loss and the actual mortality might be lower. Hooton (1987) found catch and release mortality of adult winter steelhead to average 3.4% (127 mortalities of 3,715 steelhead caught) when using barbed and barbless hooks, bait, and artificial lures. Among 336 steelhead captured on various combinations of popular terminal gear in the Keogh River, the mortality of the combined sample was 5.1%. Natural bait had slightly higher mortality (5.6%) than did artificial lures (3.8%), and barbed hooks (7.3%) had higher mortality than barbless hooks (2.9%). Hooton (1987) concluded that catching and releasing adult steelhead was an effective mechanism for maintaining angling opportunity without negatively affecting stock recruitment. Reingold (1975) showed that adult steelhead hooked, played to exhaustion, and then released returned to their target spawning stream at the same rate as steelhead not hooked and played to exhaustion. Pettit (1977) found that egg viability of hatchery steelhead was not negatively affected by catch-and-release of pre-spawning adult female steelhead. Bruesewitz (1995) found, on average, fewer than 13% of harvested summer and winter steelhead in Washington streams were hooked in critical areas (tongue, esophagus, gills, eye). The highest percentage (17.8%) of critical area hookings occurred when using bait and treble hooks in winter steelhead fisheries.

The referenced studies were conducted when water temperatures were relatively cool, and primarily involve winter-run steelhead. Catch and release mortality of steelhead is likely to be higher if the activity occurs during warm water conditions. In a study conducted on the catch and release mortality of steelhead in a California river, Taylor and Barnhart (1999) reported over 80% of the observed mortalities occurred at stream temperatures greater than 21 degrees C. Catch and release mortality during periods of elevated water temperature are likely to result in post-release mortality rates greater than reported by Nelson *et al.* (2005) or Hooton (1987) because of warmer water and that fact that summer fish have an extended freshwater residence that makes them more likely to be caught.

Juvenile steelhead occupy many waters that are also occupied by resident trout species and it is not possible to visually separate juvenile steelhead from similarly-sized, stream-resident, rainbow trout. Because juvenile steelhead and stream-resident rainbow trout are the same species, are similar in size, and have the same food habits and habitat preferences, it is reasonable to assume that catch-and-release mortality studies on stream-resident trout are similar for juvenile steelhead. Where angling for trout is permitted, catch-and-release fishing with prohibition of use of bait reduces juvenile steelhead mortality more than any other angling regulatory change. Artificial lures or flies tend to superficially hook fish, allowing expedited hook removal with minimal opportunity for damage to vital organs or tissue (Muoneke and Childress, 1994). Many studies have shown trout mortality to be higher when using bait than when angling with artificial lures and/or flies (Taylor and White 1992; Schill and Scarpella 1995; Muoneke and Childress 1994; Mongillo 1984; Wydoski 1977; Schisler and Bergersen 1996). Wydoski (1977) showed the average mortality of trout, when using bait, to be more than four times greater than the mortality associated with using artificial lures and flies. Taylor and White (1992) showed average mortality of trout to be 31.4% when using bait versus 4.9 and 3.8% for lures and flies, respectively. Schisler and Bergersen (1996) reported average mortality of trout caught on passively fished bait to be higher (32%) than mortality from actively fished bait (21%). Mortality of fish caught on artificial flies was only 3.9%. In the compendium of studies reviewed by Mongillo (1984), mortality of trout caught and released using artificial lures and single barbless hooks was often reported at less than 2%.

Most studies have found a notable difference in the mortality of fish associated with using barbed versus barbless hooks (Huhn and Arlinghaus 2011; Bartholomew and Bohnsack 2005;

Taylor and White 1992; Mongillo 1984; Wydoski 1977). Researchers have generally concluded that barbless hooks result in less tissue damage, they are easier to remove, and because they are easier to remove the handling time is shorter. In summary, catch-and-release mortality of steelhead is generally lowest when researchers are restricted to use of artificial flies and lures. As a result, all sampling via angling must be carried out using barbless artificial flies and lures when practicable (as described in the proposed action) and is expected to result in lower hooking injury and mortality that would otherwise occur.

Only a few reports are available that provide empirical evidence showing what the catch and release mortality is for Chinook salmon in freshwater. The ODFW has conducted studies of hooking mortality incidental to the recreational fishery for Chinook salmon in the Willamette River. A study of the recreational fishery estimates a per-capture hook-and-release mortality for wild spring Chinook salmon in Willamette River fisheries of 8.6% (Schroeder *et al.* 2000), which is similar to a mortality of 7.6% reported by Bendock and Alexandersdottir (1993) in the Kenai River, Alaska.

A second study on hooking mortality in the Willamette River, Oregon, involved a carefully controlled experimental fishery, and mortality was estimated at 12.2% (Lindsay *et al.* 2004). In hooking mortality studies, hooking location, gear type, and unhook time is important in determining the mortality of released fish. Fish hooked in the jaw or tongue suffered lower mortality (2.3 and 17.8% in Lindsay *et al.* (2004)) compared to fish hooked in the gills or esophagus (81.6 and 67.3%). Numerous studies have reported that deep hooking is more likely to result from using bait (e.g. eggs, prawns, or ghost shrimp) than lures (Lindsay *et al.* 2004). One theory is that bait tends to be passively fished and the fish is more likely to swallow bait than a lure. Passive angling techniques (e.g. drift fishing) are often associated with higher hooking mortality rates for salmon while active angling techniques (e.g. trolling) are often associated with lower hooking mortality rates (Cox-Rogers *et al.* 1999).

Catch and release fishing does not seem to have an effect on migration. Lindsay *et al.* (2004) noted that “hooked fish were recaptured at various sites at about the same frequency as control fish.” Bendock and Alexandersdottir (1993) found that most of their tagged fish later turned up on the spawning grounds. Cowen *et al.* (2007) found little evidence of an adverse effect on spawning success for Chinook salmon.

Not all of the fish that are hooked are subsequently landed. We were unable to find any studies that measured the effect of hooking and losing a fish. However, it is reasonable to assume that nonlanded morality would be negligible, as fish lost off the hook are unlikely to be deeply hooked and would have little or no wound and bleeding (Cowen *et al.* 2007).

Based on the available data, the *U.S. v. Oregon* Technical Advisory Committee has adopted a 10% rate in order to make conservative estimates of incidental mortality in fisheries (TAC 2008). Nonetheless, given the fact that no ESA Section 10 permit or 4(d) authorization may “operate to the disadvantage of the species,” we authorize no more than a three percent mortality rate for any listed species collected via angling, and all such activities must employ barbless artificial lures and flies whenever feasible as described in the proposed action.

Observation

For some parts of the proposed studies, listed fish would be observed but not captured (e.g., by snorkel surveys or from the banks). Observation without handling is the least disruptive method for determining a species' presence/absence and estimating their relative numbers. Its effects are also generally the shortest-lived and least harmful of the research activities discussed in this section because a cautious observer can effectively obtain data while only slightly disrupting the fishes' behavior. Fry and juveniles frightened by the turbulence and sound created by observers are likely to seek temporary refuge in deeper water or behind or under rocks or vegetation. In extreme cases, some individuals may leave a particular pool or habitat type and then return when observers leave the area. At times, the research involves observing adult fish—which are more sensitive to disturbance. During some of the research activities discussed below, redds may be visually inspected, but per NMFS' pre-established mitigation measures (included in state fisheries agency submittals), would not be walked on. Only in the rarest cases would any take be associated with these observation activities, and that would be in the form of harassment. No injuries and no deaths would be expected to occur—particularly in cases where the researchers observe from the stream banks rather than in the water. Because these effects are so small, there is little a researcher can do to mitigate them except to avoid disturbing sediments, gravels, and, to the extent possible, the fish themselves, and allow any disturbed fish the time they need to reach cover.

Sacrifice (Intentionally Killing)

In some instances, it is necessary to kill a captured fish in order to gather whatever data a study is designed to produce. In such cases, determining effect is a very straightforward process: the sacrificed fish, if they are juveniles, are forever removed from the gene pool and the effect of their deaths is weighed in the context that the effect on their listed unit and, where possible, their local population. If the fish are adults, the effect depends upon whether they are killed before or after they have a chance to spawn. If they are killed before they spawn, not only are they removed from the population, but so are all their potential progeny. Thus, killing pre-spawned adults has the greatest potential to affect the listed species. Because of this, NMFS only very rarely allows pre-spawned adults to be sacrificed. As a general rule, adult salmon and steelhead are not sacrificed for research and monitoring purposes, although the need to monitor fish tissue contaminant concentrations from species that could be recreationally harvested may require a very small number of adults to be sacrificed on occasion. In such cases, listed species would only be used if sampling unlisted adult salmon or steelhead could not provide equivalent data, and would be limited to the greatest extent possible.

Screw trapping

Smolt, rotary screw (and other out-migration) traps, are generally used to obtain information on natural population abundance and productivity. On average, they achieve a sample efficiency of four to 20% of the emigrating population from a river or stream—depending on river size. Although under some conditions traps may achieve a higher efficiency for a relatively short period of time. Based on years of sampling at hundreds of locations under hundreds of scientific research authorizations, we would expect the mortality rates for fish captured at rotary screw type traps to be one percent or less.

The potential for unexpected injuries or mortalities among listed fish is reduced in a number of ways. These can be found in the individual study protocols and in the permit conditions stated earlier. In general, screw traps are checked at least daily and usually fish are handled in the morning. This ensures that the water temperature is at its daily minimum when fish are handled. Also, fish may not be handled if the water temperature exceeds 69.8 degrees Fahrenheit (21 degrees C). Great care must be taken when transferring fish from the trap to holding areas and the most benign methods available are used—often this means using sanctuary nets when transferring fish to holding containers to avoid potential injuries. The investigators' hands must be wet before and during fish handling. Appropriate anesthetics must be used to calm fish subjected to collection of biological data. Captured fish must be allowed to fully recover before being released back into the stream and will be released only in slow water areas. And often, several other stringent criteria are applied on a case-by case basis: safety protocols vary by river velocity and trap placement, the number of times the traps are checked varies by water and air temperatures, the number of people working at a given site varies by the number of outmigrants expected, etc. All of these protocols and more are used to make sure the mortality rates stay at one percent or lower.

Tangle Netting

Tangle nets are similar to gillnets, having a top net with floats and a bottom net with weights, but tangle nets have smaller mesh sizes than gill nets. Tangle nets are designed to capture fish by the snout or jaw, rather than the gills. Researchers must select the mesh size carefully depending on their target species, since a tangle net may act as a gill net for fish that are smaller than the target size.

Tangle nets can efficiently capture salmonids in large rivers and estuaries, and have been used successfully for the lower Columbia River spring Chinook salmon commercial fishery (Ashbrook *et al.* 2005, Vander Haegen *et al.* 2004). However, fish may be injured or die if they become physiologically exhausted in the net or if they sustain injuries such as abrasion or fin damage. Entanglement in nets can damage the protective slime layer, making fish more susceptible to infections. These injuries can result in immediate or delayed mortality. Vander Haegen *et al.* (2005) reported that spring Chinook salmon had lower delayed mortality rates when captured in tangle nets (92% survival) versus gill nets (50% survival), relative to a control group. Vander Haegen *et al.* (2005) emphasized that, to minimize both immediate and delayed mortality, researchers must employ best practices including using short nets with short soak times, and removing fish from the net carefully and promptly after capture. As with other types of capture, fish stress increases rapidly if the water temperature exceeds 18 ºC or dissolved oxygen is below saturation.

Tagging/Marking

Techniques such as Passive Integrated Transponder (PIT) tagging, coded wire tagging, fin-clipping, and the use of radio transmitters are common to many scientific research efforts using listed species. All sampling, handling, and tagging procedures have an inherent potential to stress, injure, or even kill the marked fish. This section discusses each of the marking processes and its associated risks.

A PIT tag is an electronic device that relays signals to a radio receiver; it allows salmonids to be identified whenever they pass a location containing such a receiver (e.g., any of several dams) without researchers having to handle the fish again. The tag is inserted into the body cavity of the fish just in front of the pelvic girdle. The tagging procedure requires that the fish be captured and extensively handled; therefore, any researchers engaged in such activities will follow the conditions listed previously in this Opinion as part of the proposed action (as well as any permit-specific conditions) to ensure that the operations take place in the safest possible manner. In general, the tagging operations will take place where there is cold water of high quality, a carefully controlled environment for administering anesthesia, sanitary conditions, quality control checking, and a carefully regulated holding environment where the fish can be allowed to recover from the operation.

PIT tags have very little effect on growth, mortality, or behavior. The few reported studies of PIT tags have shown no effect on growth or survival (Prentice *et al.* 1987; Jenkins and Smith 1990; Prentice *et al.* 1990). For example, in a study between the tailraces of Lower Granite and McNary Dams (225 km), Hockersmith *et al.* (2000) concluded that the performance of yearling Chinook salmon was not adversely affected by gastrically- or surgically implanted sham radio tags or PIT-tags. Additional studies have shown that growth rates among PIT-tagged Snake River juvenile fall Chinook salmon in 1992 (Rondorf and Miller 1994) were similar to growth rates for salmon that were not tagged (Conner *et al.* 2001). Prentice and Park (1984) also found that PIT-tagging did not substantially affect survival in juvenile salmonids.

Coded wire tags (CWTs) are made of magnetized, stainless-steel wire. They bear distinctive notches that can be coded for such data as species, brood year, hatchery of origin, and so forth (Nielsen 1992). The tags are intended to remain within the animal indefinitely, consequently making them ideal for long-term, population-level assessments of Pacific Northwest salmon. The tag is injected into the nasal cartilage of a salmon and therefore causes little direct tissue damage (Bergman *et al.* 1968; Bordner *et al.* 1990). The conditions under which CWTs may be inserted are similar to those required for applying PIT-tags.

A major advantage to using CWTs is the fact that they have a negligible effect on the biological condition or response of tagged salmon; however, if the tag is placed too deeply in the snout of a fish, it may kill the fish, reduce its growth, or damage olfactory tissue (Fletcher *et al.* 1987; Peltz and Miller 1990). This latter effect can create problems for species like salmon because they use olfactory clues to guide their spawning migrations (Morrison and Zajac 1987).

In order for researchers to be able to determine later (after the initial tagging) which fish possess CWTs, it is necessary to mark the fish externally—usually by clipping the adipose fin—when the CWT is implanted (see text below for information on fin clipping). One major disadvantage to recovering data from CWTs is that the fish must be killed in order for the tag to be removed. However, this is not a significant problem because researchers generally recover CWTs from salmon that have been taken during the course of commercial and recreational harvest (and are therefore already dead).

Tissue Sampling

Tissue sampling techniques such as fin-clipping are common to many scientific research efforts using listed species. All sampling, handling, and clipping procedures have an inherent potential to stress, injure, or even kill the fish. This section discusses tissue sampling processes and its associated risks.

Fin clipping is the process of removing part or all of one or more fins to obtain non-lethal tissue samples and alter a fish's appearance (and thus make it identifiable). When entire fins are removed, it is expected that they will never grow back. Alternatively, a permanent mark can be made when only a part of the fin is removed or the end of a fin or a few fin rays are clipped. Although researchers have used all fins for marking at one time or another, the current preference is to clip the adipose, pelvic, or pectoral fins. Marks can also be made by punching holes or cutting notches in fins, severing individual fin rays (Welch and Mills 1981), or removing single prominent fin rays (Kohlhorst 1979). Many studies have examined the effects of fin clips on fish growth, survival, and behavior. The results of these studies are somewhat varied; however, it can be said that fin clips do not generally alter fish growth. Studies comparing the growth of clipped and unclipped fish generally have shown no differences between them (e.g., Brynildson and Brynildson 1967). Moreover, wounds caused by fin clipping usually heal quickly—especially those caused by partial clips.

Mortality among fin-clipped fish is also variable. Some immediate mortality may occur during the marking process, especially if fish have been handled extensively for other purposes (e.g., stomach sampling). Delayed mortality depends, at least in part, on fish size; small fishes have often been found to be susceptible to it and Coble (1967) suggested that fish shorter than 90 mm are at particular risk. The degree of mortality among individual fishes also depends on which fin is clipped. Studies show that adipose- and pelvic-fin-clipped coho salmon fingerlings have a 100% recovery rate (Stolte 1973). Recovery rates are generally recognized as being higher for adipose- and pelvic-fin-clipped fish in comparison to those that are clipped on the pectoral, dorsal, and anal fins (Nicola and Cordone 1973). Clipping the adipose and pelvic fins probably kills fewer fish because these fins are not as important as other fins for movement or balance (McNeil and Crossman 1979). Mortality is generally higher when the major median and pectoral fins are clipped. Mears and Hatch (1976) showed that clipping more than one fin may increase delayed mortality, but other studies have been less conclusive.

Trawls

Trawls are cone-shaped, mesh nets that are towed, often along benthic habitat (Hayes *et al.* 1996) but also in surface and mid-water column or demersal depths, depending on the target species. Rectangular doors or other supports, attached to the towing cables, keep the mouth of the trawl open. Most trawls are towed behind a boat, although some can be operated by hand. There are various types of trawls that include modified components or alternate configurations with similar components, and such variations of equipment are all included in this category because they would be expected to have similar anticipated impacts to listed fish species.

As fish enter a trawl, they may interact with the mesh itself, and also tire and fall to the codend of the trawl. Fish caught in trawls are susceptible to descaling, crushing (by debris or other fish caught in the net), and trawl net-related injuries, and are expected to die at a high percentage from these injuries. Depending on mesh size, some small fish (including juvenile salmonids, juvenile rockfish, and eulachon) are able to escape the trawl through the netting. However, not all fish that escape the trawl are uninjured, as fish may be damaged while passing through the netting. Midwater trawling may be less likely to capture heavy debris loads than benthic or demersal trawl sampling. In addition, shorter duration trawl hauls (5 to 10 minutes maximum) may reduce injuries (Stickney 1983, Hayes *et al.* 1996).

Mortality and injury rates associated with trawls can be high, particularly for small or fragile fish such as eulachon and juvenile salmonids or rockfish. However, based upon anecdotal reports and records from past SWFSC survey trawl operations, sub-adult salmon that have been incidentally captured are often alive when retrieved from the net and can be successfully returned to the water (NMFS 2008d). For fish released live, capture with trawl gear can still result in injuries and stress such as abrasions, internal crushing, loss of scales, and physical exhaustion. These injuries have the potential to lead to delayed mortality for bycatch discards as a result of the damage, or through impaired behavior leading to increased probability of predation (Davis 2002; Ryer 2004; Ryer *et al.* 2004). Little data currently exists that can accurately quantify the discard mortality of most species in any fishery or research trawl setting. Without any way to more accurately characterize the relative survival that could be expected during incidental capture at this time, we typically assume that mortality would occur for all salmonids captured in fishery trawl gear.

One possible exception to this assumption is trawl gear that includes commercial or experimental bycatch reduction devices (BRDs) intended to reduce the capture of non-target salmonids in commercial fisheries. During sampling with such devices, the majority of the salmonids captured in the trawl nets are expected to escape through the BRDs while in the water. However, there are still expected to be some salmonids that do not escape through the BRDs, and because of the injury and mortality causes described above the mortality rate is expected to be high for those individuals.

Green sturgeon, however, are expected to be impacted minimally by trawling activities. Prior analyses of the impacts of the Pacific Coast groundfish fishery on sDPS green sturgeon found that some mortalities may result from encounters with fishing gear, capture, or handling, but found that most green sturgeon observed in the groundfish bottom trawl fisheries are released alive and assumed only a 5.2% mortality rate for some sectors (NMFS 2012c). However, we currently have limited information on the mortality of green sturgeon after being caught, handled, and released. A study by Doukakis *et al.* (2020) of tagged sturgeon incidentally caught in the California halibut fishery estimated that post-release mortality ranged from 2% immediately following release to 26% at almost a month following release, indicating there could be substantial delayed mortality. However, as described below, fewer than 20 green sturgeon are expected to be handled annually at most, and none have been reported as taken over the past 5 years as a result of NWFSC research activities, so the total number of individuals that could be impacted by delayed mortality is likely to be very low.

Weirs

Capture of adult salmonids by weirs is common practice in order to collect information; (1) enumerate adult salmon and steelhead entering the watershed; (2) determine the run timing of adult salmon and steelhead entering the watershed; (3) estimate the age, sex and length composition of the salmon escapement into the watershed; and (4) used to determine the genetic composition of fish passing through the weir (i.e. hatchery versus natural). Information pertaining to the run size, timing, age, sex and genetic composition of salmon and steelhead returning to the respective watershed will provide managers valuable information to refine existing management strategies.

Some weirs have a trap to capture fish, while other weirs have a video or DIDSON sonar to record fish migrating through the weir. Weirs with or without a trap, have the potential to delay migration. All weir projects will adhere to the draft NMFS West Coast Region Weir Guidelines and have included detailed descriptions of the weirs. The Weir Guidelines require the following: (1) traps must be checked and emptied daily, (2) all weirs including video and DIDSON sonar weirs must be inspected and cleaned of any debris daily, (3) the development and implementation of monitoring plans to assess passage delay, and (4) a development and implementation of a weir operating plan. These guidelines are expected to help improve fish weir design and operation in ways which will limit fish passage delays and increase weir efficiency, thereby reducing the potential for stress, injury, or changes to migration timing on listed salmon and steelhead.

Capture at Depth

Fish have two different types of swim bladders: physotome (open swim bladder) and physoclist (closed swim bladder). Physostome fish (such as salmonids) have a swim bladder connected to the esophagus via the pneumatic duct that allows them to gulp air to fill their swim bladder or quickly release the air when necessary. Physoclist fish (such as rockfish) lack the duct connection to the esophagus (Hallacher 1974) and are dependent upon passive gas exchange through their blood in the rete mirabile within their swim bladders (Alexander 1966). This allows them to become buoyant at much deeper depths than physotome fish, but they are unable to offload gases quickly during a rapid ascent.

For rockfish caught in waters deeper than 60 feet (18.3 m), the primary cause of injury and death is often barotrauma (NMFS 2017a). During rapid decompression, swim bladder gases expand exponentially which is further exacerbated by temperature increases. This results in swim bladder expansion; reduction in body cavity space; and displacement, eversion, and/or injury to the heart, kidneys, stomach, liver, and other internal organs (Rogers *et al.* 2008, Pribyl *et al.* 2009, Pribyl *et al.* 2011). Further, expanding gas can rupture and escape from the swim bladder filling the orbital space behind the eyes, stretching the optic nerve, and causing exophthalmia (Rogers *et al.* 2008). Once on the surface, rockfish can become positively buoyant, meaning they are unable to return to their previous water depth become susceptible to predation (Starr *et al.* 2002, Hannah *et al.* 2008, Jarvis and Lowe 2008).

Methods for reducing barotrauma impacts on rockfish include handling rockfish below the surface, decreasing handling time at the surface, and rapidly submerging them to their capture depth (Parker *et al.* 2006, Hannah and Matteson 2007, Hannah *et al.* 2008). Hannah *et al.* (2008) observed that rockfish that failed to submerge either (1) did not attempt to submerge or only made weak attempts to do so, or (2) vigorously attempted to submerge and failed, leading to his conclusion that buoyancy is not the sole cause of submergence failure. Starr *et al.* (2002) captured rockfish and brought them up to 20m below the surface (below the local thermocline) where divers surgically implanted sonic tags in rockfish, placed them in a recovery cage, and released them. Because they observed no mortalities or abnormal swimming when these methods were employed, Starr *et al.* (2002) deduced that reducing surface handling time appears to improve survivorship. Jarvis and Lowe (2008) noted a 78% survivorship rate after recompression for rockfish released within 10 minutes of landing, which increased to 83% when the fish were released within 2 minutes. Another method for increasing survival for captured rockfish involves rapidly submerging the rockfish after capture and handling. Though the rockfish do not avoid effects of barotrauma when handled in this manner, the immediate impacts of decompression will stop when they are returned to their capture depth. Hochhalter and Reed (2011) compared submergence success of yelloweye rockfish released at the surface and at depth in a mark-recapture study. Though 91% of the individuals showed external signs of barotrauma after capture, the 17-day survival rate was 98.8% after resubmergence, though survival was size-dependent. Yelloweye rockfish released at the surface successfully submerged only 22.1% of the time and had an unknown survivorship rate. In a different study, Hannah and Matteson (2007) researched nine different rockfish different species from six different sites off the Oregon coast. After being captured, rockfish were briefly handled (less than two minutes), placed in a release cage with a video camera, and returned to capture depth/neutral buoyancy. Release behavior was visually observed and scored for behavioral impairment. The behavioral effects of barotrauma appeared to be highly species-specific (probably due to anatomical differences among rockfish species) and health condition at the surface did not appear to be a good indicator of survivorship potential after recompression. In addition, barotrauma effects increase with capture depth. While some gears may unintentionally capture and haul up listed rockfish that can't be released at depth, NWFSC studies specifically targeting listed rockfish at depth will use rapid descending devices to quickly recompress captured rockfish and release them at depth to minimize the impacts of barotrauma.

Species-Level Effects

The use of fisheries research methods such as those described above is expected to result in sublethal and lethal impacts across the NWFSC program that we analyze at the level of the ESU and DPS. Data provided by the NWFSC, based on past requests for authorization and their best estimates of take authorization that would be requested for new future studies, would result in the total requested annual take amounts in Table 35, below. These amounts were collated from data provided in the BA (NWFSC 2023a) and compiled as described in Section 2.1 (Analytical Approach). In cases where listed and non-listed fish can't be visually distinguished, these are also based on applying proportions estimated from past tagging or genetic sampling efforts.

Table 35. ESA-listed fish take NWFSC estimates they would request to be authorized by WCR PRD on an annual basis under the proposed action.

Species	Life Stage	Origin	Requested Take	Lethal Take
Puget Sound Chinook salmon	Adult	Natural	134	21
		LHIA	136	8
		LHAC	188	41
	Juvenile	Natural	17,357	1,832
		LHIA	7,505	612
		LHAC	12,370	2,445
Puget Sound steelhead	Adult	Natural	19	14
		LHIA	5	1
		LHAC	19	14
	Juvenile	Natural	1,573	49
		LHIA	573	17
		LHAC	1,375	47
Puget Sound/Georgia Basin DPS bocaccio	Adult	Natural	10	4
	Juvenile	Natural	25	13
Puget Sound/Georgia Basin DPS yelloweye rockfish	Adult	Natural	15	6
	Juvenile	Natural	34	18

Species	Life Stage	Origin	Requested Take	Lethal Take
Hood Canal summer-run chum salmon	Adult	Natural	40	12
	Juvenile	Natural	911	44
		LHIA	195	20
		LHAC	85	18
Ozette Lake sockeye salmon	Adult	Natural	12	12
		LHIA	1	1
		LHAC	2	2
	Juvenile	Natural	252	10
		LHIA	1	1
		LHAC	251	9
Upper Columbia River spring-run Chinook salmon	Adult	Natural	20	12
		LHAC	17	12
	Juvenile	Natural	334	27
		LHIA	17	6
		LHAC	321	54
Upper Columbia River steelhead	Adult	Natural	16	13
		LHIA	4	1
		LHAC	17	13
	Juvenile	Natural	282	29
		LHIA	25	20
		LHAC	294	45
Middle Columbia River steelhead	Adult	Natural	17	13
		LHAC	17	13
	Juvenile	Natural	314	58

Species	Life Stage	Origin	Requested Take	Lethal Take
		LHIA	10	9
		LHAC	279	31
Snake River spring/summer-run Chinook salmon	Adult	Natural	27	13
		LHAC	32	13
	Juvenile	Natural	309	48
		LHIA	10	5
		LHAC	601	313
Snake River fall-run Chinook salmon	Adult	Natural	28	13
		LHAC	41	19
	Juvenile	Natural	415	85
		LHIA	141	49
		LHAC	462	160
Snake River Basin steelhead	Adult	Natural	17	13
		LHIA	3	1
		LHAC	18	14
	Juvenile	Natural	297	41
		LHIA	51	46
		LHAC	342	86
Snake River sockeye salmon	Adult	Natural	12	12
		LHIA	1	1
		LHAC	2	2
	Juvenile	Natural	321	17
		LHIA	1	1
		LHAC	259	16

Species	Life Stage	Origin	Requested Take	Lethal Take
Lower Columbia River Chinook salmon	Adult	Natural	61	15
		LHIA	12	2
		LHAC	92	21
	Juvenile	Natural	1,145	316
		LHIA	73	37
		LHAC	1,724	762
Lower Columbia River coho salmon	Adult	Natural	51	13
		LHIA	31	2
		LHAC	320	50
	Juvenile	Natural	430	151
		LHIA	151	128
		LHAC	1,658	1,313
Lower Columbia River steelhead	Adult	Natural	17	13
		LHAC	17	13
	Juvenile	Natural	323	67
		LHIA	6	5
		LHAC	293	42
Columbia River chum salmon	Adult	Natural	36	12
		LHIA	1	1
		LHAC	2	2
	Juvenile	Natural	1,651	487
		LHIA	17	13
		LHAC	260	9
	Adult	Natural	25	12

Species	Life Stage	Origin	Requested Take	Lethal Take
Upper Willamette River Chinook salmon		LHAC	42	19
	Juvenile	Natural	429	43
		LHIA	26	5
		LHAC	558	211
Upper Willamette River steelhead	Adult	Natural	12	12
	Juvenile	Natural	277	26
Oregon Coast coho salmon	Adult	Natural	66	28
		LHAC	21	12
	Juvenile	Natural	103	103
		LHAC	11	11
Southern Oregon/Northern California Coast coho salmon	Adult	Natural	25	14
		LHAC	24	13
	Juvenile	Natural	13	13
		LHAC	11	11
Northern California steelhead	Adult	Natural	12	12
California Coastal Chinook salmon	Adult	Natural	24	13
	Juvenile	Natural	5	3
Sacramento River winter-run Chinook salmon	Adult	Natural	18	13
		LHAC	5	1
	Juvenile	Natural	6	4
		LHAC	1	1
Central Valley spring-run Chinook salmon	Adult	Natural	25	13
		LHAC	21	12
	Juvenile	Natural	7	5

Species	Life Stage	Origin	Requested Take	Lethal Take
		LHAC	9	9
California Central Valley steelhead	Adult	Natural	13	13
		LHAC	13	13
Central California Coast coho salmon	Adult	Natural	17	13
		LHAC	7	3
	Juvenile	Natural	3	3
Central California Coast steelhead	Adult	Natural	13	13
		LHAC	13	13
South-Central California Coast steelhead	Adult	Natural	13	13
Southern DPS eulachon	Adult	Natural	247,850	36,499
	Subadult	Natural	1,000	1,000
	Juvenile	Natural	60	4
Southern DPS green sturgeon	Adult	Natural	16	8

However, the take amounts displayed in the table above represent a modest overestimate of the likely effects on listed species. The true numbers of fish that would actually be taken would most likely be smaller than the amounts authorized because researchers generally request more take than they estimate will actually occur. Researchers do not want to exceed their take limits, and request take for each study and in each sampling location where listed species might be encountered. For example, the total of 12 natural-origin adult Snake River sockeye salmon requested per year in the table above represents the sum of eight different surveys, seven of which are requesting one adult fish each, and only one of which actually estimates encountering multiple adults (i.e. a groundfish survey spanning much of the CCRA). In reality, over the past ten years, the NWFSC researchers have not reported capturing or killing a single adult Snake River sockeye (Appendix A Table A1). Overall, in total over the past five years NWFSC researchers have actually taken at most 23 percent of adults they were authorized to take and at most 71 percent of juveniles authorized for any species component, although for the majority of species the actual take was only a small fraction of what was requested—typically ten percent or less (see Table A3 of Appendix A).

Further, not all of the studies described in the NWFSC fisheries research program are expected to occur every year. Some of the large-scale offshore surveys are only scheduled to occur every other year. Even for studies scheduled to occur annually, it is unlikely all of the current anticipated studies would be carried out each year because some studies are expected to conclude as others come online. It is therefore very likely that researchers will take fewer fish than authorized, and that the actual effect is likely to be much lower than the numbers stated in the tables above.

By contrast, take reported from past years of the program more closely resembles the take we expect to be incurred by this program in the future. Evaluating take amounts reported from past years allows us to evaluate likely impacts of the NWFSC fisheries research program at the species level, and for key components of the listed units (i.e., hatchery- versus naturally-produced individuals and juveniles versus adults). The total reported lethal take that occurred as a result of the NWFSC fisheries research program over the past ten years is summarized in Table A1 (Appendix A).

The best metric to estimate potential impacts of the proposed research activities on key components of the listed species is to evaluate the proportion of individuals taken relative to our best estimate of abundance during those same years, rather than numbers of individual fish taken. As the abundance of listed fish species populations fluctuates over time the same number of individual fish taken can represent a larger or smaller proportion of the population from year to year. This makes analyzing the proportion of the ESU or DPS taken a better estimate of the potential for the proposed action to negatively impact abundance or productivity, and therefore viability of a species. Because take is expected to continue at levels consistent with past years of the program, we use the most recent five years of take reported for NWFSC studies as a reasonable estimate of the potential impacts of these research activities in the future. The total take reported each year from sampling during 2018-2022 (results reported from 2019-2023) was divided by our best estimates of abundance for those same years (as reported in Biological Opinions on the issuance of research permits, Table A2, Appendix A) to calculate the proportional impact on each species component.

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. The total lethal take, or mortalities, reported from the NWFSC program over the past five years (Table A1) was compared to our estimated abundance of each species component for those years (Table A1), as described above. The percent of each species component estimated to have been killed by NWFSC research activities in the past five years is summarized in Table 36, below.

Table 36. Percent of ESA-listed fish ESU or DPS components lethally taken by NWFSC research activities from reporting years 2018-2022

Species	Life Stage	Origin	2018	2019	2020	2021	2022	Max
	Adult	Natural	0.000	0.000	0.000	0.004	0.000	0.004

Species	Life Stage	Origin	2018	2019	2020	2021	2022	Max
Puget Sound Chinook salmon		LHIA & LHAC	0.199	0.322	0.000	0.004	0.000	0.322
	Juvenile	Natural	0.007	0.018	<0.001	0.017	0.003	0.018
		LHIA	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
		LHAC	<0.001	<0.001	<0.001	0.002	0.003	0.003
Puget Sound steelhead	Adult	Natural	0.000	0.000	0.000	0.000	0.000	0.000
		LHIA & LHAC	0.000	0.000	0.000	0.000	0.000	0.000
	Juvenile	Natural	0.000	0.000	0.000	0.000	0.000	0.000
		LHIA	0.000	0.000	0.000	0.000	0.000	0.000
		LHAC	0.000	0.000	0.000	0.000	0.000	0.000
Puget Sound/Georgia Basin DPS bocaccio	Adult	Natural	0.000	0.000	0.000	0.000	0.000	0.000
	Juvenile	Natural	0.000	0.000	0.000	0.000	0.000	0.000
Puget Sound/Georgia Basin DPS yelloweye rockfish	Adult	Natural	0.000	0.000	0.000	0.000	0.000	0.000
	Juvenile	Natural	0.000	0.000	0.000	0.000	0.000	0.000
Hood Canal summer-run chum salmon	Adult	Natural	0.000	0.000	0.000	0.000	0.000	0.000
	Juvenile	Natural	0.000	0.000	0.000	0.000	0.000	0.000
		LHIA	0.000	0.000	0.000	0.000	-	0.000
		LHAC	-	-	-	-	-	0.000
Ozette Lake sockeye salmon	Adult	Natural	0.000	0.000	0.000	0.000	0.000	0.000
		LHIA	-	0.000	0.000	0.000	0.000	0.000
		LHAC	-	0.000	0.000	0.000	0.000	0.000
	Juvenile	Natural	-	0.000	0.000	0.000	0.000	0.000

Species	Life Stage	Origin	2018	2019	2020	2021	2022	Max
		LHIA	-	0.000	0.000	0.000	0.000	0.000
		LHAC	-	0.000	0.000	0.000	0.000	0.000
Upper Columbia River spring-run Chinook salmon	Adult	Natural	0.000	0.000	0.000	0.000	0.000	0.000
		LHAC	0.000	-	-	0.000	0.000	0.000
	Juvenile	Natural	0.002	0.000	<0.001	<0.001	0.000	0.002
		LHIA	0.000	0.000	0.000	<0.001	0.000	<0.001
		LHAC	<0.001	<0.001	0.002	0.001	0.001	0.002
Upper Columbia River steelhead	Adult	Natural	0.000	0.000	0.000	0.000	0.000	0.000
		LHIA	-	-	-	0.000	0.000	0.000
		LHAC	0.000	-	-	0.000	0.000	0.000
	Juvenile	Natural	0.000	0.000	0.000	0.000	0.000	0.000
		LHIA	0.000	0.000	0.000	0.000	0.000	0.000
		LHAC	0.000	<0.001	0.000	0.000	0.000	<0.001
Middle Columbia River steelhead	Adult	Natural	0.000	0.000	0.000	0.000	0.000	0.000
		LHAC	0.000	-	-	0.000	0.000	0.000
	Juvenile	Natural	0.000	0.000	0.000	0.000	0.000	0.000
		LHIA	-	0.000	0.000	0.000	0.000	0.000
		LHAC	0.000	0.000	0.000	0.000	0.000	0.000
Snake River spring/summer-run Chinook salmon	Adult	Natural	0.000	0.000	0.000	0.023	0.000	0.023
		LHAC	0.000	-	-	0.000	0.000	0.000
	Juvenile	Natural	<0.001	<0.001	0.001	<0.001	0.000	0.001
		LHIA	0.000	0.000	0.000	<0.001	0.000	<0.001
		LHAC	<0.001	<0.001	0.002	<0.001	<0.001	0.002
	Adult	Natural	0.000	0.000	0.000	0.014	0.000	0.014

Species	Life Stage	Origin	2018	2019	2020	2021	2022	Max
Snake River fall-run Chinook salmon		LHAC	0.001	-	-	0.013	0.000	0.013
	Juvenile	Natural	<0.001	<0.001	0.003	<0.001	<0.001	0.003
		LHIA	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
		LHAC	<0.001	<0.001	0.002	<0.001	<0.001	0.002
Snake River Basin steelhead	Adult	Natural	0.000	0.000	0.000	0.000	0.000	0.000
		LHIA	-	-	-	0.000	0.000	0.000
		LHAC	0.000	-	-	0.000	0.000	0.000
	Juvenile	Natural	<0.001	<0.001	0.000	<0.001	0.000	<0.001
		LHIA	0.000	0.000	0.000	0.000	0.000	0.000
		LHAC	<0.001	<0.001	0.000	<0.001	<0.001	<0.001
Snake River sockeye salmon	Adult	Natural	0.000	0.000	0.000	0.000	0.000	0.000
		LHIA	-	0.000	-	0.000	0.000	0.000
		LHAC	-	0.000	-	0.000	0.000	0.000
	Juvenile	Natural	0.000	0.000	0.000	0.000	0.000	0.000
		LHIA	-	-	-	-	-	-
		LHAC	0.000	0.000	0.000	0.002	0.005	0.005
Lower Columbia River Chinook salmon	Adult	Natural	0.000	0.000	0.000	0.007	0.000	0.007
		LHIA	0.005	0.000	0.000	0.011	0.000	0.011
		LHAC	0.005	0.000	0.000	0.011	0.000	0.011
	Juvenile	Natural	0.002	<0.001	<0.001	<0.001	<0.001	0.002
		LHIA	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
		LHAC	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lower Columbia	Adult	Natural	0.000	0.000	0.000	0.000	0.000	0.000
		LHIA	0.000	0.000	0.000	0.000	0.000	0.000

Species	Life Stage	Origin	2018	2019	2020	2021	2022	Max
River coho salmon		LHAC	0.000	0.000	0.000	0.000	0.000	0.000
	Juvenile	Natural	0.006	0.002	0.002	0.002	0.004	0.006
		LHIA	0.006	0.006	0.006	0.009	0.007	0.009
		LHAC	0.007	0.002	<0.001	0.002	0.002	0.007
Lower Columbia River steelhead	Adult	Natural	0.000	0.000	0.000	0.000	0.000	0.000
		LHAC	0.000	0.000	0.000	0.000	0.000	0.000
	Juvenile	Natural	0.000	0.000	0.000	0.000	0.000	0.000
		LHIA	-	0.000	0.000	0.000	0.000	0.000
		LHAC	<0.001	<0.001	0.000	<0.001	<0.001	<0.001
Columbia River chum salmon	Adult	Natural	0.000	0.000	0.000	0.000	0.000	0.000
		LHIA	-	0.000	-	0.000	0.000	0.000
	Juvenile	Natural	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
		LHIA	0.001	<0.001	0.002	0.005	0.004	0.005
		LHAC	-	-	-	-	-	-
Upper Willamette River Chinook salmon	Adult	Natural	0.000	0.000	0.000	0.009	0.000	0.009
		LHAC	-	-	0.000	0.008	0.000	0.008
	Juvenile	Natural	0.013	<0.001	<0.001	<0.001	<0.001	0.013
		LHIA	0.000	0.000	0.024	-	-	0.024
		LHAC	0.001	<0.001	<0.001	0.002	0.001	0.002
Upper Willamette River steelhead	Adult	Natural	0.000	0.000	0.000	0.000	0.000	0.000
	Juvenile	Natural	0.000	0.000	0.000	0.000	0.000	0.000
Oregon Coast coho salmon	Adult	Natural	0.000	0.001	0.000	0.000	0.000	0.001
		LHAC	-	-	-	0.000	0.000	0.000
	Juvenile	Natural	0.000	0.000	0.000	0.000	0.000	0.000

Species	Life Stage	Origin	2018	2019	2020	2021	2022	Max
		LHAC	0.000	0.000	0.000	0.000	0.000	0.000
Southern Oregon/Northern California Coast coho salmon	Adult	Natural	0.000	0.000	0.000	0.000	0.000	0.000
		LHAC	0.000	0.000	0.000	0.000	0.000	0.000
	Juvenile	Natural	0.000	0.000	0.000	0.000	0.000	0.000
		LHAC	0.000	0.000	0.000	0.000	0.000	0.000
Northern California steelhead	Adult	Natural	0.000	0.000	0.000	0.000	0.000	0.000
California Coastal Chinook salmon	Adult	Natural	0.000	0.000	0.000	0.000	0.000	0.000
	Juvenile	Natural	-	0.000	0.000	0.000	0.000	0.000
Sacramento River winter-run Chinook salmon	Adult	Natural	0.000	0.000	0.000	0.000	0.000	0.000
	Juvenile	Natural	0.000	0.000	0.000	0.000	0.000	0.000
		LHAC	0.000	0.000	0.000	0.000	0.000	0.000
Central Valley spring-run Chinook salmon	Adult	Natural	0.000	0.000	0.000	0.000	0.000	0.000
		LHAC	0.000	0.000	-	0.000	0.000	0.000
	Juvenile	Natural	0.000	0.000	<0.001	0.000	0.000	<0.001
		LHAC	0.000	0.000	<0.001	0.000	0.000	<0.001
California Central Valley steelhead	Adult	Natural	0.000	0.000	0.000	0.000	0.000	0.000
		LHAC	0.000	0.000	-	0.000	0.000	0.000
Central California Coast coho salmon	Adult	Natural	0.000	0.000	0.000	0.000	0.000	0.000
	Juvenile	Natural	-	0.000	0.000	0.000	0.000	0.000
Central California Coast steelhead	Adult	Natural	0.000	0.000	0.000	0.000	0.000	0.000
		LHAC	0.000	0.000	-	0.000	0.000	0.000

Species	Life Stage	Origin	2018	2019	2020	2021	2022	Max
South-Central California Coast steelhead	Adult	Natural	0.000	0.000	0.000	0.000	0.000	0.000
Southern DPS eulachon	Adult	Natural	<0.001	0.005	0.000	0.014	0.007	0.014
	Subadult	Natural	<0.001	0.005	0.000	0.014	0.007	0.014
	Juvenile	Natural	-	0.005	0.000	0.014	0.007	0.014
Southern DPS green sturgeon	Adult	Natural	0.000	0.000	0.000	0.000	0.000	0.000

In the table above, the ‘Max’ column on the right reports the highest percentage of an ESA-listed species component that was killed in any of the past five years. In most cases, while many individuals of these species and age classes have been captured and handled over the past 5 years, and some have had various tagging, marking, or sample collection procedures performed on them, very few have been killed as a result of NWFSC fisheries research activities. For many species and years there has been no take at all, or such a small amount that it constitutes less than 0.001 percent of that species component.

We consider the past 5 years of reporting to be representative of impacts we anticipate in the future. The highest proportion of any ESU or DPS component killed as a result of research in any year was just over 0.3% (hatchery Puget Sound Chinook salmon adults), and we recognize that any number of changes in abundance or habitat, or unexpected events in future surveys, could cause similar or slightly more impactful sampling years. Therefore, for listed fish, a one-year maximum mortality of up to 0.5% of the abundance of an ESU or DPS component could be reasonably expected. Because hatchery-origin fish abundance can be increased in response to abundance changes, and these fish are generally considered to be in excess of recovery needs, we are most concerned about the potential for NWFSC research take to result in adverse impacts of natural-origin ESU/DPS components of species, which could also reasonably be expected to reach up to 0.5% in a given year based on past data. In addition, a sustained increase of 5 or more years in the relative (i.e., proportional) annual mortality for natural-origin fish could result in adverse effects to the species or would have the possibility of accumulating impacts over time. The highest 5-year average rate of take observed previously was just over 0.1%, and similarly could be expected to be slightly higher in the future given habitat, abundance, and fieldwork uncertainties. We therefore expect an annual average of up to 0.25% of a listed ESU or DPS component could be lethally taken over any future 5-year period (i.e., as a 5-year rolling average).

Although take beyond these amounts wouldn't necessarily mean that the program is operating to listed species' disadvantage, it would represent a point at which we believe we must take a more in-depth look at the effects a program is having before we can determine that no disadvantage is occurring (as is required by the implementing regulations for issuing Section 10(a)(1)(A) permits). In our experience, we have found that when standard operating protocols are followed and researchers utilize all means of mitigation measures and best practices to reduce take, research programs are generally able to stay well below this amount. We therefore anticipate take of listed fish species will be at or below these thresholds.

Because the research would take place over such a broad area, and in lower reach, estuarine, nearshore, and offshore areas where individuals from many populations mix, the potential losses cannot be ascribed to any population for any species. As a result, though the research may in some instances have a very small impact on species abundance and productivity, it would in no measurable way impact structure or diversity for any species.

Lastly, we consider the beneficial impacts of the proposed action to the listed species. In many cases, and all those involving directed (intentional) take, the research being conducted by the NWFSC adds critical knowledge about the species' status—knowledge that we are required to have every five years to perform status reviews for all listed species. The NWFSC also conducts studies to investigate threats to the listed species, such as key sources of mortality or predicted habitat contractions under climate change, which provide critical information managers need to monitor and support recovery for listed species. Data gathered on our non-listed species allow for West Coast fisheries to be managed sustainably, which further supports healthy ocean ecosystems and food webs in the action area that can indirectly benefit threatened and endangered species. Such studies also provide information on conditions in the marine environment that can be used for listed species management and recovery planning. So, in evaluating the impacts of the research program, any effects on abundance and productivity are weighed in light of the potential value of the information collected as a result of the research. Regardless of its relative magnitude, the negative effects associated with the research program on these species would to some extent be offset by gaining information that would be used to help the listed species survive and recover.

Vessel Collision

Vessel collision is not known to be significant threat to species of marine or anadromous fish, including salmonids, eulachon, green sturgeon, and rockfish. While collisions are possible at or near the surface, it is likely that most fish are either somewhere in the water column below vessels or are readily able to avoid vessels with evasive swimming maneuvers. The lateral line system of fishes likely contributes to their ability to detect the presence of oncoming vessels through changes in water pressure. Without any further information suggesting that marine fish are subject to vessel collisions, we assume these are unlikely events for listed fish.

Acoustic Disturbance

Fish react to underwater sounds that are especially strong and/or intermittent low frequency sounds. Short duration, sharp sounds can cause overt or subtle changes in fish behavior and local distribution. Hastings and Popper (2005) identified several studies that suggest fish may relocate to avoid certain areas of sound energy. Additional studies have documented effects of sounds on fish, although several are based on studies of lower frequency sound in support of large multi-year bridge construction projects (e.g., Scholik and Yan 2002; Popper and Hastings 2009) compared to the relative high frequency active acoustic sources used by the NWFSC. Sound pulses at received levels of 160 dB re 1 μPa may cause subtle changes in fish behavior. Sound pressure levels of 180 dB re 1 μPa may cause noticeable changes in behavior (Pearson *et al.* 1992; Skalski *et al.* 1992), and sound pressure levels of sufficient strength have been known to cause injury to fish and fish mortality. If there is any detection of loud sounds by fish, the most likely reaction would be temporary behavioral avoidance of the area.

Sonars and other active acoustic sources used by the NWFSC are generally operated at frequencies well above the hearing ranges of most fishes and invertebrates, with the exception of some clupeid fishes, including shads and menhaden, which can detect and respond to ultrasonic frequencies (see Popper 2008; Hawkins *et al.* 2014 for review). Hearing thresholds have been determined for about 100 living fish species. These studies show that, with few exceptions, fish cannot hear sounds above about 3-4 kHz, and that the majority of species are only able to detect sounds to 1 kHz or even below. The hearing capability of Atlantic salmon (*Salmo salar*) indicates relatively poor sensitivity to sound (Hawkins and Johnstone 1978). Laboratory experiments yielded responses only up to 580 Hz and only at high sound levels. The Atlantic salmon is considered to be a hearing generalist, and this is probably the case for all other salmonids studied to date based on studies of hearing (see Popper 2008 for review). The hearing ranges for other species of ESA-listed fish species that may be exposed to active acoustic sources used by the NWFSC (eulachon, green sturgeon, and rockfish) have not been described, but generally speaking we do not expect these species are able to detect high frequency sound from active acoustic sources used during NWFSC research. One possible exception could be eulachon, given the general similarity as a small, schooling fish commonly preyed upon by echolocating marine mammals, with some clupeid species that apparently can detect high frequency sound. While the hearing capabilities of eulachon is uncertain, even if high frequency hearing exists for them, the most likely impact of temporary exposure to high frequency active sources is temporary disturbance that will not result in any significant impact to the health of the individuals.

Given that ESA-listed fish all have low frequency hearing ranges, we expect they would be able to detect the presence of NWFSC research vessels, at least to some degree. There have been some investigations into the impact of low frequency sounds, typically associated with high intensity activities (and low frequency) such as pile-driving and explosives. In general, results indicate that with the possible exception of very loud sources (sound levels well in excess of 200 dB re μPa) only fish with swim bladders and that are located very near impulsive sources for extended periods of time are likely to be injured (see Popper *et al.* 2014 for review). The sound pressure levels produced by NWFSC research vessels would in all cases be substantially lower than what might cause injuries. As a result, we do not expect that any sounds produced by active acoustic sources or vessel noise will affect any ESA-listed fish species in any way that will decrease their fitness or impact their survival.

Prey Reduction

In addition the relative low levels of total magnitude of prey removals from NWFSC research minimizing the impact on listed species, the nature of NWFSC research typically moving from station to station spreads out small prey removals across large areas of the action area over extended periods of time, as opposed to concentrating them in certain areas/times where localized prey depletions which could potentially lead to adverse effects on foraging efficiency or nutritional deficiencies for individuals. We have no models sophisticated enough to combine information on the relative effects of varying prey densities, foraging efficiency, and nutritional needs at an individual or population level for these ESA-listed species. However, we do not expect that small amounts of prey removal spread out across large areas in space and time are likely to significantly affect the fitness or survival of any ESA-listed species considered in this Opinion. Additional consideration of prey removals on ESA-listed species and designated critical habitats within the action area can be found in section 2.5.1 (Effects on Critical Habitat) and 2.12. (“Not Likely to Adversely Affect” Determinations).

Marine Invertebrates

Sunflower sea stars are habitat generalists that consume a wide variety of invertebrate prey, and also opportunistically scavenge on vertebrates. They can be found on soft or hard-bottom substrates in marine areas, and are occasionally found in the deep parts of tide pools. However, areas with substantial freshwater input, e.g., river mouths, are known to have a lower likelihood of sunflower sea star occurrence. For these reasons most of the NWFSC research activities conducted in freshwater or estuarine areas, and those conducted in nearshore or offshore areas using mid-water or surface-oriented sampling gear are not expected to interact with sunflower sea stars or their prey. However, surveys using demersal or benthic trawling methods used on soft or sandy bottom substrates are likely to interact with sunflower sea stars.

The NWFSC research activities would likely adversely affect sunflower sea star because it employs bottom trawling gear over a broad area where the species is known to occur. Although data suggest the density of sunflower sea stars is low, we expect a small number of sunflower sea stars would be harmed, injured, or killed given the size of the action area that could be affected by sampling and the duration of the proposed NWFSC activities (i.e., will continue for the foreseeable future). Potential adverse impacts to sunflower sea stars include, but are not limited to, relocation, behavioral disruption (e.g., feeding, spawning), increased stress (which is linked with SSWS susceptibility), and physical contact resulting in injury or death.

The NWFSC has recorded catch of sunflower sea stars in their groundfish bottom trawl survey gear in the past, although there has been no formal reporting of this species. Information shared from the NWFSC indicates they annually captured anywhere from 126 to 397 individuals in the years prior to the onset of SSWS (2004-2014), but only one to four individuals per year from 2015-2018 (A. Keller, pers. comm. May 6, 2024). In the coming years we first anticipate that take of sunflower sea stars will initially continue to be limited to less than 10 individuals per year, as their low abundance and dispersed distribution make interactions rare. As the species rebounds we expect that numbers of sea stars incidentally caught and killed will also increase, up to 400-500 per year if the population recovers to its pre-listing status. Given the broad distribution of the sampling activities, such an increase in catch would not be expected to represent a proportional increase in individuals removed from the population. Take of this species is not prohibited, but handling these number of individuals each year, and unintentionally killing a subset of them, could have a very small impact on the abundance or productivity of the population.

Food for sunflower sea star (mollusks, other sea stars, other benthic organisms) is also likely to be smothered or removed in small swaths of seafloor where benthic survey gear will be used. In the areas where soft or sandy bottom trawl gear is used, removed prey will likely not repopulate for some time, likely reducing the fitness and ability to resist diseases of a small number of sea stars that are likely to enter the affected area before the habitat recovers. However, we do not expect that small amounts of prey removal spread out across large areas in space and time are likely to significantly affect the fitness or survival of sunflower sea stars.

2.6 Cumulative Effects

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

Some continuing non-federal activities are reasonably certain to contribute to the overall environmental health and habitat quality within the action area. In section 2.4 (Environmental Baseline) we described the current and ongoing impacts associated with other activities that affect ESA-listed species along the U.S. West Coast. We are reasonably certain that these activities and impacts will continue to occur while this proposed action occurs.

Some continuing non-federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult if not impossible to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline *vs.* cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described earlier in the discussion of environmental baseline (Section 2.4).

Future state, tribal, and local government actions will likely be in the form of legislation, administrative rules, or policy initiatives. Government and private actions may include changes in land and water uses, including ownership and intensity, any of which could impact listed species or their habitat. Government actions are subject to political, legislative, and fiscal uncertainties. These realities, added to the geographic scope of the action area, which encompasses numerous government entities exercising various authorities, make any analysis of cumulative effects difficult and speculative. For more information on the various efforts being made at the local, tribal, state, and national levels to conserve listed species on the West Coast, see any of the recent 5-year reviews, listing Federal Register notices, and recovery planning documents, as well as recent consultations on issuance of Section 10(a)(1)(A) research permits for marine and anadromous fishes.

Thus, non-federal activities are likely to continue affecting listed species and habitat within the action area. These cumulative effects in the action area are difficult to analyze because of this Opinion’s large geographic scope, the different resource authorities in the action area, the uncertainties associated with government and private actions, and the changing economies of the region. Whether these effects will increase or decrease is a matter of speculation; however, it seems likely that they will continue to increase as a general pattern over time. The primary cumulative effects in freshwater environments will arise from those water quality and quantity impacts that occur as human population growth and development shift patterns of water and land use, thereby creating more intense pressure on streams and rivers within this geography in terms of volume, velocities, pollutants, baseflows, and peak flows. In the nearshore and marine environment continued development of offshore energy projects, marine aquaculture, and marine vessel traffic between major port routes are also expected to generally increase over time. But the specifics of these effects, too, are impossible to predict at this time. In addition, there are the aforementioned effects of climate change—many of those will arise from or be exacerbated by actions taking place on the West Coast and elsewhere that will not undergo ESA consultation. Although many state, tribal, and local governments have developed plans and initiatives to benefit listed species, they must be applied and sustained in a comprehensive way before NMFS can consider them “reasonably foreseeable” in its analysis of cumulative effects. We can, however, make some generalizations based on population trends.

Trends in Human Use and Development

Puget Sound/Western Washington

Non-federal actions are likely to continue affecting listed species. The cumulative effects in this portion of the action area are difficult to analyze because of this Opinion’s geographic scope, however, based on the trends identified in the baseline, the adverse cumulative effects are likely to increase. From 1960 through 2020, the population in Puget Sound has gained 2.8 million people, with a current population estimate of 2.26 million in 2020 (PSRG 2020). During this population boom, urban land development has eliminated hydrologically mature forest and undisturbed soils resulting in significant change to stream channels (altered stream flow patterns, channel erosion) which eventually results in habitat simplification (Booth *et al.* 2002). Combining this population growth with over a century of resource extraction (logging, mining, etc.), Puget Sound's hydrology has been greatly changed and has created a different environment than what Puget Sound salmonids evolved in (Cuo *et al.* 2009). French *et al.* (2022) has documented adult coho salmon mortality rates of 60-100% for the past decade in urban central Puget Sound streams that are high in metals and petroleum hydrocarbons especially after stormwater runoff. In addition, marine water quality factors (e.g. climate change, pollution) are likely to continue to be degraded by various human activities that will not undergo consultation. Although state, tribal, and local governments have developed plans and initiatives to benefit listed fish, they must be applied and sustained in a comprehensive way before NMFS can consider them "reasonably foreseeable" in its analysis of cumulative effects. Thus, the most likely cumulative effect is that the habitat in the action area is likely to continue to be degraded with respect to its ability to support the listed salmonids.

Western Oregon

The situation in Western Oregon is likely to be similar to that of the Puget Sound region: cumulative effects are likely to continue increasing both in the Willamette valley and along the coast, with nearly all counties west of the Cascade range showing year-by-year population increases of 1-2% over the last several years (1970-2022; PNREAP 2024). The result of this growth is that there will be more development and therefore more habitat impacts such as simplification, hydrologic effects, greater levels of pollution (in the Willamette Valley), other water quality impacts, soil disturbance, etc. These effects would be somewhat lessened in the coastal communities, but resource extraction (particularly timber harvest) would probably continue to increase slightly. Though once again, most such activities, whether associated with development or extraction, would undergo formal consultation if they were shown to take place in (or affect) critical habitat or affect listed species. So, it is difficult to characterize the effects that would not be consulted upon beyond saying they are likely to increase both in severity and geographic scope.

California

According to the U.S. Census Bureau, the State of California's population increased 4.6%, or over 1.7 million people, from 2010 to 2023 (Census Bureau 2024). If this trend in population growth continues, vessel traffic in and out of major ports would be expected to increase, particularly for container ships delivering goods, although the traffic control measures for vessels and port capacity would constrain this increase. Therefore, the most likely cumulative effect is that the habitat in the action area is likely to continue to be degraded with respect to water quality and underwater noise, with increased potential for vessel interactions with listed species.

Summary

This consultation incorporates a vast project action area encompassing the coastal waters off of Washington, Oregon, and California, including areas of the Columbia River and Puget Sound. During this consultation, we were not provided with and did not identify any specific additional state, private, or foreign government activities that are reasonably certain to occur within the action area, which do not involve federal activities, and could result in cumulative effects to ESA-listed species and designated critical habitat within the action area. Because the action area has extensive overlap with designated critical habitat and navigable marine waters, the vast majority of future actions in the area will undergo section 7 consultation with one or more of the federal entities with regulatory jurisdiction over water quality, habitat management, flood management, navigation, or hydroelectric generation. In the marine environment, this also includes state, federal, or foreign government actions related to ocean use policy and management of public resources, such as fishing or energy development projects. In almost all instances, proponents of future actions will need government funding or authorization to carry out a project that may affect ESA-listed species, and therefore the effects such a project may have on listed species will be analyzed when the need arises.

Changes in ocean use policies as a result of non-federal government action are highly uncertain and may be subject to sudden changes as political and financial situations develop. Examples of actions that may occur include development of aquaculture projects; changes to state fisheries which may alter fishing patterns or influence the bycatch of ESA-listed marine mammals and sea turtles; installation of hydrokinetic projects near areas where marine mammals and sea turtles are known to migrate through or congregate; designation or modification of marine protected areas that include habitat or resources that are known to affect marine mammals and sea turtles; and coastal development which may alter patterns of shipping or boating traffic. However, none of these potential state, local, or private actions, can be anticipated with any reasonable certainty in the action area at this time, and most of those described as examples would likely involve federal involvement of some type given the federal government's role in regulating activity in the ocean across numerous agencies and activities.

In developing this biological Opinion, we considered several efforts being made at the local, tribal, state, and national levels to conserve listed species—primarily final recovery plans and efforts laid out in the most recent 5-year reviews for Pacific salmon and steelhead listed under the Endangered Species Act. The recovery plans, status summaries, and limiting factors that are part of the analysis of this Opinion are discussed in detail in Table 1 (Section 2.2.2). The result of that review was that listed salmon and steelhead take—particularly take associated with monitoring and habitat restoration—is likely to continue to increase in the region for the foreseeable future. However, as noted above, all actions falling in those categories would also have to undergo consultation (like that in this Opinion) before they are allowed to proceed.

2.7 Integration and Synthesis

The Integration and Synthesis section is the final step in assessing the risk that the proposed action poses to species and critical habitat. In this section, we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

Sea Turtles

Based on the analysis of potential effects from the NWFSC research activities considered in this Opinion, we determined that the likelihood of adverse effects from incidental capture or entanglement in research gears (including survey trawls or longlines) for ESA-listed sea turtles in the action area is not discountable. We have considered potential disturbance from active acoustics and vessels, the potential for vessel strikes, and potential impacts from reduction of prey impacts as well, and determined that adverse effects from these factors are either very unlikely to occur (i.e., acoustics, vessel noise, or vessel strikes) or would be so small they would have minimal, if any, effects on the species (i.e., prey removal). We have considered that up to 1 individual sea turtle of any species could be incidentally captured or entangled in any given year throughout the full range of the action area, and these turtles could be of any age or sex in these respective species. Based on the nature of NWFSC research operations and the proposed use of mitigation measures and proper handling, we conclude the most likely outcome from any incidental captures or entanglements is that individual turtles will survive these encounters. As a result, we have concluded that that the proposed activities are not likely to have a detectable impact on any ESA-listed sea turtle populations in terms of their current abundance or future reproductive output potential, or population structure and diversity. When the effect of this proposed action is added to the status, environmental baseline, and cumulative effects of other activities, and the anticipated effects of climate change over the foreseeable future, there is no increase in the risks of extinction or impediments to recovery for any of these ESA-listed sea turtle species. Ultimately, because only minimal measurable impacts on these species are anticipated, we conclude that the proposed action will not reduce the likelihood of survival and recovery of the following sea turtle species: leatherback sea turtle; North Pacific DPS of loggerhead sea turtle; olive ridley sea turtle; and East Pacific DPS green sea turtle.

Marine and Anadromous Fish

Many ESA-listed fish from several species are expected to be handled and killed, either intentionally or unintentionally, as a result of the proposed action.

However, across these listed species, the total mortalities are so small relative to abundance and so widely distributed across each listed unit such that they are unlikely to have any lasting detrimental effect on the species' numbers, reproduction, or distribution.

As described in further detail below, because we found for each ESU and DPS that . . .

1. The NWFSC research activities' expected detrimental effects on the species' abundance and productivity would be small, even in combination with all the rest of the research authorized in the action area; and
2. That slight impact would be distributed throughout the species' entire range and would therefore be so attenuated as to have no appreciable effect on spatial structure or diversity,

. . . we determined that the impact of the NWFSC research program would be restricted to a small effect on abundance and productivity. Also, and again, those small effects the research program has on abundance and productivity are offset to some degree by the beneficial effects the program as a whole generates in fulfilling a critical role in promoting the species' health by producing information managers need to help recover listed species.

As noted earlier, no listed species currently has all its biological requirements being met. Their status is such that there must be a substantial improvement in the environmental conditions of their habitat and other factors affecting their survival if they are to begin to approach recovery. In addition, while the future impacts of cumulative effects are uncertain at this time, they are likely to continue to be negative. Nonetheless, in no case would the proposed actions exacerbate any of the negative cumulative effects discussed (habitat alterations, etc.) and in all cases the research may eventually help to limit adverse effects by increasing our knowledge about the species' requirements, habitat use, and abundance. The effects of climate change are also likely to continue to be negative. However, given the proposed actions' relatively small areas impacted relative to the action area, and the temporary nature of impacts of any particular study, those negative effects are too small to be effectively gauged as an additional increment of harm over the time span considered in this analysis. Moreover, many studies that are part of the NWFSC research program would actually help monitor the effects of climate change on protected species. So while we can expect both cumulative effects and climate change to continue their negative trends, it is unlikely that the proposed actions would have any additive impact to the pathways by which those effects are realized (e.g., a slight reduction in salmonid abundance would have no effect on increasing water temperatures).

To this picture, it is necessary to add the increment of effect represented by the proposed action. Our analysis shows that the proposed research activities would have slight negative effects on each species' abundance and productivity, but those reductions are so small as to have no more than a very minor effect on the species' survival and recovery. In all cases, even the worst possible effect on abundance is expected to be minor compared to overall population abundance, the activity has never been identified as a threat, and the research is designed to benefit the species' survival in the long term.

For over three decades, research and monitoring activities conducted on anadromous salmonids and listed marine fish have provided resource managers with a wealth of important and useful information regarding their populations. For example, juvenile fish trapping efforts have enabled managers to produce population inventories, PIT-tagging efforts have increased our knowledge of anadromous fish abundance, migration timing, and survival, and nearshore juvenile fish surveys have enhanced our understand of how fish behave and survive when moving past modified shorelines and as they enter the marine environment. By issuing research authorizations—including many of those being contemplated again in this Opinion—WCR PRD has allowed information to be acquired that has enhanced resource managers' abilities to make more effective and responsible decisions with respect to sustaining anadromous salmonid populations, mitigating adverse impacts on endangered and threatened salmon and steelhead, and implementing recovery efforts. The resulting information continues to improve our knowledge of the respective species' life histories, specific biological requirements, genetic make-up, migration timing, responses to human activities (positive and negative), and survival in the rivers and ocean. And that information, as a whole, is critical to the species' survival.

Additionally, the information being generated is, to some extent, legally mandated. Though no law calls for the work being done in any particular permit or authorization, the ESA (section 4(c)(2)) requires that we examine the status of each listed species every five years and report on our findings. At that point, we must determine whether each listed species should (a) be removed from the list (b) have its status changed from threatened to endangered, or (c) have its status changed from endangered to threatened. As a result, it is legally incumbent upon us to monitor the status of every species considered here, and fisheries research programs, as a whole, are one of the primary means we have of doing that.

Thus, we expect the detrimental effects on the species to be minimal and those impacts would only be seen in terms of slight reductions in juvenile and adult abundance and productivity. And because these reductions are so slight, the proposed action would have no appreciable effect on the species' diversity or structure. Moreover, we expect the actions to provide lasting benefits for the listed fish and that all habitat effects would be negligible. And finally, we expect the NWFSC research program as a whole and the associated permitting and authorization actions considered here to generate information we need to fulfill our mandate under the ESA.

Marine Invertebrates

The sunflower sea star is proposed for listing as threatened throughout its range, and no data exist to suggest anything other than a single, panmictic population. So, to reach a determination of jeopardy, a proposed action would have to impact range-wide population dynamics. While NWFSC research activities are proposed to occur over a broad geographic area overlapping with the range of sunflower sea star, very few of the NWFSC studies would actually employ bottom trawl gear that could interact with sea stars or their habitats or their prey, and these efforts would only impact small areas of seafloor dispersed over the entire study area. Very few sea stars are expected to be taken as a result of this effort, and impacts to their available prey are not expected to significantly affect the fitness or survival of the species. These very small impacts would not rise to the level of affecting range-wide population dynamics, nor have more than the most minor effect on the species' numbers, reproduction, or distribution.

Critical Habitat

As previously discussed, we do not expect the NWFSC research program activities to have any appreciable effect on any listed species' critical habitat. The activities' short durations, minimal intrusion, and overall lack of measurable effect signify that even when taken together they would have no discernible impact on critical habitat.

2.8 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, the effects of other activities caused by the proposed action, and the cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of Leatherback sea turtles, North Pacific DPS Loggerhead sea turtles, Olive Ridley sea turtles, East Pacific DPS green sea turtles, Puget Sound, Upper Columbia River, Snake River spring/summer, Snake River fall-run, Lower Columbia River, Upper Willamette River, Sacramento River winter-run, Central Valley Spring-run, California Coastal Chinook salmon; Lower Columbia River, Oregon Coast, and Southern Oregon/Northern California Coast coho salmon; Hood Canal Summer-run and Columbia River chum salmon; Snake River sockeye salmon; Puget Sound, Upper Columbia River, Middle Columbia River, Snake River Basin, Lower Columbia River, Northern California, and California Central Valley steelhead; sDPS green sturgeon; sDPS eulachon; PS/GB bocaccio; PS/GB yelloweye rockfish; or Sunflower sea stars, or destroy or adversely modify their designated critical habitats.

2.9 Incidental Take Statement

Section 9 of the ESA and federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). "Harass" is further defined by interim guidance as to "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering." "Incidental take" is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this ITS.

Amount or Extent of Take

In the biological opinion, NMFS determined that incidental take is reasonably certain to occur as follows:

Sea Turtles

It is estimated that one sea turtle from any of the four species listed here may be incidentally captured in NWFSC research activities in any given year. We expect that sea turtles will be released alive and survive.

Table 37. Estimated Incidental Take of Sea Turtles

Species	Life Stage	Total Take	Lethal Take
Sea turtles (leatherback, North Pacific loggerhead, olive ridley, green)	Juvenile or adult	1	0

Marine and Anadromous Fish

The majority of take of ESA-listed rockfish, sturgeon, eulachon, salmon, and steelhead associated with the proposed action will be in the form of research activities intended to take these protected species for the express purpose of studying them and collecting data important to recovery efforts. The directed (intentional) take associated with such studies would be authorized through individual Section 10(a)(1)(A) research permits issued for each study as described in the Proposed Action (Section 1.3.2). In those instances, there is no incidental take at all. The reason for this is that all the take contemplated for those studies would be carried out under permits that allow the permit holders to directly take the animals in question, and therefore not cause any incidental take. While such studies often target some, but not all, of the ESA-listed fish species in their sampling area, we do not distinguish these species within a Section 10(a)(1)(A) permit and consider all listed species taken as part of these studies to be intentional. The amounts of direct take have been analyzed in the effects section above (Section 2.5) and are included in the total amounts of take of the program that would be reviewed annually to determine whether the program as a whole has met any reinitation triggers (Section 2.11).

NWFSC studies that do not target any ESA-listed fish species and are authorized through DTA letters (see Section 1.3.2) may unintentionally take fish from listed ESUs or DPSs, and this take is considered incidental to the action they are undertaking. Specific amounts of take for each listed species component will be enumerated in individual DTA letters the WCR's PRD issues to NWFSC researchers as specific studies are proposed and approved. We cannot accurately predict the exact total amounts of individual ESA-listed fish incidental take expected to occur as a result of the proposed NWFSC research program as a whole, as the exact numbers of individual fish for each study that may be requested and taken, and the number of active studies, is expected to change over time. We also expect thes numbers of fish to change as abundance of the various species changes. Therefore instead, we rely on our estimates of a proportion of abundance of listed ESUs and DPSs that we expect to be taken, which is also considered a better measure of impacts to species' viability (see Section 2.5). The effects of the program on listed fish species are also best evaluated with incidental and directed (through Section 10(a)(1)(A) permits) take combined so as not to segment the action and parse the impacts of the entire program.

As the proposed action is composed of research activities that do and do not intentionally target ESA-listed fish, the reinitiation triggers specified below (Section 2.11) evaluate the effects of incidental and directed take in total to ensure that the effects of the program overall do not exceed the effects analyzed in this Opinion. The overall take expected, and identified in section 2.11, is a reasonable surrogate for the amount of incidental take because take from incidental take studies is never expected to exceed that of the program as a whole. The types of studies conducted by the NWFSC, and whether they target listed species intentionally or catch them incidentally, is largely determined by long-standing programs of NWFSC research driven by their mission. While individual studies may start and stop, and the focal topics of some divisions and research programs may change over time, NWFSC research is broadly expected to continue to meet both sustainable fisheries and protected species mandates, and therefore continue to include a mix of both directed and incidental take studies similar to what it has over the past 20 years.

Marine Invertebrates

In the case of a species without 4(d) protective regulations such as the sunflower sea star, incidental take is not prohibited. As described in Section 2.5 (Effects of the Action), we anticipate NWFSC research activities are expected to incidentally take fewer than 10 individual sunflower sea stars per year initially, although if the species recovers rapidly that number could soon increase to levels near the previously observed 400 individuals per year. We don't have further information to predict the rate at which this might occur over time. While annual take of sunflower sea stars by the NWFSC has not previously exceeded 400 individuals per year, we acknowledge there are circumstances that can't be foreseen (such as encountering previously unknown areas of increased density, or changes to sampling methods) that could increase catch of this species. We therefore anticipate capture of up to 500 individuals per year could occur anywhere in the action area as a result of the proposed action.

Effect of the Take

In the biological opinion, NMFS determined that the amount or extent of anticipated take (direct and incidental), coupled with other effects of the proposed action, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

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).

1. The NWFSC shall minimize the amount of serious injury and or mortality among ESA-listed animals that are incidentally taken in any research survey. The NWFSC shall also minimize mortality of ESA-listed fish species that are intentionally captured and handled while conducting the proposed research activities.

2. The NWFSC shall monitor, document, and report all take of protected species resulting from their research.

Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, the federal action agency must comply (or must ensure that any applicant complies) with the following terms and conditions. The NWFSC or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this ITS (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse.

1. The following terms and conditions implement reasonable and prudent measure 1:

    1a. The NWFSC shall implement mitigation and avoidance measures described in section 1.3.1 of this Opinion to avoid interactions with protected marine mammal and turtle species, including those required in the 2018 MMPA LOA and described in the NWFSC 2022 application for renewal of authorization under the MMPA, and those described in future LOAs for this action.

    1b. The NWFSC shall implement measures to minimize the handling and improve the survival of all ESA-listed species incidentally captured or entangled in NWFSC research survey gear, allowing for biological sampling as appropriate. As part of this, the NWFSC shall adopt the procedures for handling and sampling of incidentally captured sea turtles described in the Southwest Fisheries Science Center's turtle handling procedures (SWFSC-PIRO 2023), and standard methods consistent with the protocol required for safe sea turtle handling in 50 CFR 223.206(d)(1).

1c. The NWFSC shall follow all measures described in the proposed action and conditions in project-specific authorizing DTA letters and Section 10(a)(1)(A) permits for minimizing harm and reducing mortality to the greatest extent possible for ESA-listed fish species incidentally or intentionally captured as part of the proposed research activities.

1d. Chief Scientists and all staff responsible for overseeing implementation of minimization and avoidance measures for ESA-listed species and marine mammals, as well as safe handling of and scientific sample collection from these species, shall receive training on procedures and protocols, including avoidance and mitigation measures and listed species handling, sampling, and processing, updated as deemed necessary by the NWFSC in consultation with WCR.

2. The following terms and conditions implement reasonable and prudent measure 2:

2a. The NWFSC shall monitor and record the incidental capture or entanglement of all ESA-listed turtles and marine mammals. Any takes of ESA-listed marine mammals or sea turtles must be reported through the following routes:

Hotline:

- If an animal is entangled and alive, the NWFSC shall report the incident to the Entanglement Reporting Hotline (1-877-767-9425) as soon as practicable.
- If an animal is dead, injured, or stranded, the NWFSC shall report the incident to the WCR Marine Mammal Stranding Network Hotline (1-866-767-6114) as soon as practicable.

Stranding Network:

- The NWFSC shall ensure that the incident is also reported to the NMFS WCR Stranding Coordinators as soon as practicable (if not immediately notified through the Stranding Network Hotline).
    - The current Stranding Coordinator for incidents off the coast of Oregon and Washington is Kristin Wilkinson (206-550-6208 or Kristin.Wilkinson@noaa.gov)
    - The current Stranding Coordinator for incidents that occur off the coast of California is Justin Viezbicke (562-506-4315 or Justin.Viezbicke@noaa.gov)
- The NWFSC shall report such incidents within 48 hours of returning to port through the Protected Species Incidental Take (PSIT) database.
- The NWFSC shall take steps necessary to ensure that data and/or stranding forms are submitted to the WCR Stranding Coordinator in a timely fashion upon return to port.

Research Permitting Team:

- The NWFSC shall notify the WCR PRD of incidental take of **ESA-listed marine mammals or turtles** within 48 hours of such an incident. The NWFSC may contact the WCR PRD research permitting team at nmfs.wcr-research-permits@noaa.gov or the lead permitting analyst named on the project-specific DTA letter or Section 10(a)(1)(A) permit for a given study to fulfill this requirement.

2b. An annual report summarizing the take of all ESA-listed turtles and marine mammals during the previous research season shall be provided by April 1st each year to the following address:

Assistant Regional Administrator
NMFS West Coast Region Protected Resources Division
501 W. Ocean Blvd, Suite 4200
Long Beach, CA 90802

Or via email at Chris.Yates@noaa.gov, and copied to Diana Dishman at Diana.Dishman@noaa.gov.

Information included in the annual reports must include: species name, number(s), size/weight/age class/gender (if applicable), and any available information on the date, location (latitude and longitude), and release condition associated with each take of all ESA-listed species, as well as pertinent details on the sampling equipment and monitoring and mitigation measures in use at the time when takes occurred. The NWFSC may elect to use the annual report and format required for MMPA LOA reporting for marine mammals, augmented as necessary to fulfill the reporting requirement for ESA-listed species, to fulfill this requirement.

2c. The NWFSC shall abide by the reporting requirements of individual DTA letters and Section 10(a)(1)(A) permits issued to each project to report all incidental and directed take of ESA-listed fish and invertebrates on an annual basis.

- In order to meet this requirement, the NWFSC shall also regularly update the reporting tools used to estimate the proportion of listed salmon and steelhead from ESA-listed ESUs or DPSs among fish collected of a given species when individuals from listed units and unlisted stocks are visually indistinct. The NWFSC shall submit in writing to WCR PRD a proposal for updating the tool(s) and/or proportions used for this purpose based on new data available over the past 5 years no later than one year from the date of this Opinion. This proposal must include data sources that will be used, an explanation of how the information will be applied or interpreted to generate estimates for reporting, and a plan for revisiting the information at a minimum of every 5 years to update the tool(s) and/or proportions as needed.

2d. The NWFSC and OPR shall meet with WCR PRD as soon as practicable after each time a new MMPA LOA is proposed to be issued by OPR for the proposed action, to review any new information regarding impacts to ESA-listed species from NWFSC research, any new science or commercial data related to ESA-listed species, any new or revised ESA-listing decisions, or any other relevant developments which have occurred in the years since this consultation was completed or the most recent LOA was issued (whichever is more recent) that may be applicable to this proposed action.

If compliance with the MMPA requires additional meetings between the NWFSC and OPR to discuss information related to the impacts of NWFSC research activities on marine mammals, the NWFSC shall provide WCR PRD the option to attend such meetings with reasonable advance notice.

2.10 Conservation Recommendations

Section 7(a)(1) of the ESA directs federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, “conservation recommendations” are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

1. Because there are increasing conservation and management needs for information about the factors that influence the presence, abundance, and distribution of many ESA-listed species throughout the proposed action area, the NWFSC should document all sightings of and encounters with ESA-listed species that may contribute to the body of knowledge regarding how these species interact with the marine ecosystem. This effort could be used to complement other NWFSC and NOAA initiatives aimed at developing approaches to use ecosystem data to inform management of ESA-listed species and other protected resources.

2. The NWFSC, in conjunction with the WCR and OPR, should develop and implement additional mitigation and avoidance measures for ESA-listed species and other marine mammals, as well as find ways to modify current measures to minimize interactions with protected resources while maximizing the efficiency and performance of NWFSC research activities. Specific examples include research into efficacy and modification of exclusion devices in survey trawl nets, along with investigation of other operational strategies to minimize incidental bycatch risks. In support of this effort, the NWFSC should conduct an internal review of any incidents in which take of ESA-listed marine mammals or turtles appeared likely or possible to occur but was narrowly avoided

(sometimes referred to as "near miss" incidents) to determine what, if anything can be done to avoid similar situations in the future.

3. NWFSC researchers should coordinate with other NMFS researchers and collaborators working on emerging technologies for aquatic biological monitoring to identify opportunities to use new sampling methods that could reduce the impacts of NWFSC research activities to listed species. Less invasive or non-invasive sampling methods should be incorporated into NWFSC research activities, as feasible, as they become mature and are confirmed to be suitable substitutes for current invasive techniques that result in the directed or unintentional take of protected species.

2.11 Reinitiation of Consultation

This concludes formal consultation for Consultation on Fisheries Research Conducted and Funded by the Northwest Fisheries Science Center and Issuance of ESA Section 10(a)(1)(A) Scientific Research Permits affecting Salmon, Steelhead, Eulachon, Green Sturgeon and Rockfish in the West Coast Region Pursuant to those Research Activities.

There are no definitive expiration (sunset) dates for the NWFSC research program or future authorizations the WCR's PRD may issue; therefore, there is no pre-determined end date on this biological opinion. As discussed above (see Proposed Action Section 1.3 and the Integration and Synthesis Section 2.7), the standard sampling practices, terms and conditions, and annual review of the NWFSC research program's reported take are critically important for reducing risk to listed species over time. The standard reinitiation triggers that apply to all biological opinions provide an additional safeguard against jeopardy or adverse modification over time. Under 50 CFR 402.16(a): "Reinitiation of consultation is required and shall be requested by the agency, where discretionary agency involvement or control over the action has been retained or is authorized by law and: (1) If the amount or extent of taking specified in the incidental take statement is exceeded; (2) If new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) If the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion or written concurrence; or (4) If a new species is listed or critical habitat designated that may be affected by the identified action."

(1) In the context of this Opinion, the reinitiation trigger set out in #1 could be invoked if the NWFSC research program exceeded the amount of sea turtle take set out in the Incidental Take Statement (Section 2.9) which is one incidental capture of a sea turtle of any listed species per year. Furthermore, review of the combined incidental and directed take of ESA-listed fish annually (see bullet 3, below) will establish a suitable trigger for reinitiation based on effects to listed fish species.

(2) Given the annual review of listed fish take, and recurring review of the entire action with issuance of subsequent MMPA LOA proposed rules built into the proposed action, the proposed action is structured such that some new information regarding the effects of research activities on ESA-listed species and/or critical habitat can be incorporated into the NWFSC research program. Adjustments to individual studies designed to be consistent with or more protective of listed species than the status quo can be made without exceeding the effects considered in this Opinion, because they would not involve new effects not previously considered. Changes to individual studies may also be made without affecting listed species or critical habitat in a manner or to an extent not previously considered for the NWFSC research program as a whole. However, if new effects not previously considered come to light, or are discovered to affect listed species to an extent not previously considered, reinitiation would be required.

(3) Reinitiation trigger #3 could be invoked if the NWFSC modifies its program of research activities such that the adverse effects to ESA-listed species or designated critical habitat are greater than those effects considered in the biological opinion under the proposed action. For listed fish, a one-year maximum mortality greater than 0.5% of the abundance of natural-origin ESU/DPS components of species could result in adverse effects to the species beyond those considered in this Opinion. In addition, a sustained increase of five or more years in the relative (i.e., proportional) annual mortality for natural-origin fish could result in adverse effects to the species beyond those considered in this Opinion. WCR PRD will annually calculate a running 5-year average for mortality for each species and consider a 5-year average of more than 0.25% of the estimated abundance for a listed fish species component to be an indicator of a sustained increase. Such changes to the proposed action, therefore, would trigger reinitiation of formal consultation on the affected species.

(4) Reinitiation trigger #4 could be invoked if a new species is listed or critical habitat designated that may be affected by the action, but would not be invoked by the listing of sunflower sea stars, as they are included in this conference opinion and we have concluded the proposed action is not likely to jeopardize their continued existence.

2.12 "Not Likely to Adversely Affect" Determinations

Under the ESA, "effects of the action" are 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 (50 CFR 402.02). When evaluating whether the proposed action is not likely to adversely affect listed species or critical habitat, NMFS considers whether the effects are expected to be completely beneficial, insignificant, or discountable. Completely beneficial effects are contemporaneous positive effects without any adverse effects to the species or critical habitat. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Effects are considered discountable if they are extremely unlikely to occur.

We do not anticipate the proposed action will adversely affect blue whales, fin whales, Mexico DPS and Central America DPS humpback whales, sei whales, sperm whales, Southern Resident killer whales, Western North Pacific DPS gray whales, or Guadalupe fur seals.

A conclusion that a proposed action “Is not likely to adversely affect critical habitat” is appropriate when the effects of an action on critical habitat physical or biological features (PBFs) are expected to be discountable, insignificant, or wholly beneficial. Wholly beneficial effects are positive only: an action cannot be deemed wholly beneficial if it has any adverse effect on critical habitat. Insignificant effects relate to the magnitude and duration of the impact and should never reach the scale where any critical habitat physical or biological feature is altered to the point that its ability to support listed species’ conservation needs is reduced. Therefore, effects would be insignificant when a person would not be able to meaningfully measure, detect, or evaluate changes in the value of one or more PBFs. Effects are considered discountable if they are extremely unlikely to occur.

We do not anticipate that the proposed action will adversely affect the designated critical habitats of Steller sea lions, Southern Resident killer whales, or Mexico DPS and Central America DPS humpback whales.

Status and Occurrence

Marine Mammals

Blue Whales

Blue whales are listed as endangered under the ESA (35 FR 18319, December 2, 1970) throughout their range. A 5-year review was published in 2020 (NMFS 2020a) recommending no change to the endangered status. The final recovery plan (NMFS 1998) was revised in 2020 (NMFS 2020b). The revised recovery plan defines nine blue whale management units, including the eastern North Pacific population (NMFS 2020b). The current global mature population size is uncertain, but estimated to be in the range of 5,000-15,000 mature individuals (NMFS 2020a). Although still depleted compared to historical abundance, blue whale populations around the world show signs of growth.

Blue whales inhabit both coastal and pelagic environments and are frequently found on the continental shelf (Calambokidis *et al.* 1990, Fiedler *et al.* 1998) and also far offshore in deep water (Wade & Friedrichsen 1978). Blue whales feed almost exclusively on euphausiids (krill) (Yochem & Leatherwood 1985) and make seasonal migrations between feeding and breeding locations, with their distribution often being linked to the patterns of aggregated prey. Like other baleen whales, the seasonal and inter-annual distribution of blue whales is strongly associated with both the static and dynamic oceanographic features such as upwelling zones that aggregate their prey. Pole-ward movements in spring allow the whales to take advantage of high zooplankton production in summer, while movement toward the subtropics in the fall allows blue whales to reduce their energy expenditure while fasting and to avoid ice entrapment.

Two stocks of blue whales identified through the MMPA SARs occur in the U.S. Pacific waters: the central North Pacific stock (formerly the Western North Pacific (formerly Hawaiian stock)) and the eastern North Pacific stock (formerly California/Mexico stock) (Carretta *et al.* 2023). The eastern North Pacific stock feeds off the west coast of the United States in summer and fall, and most of the stock is believed to migrate south to spend the winter and spring off Baja California, the Gulf of California, and on the Costa Rica Dome (Carretta *et al.* 2023). Nine biologically important feeding areas have been identified off the California coast (Calambokidis *et al.* 2015). In fall, blue whales migrate northward along the North American coast to secondary feeding areas off Oregon/Washington and further north.

There appears to be a northward shift based on increasing numbers of blue whales found in Oregon and Washington waters during line transect surveys (Carretta *et al.* 2023). The best estimate of the eastern North Pacific blue whale stock is 1,898 individuals based on mark-recapture methods for 2015 to 2018 (Calambokids and Barlow 2020). The minimum population estimate is 1,767 individuals with a PBR[6] of 7 whales per year (or 4.1 whales per year in U.S. waters) (Carretta *et al.* 2023). There may be evidence of a population size increase in the eastern North Pacific blue whale stock since the 1990s, but a formal trend analysis is lacking and the current population trend is unknown (Carretta *et al.* 2023).

Vessel collisions are identified as a stressor for blue whales in the revised recovery plan (NMFS 2020b). The observed annual incidental mortality and serious injury rate from ship strikes (0.8 whales per year) is less than the calculated PBR for this stock. This rate, however, does not include unidentified large whales struck by ships, nor does it include undetected and unreported vessel collisions of blue whales. Carretta *et al.* (2018) estimated that the vessel strike detection rate of blue whales is approximately one percent (also see Rockwood *et al.* 2017). In the California Current, the number of blue whales struck by ships likely exceeds the PBR for this stock (Redfern *et al.* 2013; Carretta *et al.* 2023).

Blue whales are occasionally documented as entangled in fishing gear along the U.S. West Coast (Carretta *et al.* 2023). Since 2007, there have been 9 confirmed entanglements, and one individual documented scars likely resulting from an entanglement along the U.S. West Coast (Carretta *et al.* 2022b). All of these individuals were reported in California; however, the reporting location does not always correspond with the region that the gear was originally set (Saez *et al.* 2021). The annual mortality and serious injury associated with fisheries is estimated to be 1.54 blue whales (Carretta *et al.* 2023).

[6] PBR, or potential biological removal, is defined by the MMPA as the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population).

Critical Habitat – Critical habitat has not been designated for blue whales.

Humpback Whales

Humpback whales were listed as endangered under the ESA (35 FR 18319, December 2, 1970), with a final recovery plan issued in November 1991 (NMFS 1991).

Humpback whales are found in all oceans of the world and migrate from higher latitude feeding grounds to low latitude calving areas. Humpbacks primarily occur near the edge of the continental slope and deep submarine canyons where upwelling concentrates zooplankton near the surface for feeding. Known prey organisms include species representing Clupea (herring), Scomber (mackerel), Ammodytes (sand lance), Sardinops (sardine), Engraulis (anchovy), Mallotus (capelin), and krills such as Euphausia, Thysanoessa, and Meganyctiphanes (Baker 1985; Geraci *et al.* 1989; Clapham *et al.* 1997; Clapham 2009). Humpback whales also exhibit flexible feeding strategies, sometimes foraging alone and sometimes cooperatively (Clapham 1993). Unlike most baleen whales, which forage primarily on euphausiids (krill), humpback whales will shift trophic levels depending on the oceanographic conditions and relative abundance of the prey items, for example between krill and small schooling fish (primarily anchovies and sardines).

Fleming *et al.* (2016) collected skin samples during 1993-2012 from humpback whales throughout the California Current (between 34°N and 42°N), and used stable isotope analysis to evaluate the relative contribution of euphausiids versus fish to the diet. In this study, shifts in stable isotope signatures over the 20-year time shifts corresponded to shifts in relative prey abundance (krill versus anchovy and sardine) and changing oceanographic conditions within the California Current. Fleming *et al.* (2016) demonstrated that krill dominated humpback whale diet during positive phases of the North Pacific Gyre Oscillation (NPGO), with cool sea surface temperature, strong upwelling, and high krill biomass. Conversely, schooling fish dominated humpback whale diet during years characterized by negative NPGO shifts, delayed seasonal upwelling, and warmer temperatures. These results suggest that the dominant prey in humpback whale diet switched from krill to fish, and back to krill during the 20-year period, depending on the relative abundance of each prey.

On September 8, 2016, NMFS published a final rule to divide the globally listed endangered humpback whale into 14 DPSs and listed four DPSs as endangered and one as threatened (81 FR 62259). NMFS has identified three DPSs of humpback whales that may be found off the coasts of Washington, Oregon, and California. The Hawaii DPS (found off Washington and southern British Columbia [SBC] and the North Pacific), which is not listed under the ESA; the Mexico DPS (found all along the U.S. west coast), which is listed as threatened under the ESA; and the Central America DPS (found predominantly off the coasts of Oregon and California), which is listed as endangered under the ESA.

The 2022 MMPA SARs for humpback whales more closely align with the new ESA listings and DPS designations (Carretta *et al.* 2023). Along the U.S. West Coast, all humpback whales are considered part of the Central America/Southern Mexico - California-Oregon-Washington (CA/OR/WA) stock (which aligns with the Central America DPS), the Mainland Mexico - CA-OR-WA stock, the Mexico - North Pacific stock (the latter two which make up the Mexico DPS), or the Hawaii stock (which is corresponds with the non-ESA listed Hawaii DPS).

The Central America DPS spends the winter primarily along Central America and southern Mexico (Curtis *et al.* 2022). The Mexico DPS winters along the Pacific coast of mainland Mexico, the Baja California Peninsula and the Revillagigedos Islands and spends summer off of the U.S. West Coast, including the Salish Sea (Martien *et al.* 2021). As a result, both the endangered Central America DPS and the threatened Mexico DPS at times travel and feed off the U.S. west coast. The non-listed Hawaii DPS, which is part of the newly designated Hawaii stock, spends winters in Hawaii and summers in Alaska, and its distribution may partially overlap with that of the Central America or Mexico stocks off the coast of Washington and British Columbia (Clapham 2009). There is some mixing between these populations, though they are still considered distinct stocks. Based on the presence of both listed DPSs along the West Coast of the U.S. (Wade et al 2016; Wade 2021; Lizewski *et al.* 2021), this analysis evaluates impacts on both the Central American and Mexico DPSs of humpback whales, as both are expected to occur in the action area.

The best current estimate of abundance for the Central America DPS is 1,496 individuals (Curtis *et al.* 2022). The growth rate for the Central American population is likely considerably lower than the growth rate for the full U.S. West Coast humpback whale population, possibly as low as 1.6% (Curtis *et al.* 2022), although some estimate it as high as 8.2% (Calambokidis and Barlow, 2020). Curtis *et al.* (2022) estimated the abundance of the Mexico DPS in the U.S. West Coast EEZ based on the total abundance in the area (4,973 whales; Calambokidis and Barlow 2020) minus the abundance estimate for the Central America DPS (1,496 whales) at 3,477 whales.

The impact of fisheries on humpback whales is likely underestimated, since the serious injury or mortality of large whales due to entanglement in gear may go unobserved because whales swim away with a portion of the net, line, buoys, or pots. Pot and trap gear are the most commonly documented source of mortality and serious injury to humpback whales off the U.S. West Coast (Carretta *et al.* 2023; Carretta *et al.* 2022b) and entanglement reports have increased considerably since 2014. Between 2016 and 2020, 257 large whales were reported as having human-caused serious injuries or mortalities. Of these, 153 were humpback whales (Carretta *et al.* 2022b). An additional 34 humpback whales were confirmed as entangled from 2021 to 2022 (NMFS 2022; 2023). There was a record high of 53 reported entanglements in 2016, of which 48 were confirmed (Saez *et al.* 2021).

Vessel strikes are likely the second greatest cause of death for humpback whales along the U.S. west coast, behind entanglements (Rockwood *et al.* 2017). Humpback whales, especially calves and juveniles, are highly vulnerable to vessel collisions (Stevick *et al.* 1999) and other interactions with non-fishing vessels. Humpback whales spend the vast majority of their time within 30 meters of the sea surface (90 percent at night and 69 percent during daytime), increasing their risk of vessel strike (Calambokidis *et al.* 2019). Off the U.S. west coast, humpback whale distribution overlaps significantly with the transit routes of large commercial vessels, including cruise ships, large tug and barge transport vessels, and oil tankers, along with fishing vessels (Rockwood *et al.* 2017; Redfern *et al.* 2020). Rockwood *et al.* (2017) modeled vessel collisions along the west coast and determined there were an average of 2.8 humpback whale strikes per year from 2006 to 2016, with a minimum of 8.2 and a best estimate of 28 deaths over the 10-year time period based on carcass buoyancy; however, this may be underestimating the avoidance behavior of humpback whales (Lesage *et al.* 2017; Garrison *et al.* 2022; Schuler *et al.* 2019). San Francisco Bay, Santa Barbara Channel, and the Strait of Juan de Fuca have all been identified as high risk areas of vessel strike for humpback whales (Nichol *et al.* 2017; Rockwood *et al.* 2020; 2021).

Critical Habitat – NMFS designated critical habitat for humpback whales on April 21, 2021 (86 FR 21082). The area stretches across the majority of the west coast of the U.S. and includes 48,521 nmi^2 for the Central American DPS, and 116,098 nmi^2 for the Mexico DPS. The Central America DPS critical habitat is located entirely along the U.S. West Coast and the Mexico DPS critical habitat is designated in the eastern Bering Sea, Gulf of Alaska, and the California Current Ecosystem. The designation includes a prey biological feature for both DPSs including primarily euphausiids (*Thysanoessa, Euphausia, Nyctiphanes,* and *Nematoscelis*) and small pelagic schooling fishes, such as Pacific sardine (*Sardinops sagax*), northern anchovy (*Engraulis mordax*), and Pacific herring (*Clupea pallasii*) of sufficient quality, abundance, and accessibility within humpback whale feeding areas to support feeding and population growth for both DPSs. The prey biological feature for the Mexico DPS also includes capelin (*Mallotus villosus*), juvenile walleye pollock (*Gadus chalcogrammus*), and Pacific sand lance (*Ammodytes personatus*).

Fin Whales

Fin whales are listed as endangered under the ESA (35 FR 18319, December 2, 1970) throughout their range. A 5-year review was issued in July 2019 (NMFS 2019d) recommending downlisting to threatened status. A final recovery plan for fin whales was issued in July 2010 (NMFS 2010a).

Fin whales are distributed widely in the world's oceans and occur in both the Northern and Southern Hemispheres, but the density of individuals in any one area changes seasonally (NMFS 2019d). They are generally not found near the equator, staying above 20 degrees north and south (Edwards *et al.* 2015). In the North Pacific, individuals are found from Baja California to Japan and as far north as the Chukchi Sea (Rice 1974). They may extend further north as new habitat and prey become available with the melting of sea ice (Crance *et al.* 2015). Unlike blue whales, fin whales feed on both krill and fish (Calambokidis *et al.* 2015). The local distribution of fin whales throughout much of the year is likely driven by prey availability. Fin whales in the northern hemisphere typically feed on planktonic crustaceans, including *Thysanoessa* sp. euphausiids and *Calanus* sp. copepods, and schooling fish, including herring, capelin and mackerel (Aguilar 2009).

Fin whales can occur year-round off California, Oregon, and Washington (Carretta *et al.* 2017). The greatest densities of fin whales appear to occur near the continental shelf and slope (Schorr *et al.* 2010). The Southern California Bight is a hotspot for fin whales, with whales present at least 6 months out of the year although there may be a resident population (Carretta *et al.* 2023). Three stocks are generally recognized off the west coast of the United States: the California/Oregon/Washington stock, the Hawaii stock, and the Northeast Pacific (Alaska stock) (Carretta *et al.* 2023), with California/Oregon/Washington stock occurring in the action area. Fin whales from this stock are year-round residents off the coast of California; they summer off the Oregon coast and may pass by the Washington coast. They are a pelagic species, seldom found in waters shallower than 656 ft. (200 m). Association with the continental slope is common (Schorr *et al.* 2010).

The best estimate of the California/Oregon/Washington stock is 11,065 individuals with a minimum population estimate of 7,970 individuals and a PBR of 80 whales per year (Carretta *et al.* 2023). There is strong evidence that the population increased between 1991 and 2018 (Carretta *et al.* 2023).

Vessel collisions are identified as a threat for fin whales. Because many collisions go unreported or undetected along with the offshore distribution of fin whales, the size of the impact of vessel collisions on fin whale recovery is not well understood (NMFS 2019c). Nichol *et al.* (2017) found that the west coast of Vancouver Island, Canada, and the offshore approaches to the shipping lanes and the western portion of the Strait of Juan de Fuca, are areas where fin whales are vulnerable to vessel collisions. Fin whales were involved in 23 vessel collisions on the U.S. West Coast since 2008 with 19 reported in California and four reported in Washington (Carretta *et al.* 2022b; NMFS WCR Stranding database).

There have been nine reports of fin whale entanglements in the U.S. West Coast since 1999 (Saez *et al.* 2021; Carretta *et al.* 2022b). All of these reports, except one, have been in unidentified fishing gear. Additionally, all of the entanglements have been reported in California with the exception of a 2006 report in Washington. Carretta *et al.* (2023) estimates a mean annual mortality and serious injury of 0.64 whales for the CA/OR/WA fin whale stock from fishery interactions.

Critical Habitat – Critical habitat has not been designated for fin whales.

Sei Whales

Sei whales are listed as endangered under the ESA (35 FR 18319, December 2, 1970) throughout their range, and a final recovery plan for sei whales was issued in December 2011 (NMFS 2011). A 5-year review was published in 2021 (NMFS 2021e) recommending no change to the endangered status.

Sei whales have a worldwide distribution, but are found primarily in cold temperate to subpolar latitudes rather than in the tropics or near the poles (Horwood 2009). Sei whales spend the summer months feeding in subpolar higher latitudes and return to lower, temperate latitudes to calve in the winter. There is some evidence from whaling catch data of differential migration patterns by reproductive class, with pregnant females arriving at and departing from feeding areas earlier than males (Mizroch *et al.* 1984). For the most part, the location of winter breeding areas is unknown (Horwood 2009). Sei whales are most often found in deep, oceanic waters of the cool temperate zone. They appear to prefer regions of steep bathymetric relief, such as the continental shelf break, canyons, or basins situated between banks and ledges and do not appear to associate with coastal features (NMFS 2011). On feeding grounds, the distribution is largely associated with oceanic frontal systems (Horwood 2009). In the North Pacific, sei whales feed along the cold eastern currents (Perry *et al.* 1999). Sei whales are opportunistic feeders with a diverse prey base including calanoid copepods, krill, fish, and squid.

The dominant food for sei whales off California during June through August is the northern anchovy, while in September and October they eat primarily krill.

Sei whales in the Eastern North Pacific are considered a separate stock (Carretta *et al.* 2023). While NMFS acknowledges that the MMPA stock structure does not align with the ESA-listed entity for sei whales, the MMPA SAR contains the best available demographic information for sei whales in U.S. waters (Carretta *et al.* 2023). The best estimate of sei whale abundance for California, Oregon, and Washington waters is 519 individuals with a minimum population estimate of 374 individuals and a PBR of 0.75 whales per year (Carretta *et al.* 2023).

Sei whales were documented as entangled in the Northwest Atlantic and in Hawaii in 2017 and 2011, respectively. The California swordfish drift gillnet fishery is the only fishery identified in the U.S. West Coast that is likely to take sei whales, although no serious injuries nor mortalities were observed during more than 8,600 monitored fishing sets from 1990-2014 (NMFS 2021; Carretta *et al.* 2023).

Reports of vessel collisions of sei whales are relatively rare, however, this is suspected to underrepresent the number of strikes occurring given that the whales generally do not strand due to their offshore distribution (NMFS 2021e). A handful of strike deaths have been reported in other sei whale regions. One vessel collision death was reported in Washington in 2003 by a shipping vessel. Another individual was associated with a vessel collision in southern California by an unknown vessel type, although further review determined the strike was likely post-mortem (Carretta *et al.* 2023).

Critical Habitat – Critical habitat has not been designated for sei whales.

Sperm Whales

Sperm whales are listed as endangered under the ESA (35 FR 18319, December 2, 1970) throughout their range, and a final recovery plan for sperm whales was issued in December 2010

(NMFS 2010b). A 5-year review was released in June 2015 (NMFS 2015) recommending no change to the endangered status. A new 5-year review was initiated in May 2021 (86 FR 28577, May 27, 2021).

Sperm whales are distributed globally and are found in all deep oceans, from the equator to the edge of the pack ice in the Arctic and Antarctic (Rice 1989). As described by Carretta *et al.* (2023, and citations therein), populations of sperm whales exist in waters of the California Current Ecosystem throughout the year. They are distributed across the entire North Pacific and into the southern Bering Sea in summer but the majority are thought to be south of 40$_o$N in winter. Sperm whales are found year round in California waters, but they reach peak abundance from April through mid-June and from the end of August through mid-November. Acoustic detections of sperm whales in the offshore waters of the outer Washington coast occurred all months of the year, with peak occurrence April to August. Detections inshore from April to November were generally faint enough to suggest that the whales were offshore (Oleson *et al.* 2009). Sperm whales consume numerous varieties of deep water fish and cephalopods.

For the MMPA SARs, sperm whales within the Pacific U.S. Exclusive Economic Zone (EEZ) are divided into three discrete, non-contiguous areas: 1) California, Oregon, and Washington waters, 2) waters around Hawaii, and 3) Alaska waters (Carretta 2023). The most recent abundance estimates for sperm whales off California, Oregon, and Washington out to 300 nautical miles were derived from trend-model analysis of line-transect data collected during six surveys from 1991 to 2014. Using this method, estimates ranged from 2,000 to 3,000 animals (Moore and Barlow 2017). The most recent estimate of abundance for the California/Oregon/Washington stock is 1,997 individuals; the minimum population estimate is 1,270 animals with a PBR of 2.5 whales per year. The population appears to be stable (Carretta *et al.* 2023).

Sperm whales spend long periods (typically up to 10 minutes) “rafting” at the surface between deep dives which makes them vulnerable to vessel collisions (NMFS 2015). Since 2007, there have been three confirmed vessel strikes of sperm whales on the U.S. West Coast (two in 2007 and one in 2012). One of the strikes in 2007 involved an idling sablefish longline vessel, although the whale did not appear to have any injuries as a result of the interaction (Carreta *et al.* 2023).

The mean annual estimated mortality and serious injury attributable to commercial fisheries interactions was 0.64 sperm whales per year, based on observer and stranding data from 2001 to 2012, however entanglements may go undetected. There were 11 sperm whale entanglement reports from 2008 to 2021 (Carretta *et al.* 2022b; WCR Stranding Network database). The California drift gillnet fishery and the limited entry sablefish hook and line fishery have both been involved in sperm whale entanglements.

Critical Habitat – Critical habitat has not been designated for sperm whales.

Southern Resident Killer Whales

The Southern Resident killer whale (SRKW) DPS was listed as endangered under the ESA in 2005 (70 FR 69903, November 18, 2005) and the final recovery plan was completed in 2008 (NMFS 2008a). Several factors identified in the recovery plan for SRKWs may be limiting their recovery. The primary threats include quantity and quality of prey, toxic chemicals that accumulate in top predators, and disturbance from sound and vessels. It is likely that multiple threats are acting together to impact the whales. Although it is not clear which threat or threats are most significant to the survival and recovery of SRKWs, all of the threats identified are potential limiting factors in their population dynamics (NMFS 2008a). A 5-year review under the ESA completed in 2021 concluded that SRKWs should remain listed as endangered and includes recent information on the population, threats, and new research results and publications (NMFS 2021).

The SRKW DPS consists of three pods (J, K, and L) that inhabit coastal waters off Washington, Oregon, and Vancouver Island, Canada, and are known to travel as far south as central California and as far north as Southeast Alaska (NMFS 2008a; Hanson *et al.* 2013; Carretta *et al.* 2023). Seasonal movements are likely tied to migration of their primary prey, salmon. During the spring, summer, and fall months, SRKWs spend a substantial amount of time in the inland waterways of the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound (Bigg 1990 Ford *et al.* 2000; Krahn *et al.* 2002; Hauser *et al.* 2007; NMFS 2021; Ettinger *et al.* 2022; Thornton *et al.* 2022). During fall and early winter, SRKWs, and J pod in particular, expand their routine movements into Puget Sound, likely to take advantage of chum, coho, and Chinook salmon runs (Osborne 1999; Hanson *et al.* 2010; Ford *et al.* 2016). Although seasonal movements are somewhat predictable, there can be large inter-annual variability in arrival time and days present in inland waters from spring through fall, with late arrivals and fewer days present in recent years (NMFS 2021; Ettinger *et al.* 2022).

Land- and vessel-based opportunistic and survey-based visual sightings, satellite tracking, and passive acoustic research have provided an updated estimate of the whales' coastal range. In recent years, several sightings and acoustic detections of SRKWs have been obtained off the Washington, Oregon, and California coasts in the winter and spring (Hanson *et al.* 2010; Hanson *et al.* 2013, Hanson *et al.* 2017, Emmons *et al.* 2021, NMFS 2021c). Satellite-linked tag deployments in the winter indicate that K and L pods use the coastal waters along Washington, Oregon, and California during non-summer months (Hanson *et al.* 2017; NMFS 2021c), while J pod occurred frequently near the western entrance of the Strait of Juan de Fuca but spent relatively little time in other outer coastal areas. A full description of the geographic area occupied by SRKW can be found in the biological report that accompanies the final critical habitat rule (NMFS 2021b).

SRKWs consume a variety of fish species (22 species) and one species of squid (Ford *et al.* 1998; Ford 2000; Ford and Ellis 2006; Hanson *et al.* 2010; Ford *et al.* 2016), but salmon are identified as their primary prey. The diet of SRKWs is the subject of ongoing research, including direct observation of feeding, scale and tissue sampling of prey remains, and fecal sampling. The diet data suggest that SRKWs are consuming mostly larger (i.e., generally age 3 and up) Chinook salmon (Ford and Ellis 2006). Chinook salmon is their primary prey despite the much lower abundance in comparison to other salmonids in some areas and during certain time periods. Scale and tissue sampling from May to September in inland waters of Washington and British Columbia, Canada, indicate that their diet consists of a high percentage of Chinook salmon (monthly proportions as high as >90%) (Hanson *et al.* 2010; Ford *et al.* 2016). Ford *et al.* (2016) confirmed the importance of Chinook salmon to SRKWs in the summer months using DNA sequencing from whale feces. Salmon and steelhead made up to 98% of the inferred diet, of which almost 80% were Chinook salmon. Coho salmon and steelhead are also found in the diet in inland waters in spring and fall months when Chinook salmon are less abundant (Ford *et al.* 1998; Ford and Ellis 2006; Hanson *et al.* 2010; Ford *et al.* 2016).

Prey remains and fecal samples collected in inland and coastal waters during October through May indicate Chinook salmon and chum salmon are primary contributors of the whale's diet during the fall, winter, and spring months as well (Hanson *et al.* 2021). Analysis of prey remains and fecal samples sampled during the winter and spring in coastal waters indicated the majority of prey samples were Chinook salmon (approximately 80% of prey remains and 67% of fecal samples were Chinook salmon), with a smaller number of steelhead, chum salmon, and halibut detected in prey remain samples and foraging on coho, chum, steelhead, big skate, and lingcod detected in fecal samples (Hanson *et al.* 2021). The occurrence of K and L pods off the Columbia River in March suggests the importance of Columbia River spring runs of Chinook salmon in their diet (Hanson *et al.* 2013). Chinook salmon genetic stock identification from samples collected in winter and spring in coastal waters included 12 U.S. west coast stocks, and over half the Chinook salmon consumed originated in the Columbia River (Hanson *et al.* 2021).

At the time of the 2023 population census, there were 75 SRKWs counted in the population (CWR 2023). The abundance estimate for this stock of killer whales is a direct count of individually identifiable animals, and as such serves as both a best estimate of abundance and a minimum estimate of abundance. The NWFSC continues to evaluate changes in fecundity and mortality rates. Population projections using survival and fecundity rates from a recent five-year period (2017-2021) project a downward trend over the next 25 years (NMFS 2021). Recent genomic analyses indicate that the SRKW population has greater inbreeding and carries a higher load of deleterious mutations than do Alaska resident or transient killer whales, and that inbreeding depression is likely impacting the survival and growth of the population (Kardos *et al.* 2023). These factors likely contribute to the SRKW population's poor status.

The most recent PBR level for this stock is 0.13 whales per year, which was based on the minimum population size of 74 whales from the 2021 July census. A recent examination of all killer whale ecotype strandings found that three whales, including one SRKW (L98 who was habituated to humans) died from vessel strikes (Raverty *et al.* 2020). The cause of death of L112 was determined to be blunt force trauma to the head, however the source of the trauma (vessel strike, intraspecific aggression, or other unknown source) could not be established (Carretta *et al.* 2023). Total observed fishery mortality and serious injury for this stock is zero; however, recovery of a SRKW carcass is rare and undetected mortality and serious injury may occur.

Critical Habitat – In November 2006, NMFS designated critical habitat for the SRKW DPS (71 FR 69054, November 29, 2006). This designation includes approximately 2,500 square miles of Puget Sound, including three specific areas: (1) the Summer Core Area in Haro Strait and waters around the San Juan Islands; (2) Puget Sound; and (3) the Strait of Juan de Fuca. Areas with water less than 20 feet deep are not included in the designation. Three physical or biological essential features were identified: (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality and availability to support individual growth, reproduction and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging.

In September 2021, NMFS revised the critical habitat designation for the SRKW DPS by designating six additional coastal critical habitat areas along the U.S. West Coast (86 FR 41668, August 2, 2021). The revision added to the existing critical habitat approximately 15,910 square miles of marine waters between the 6.1-meter and 200-meter depth contours from the U.S.-Canada border to Point Sur, California. The same physical or biological essential features were identified for coastal critical habitat, and each coastal area contains all three physical or biological essential features identified in the 2006 designation.

Western North Pacific Gray Whales

There are two recognized gray whale stocks in the North Pacific, the eastern North Pacific (ENP) which is not listed under the ESA, and the western North Pacific (WNP) DPS which is listed as endangered under the ESA (35 FR 18319, December 2, 1970). A 5-year review was published in 2023 (NMFS 2023g) recommending no change to the endangered status.

A new DPS analysis was also published in March 2023 (Weller *et al.* 2023). The Status Review Team (SRT) determined that three groups or "units" of gray whales each meet the DPS Policy criteria for discreteness and significance: (1) gray whales that spend their entire lives in the WNP (termed the "WNP-only unit"), (2) gray whales that feed in the WNP in the summer and fall and migrate to the ENP (including Mexico) in the winter ("WNP-ENP unit"), and 3) a single unit consisting of both the WNP-only and WNP-ENP units (termed the combined option). The SRT recommended using the combined option to define the WNP gray whale DPS as a practical approach given the difficulty in assigning an individual to a unit and as a practical means to provide positive management to the DPS throughout its entire range (Weller *et al.* 2023). Considering this, WNP gray whales are gray whales that spend all or part of their lives in the western North Pacific in the waters of Vietnam, China, Japan, Korea (Republic of Korea and/or Democratic People's Republic of Korea), or the Russian Far East, including southern and southeastern Kamchatka but not necessarily areas north of 55°N in eastern Kamchatka (NMFS 2023g). This definition is consistent with that used in the International Union for Conservation of Nature (IUCN)/International Whaling Commission's (IWC) Western Gray Whale Conservation Management Plan as well as with how the western gray whale subpopulation has been evaluated by the IUCN (Cooke *et al.* 2018). The animals that feed in the western North Pacific, including those whales found off Sakhalin and southeastern Kamchatka, represent the only large feeding concentration of gray whales in the western North Pacific, and their numbers remain small (171 to 214 age 1+ years; Cooke *et al.* 2019).

Gray whales occur along the eastern and western margins of the North Pacific, generally migrating between summer feeding grounds in high latitudes and winter breeding grounds in lower latitudes. Gray whale migration is typically limited to relatively near shore areas along the North American west coast during the winter and spring months (November-May). Gray whales are bottom feeders, sucking in sediment and eating benthic amphipods (Brower *et al.* 2017). Historically, the WNP gray whales were considered geographically isolated from the ENP stock. However, recent satellite tagging data, genetic, and photo-identification matches between Sakhalin, Canada, the United States, and Mexico have identified 60 whales known to travel between the eastern and western North Pacific (Weller *et al.* 2012; Mate *et al.* 2015; Martinez-Aguilar *et al.* 2022). This raises questions about the proportion of WNP gray whales that remain in the western North Pacific year-round. Based on population modeling that incorporated data on known movements of WNP gray whales into the eastern North Pacific, Cooke *et al.* (2019) concluded that 45-80% of Sakhalin whales migrate to the eastern North Pacific in the winter. This finding indicates that at least 20%, and perhaps more, of the whales migrate elsewhere, presumably to wintering areas off the Asian coast. Thus, the number of WNP gray whales remaining in the western North Pacific year-round is likely small (possibly fewer than 50 whales, Cooke 2017), making these whales more vulnerable than previously thought (Weller *et al.* 2012).

The WNP population is estimated at approximately 290 individuals of age one year and above based on photo-id data collected off Sakhalin (Cooke 2017, Cooke *et al.* 2018) with a minimum abundance of 271 whales, and a PBR of 0.12 WNP gray whales per year (Carretta *et al.* 2023). Based on the positive growth rates and estimates that the number of mature WNP gray whales now is greater than 50, the IUCN down listed the WNP gray whale from Critically Endangered to Endangered status in 2018 (Cooke *et al.* 2018).

Coastal net fisheries represent a significant threat to WNP gray whales. A number of individuals have become entangled and died in fishing gear (in WNP waters) and others show signs of entanglement scarring (NMFS 2023g). Illegal harvest of individuals may also be occurring. Like other whales, WNP gray whales are at risk of vessel collisions with high risk areas near Kamchatka, the Bering Sea, Gulf of Alaska, and along the North American west coast (Silber *et al.* 2021).

WNP gray whales may be impacted by oil and gas exploration, especially near the feeding area off Sakhalin Island. This could lead to disturbance from noise, vessel strike, exposure to oil, and impacts to their prey (NMFS 2023g). Amphipod biomass has decreased in recent years around Sakhalin Island. Since January 2019, higher than normal numbers of gray whale strandings have occurred along the west coast of North America from Mexico through Alaska, which led to the declaration of an Unusual Mortality Event (UME) in September 2019. The cause of these strandings is still not known although several whales showed evidence of emaciation. However, this finding wasn’t consistent across individuals. It is not known whether stranded gray whales during this event have been from the WNP population (NMFS 2023g).

Critical Habitat – Critical habitat has not been designated for WNP gray whales.

Guadalupe Fur Seals

In the U.S., Guadalupe fur seals were listed as threatened under the ESA on December 16, 1985 (50 FR 51252). The population is considered a single stock because all are recent descendants from one breeding colony at Guadalupe Island, Mexico. There is no recovery plan for Guadalupe fur seals. A status review was published in 2021 recommending no change to their threatened status (McCue *et al.* 2021).

Prior to harvest during the 19th century, Guadalupe fur seals ranged from Monterey Bay, California to the Revillagigedo Islands, Mexico (Hanni *et al.* 1997, Repenning *et al.* 1971). They are currently found along the west coast of North America from Central Mexico (Ortega-Ortiz *et al.* 2019) to southern British Columbia, Canada (Norris *et al.* 2017). The species breeds primarily in Mexico on Guadalupe Island, but in recent years a small number of pups (<30 per year) have been born at the San Benito Archipelago (Aurioles-Gamboa *et al.* 2010; Sierra-Rodríguez 2015; Elorriaga-Verplancken *et al.* 2016; Norris and Elorriaga-Verplancken 2019, 2020). In the U.S., they haul out on the California Channel Islands and occasionally on the Farallon Islands. Their presence along the U.S. west coast has increased, and in the last several years a few pups, some of which likely are hybrid Guadalupe fur seals and California sea lions (*Zalophus californianus*), have been born on the Channel Islands (i.e., San Miguel Island) off southern California. They prefer shorelines with abundant large rocks and lava blocks and are often found at the base of steep cliffs and in caves and recesses, which provide protection and cooler temperatures, particularly during the summer breeding season (Aurioles-Gamboa 2015; McCue *et al.* 2021).

Though relatively little empirical data exists to describe population-level dispersal or migratory patterns, like most otariids, adult females tend to remain around the breeding areas when they are nursing pups, but males appear to migrate away from these areas during the winter (Norris *et al.* 2017). Recent tracking data collected from Guadalupe fur seals tagged at Guadalupe Island in 2016 and 2017 revealed habitat use within the fur seals' range. Tagged pups generally traveled north of Guadalupe Island towards offshore waters of central California while non-pups (adult females and juvenile males and females) ranged up to 2,000 kilometers north and south of Guadalupe Island (Norris *et al.* 2017). Territorial males arrive at the rookeries in June and depart by early August (Seagars 1984; McCue *et al.* 2021) while females arrive in late May through June (Seagars 1984). Researchers know little about the whereabouts of Guadalupe fur seals during the non-breeding season from September through May, but they are presumably solitary when at sea.

Researchers studying the feeding habitats of the Guadalupe fur seal found that they feed on deep-water cephalopods and small schooling fish. Digestive tracts of stranded animals in central and northern California contained primarily squid (*Loligo opalescens* and *Onychoteuthis borealojaponica*) with a few otoliths of lampfish (*Lampanyctus*) and Pacific sanddab (*Citharichthys sordidus*) (Hanni *et al.* 1997). Recent studies of their feeding habits also indicate that off their main colony on Guadalupe Island, they primarily target cephalopods, with fish comprising a minor component of their diet (McCue *et al.* 2021).

The most recent estimate of population size is based on pup count data from 2013, with an estimate of 34,187 individuals and a minimum population size of 31,019 animals (Garcia-Aguilar *et al.* 2018; Carretta *et al.* 2023). This is estimated to be only one-fifth of the historical pre-exploitation size (Garcia-Aguilar *et al.* 2018). The PBR for Guadalupe fur seals is 1,062 individuals per year which is not prorated for U.S. waters given that the proportion of time spent there compared to in Mexico is unknown (Carretta *et al.* 2023).

No Guadalupe fur seals have been observed entangled in California gillnet fisheries between 1990 and 2017 (Carretta *et al.* 2023) although 12 individuals have shown signs of gillnet entanglements from 2007 to 2020 (Carretta *et al.* 2012; Carretta *et al.* 2016; Carretta *et al.* 2020; Carretta *et al.* 2022b). Individuals have been observed hooked in the Hawaii shallow set longline fishery (Carretta *et al.* 2019). Other sources of injury include unidentified fishery interactions, marine debris, shootings, unidentified trawl fisheries, hook and line fishery, and unidentified net fishery (Carretta *et al.* 2022b).

In 2015, Guadalupe fur seal strandings were greater than eight times the preceding 5-year average in California and declared a UME. A UME was also declared off of Oregon and Washington in 2019. The UME was closed in September 2021 with a total of 715 seals stranding. Scientists believe that the UME was caused by suboptimal prey conditions resulting from unprecedented ocean warming in the Northeast Pacific.[7]

Critical Habitat – Critical habitat has not been designated for Guadalupe fur seals.

Marine and Anadromous Fish

Southern California Steelhead

On August 18, 1997, NMFS listed SC steelhead as an endangered species (62 FR 43937). NMFS concluded that the SC steelhead DPS was in danger of extinction throughout all or a significant portion of its range. There is no hatchery production in support of this DPS. The geographic range of the SC steelhead DPS extends from the Santa Maria River, near Santa Maria, to the California–Mexico border, which represents the known southern geographic extent of the anadromous form of *O. mykiss*. NMFS described historical and recent steelhead abundance and distribution for the southern California coast through a population characterization (Boughton *et al.* 2006). Surveys in Boughton *et al.* (2005) indicate between 58 percent and 65 percent of the historical steelhead basins currently harbor *O. mykiss* populations at sites with connectivity to the

[7] More information on the UME can be found at https://www.fisheries.noaa.gov/national/marine-life-distress/unusual-mortality-event-2015-2021-guadalupe-fur-seal-and-2015.

ocean. Most of the apparent losses of steelhead were noted in the south, including Orange and San Diego Counties (Boughton *et al.* 2005).

While 46 drainages support the SC steelhead DPS (Boughton *et al.* 2005), only 10 population units possess a high and biologically plausible likelihood of being viable and independent (Boughton *et al.* 2006). Very little data regarding abundances of Southern California Coast steelhead are available, but the picture emerging from available data suggest very small (<10 fish) but surprisingly consistent annual runs of anadromous fish across the diverse set of basins that are currently being monitored (NMFS 2023f). It is believed that population abundance trends can significantly vary based on yearly rainfall and storm events within the range of the Southern California Coast DPS (Williams *et al.* 2011). A relatively large number of adult steelhead were observed in 2008, two years after an extended wet spring that presumably gave smolts ample opportunity to migrate to the ocean. Some of the strength of the 2008 season may also be an artifact of conditions that year. Low rainfall appears to have caused many spawners to get trapped in freshwater, where they were observed during the summer; in addition, low rainfall probably improved conditions for viewing fish during snorkel surveys, and for trapping fish in weirs (Williams *et al.* 2011).

There is little new evidence to suggest that the status of the Southern California DPS has changed appreciably in either direction in recent years (SWFSC 2023, NMFS 2023f). The most recent SC steelhead recovery plan found no evidence that the annual return of anadromous adults has changed since the original 2005 status review, which estimated the number to be less than 500 individuals (NMFS 2012b). The SC steelhead DPS is also influenced by the presence of a significant unlisted resident population of *O. mykiss.* Due to the phenotypic plasticity between these two life history strategies that has been demonstrated in *O. mykiss*, it is possible that additional outmigrants may be derived from this unlisted resident population, or that some residual offspring of anadromous parents may express a resident life history (NMFS 2023f).

The majority of lost populations (68 percent) of SC steelhead have been associated with anthropogenic barriers to steelhead migration (e.g., dams, flood-control structures, culverts, etc.). Additionally, investigators have found that barrier exclusions are statistically associated with highly-developed watersheds. SC steelhead populations experience a high magnitude of threat to a small number of extant populations vulnerable to extirpation due to loss of accessibility to freshwater spawning and rearing habitat, low abundance, degraded estuarine habitats and watershed processes essential to maintain freshwater habitats (NMFS 2012b). The practice of fire suppression within the range of this DPS, and the associated potential for increased fire intensity and duration, has also been identified as a potential threat to the steelhead in this DPS (62 FR 43937). The recovery potential is low to moderate due to the lack of additional populations, lack of available/suitable freshwater habitat, steelhead passage barriers, and inadequate instream flow.

Proposed Action Effects

We relied on the proposed marine mammal take mitigation, monitoring, and reporting measures described in the NWFSC's PEA (NWFSC 2018) and SPEA (NWFSC 2023b), application for the

LOA (NWFSC 2022a), and in its BA (NWFSC 2023a) when evaluating the potential impacts of the proposed fisheries research activities in this Opinion.

To avoid or minimize the potential for these activities to adversely affect protected species and their critical habitats, the NWFSC also proposes to implement several mitigation measures while conducting its research. These include measures to greatly reduce the likelihood of marine mammals or sea turtles interacting with research vessels or survey gear, and reduce the impact of anticipated interactions with ESA-listed fish and invertebrates to the greatest extent feasible. For all species, these measures include sufficient training and coordination among research personnel to ensure the best practices are consistently employed. To reduce the likelihood of marine mammals interacting with research equipment these mitigation measures generally include:

- Vessel speed reductions;
- Observers to monitor the area for the presence of these species before deploying gear;
- Protocols to move to other survey areas if species are sighted within certain distances of the research vessel (i.e., the “move-on” rule); as well as
- Limiting trawl durations and taking care to retrieve gear in ways that avoid or minimize potential harm.

We incorporate by reference and adopt those descriptions from the SPEA (NWFSC 2023b) and 2022 LOA application (NWFSC 2022a) here and apply them throughout this section covering the description of the proposed federal action (50 CFR 402.14(h)(3)).

In the future, LOAs would need to continue to be obtained for this work to proceed. While the details of any future LOA may change, given (1) the requirements of Section 101(a)(5) of the MMPA, (2) the conditions of the NWFSC’s prior and currently proposed LOAs, and (3) requirements of LOAs issued by OPR to other NMFS Science Centers for similar work over the past decade, it is reasonably certain that future LOAs will continue to require that the researchers have the smallest practicable adverse impact on the affected marine mammals. See Section 1.3 for further details.

Discountable Effects

For the species found in Section 2.12,, both gear interaction/entanglement and vessel collisions were considered to be extremely unlikely to occur. While NWFSC research activities and these listed species may overlap in space and time, the mitigation measures proposed and lack of previous encounters support our conclusion that the likelihood of such encounters is so low as to be discountable.

Gear Interaction and Entanglement

Marine Mammals

NWFSC surveys involve the use of gear that has the potential to take marine mammals, including bottom, midwater, and surface trawls, purse seines, tangle nets, and hook and line gear (including rod and reel, troll, and longline deployments) in the PSRA, LCRRA, and CCRA. These takes may occur in two forms: (1) take by accidental entanglement that may cause mortality and serious injury, and (2) take by accidental entanglement that may cause non-serious injury (Level A harassment take under the MMPA). Entanglement of ESA-listed marine mammals, including some species of whales, is known to be an issue with commercial fishing gear on the U.S. west coast (Saez *et al.* 2021), although usually associated with fixed pot/trap and gillnet gear.

From 1999-2014, the NWFSC incidentally caught 42 marine mammals that are not listed under the ESA during fisheries-related research activities (see Table 4.2-16 in the Final PEA). Although marine mammals have the potential to be caught in numerous gear types used by the NWFSC, historical interactions have only occurred with the Nordic 264 surface trawl and modified Cobb trawl nets. The majority (33) were taken during the Juvenile Salmon PNW Coastal Survey. Species involved were Pacific white-sided dolphins (24), Steller sea lions (8), California sea lions (4, including one released alive), harbor seals (3), including one released alive), northern fur seal (1), and unidentified porpoise/dolphin (2). The three other surveys with reported marine mammal takes are the Juvenile Rockfish Survey (2), the Skagit Bay Juvenile Salmon Survey (1), and the PNW Piscine Predator and Forage Fish Survey (6). The last survey is no longer being conducted. There are no records of marine mammal take for 2015-2018 for any NWFSC survey.

Since 2018, the NWFSC had no takes of marine mammals due to interactions with trawl gear until 2023 (NWFSC 2023b). In 2023, one adult California sea lion was incidentally caught with bottom trawl gear and two Pacific white-sided dolphins were incidentally caught during a deployment using mid-water trawl gear; all animals were discovered dead when the gear was brought aboard. An additional juvenile California sea lion was encountered while deploying a bottom trawl net in 2023, although based on the carcass condition when it was discovered it was presumed to be dead prior to interaction with the survey gear (unpublished reports from NWFSC, also available through the Protected Species Incidental Take (PSIT) database).

Up until 2018, the NWFSC had no history of marine mammal takes in hook-and-line gear (including longlines, rod and reel, and trolling deployments) or purse seine or tangle net gear (NMFS 2018). However, on Sept 28, 2021, a California sea lion was taken during a hook and line survey from a contracted ship in the vicinity of Catalina Island (NWFSC 2022a). The sea lion swallowed the hook and was observed swimming away with two additional hooks and a lead sinker dangling from its mouth. A California sea lion believed to be the same one was observed later without the gear in its mouth. The take was entered into the Protected Species Incidental

Take (PSIT) database as "injured." No other M/SI or Level A takes were recorded for hook and line surveys over the period 2018-2021.

No currently ESA-listed marine mammal species have ever been reported captured/entangled during any NWFSC research activity (the Eastern DPS of Steller sea lions were delisted in 2013). As a result, the NWFSC did not request any lethal or serious injury take, or any Level A (non-serious injury) harassment take under the MMPA for any ESA-listed marine mammals in their LOA application.

While the bycatch of large whales in commercial trawl fishing gear is not unprecedented, it is not a common event in any U.S. west coast fishery (NMFS observer data), nor would it ever be expected to occur in a NWFSC survey trawl. For most of the ESA-listed marine mammal species, the risk of incidental capture or entanglement is very low in trawl gear given the slow speed and relatively small size of survey trawls fished at/near the surface. However, smaller ESA-listed marine mammals, such as Guadalupe fur seals, could be at more risk of capture if they encountered NWFSC survey trawls, as evidenced by the historical capture of other pinnipeds and dolphins. Mitigation measures include a move-on rule to minimize chances for gear to be deployed with marine mammals nearby and modified net retrieval procedures if marine mammals are sighted while gear is in the water. Use of dedicated marine mammal observers prior to and during survey trawl operations should help research vessels identify the presence of ESA-listed marine mammals during operations, and vessels can take necessary evasive action. Use of marine mammal excluder devices should also help any smaller ESA-listed marine mammal escape relatively unharmed if they do enter a trawl net.

Risks of interactions between longline gear and ESA-listed marine mammals include hooking or entanglement with the gear, especially for pelagic longlines. These interactions could result from direct predation of bait or depredation on fish that are already captured by the longline, or by unknowingly swimming into the gear and becoming entangled. Bottom longlines do present some risk of entanglement due to vertical lines running from the surface to the bottom, but gangions and hooks are relatively low in profile on the bottom and likely less vulnerable to hooking or predation by marine mammals than the profile of hooks suspended in the water column in pelagic longline gear. Compared to commercial longline fishing gear operations, NWFSC research gear is typically shorter in length, uses less hooks, and soaks for less time, which may contribute to the lack of ESA-listed marine mammal bycatch that has occurred historically during NWFSC research activities. Use of dedicated marine mammal observers prior to and during longline survey operations is expected to help research vessels identify the presence of ESA-listed marine mammals, and act accordingly to minimize incidental capture and entanglement risks.

Although several modifications are being proposed to previously evaluated studies' gear types, deployment durations, location, and timing, we do not anticipate that any of the proposed changes (described in detail in Section 2.1 of the BA) will increase the risk of marine mammal interaction or entanglement for this research program overall. While individual studies may shift their effort among gear types or continue to develop study-specific modifications to their gear and methods, the risk these gears pose to ESA-listed marine mammals as a program of activities across the action area remains essentially unchanged. Similarly, it is expected that researchers will continue to adjust and adapt their sampling methods and equipment in the future. However, as proposed, any such changes would only be those expected to have equivalent or lesser impacts on ESA-listed species (Section 2.1 of the BA), and therefore would not be expected to increase the risk of entanglement or interaction with gear to ESA-listed marine mammals.

Predicting future events is challenging, but if a particular event has never occurred before—i.e., NWFSC research program has never captured or entangled currently ESA-listed marine mammals, we deem the risks associated with the program to be very low—though they cannot be completely eliminated. Any future take events could change this assessment, but until that time, and given the historical performance of NWFSC research activities, we conclude that the likelihood of incidentally capturing or entangling ESA-listed marine mammals is discountable.

Marine and Anadromous Fish

The proposed NWFSC research activities have the potential to overlap in space and time with SC steelhead, as outmigrating subadult steelhead may disperse broadly westward into offshore areas of the Eastern Pacific (Quinn and Myers 2004), and the distribution of SC steelhead in the ocean is not well known (NMFS 2012b). However, as described in the prior consultation on the NWFSC research program (NMFS 2016f) it is unlikely that any individuals would be encountered. The most recent abundance estimates indicate that there are very small numbers of fish persisting in this DPS, and their distribution is at the southern edge of NWFSC research Activities (SWFSC 2023, NMFS 2023f). Further, reporting from the past 10 years of NWFSC research activities which have the potential to overlap with the range of this DPS (i.e., offshore surveys in the CCRA) shows that they have not captured a single steelhead which could be attributed to this DPS (APPS reporting data from 2013-2023). Therefore, the fact that this DPS exists in such low abundance, has limited overlap of known ocean distribution and survey activities in space and time, and there is no record of any previous NWFSC take of steelhead off the coast of California, we conclude that the likelihood of such encounters is so low as to be discountable.
There is no overlap of NWFSC research activities with designated SC steelhead critical habitat.

Vessel Collisions

Vessel strikes are considered a serious and widespread threat to ESA-listed species (especially large cetaceans) and are the most well-documented "marine road" interaction with large whales (Pirotta *et al.* 2019). This threat increases as commercial shipping lanes and other high traffic vessel areas overlap important breeding and feeding habitats, and as whale populations recover and populate new areas (Swingle *et al.* 1993; Wiley *et al.* 1995). Vessel collisions were implicated in the deaths of seven fin whales, 13 humpback whales, and one blue whale along the U.S. west coast during 2015-2020, along with one additional serious injury to an unidentified large whale attributed to a vessel collision (Carretta *et al.* 2023). As vessel traffic becomes more widespread, an increase in vessel interactions with cetaceans and other listed species is to be expected. The vast majority of commercial vessel strike mortalities of cetaceans are likely undocumented, as most may not be observed and/or reported and carcasses are likely to end up sinking rather than washing up on shore.

Collisions of ships and marine mammals can cause major wounds, which may lead to the death of the animal. An animal at the surface could be struck directly by a vessel, a surfacing animal could hit the bottom of a vessel, or an animal just below the surface could be cut by a vessel's propeller. In most cases, serious injuries are often assumed to result in death given the severity of the wounds and that animals are not adequately monitored to confirm they survived following such events (e.g. Vanderlaan and Taggart 2007). While any vessel has the potential to hit cetaceans, the severity of injuries typically depends on the size and speed of the vessel (Knowlton and Kraus 2001; Laist *et al.* 2001; Vanderlaan and Taggart 2007).

Jensen and Silber (2004) summarized large whale vessel collisions world-wide from 1975 to 2003 and found that most collisions occurred in the open ocean involving large vessels. Commercial fishing vessels were responsible for four of 134 records (3%), and one collision (0.75%) was reported for a research boat, pilot boat, whale catcher boat, and dredge boat. Schoeman *et al.* (2020) also reviewed global records of vessel collisions with marine mammals, and found a broad range of vessel types are involved with collisions, although the relationship between vessel speed and severity of injury depends both on the vessel type and the species involved. With respect to large whales, lethal or severe injuries are often caused by vessels 80 meters (262.5 feet) in length or greater, traveling 25.9 kilometers per hour (14 knots) or faster (Laist *et al.* 2001). Most publications on the topic discuss collisions between large whales and large vessels; however, smaller marine mammals may also be at risk of collision (Schoeman *et al.* 2020). The probability of a vessel collision depends on the number, size, and speed of vessels, as well as the distribution, abundance, and behavior of the species (Conn and Silber 2013; Hazel *et al.* 2007; Jensen and Silber 2004; Laist *et al.* 2001; Vanderlaan and Taggart 2007).

Vessel transits associated with the proposed research activities are relatively infrequent and spread out over a very broad area compared to the distributions of ESA-listed cetaceans. The traffic patterns typically involve research vessels departing from and returning to port less than 20 times per survey (anywhere from two to ten round-trips per study) for only five or six studies a year, and these some of these studies are only conducted every other year. These return trips to and from port are also spread out over months, and occur over the entire action area, so they are not concentrated in any particular areas known to have high concentrations of ESA-listed whales. The majority of surveys also do not conduct research activities during months associated with peak gray whale migration along the U.S. West Coast (December and January southward, or February through early May northward), though a few studies may be active during these times.

The proposed survey activities would require the NWFSC vessels to spend the majority of their time at sea moving at slow operational speeds necessary for gear deployment; typically 4 knots or less. Outside of operations, each vessel's cruising speed is approximately 10 knots (but range from 6-14 knots), which is generally below the speed at which studies have noted reported increases of marine mammal injury or death (~14 knots; Laist *et al.* 2001). The relatively low speed of gliders or other autonomous surface vehicles (typically 1–3 knots with a maximum speed of 8 knots) reduce the risk of collision with marine mammals such that this potential effect is considered negligible. Research vessels operated by the NWFSC are also typically smaller than ocean-going shipping vessels (e.g., the *Reuben Lasker* is 208.7 ft long, and fishing vessels under contract are much smaller still) and more maneuverable, which in combination with proposed mitigation measures, further reduces the likelihood of collision.

Preventative measures during cruises would include the NWFSC maintaining constant watch and slowing down or taking evasive maneuvers to avoid collisions with marine mammals or other species. During offshore surveys, the officer on watch, Chief Scientist (or other crew member), and crew standing watch on the bridge would visually scan for marine mammals during all daytime operations with 360-degree coverage around the vessel. At any time during a survey or in transit, if a crew member standing watch or dedicated marine mammal observer sights marine mammals that may intersect with the vessel course that individual would immediately communicate the presence of marine mammals to the bridge for appropriate course alteration or speed reduction, as possible, to avoid incidental collisions.

Based on the infrequent and broadly distributed patterns of vessel movements, slow speeds of the NWFSC vessels, the preventative measures proposed, and the fact that no collisions with large whales have been reported from any fisheries research activities conducted or funded by the NWFSC (NWFSC 2018; NWFSC 2023b),the probability of vessel and marine mammal interactions occurring during NWFSC operations is extremely small, and we conclude the risk of adverse effects to ESA-listed marine mammals as a result of collisions with NWFSC research vessels is discountable.

Insignificant Effects

Of the effect pathways identified for the proposed action, both prey removal and acoustic impacts are reasonably certain to occur. Research vessels will be actively deploying gear and instruments with the intent of capturing and removing fish species, and characterizing their abundance and distribution with acoustic data collection. However, the magnitude of these impacts is expected to be so small they cannot be meaningfully measured, detected, or evaluated with regard to their effect on any listed species or their critical habitat.

Prey Removal

Various NWFSC research surveys capture many species of fish and invertebrates that are sources of prey for ESA-listed species.

The 2023 SPEA analyzed the potential impacts of prey removals on marine mammal species and determined that the total amount of these species taken in research surveys is very small relative to their overall biomass in the area. In addition to the small amount of biomass removed, the size classes of fish targeted in research surveys are generally juveniles, some of which are only centimeters long, that are not expected to be prey of many ESA-listed species in the study areas.

As described further in the analysis in Section 2.5, the magnitude of prey reduction associated with NWFSC research, assuming all captures actually lead to mortality and prey removal, is insignificant compared to the overall amount of forage that is expected to be available for ESA-listed species. In addition to the small magnitude of prey reductions that are expected to result from the proposed action, the temporal and spatial distributions are also important to consider. Surveys generally are spread out systematically over large areas such that prey removals are not concentrated during any place or time in a manner that is expected to affect foraging for any ESA-listed marine mammals in a discernible manner. As a result, we anticipate that the proposed action is only expected to have very minor and transitory impacts on prey used by the ESA-listed marine mammal species in the action area, and the risks of local depletions that could have an impact on the overall health and fitness of ESA-listed marine mammals are insignificant (see below for more on Southern Resident killer whales and salmon, and for humpback whales and forage fish).

Southern Resident Killer Whales

The proposed actions may affect SRKWs and their critical habitat by reducing availability of their preferred prey, Chinook salmon. This analysis focuses on Chinook salmon availability because the best available information indicates that salmon are the preferred prey of SRKWs year-round, including in inland and coastal waters. Focusing on Chinook salmon provides a conservative estimate of potential effects of the action on SRKWs because the total abundance of all salmon and other potential prey species is orders of magnitude larger than the total abundance of Chinook salmon. Further, prey quantity and availability are essential features of SRKW critical habitat, which may be affected by the proposed action. To assess the effects of the proposed research activities on SRKWs and their critical habitat, we considered the geographic area of overlap in the marine distribution of Chinook salmon affected by the action, and the range of SRKWs. We also considered the importance of the affected Chinook salmon ESUs compared to other Chinook salmon runs in the SRKW diet composition, and the influence of hatchery mitigation programs.

The NWFSC proposes to kill an annual maximum of 9,664 juvenile and 1,179 adult (or subadult) Chinook salmon during the course of research (Appendix A Table A4). These numbers include both ESA-listed and non-listed Chinook salmon. However, in the last 10 years (2013-2022), a total of 8,810 juvenile and 179 adult (or subadult) ESA-listed Chinook salmon have been killed (averaging 881 juveniles and 18 adults per year) (Appendix A Table A1). As the effects analysis for salmonids illustrated, these losses—even in total—are expected to have only very small effects on salmonid abundance and productivity and no appreciable effect on diversity or distribution for any listed Chinook salmon ESUs. The affected Chinook salmon ESUs, in addition to unlisted salmon, are:

- Puget Sound
- Upper Columbia River spring run
- Snake River spring/summer run
- Snake River fall run

- Lower Columbia River
- Upper Willamette River
- California Coastal
- Sacramento River winter run
- Central Valley spring run

The fact that the research would kill Chinook salmon could affect prey availability to SRKWs throughout their critical habitat. However, it is unlikely that SRKWs would detect such a small number of prey removed on an annual basis, especially as the affected ESUs are spread throughout the U.S. west coast. As such, the expected prey removal due to the proposed action is therefore expected to have minimal, if any, effect on prey availability for SRKWs and their critical habitat.

Because SRKWs prey on adult salmon, to determine the effect juvenile losses might have on SRKWs and their critical habitat, we convert those juvenile fish mortalities to adult equivalents. Using procedures following the Pacific Salmon Commission's Chinook Technical Committee (PSC 2023), we applied age-specific natural mortality rates to the expected number of juvenile mortalities to calculate the number of adults that would be removed from the SRKW prey base. Here, juveniles refer to smolts, fry, and subyearlings. Applying a 40% mortality rate from age 1 to 2, and a 30% mortality rate from age 2 to 3 (PSC 2023), this would translate to the effective loss of about 370 adult Chinook salmon equivalents annually due to research activities. Taken together, this would mean that the research, in total, could remove something on the order of 388 adult Chinook from the SRKW prey base in any given year (or 3,880 over a 10-year period). Given that the number of adult Chinook salmon (listed and unlisted) in the ocean at any given time is several orders of magnitude greater than that figure, it is unlikely that SRKW would intercept and feed on many (if any) of these salmon, nor that they would detect such a reduction in the available prey in their critical habitat.

Given these circumstances, and the fact that we anticipate no direct interaction between any of the researchers and SRKWs, NMFS finds that potential adverse effects of the proposed research on SRKWs are insignificant and determines that the proposed action may affect, but is not likely to adversely affect, SRKWs or their critical habitat.

Mexico DPS and Central America DPS humpback whales

Humpback whales have a diverse diet that slightly varies across feeding aggregation areas. The species is known to feed on both small schooling fish and on euphausiids (krill), and the relative contribution of various prey species may change depending on the relative prey abundance. Here we assess prey removal due to the proposed research activities for the most common prey species for humpback whales (discussed above), including krill, herring, mackerel, anchovy, and sardine.

Scientists estimate that large baleen whales consume around 3 to 4 percent of their body weight per day. Since a large humpback whale may weigh approximately 40 tons, during a normal day in the summer feeding season one whale may consume between 1 to 1.5 tons of food per day (Clapham 2013). Given that humpback whales generally feed off the U.S. West Coast from April through November (~8 months), one humpback whale can eat up to 240 tons of food (including euphausiids and small schooling fish) during the foraging season.

As seen in Table 38, the NWFSC is expected to remove less than 1 metric ton (mt) of humpback prey biomass per year from trawling surveys, based on reported removals from 2017-2022. Assuming each whale is consuming between 1 and 1.5 tons of fish per day, this amounts to less than one day's worth of food for a single whale removed over the course of a year and a wide geographic area. Given that there may be ~5000 humpback whales off the U.S. West Coast (Calambokidis and Barlow 2020), that may equate to a foraging need of ~1 million mt for a given feeding season. Ultimately, the potential removal of prey by the NWFSC represents a negligible portion of the total and daily prey needs of the humpback whale DPSs. We know that humpback whales are plastic feeders, capable of switching prey among schooling fish or euphausiids, as available. As a result, we conclude NWFSC prey removals will have insignificant effects on both the Central America and Mexico humpback whale DPSs and their critical habitats.

Table 38. Common humpback whale prey species and annual reported total catch in metric tons (mt) by NWFSC research activities from 2017-2021.

Prey species	Total catch (mt)
Anchovy	0.0640102
Herring	0.0650566
Invertebrates	0.02
Krill	0.03778152
Mackerel	0.000026
Pollock	0.005616
Sandlance	0.00002241
Sardine	0.0153354
Smelt	0.0243972
Squid	0.237222133
Ecosystem Component Species*	0.015
Total	**0.484467463**

* Ecosystem Component Species are those species that the Pacific Fishery Management Council and NOAA Fisheries have determined do not require specific management, but are identified to achieve ecosystem management objectives.

Acoustic Impacts

NWFSC research activities are expected to create underwater noise as a result of vessel transits and operations to conduct boat-based surveys, and through the use of active acoustic research devices. As described in the MMPA LOA application (NWFSC 2022a), no Level A or B take is anticipated to occur under the MMPA due to acoustic sources during the course of research.

Exposure to loud noise is one of the potential stressors to marine species, as noise and acoustic influences may seriously disrupt communication, navigational ability, foraging, and social patterns. In particular, marine mammals rely substantially upon sound to communicate, navigate, locate prey, and sense their environment. The 2007 Marine Mammal Noise Exposure Criteria provides a comprehensive review of marine mammal acoustic sensitivities including designating functional hearing groups (Southall *et al.* 2007). Assignment to these groups was based on behavioral psychophysics (the relationship between stimuli and responses to stimuli), evoked audiometry potential, auditory morphology, and, for pinnipeds, whether they were hearing through air or water. Because no direct measurements of hearing exist for baleen whales, hearing sensitivity was estimated from behavioral responses (or lack thereof) to sounds, commonly used vocalization frequencies, body size, ambient noise levels at common vocalization frequencies, and cochlear measurements. In 2019, Southall *et al.* (2019) published an update to the 2007 Marine Mammal Noise Exposure Criteria, which confirms the weighting functions and thresholds used by NMFS and cited in the 2018 revised NMFS Technical Guidance (NMFS 2018e). The NMFS Technical Guidance continues to be used for defining regulatory thresholds for calculating incidental takes of marine mammals under the MMPA. Table 39 presents the functional hearing groups and representative species or taxonomic groups for each. All of the ESA-listed marine mammals found in the proposed project areas are in the first two groups, low frequency cetaceans (baleen whales) and mid frequency cetaceans (odontocetes), and the last group (fur seals).

Table 39. Marine mammal functional hearing groups (adapted from NMFS 2018e).

Hearing Group	Hearing Range
Low-frequency cetaceans (e.g. baleen whales)	7 Hz to 35 kHz
Mid-frequency cetaceans (e.g. killer whales)	150 Hz to 160 kHz
High-frequency cetaceans (e.g. true porpoises)	275 Hz to 160 kHz
Phocid pinnipeds (true seals)	50 Hz to 86 kHz

Otariid pinnipeds (sea lions and fur seals)	60 Hz to 39 kHz

Potential Responses from Exposure

Based on past studies and observations, we consider that sounds generated by vessels or active acoustic sources used during NWFSC research activities could cause the following possible impacts or responses: temporary behavioral disturbance; masking of natural sounds; temporary or permanent hearing impairment; and/or non-auditory physical or physiological effects (Richardson *et al.* 1995; Wartzok *et al.* 2003; Gordon and Moscrop 2006; Southall *et al.* 2007). Below we briefly discuss these four potential impacts.

Marine mammals may behaviorally react to sound when exposed to anthropogenic noise. Disturbance includes a variety of effects, including subtle to conspicuous changes in behavior, movement, and displacement. Controlled experiments involving exposure to loud impulse sound sources (typically low frequency) with captive marine mammals showed pronounced behavioral reactions, including avoidance of loud sound sources. Observed responses of wild marine mammals to loud pulsed sound sources (typically seismic airguns or acoustic harassment devices, or impact pile-driving) have been varied but often consist of avoidance behavior or other behavioral changes suggesting discomfort (see Southall *et al.* 2007 for review). The exposure to active acoustic sources could result in temporary, short-term changes in an animal's typical behavior and/or avoidance of the affected action area. While low frequency cetaceans (e.g., blue whales) have been observed to respond behaviorally to low- and mid-frequency sounds, there is little evidence of behavioral responses in these species to high frequency sound exposure (see e.g., Jacobs and Terhune 2002; Kastelein *et al.* 2006). Sperm whales have been observed to interrupt their activities by frequently stopping echolocation and leaving the area in the presence of underwater pulses made by echosounders and military submarine sonar near where the sperm whales are located (Watkins *et al.* 1985).

The term masking refers to the inability of a subject to recognize the occurrence of an acoustic stimulus as a result of the interference of another acoustic stimulus (Clark *et al.* 2009). Introduced underwater sound may, through masking, reduce the effective communication distance of a marine mammal species if the frequency of the source is close to that used as a signal by the marine mammal, and if the anthropogenic sound is present for a significant fraction of the time (Richardson *et al.* 1995). Masking can also interfere with detection of acoustic signals such as communication calls, echolocation sounds, and environmental sounds important to marine mammals. Therefore, under certain circumstances, or sustained exposure, marine mammals whose acoustic sensors or environment are being severely masked could also be impaired from maximizing their performance fitness in survival and reproduction.

Marine mammals exposed to high intensity sound repeatedly or for prolonged periods can experience a hearing threshold shift, which is the loss of hearing sensitivity at certain frequency ranges (Kastak *et al.* 1999; Finneran *et al.* 2002, 2005). Threshold shifts can be permanent (PTS), in which case the loss of hearing sensitivity is not recoverable, or temporary (TTS), in which case the animal's hearing threshold would recover over time (Southall *et al.* 2007; NMFS 2018e). Marine mammals depend on acoustic cues for vital biological functions (e.g., orientation, communication, finding prey, avoiding predators); thus, PTS or TTS may result in reduced fitness in survival and reproduction. However, the impact of TTS depends on the frequency and duration of TTS, as well as the biological context in which it occurs. TTS of limited duration, occurring in a frequency range that does not coincide with that used for recognition of important acoustic cues, would have little to no effect on an animal's fitness. Repeated sound exposures that lead to TTS could cause PTS. PTS, in the unlikely event that it occurred, would constitute injury, but TTS is not considered injury (Southall *et al.* 2007; NMFS 2018e).

Non-auditory physiological effects or injuries that theoretically could occur in marine mammals exposed to strong underwater sound include stress, neurological effects, bubble formation, resonance, and other types of organ or tissue damage (Cox *et al.* 2006; Southall *et al.* 2007). Studies examining such effects are limited, however. In general, very little is known about the potential for strong underwater sounds to cause non-auditory physical effects in marine mammals. Such effects, if they occur at all, would presumably be limited to short distances from the sound source and to activities that extend over a prolonged period.

Active Acoustics

NWFSC research utilizes various types of sonar systems with various frequency ranges from 1.5 kHz to above 400 kHz (see Table 40). These types of sound sources are considered non-impulsive or continuous sources and would not be used at thresholds that could cause physical injury to marine species. Some active fisheries acoustic sources (e.g. short range echosounders, acoustic Doppler current profilers) have very high output frequencies (>180 kHz; outside the functional hearing range of marine mammals, see Table 39) and generally short duration signals and highly directional beam patterns. These sources are determined to have essentially no probability of being detected by, or resulting in any potential adverse impacts on, marine species. Hearing impairment and non-auditory physical effects (e.g. stress) are not anticipated due to NWFSC research because animals would not be exposed to strong, pulsed underwater sounds. Although sounds that are above the functional hearing range of marine animals may be audible if sufficiently loud, the relative output levels of these sources and the levels that would likely be required for animals to detect them would be on the order of a few meters. Therefore, the probability for injury or disturbance from these sources (where the frequency is > 180 kHz) is extremely unlikely.

Table 40. Operating characteristics of NWFSC research underwater sources.

Equipment	Operating Frequencies (kHz)	Maximum Source Level (dB)	Single Ping Duration (ms) and Repetition Rate (Hz)	Orientation/ Directionality	Nominal Beam Width

Simrad EK500, EK60, EK80 Echosounders	10, 18, 38, 70, 120, 200, 333, 400	224	Variable; most common is 1ms and 0.5 Hz	Downward	11°@18 kHz 7°@38 kHz
Simrad ME70 Multibeam Echosounder	70-120	205	0.06-5 ms; 1-4 Hz	Downward	140°
Simrad SX90 Narrow Beam Sonar	20-30	219	Variable	Omnidirectional	4–5° (variable for tilt angles)
Teledyne RD Instruments ADCP Ocean Surveyor	75	224	0.2 Hz	Downward	30°
Simrad ITI Monitoring System	27-33	214	0.05-0.5 Hz	Downward	40°

Some of the lower frequency and higher power systems may be detectable over moderate ranges for some species. For some ESA-listed baleen whales (blue whales, fin whales, and sei whales), we conclude it is unlikely that they will detect most of these active acoustic sources, due to their relative low frequency hearing range. For odontocete cetaceans (sperm whales and SRKWs), and to a lesser degree humpback whales and other pinnipeds (Guadalupe fur seals), we conclude that these species could be exposed to and detect at least some of the active acoustic sources used during NWFSC research.

As described in the NWFSC BA (NWFSC 2023a), based on information in Crocker and Fratantonio (2016), NMFS developed a user tool to estimate the distances potentially ensonified by echosounders. Assuming a maximum source level of 224 decibels (dB) referenced at 1 micropascal at 1 meter (dB re 1 μPa@1m), frequency of 18 kHz beam width of 11°, and water depth of 200m, underwater sound from an EK60 echosounder (the echosounder most frequently used for research) exceeding the Level B behavioral threshold limit of 120 dB would only extend horizontally approximately 19 m from the source. Considering the highly directional nature of the echosounders and the mitigation measures to observe for and avoid marine mammals within close proximity to research vessels during research activities, the potential sound levels and effects of this type of equipment on marine mammals are considered insignificant.

If a marine mammal does react to an underwater sound from NWFSC research by changing its behavior or moving a small distance, it is likely to be brief, minor, and unlikely to rise to the level of measurable impacts. We expect that any potential disturbance would be localized to a relatively small area surrounding a research vessel, and would last only a short time because vessels are expected to be moving through and away from areas at the same time marine mammals might be simultaneously avoiding those vessels. Even if vessels are stationary for a period of time, we expect animals to move away from the “zone of influence” to avoid the disturbing sound. Because sound levels surrounding any area that a vessel has occupied or traveled through would return to ambient levels relatively quickly, we expect that marine mammals would be able to resume any activity that might have been temporarily affected, in the unlikely event that any behaviors were affected to begin with. Additionally, given the short time period that avoidance behavior is expected in comparison to the normal expenditures that may occur during most any day for an individual, we do not expect an individual to experience stress or depletion of energy reserves that exceed the natural variability for animals in the environment.

The net result of any temporary disturbance could be increased energetic expenditure to move and avoid the presence of NWFSC research vessels, or temporary exclusion from an area that might include an important resource such as forage. However, we do not expect this short-term disturbance to be significant enough to result in behavioral modifications (e.g., prolonged changes in diving/surfacing patterns, habitat abandonment due to loss of desirable acoustic environment, or more than brief cessation of feeding or social interaction) that would lead to a discernible effect on growth, survival, reproduction, or any aspect of fitness or overall health of individuals.

It is possible that an individual could receive multiple exposures to NWFSC active acoustics over time, either by encountering the same vessel again as the boats and whales continue moving around (different than whales or vessels actually following each other around), or a different NWFSC research vessel conducting a different survey at another time and/or place. It is also possible that marine mammals may elect to remain in the “zone of influence” despite the sound levels due to sufficient impetus to remain in that area to continue foraging in the presence of a desired prey field. However, based on the temporary nature of any behavioral reaction or impact that each encounter is expected to result in, and that these events will likely be separated in space and time, we conclude that those incidents can be considered isolated where animals have resumed activities and recovered from any previous temporary exposure. Considering the relatively low total number of instances of exposures to potentially disturbing sound levels each year that have been predicted for ESA-listed marine mammals that may be able to detect the active acoustics as a result of the proposed action, no Level B exposures anticipated under the MMPA (FR notice), and the large extent of area that NWFSC covers during the course of a year, we conclude it is extremely unlikely that any individual will accumulate a large number of exposures to NWFSC research vessels over the course of a year, and that exposure will be dispersed throughout the population over the range of NWFSC activities.

Vessel Noise

In addition to active acoustic sources, the vessels used for research also produce relatively loud sounds at a much lower frequency. The specific sound profiles of the research vessels used are not readily available. McKenna *et al.* (2012) described large commercial vessel traffic sound profiles where bulk container and tanker ships produce broadband sounds at or greater than 180 dB re μPa@1m, with the highest source level <100 Hz. The research vessels used by the NWFSC vary in length; however, even the largest research vessels are smaller than the commercial vessels that produce these source levels. As a result, we assume that NWFSC research vessels produce low frequency sounds that are loud, but at somewhat lower levels than very large container ships. Clark *et al.* (2009) examined the concepts of marine mammal communication masking by noise, including sound produced by vessel traffic, and found significant potential for masking effects. There is some evidence that whales can, but sometimes do not, compensate for such changes in their ambient noise environment. For example, killer whales increase the amplitudes of their calls with increasing noise in the 1–40 kHz frequency band (Holt *et al.* 2009).

The transitory nature of NWFSC research cruises that typically cover vast areas of ocean and do not remain in the same places for many days and weeks should preclude any sustained lasting impacts from sound produced by NWFSC research vessels to any individuals that would lead to significant or sustained changes in behavior that would be expected to produce decreased fitness or survival that could warrant consideration as take under the ESA. The sheer size of the proposed project area covered by research activities and the relative frequency and footprint of the NWFSC vessels transiting or operating through any given area at most a few times a year leads us to conclude that the potential for impacts accumulating in any one area during the year in a significant or detectable manner is discountable. Accumulation of anthropogenic noise, and specifically vessel noise, is a known problem for marine life including many of the ESA-listed marine mammal species considered in this Opinion. However, it is currently not possible to assess the contribution that a relatively small number of research cruise trips spread throughout a vast area of the ocean over the course of a year may be contributing to the overall magnitude of this problem in a meaningful way. Based on the transitory nature of NWFSC research and the relatively limited presence of NWFSC vessels throughout the action area during the year, we conclude the effects of vessel noise on ESA-listed marine mammals are insignificant.

Mitigation measures

As part of mitigation measures being implemented to reduce marine mammal bycatch in research survey trawls, the NWFSC would deploy pingers with variable frequency (10-160 kHz) and duration (200-400 microseconds), repeated every 5 to 6 seconds (NWFSC 2018). The pingers generate a maximum sound pressure level of 145 dB RMS referenced to 1 micropascal at 1m. By definition, the intention of these pingers is to influence the behavior of marine mammals, including ESA-listed species, to detect and otherwise avoid capture in survey gear. The exact mechanisms of how pingers have contributed to successful deployment and reduction of some marine mammal bycatch in other commercial fishing settings, or if these pingers will contribute to reduced bycatch in survey trawl gear is unclear. Section 109(h) of the MMPA (16 U.S.C. 1379(h)) allows for the taking of marine mammals in a humane manner by federal, state, or local government officials or employees in the course of their official duties if the taking is necessary for “the protection or welfare of the mammal,” “the protection of the public health and welfare,” or “the non-lethal removal of nuisance animals.” NWFSC use of pingers as a deterrent device, which may cause Level B harassment of marine mammals under the MMPA, is intended solely for the avoidance of potential marine mammal interactions with NWFSC research gear (i.e., avoidance of Level A harassment, serious injury, or mortality). Therefore, use of such deterrent devices, and the taking that may result, is for the protection and welfare of the mammal and is covered explicitly under MMPA Section 109(h)(1)(A). Under the ESA, the action of preempting bycatch events is considered beneficial, as long as no other contemporaneous adverse effects are occurring as a result. At this point, we assume pingers are beneficial in helping to reduce the chances of bycatch for ESA-listed marine mammals, and we have not identified any adverse effect likely to occur as a result of them. The sounds produced by these pingers are at least partially audible to ESA-listed marine mammals, but are still well under the levels of sound being produced by other active acoustic equipment used. As a result, we do not expect these pingers to produce any injurious effects to any ESA-listed species.

Acoustics Summary

Based on the characterization of active acoustic sound sources used by the NWFSC, we conclude that some of the sources used are likely to be entirely inaudible to all marine mammal species (other than maybe in the immediate vicinity of sound sources) including the ESA-listed species considered in this Opinion. We also conclude that some of the lower frequencies may be detectable over moderate distances from sound sources for some ESA-listed species, although this depends strongly on inter-specific differences in hearing capabilities. For some ESA-listed baleen whales (blue whales, fin whales, and sei whales), we conclude it is unlikely that they will detect most of these active acoustic sources, due primarily to their relative low frequency hearing range. For odontocete cetaceans (sperm whales and SRKWs), and to a lesser degree humpback whales and other pinnipeds (Guadalupe fur seals), we conclude that these species could be exposed to and detect at least some of the active acoustic sources used during NWFSC research.

Given that NWFSC research vessels are not expected to remain in the same area for multiple days and weeks, any masking of communication or other sounds will be ephemeral and brief, and animals would be expected to either continue those communications while avoiding NWFSC vessels and/or resuming them in the area shortly after the departure of those vessels such that changes to their communications as a result of the action could not be meaningfully measured. We do not expect the project to result in any temporary or permanent hearing impairment, any discernable non-auditory physical or physiological effects, or measurable effects as a result of masking. Most likely, if any ESA-listed marine mammals detect active acoustic sound sources at all, they could show some temporary avoidance of the areas where received levels of sound are high enough that hearing impairment could potentially occur. In those cases, the avoidance responses of the animals themselves would most likely avoid the potential for effects that may only occur during extended exposures at close proximity to these sounds. Therefore, we conclude the risks of hearing impairment, non-auditory physical injuries, and adverse effects from masking resulting from exposure to active acoustics are discountable. We also conclude it is likely that animals that have been temporarily disturbed and/or displaced by avoiding the active acoustics of NWFSC research will not experience energetic costs that lead to measurable or biologically meaningful impacts that could affect the fitness of individuals with respect to survival, growth, and reproduction. We expect the effects of disturbance and avoidance from this proposed action to be temporary and insignificant. As a result, we conclude that the risks associated with exposure to active acoustics leading to short term disturbance and effects on foraging habitat are insignificant.

We conclude that short term exposure to active acoustic sources aboard NWFSC research vessels present insignificant risks for ESA-listed marine mammals. We expect exposures that are actually detectable may lead to a temporary disturbance and avoidance of NWFSC vessels that, if it occurs, will not have any discernable effects to health or fitness as a result of this exposure for any of these ESA-listed marine mammals listed above. This response would result primarily from temporary exposure to relatively high frequency sounds for short durations as the NWFSC research vessels transit through while actively conducting research or en route to a new sampling location, or remain stationary for a relative short period of time.

Based on the analyses presented above, we conclude that the impacts expected to result from the proposed use of active sound sources by the NWFSC are insignificant, and the risks of injury or disturbance that could lead to adverse effects on the health, behavioral ecology, and social dynamics of individuals of any ESA-listed marine mammal species in ways or to a degree that would reduce their fitness are discountable. Because our analysis indicates that the expected behavioral responses of these animals are not expected to disrupt the foraging, migrating or other behaviors of these animals to such an extent that we would expect reduced growth, reproduction or survival, any responses would not result in “take” under the ESA. Consequently, no incidental ESA take of ESA-listed marine mammals as a result of exposure to active acoustic sources used during NWFSC research activity is anticipated.

Conclusions

Based on the information above we conclude the following for the identified pathways of potential effects to (1) ESA-listed marine mammals and their critical habitats, (2) leatherback sea turtle critical habitat, and (3) SC steelhead:

- ESA-listed marine mammals are extremely unlikely to become entangled in NWFSC gear or equipment or be struck by a vessel based on the lack of such incidents over the past several years and the mitigation measures proposed to avoid such interactions.
- Acoustic impacts are likely to occur but be so minimal that they have immeasurably small impacts to ESA-listed marine mammal and natural behaviors.
- Prey species consumed by ESA-listed marine mammals and leatherback turtles are expected to be removed, but in such small quantities compared to the available prey base and spread out over such a wide area that removals aren’t expected to be detectable as a reduction in available prey.
- SC steelhead are extremely unlikely to interact with NWFSC gear or equipment based on the very low likelihood of encounter given the abundance and distribution of the DPS, and the lack of such incidents during prior NWFSC surveys.

We therefore find that all of the above impacts are either insignificant or discountable, and therefore not likely to adversely affect ESA-listed marine mammals or their critical habitats, leatherback sea turtle critical habitat, or the SC steelhead DPS.

3. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the Opinion addresses these DQA components, documents compliance with the DQA, and certifies that this Opinion has undergone pre-dissemination review.

3.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this Opinion are NOAA Fisheries' NWFSC and WCR PRD. Other interested users could include NMFS' OPR, other research permit applicants, institutions conducting fisheries research on the West Coast of the U.S., users of NWFSC research products (including the PFMC and commercial and recreational fishers), and others interested in the conservation of the affected ESUs/DPS. Individual copies of this Opinion were provided to the NWFSC. The document will be available within 2 weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. The format and naming adhere to conventional standards for style.

3.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

3.3 Objectivity

Information Product Category: Natural Resource Plan

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook and ESA regulations 50 CFR 402.01 et seq.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this opinion contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA, and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

4. REFERENCES

4.1 Federal Register Notices

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5. APPENDICES

Appendix A – Supplemental Tables

Table A1. Reported actual lethal take of ESA-listed fish species during NWFSC research activities, as summarized from the APPS permitting database, from 2013-2022.

Species	Life Stage	Origin	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total	Average	Max
Puget Sound Chinook salmon	Adult	Natural	2	2	7	0	1	0	0	0	1	0	13	2	7
		LHIA	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHAC	1	0	1	0	1	28	50	0	1	0	82	15	50
	Juvenile	Natural	117	864	684	0	576	197	548	5	650	103	3,744	681	864
		LHIA	13	81	1	10	39	16	11	3	70	41	285	52	81
		LHAC	60	151	18	28	148	150	150	8	468	678	1,859	338	678
Puget Sound steelhead	Adult	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHIA	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHAC	0	0	0	0	0	0	0	0	0	0	0	0	0
	Juvenile	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHIA	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHAC	0	0	0	0	0	0	0	0	0	0	0	0	0

Species	Life Stage	Origin	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total	Average	Max
Puget Sound/Georgia Basin DPS bocaccio	Adult	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
	Juvenile	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
		Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
Puget Sound/Georgia Basin DPS yelloweye rockfish	Adult	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
	Juvenile	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
		Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
Hood Canal summer-run chum salmon	Adult	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
	Juvenile	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHIA	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHAC	0	0	0	0	0	0	0	0	0	0	0	0	0
Ozette Lake sockeye salmon	Adult	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHIA	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHAC	0	0	0	0	0	0	0	0	0	0	0	0	0
	Juvenile	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHIA	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHAC	0	0	0	0	0	0	0	0	0	0	0	0	0

Species	Life Stage	Origin	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total	Average	Max
Upper Columbia River spring-run Chinook salmon	Adult	Natural	0	1	0	0	1	0	0	0	0	0	2	0	1
		LHAC	0	1	1	0	1	0	0	0	0	0	3	1	1
	Juvenile	Natural	0	0	1	0	0	8	0	1	1	0	11	2	8
		LHIA	0	0	0	1	0	0	0	0	1	0	2	0	1
		LHAC	0	2	3	4	1	5	2	11	8	8	44	8	11
Upper Columbia River steelhead	Adult	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHIA	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHAC	0	0	0	0	0	0	0	0	0	0	0	0	0
	Juvenile	Natural	1	0	2	0	0	0	0	0	0	0	3	1	2
		LHIA	0	0	3	1	0	0	0	0	0	0	4	1	3
		LHAC	1	0	6	1	0	0	1	0	0	0	9	2	6
Middle Columbia River steelhead	Adult	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHAC	0	0	0	0	0	0	0	0	0	0	0	0	0
	Juvenile	Natural	1	0	6	0	0	0	0	0	0	0	7	1	6
		LHIA	2	0	0	0	0	0	0	0	0	0	2	0	2
		LHAC	1	0	5	1	0	0	0	0	0	0	7	1	5

Species	Life Stage	Origin	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total	Average	Max
Snake River spring/summer-run Chinook salmon	Adult	Natural	0	0	4	0	1	0	0	0	1	0	6	1	4
		LHAC	1	0	1	0	1	0	0	0	0	0	3	1	1
	Juvenile	Natural	0	1	7	7	4	1	1	10	1	0	32	6	10
		LHIA	0	0	7	12	0	0	0	0	1	0	20	4	12
		LHAC	5	12	29	43	20	37	19	94	44	28	331	60	94
Snake River fall-run Chinook salmon	Adult	Natural	0	0	1	0	1	0	0	0	1	0	3	1	1
		LHAC	2	1	3	0	1	1	0	0	2	0	10	2	3
	Juvenile	Natural	0	0	0	0	6	5	2	19	3	5	40	7	19
		LHIA	1	2	3	3	4	7	6	4	10	12	52	9	12
		LHAC	1	2	0	0	3	3	3	43	4	2	61	11	43
Snake River Basin steelhead	Adult	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHIA	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHAC	0	0	0	0	0	0	0	0	0	0	0	0	0
	Juvenile	Natural	3	0	13	0	0	1	1	0	1	0	19	3	13
		LHIA	2	0	5	1	0	0	0	0	0	0	8	1	5
		LHAC	10	0	42	5	1	1	2	0	1	1	63	11	42

Species	Life Stage	Origin	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total	Average	Max
Snake River sockeye salmon	Adult	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHIA	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHAC	0	0	0	0	0	0	0	0	0	0	0	0	0
	Juvenile	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHIA	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHAC	0	1	3	7	0	0	0	0	6	14	31	6	14
Lower Columbia River Chinook salmon	Adult	Natural	0	2	4	0	1	0	0	0	2	0	9	2	4
		LHIA	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHAC	2	1	3	2	2	2	0	0	2	0	14	3	3
	Juvenile	Natural	5	2	72	33	16	208	28	36	69	71	540	98	208
		LHIA	0	0	11	8	1	4	6	9	4	4	47	9	11
		LHAC	42	20	121	173	31	149	132	71	236	83	1,058	192	236
Lower Columbia River coho salmon	Adult	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHIA	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHAC	0	0	0	0	0	0	0	0	0	0	0	0	0
	Juvenile	Natural	2	11	75	49	6	39	11	10	15	30	248	45	75

Species	Life Stage	Origin	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total	Average	Max
		LHIA	0	4	12	7	1	62	18	16	24	22	166	30	62
		LHAC	51	68	731	275	39	411	154	42	175	191	2,137	389	731
Lower Columbia River steelhead	Adult	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHAC	0	0	0	0	0	0	0	0	0	0	0	0	0
	Juvenile	Natural	1	0	7	0	0	0	0	0	0	0	8	1	7
		LHIA	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHAC	5	0	3	2	0	1	1	0	1	1	14	3	5
Columbia River chum salmon	Adult	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHIA	0	0	0	0	0	0	0	0	0	0	0	0	0
	Juvenile	Natural	1	1	0	6	0	34	11	1	61	73	188	34	73
		LHIA	0	0	0	0	0	11	6	10	26	24	77	14	26
		LHAC	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Willamette River Chinook salmon	Adult	Natural	0	0	2	0	1	0	0	0	1	0	4	1	2
		LHAC	4	1	8	1	4	2	0	0	2	0	22	4	8
	Juvenile	Natural	1	2	13	19	0	163	1	4	7	2	212	39	163
		LHIA	0	0	0	1	0	0	0	1	0	0	2	0	1

Species	Life Stage	Origin	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total	Average	Max
		LHAC	18	30	91	51	11	70	32	42	76	45	466	85	91
Upper Willamette River steelhead	Adult	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
	Juvenile	Natural	1	0	3	0	0	0	0	0	0	0	4	1	3
Oregon Coast coho salmon	Adult	Natural	0	0	0	0	0	0	1	0	0	0	1	0	1
		LHAC	0	0	0	0	0	0	0	0	0	0	0	0	0
	Juvenile	Natural	0	8	49	29	4	0	0	0	0	0	90	16	49
		LHAC	0	0	4	1	0	0	0	0	0	0	5	1	4
Southern Oregon/Northern California Coast coho salmon	Adult	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHAC	0	0	0	0	0	0	0	0	0	0	0	0	0
	Juvenile	Natural	0	1	5	3	0	0	0	0	0	0	9	2	5
		LHAC	0	1	7	3	0	0	0	0	0	0	11	2	7
Northern California steelhead	Adult	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
California Coastal Chinook salmon	Adult	Natural	0	0	1	0	1	0	0	0	0	0	2	0	1
	Juvenile	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
	Adult	Natural	0	0	1	0	1	0	0	0	0	0	2	0	1

Species	Life Stage	Origin	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total	Average	Max
Sacramento River winter-run Chinook salmon	Juvenile	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHAC	0	0	0	0	0	0	0	0	0	0	0	0	0
Central Valley spring-run Chinook salmon	Adult	Natural	0	0	1	0	1	0	0	0	0	0	2	0	1
		LHAC	0	0	1	0	1	0	0	0	0	0	2	0	1
	Juvenile	Natural	0	0	0	0	0	0	0	1	0	0	1	0	1
		LHAC	0	0	0	0	0	0	0	3	0	0	3	1	3
California Central Valley steelhead	Adult	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHAC	0	0	0	0	0	0	0	0	0	0	0	0	0
Central California Coast coho salmon	Adult	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
	Juvenile	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
Central California Coast steelhead	Adult	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
		LHAC	0	0	0	0	0	0	0	0	0	0	0	0	0
South-Central California Coast steelhead	Adult	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
Southern DPS eulachon	Adult	Natural	3,721	6,477	5,423	638	260	276	987	0	3,800	1,779	23,361	4,247	6,477
	Subadult	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0

Species	Life Stage	Origin	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total	Average	Max
	Juvenile	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0
Southern DPS green sturgeon	Adult	Natural	0	0	0	0	0	0	0	0	0	0	0	0	0

Table A2. Estimated abundance of ESA-listed fish species from 2018-2022, used to estimate the proportion of the ESU or DPS impacted by the NWFSC research activities.

Species	Life Stage	Origin	2018	2019	2020	2021	2022	Average
Puget Sound Chinook salmon	Adult	Natural	22,194	22,398	21,486	23,371	23,371	22,564
		LHAC & LHIA	14,101	15,543	18,060	23,232	23,232	18,834
	Juvenile	Natural	2,903,573	3,035,288	3,163,652	3,728,240	3,728,240	3,311,799
		LHIA	7,172,240	7,271,130	7,470,630	8,280,000	8,680,000	7,774,800
		LHAC	36,097,500	36,297,500	47,372,500	26,192,500	25,624,500	34,316,900
Puget Sound steelhead	Adult	Natural	0	0	0	19,079	18,196	7,455
		LHAC & LHIA	0	0	0	735	1,618	471
		LHAC, LHIA & NOR	19,313	19,313	19,456	0	0	11,616
	Juvenile	Natural	2,196,901	2,196,901	2,210,140	2,253,842	2,253,842	2,222,325
		LHIA	113,500	112,500	112,500	87,500	53,000	95,800
		LHAC	110,230	110,000	110,000	186,000	226,000	148,446
Puget Sound/Georgia Basin DPS bocaccio	Adult	Natural	4,606	4,606	4,606	4,606	4,606	4,606
Puget Sound/Georgia Basin DPS	Adult	Natural	47,407	66,998	66,998	114,494	114,494	82,078

Species	Life Stage	Origin	2018	2019	2020	2021	2022	Average
yelloweye rockfish								
Hood Canal summer-run chum salmon	Adult	Natural	25,883	38,697	25,146	28,117	28,117	29,192
		LHAC & LHIA	2,066	1,829	0	881	881	1,131
		LHIA	0	0	1,452	0	0	290
	Juvenile	Natural	4,087,518	5,926,865	3,889,955	4,240,958	4,240,958	4,477,251
		LHIA	150,000	150,000	150,000	150,000	0	120,000
Ozette Lake sockeye salmon	Adult	Natural	2,143	2,143	0	5,876	5,876	3,208
		LHAC & LHIA	178	178	0	309	309	195
		LHAC, LHIA & NOR	0	0	5,036	0	0	1,007
	Juvenile	Natural	477,836	477,836	1,037,787	1,273,337	1,273,337	908,027
		LHIA	259,250	259,250	259,250	259,250	259,250	259,250
		LHAC	45,750	45,750	45,750	45,750	45,750	45,750
Upper Columbia River spring-run Chinook salmon	Adult	Natural	3,488	2,872	2,872	813	813	2,172
		LHAC & LHIA	6,478	0	0	1,140	1,140	1,752
		LHIA	0	3,364	3,364	0	0	1,346
		LHAC	0	6,226	6,226	0	0	2,490
	Juvenile	Natural	474,383	475,657	468,820	518,360	488,401	485,124
		LHIA	384,079	318,246	368,642	443,774	470,744	397,097

Species	Life Stage	Origin	2018	2019	2020	2021	2022	Average
		LHAC	614,420	610,306	621,759	591,769	682,958	624,242
Upper Columbia River steelhead	Adult	Natural	3,618	3,988	1,931	1,465	1,465	2,493
		LHAC & LHIA	12,112	0	0	2,893	2,893	3,580
		LHIA	0	2,403	1,163	0	0	713
		LHAC	0	10,965	5,309	0	0	3,255
	Juvenile	Natural	176,213	169,120	199,380	161,936	150,459	171,422
		LHIA	159,702	144,067	138,601	132,453	139,810	142,927
		LHAC	642,307	662,848	687,567	743,457	765,850	700,406
Middle Columbia River steelhead	Adult	Natural	9,242	6,666	5,052	13,598	13,598	9,631
		LHAC & LHIA	914	0	0	713	713	468
		LHIA	0	148	112	0	0	52
		LHAC	0	592	448	0	0	208
	Juvenile	Natural	417,218	415,358	407,697	375,923	351,481	393,535
		LHIA	93,680	101,806	110,469	115,610	113,302	106,973
		LHAC	360,184	399,824	444,973	432,003	372,581	401,913
Snake River spring/summer-run Chinook salmon	Adult	Natural	18,270	12,798	12,798	4,419	4,419	10,541
		LHAC & LHIA	4,010	0	0	2,822	2,822	1,931
		LHIA	0	421	421	0	0	168
		LHAC	0	2,387	2,387	0	0	955

Species	Life Stage	Origin	2018	2019	2020	2021	2022	Average
	Juvenile	Natural	1,383,142	1,296,641	1,007,526	822,632	682,600	1,038,508
		LHIA	1,001,592	868,679	775,305	728,543	695,385	813,901
		LHAC	4,453,059	4,760,250	4,453,663	4,747,112	4,743,977	4,631,612
Snake River fall-run Chinook salmon	Adult	Natural	12,029	9,446	10,337	7,262	7,262	9,267
		LHAC & LHIA	97,326	0	0	14,879	14,879	25,417
		LHIA	0	12,383	13,551	0	0	5,187
		LHAC	0	11,430	15,508	0	0	5,388
	Juvenile	Natural	585,720	654,512	692,819	742,699	799,765	695,103
		LHIA	2,878,985	2,855,972	2,862,418	2,954,366	2,966,190	2,903,586
		LHAC	2,707,553	2,636,362	2,483,713	2,570,139	2,608,733	2,601,300
Snake River Basin steelhead	Adult	Natural	29,289	18,423	10,547	9,965	9,965	15,638
		LHAC & LHIA	263,601	0	0	3,285	3,285	54,034
		LHIA	0	28,187	16,137	0	0	8,865
		LHAC	0	138,887	79,510	0	0	43,679
	Juvenile	Natural	804,571	817,382	798,341	790,184	573,245	756,745
		LHIA	749,088	646,703	705,490	496,078	528,903	625,252
		LHAC	3,345,005	3,333,974	3,300,152	3,135,597	3,058,720	3,234,690
Snake River sockeye salmon	Adult	Natural	0	546	546	16	16	225
		LHAC & LHIA	0	4,004	0	97	97	840

Species	Life Stage	Origin	2018	2019	2020	2021	2022	Average
		LHAC	0	0	4,004	0	0	801
		LHAC, LHIA & NOR	712	0	0	0	0	142
	Juvenile	Natural	19,735	19,805	19,181	19,047	18,000	19,154
		LHAC	191,246	205,252	242,610	271,029	298,464	241,720
Lower Columbia River Chinook salmon	Adult	Natural	29,469	29,469	29,469	29,298	29,298	29,401
		LHAC & LHIA	38,594	38,594	38,594	18,814	18,814	30,682
	Juvenile	Natural	11,069,721	11,856,775	11,745,027	11,216,357	11,135,315	11,404,639
		LHIA	627,552	1,070,903	962,458	857,117	942,328	892,072
		LHAC	32,898,972	32,854,727	31,353,395	30,973,516	30,923,844	31,800,891
Lower Columbia River coho salmon	Adult	Natural	32,986	29,866	29,866	18,714	18,714	26,029
		LHAC & LHIA	23,082	8,791	8,791	15,949	15,949	14,512
	Juvenile	Natural	687,861	651,378	661,468	776,286	827,007	720,800
		LHIA	1,097,950	287,056	249,784	267,649	324,130	445,314
		LHAC	6,132,000	7,055,635	7,287,647	7,626,390	7,941,886	7,208,712
Lower Columbia River steelhead	Adult	Natural	12,920	12,920	12,920	8,152	8,152	11,013
		LHAC & LHIA	22,297	22,297	22,297	6,382	6,382	15,931
	Juvenile	Natural	323,607	333,902	352,146	371,241	375,208	351,221
		LHIA	22,649	8,163	9,138	15,223	14,801	13,995

Species	Life Stage	Origin	2018	2019	2020	2021	2022	Average
		LHAC	1,194,301	1,237,722	1,197,156	1,178,520	1,183,963	1,198,332
Columbia River chum salmon	Adult	Natural	10,644	10,644	10,644	17,305	17,305	13,308
		LHAC & LHIA	426	426	0	1,145	1,145	628
		LHIA	0	0	426	0	0	85
	Juvenile	Natural	5,362,740	5,828,526	6,626,218	7,533,081	7,777,554	6,625,624
		LHIA	734,059	648,047	601,503	523,500	554,973	612,416
Upper Willamette River Chinook salmon	Adult	Natural	11,443	10,203	10,203	10,531	10,531	10,582
		LHAC & LHIA	0	0	31,476	25,380	25,380	16,447
		LHIA	101	0	0	0	0	20
		LHAC	34,353	31,476	0	0	0	13,166
	Juvenile	Natural	1,275,681	1,275,681	1,211,863	1,164,252	1,159,334	1,217,362
		LHIA	16,278	157	4,214	0	0	4,130
		LHAC	5,543,371	5,210,226	4,709,045	4,547,100	4,361,832	4,874,315
Upper Willamette River steelhead	Adult	Natural	4,280	2,912	2,912	2,628	2,628	3,072
	Juvenile	Natural	143,898	143,898	140,396	136,980	135,303	140,095
Oregon Coast coho salmon	Adult	Natural	135,705	94,320	94,320	60,624	60,624	89,119
		LHAC & LHIA	0	0	0	638	638	255
		LHAC	1,201	559	559	0	0	464
	Juvenile	Natural	10,119,970	6,641,564	6,641,564	4,288,340	4,288,340	6,395,956

Species	Life Stage	Origin	2018	2019	2020	2021	2022	Average
		LHAC	60,000	60,000	60,000	60,000	60,000	60,000
Southern Oregon/Northern California Coast coho salmon	Adult	Natural	9,056	9,065	9,065	0	0	5,437
		LHAC & LHIA	10,934	10,934	10,934	0	0	6,560
		LHAC, LHIA & NOR	0	0	0	12,641	12,641	5,056
	Juvenile	Natural	1,101,382	2,013,593	2,013,593	884,870	884,870	1,379,662
		LHIA	575,000	575,000	575,000	75,000	75,000	375,000
		LHAC	200,000	200,000	200,000	575,000	575,000	350,000
Northern California steelhead	Adult	Natural	7,221	7,221	7,221	0	0	4,333
		LHAC, LHIA & NOR	0	0	0	8,356	8,356	3,342
	Juvenile	Natural	821,389	821,389	821,389	950,495	950,493	873,031
California Coastal Chinook salmon	Adult	Natural	7,034	7,034	7,034	13,169	13,169	9,488
	Juvenile	Natural	1,278,078	1,278,078	1,278,078	2,392,807	2,392,807	1,723,970
Sacramento River winter-run Chinook salmon	Adult	Natural	2,106	210	210	1,185	1,185	979
		LHAC & LHIA	215	2,232	0	2,697	2,697	1,568
		LHAC	0	0	2,232	0	0	446
	Juvenile	Natural	161,840	195,354	195,354	125,038	125,038	160,525
		LHAC	193,900	200,000	200,000	158,855	158,855	182,322
	Adult	Natural	11,468	3,727	3,727	6,756	6,756	6,487

Species	Life Stage	Origin	2018	2019	2020	2021	2022	Average
Central Valley spring-run Chinook salmon		LHAC & LHIA	8,213	2,273	0	2,083	2,083	2,930
		LHAC	0	0	2,273	0	0	455
	Juvenile	Natural	2,386,000	775,474	775,474	1,838,954	1,838,954	1,522,971
		LHAC	2,878,601	2,169,329	2,169,329	2,000,000	2,000,000	2,243,452
California Central Valley steelhead	Adult	Natural	1,686	1,686	1,686	0	0	1,012
		LHAC & LHIA	3,856	3,856	0	0	0	1,542
		LHAC	0	0	3,856	0	0	771
		LHAC, LHIA & NOR	0	0	0	11,494	11,494	4,598
	Juvenile	Natural	630,403	630,403	630,403	1,307,442	1,307,443	901,219
		LHAC	1,600,653	1,600,653	1,600,653	1,050,000	1,050,000	1,380,392
Central California Coast coho salmon	Adult	Natural	0	1,932	1,932	0	0	773
		LHIA	0	327	327	0	0	131
		LHAC, LHIA & NOR	1,621	0	0	2,308	2,308	1,247
	Juvenile	Natural	90,000	158,130	158,130	161,560	161,560	145,876
		LHIA	250,000	165,880	165,880	140,000	140,000	172,352
Central California Coast steelhead	Adult	Natural	2,187	2,187	2,187	0	0	1,312
		LHAC & LHIA	3,866	3,866	0	0	0	1,546
		LHAC	0	0	3,866	0	0	773

Species	Life Stage	Origin	2018	2019	2020	2021	2022	Average
		LHAC, LHIA & NOR	0	0	0	1,906	1,906	762
	Juvenile	Natural	248,771	248,771	248,771	216,808	216,808	235,986
		LHAC	648,891	648,891	648,891	520,000	520,000	597,335
South-Central California Coast steelhead	Adult	Natural	0	0	695	0	0	139
		LHAC, LHIA & NOR	695	695	0	196	196	356
	Juvenile	Natural	79,057	79,057	79,057	22,295	22,295	56,352
Southern DPS eulachon	Adult	Natural	81,736,000	18,796,090	32,029,043	26,797,375	26,797,375	37,231,177
Southern DPS green sturgeon	Adult	Natural	1,348	4,387	2,106	2,127	2,127	2,419
	Subadult	Natural	7,076	11,055	11,055	11,165	11,165	10,303
	Juvenile	Natural	2,808	2,106	4,387	4,431	4,431	3,633

Table A3. Total authorized take and total reported (actual) take, including all handling take as well as lethal take, from NWFSC research activities from 2013-2022. The percent columns are a calculated proportion of the two values (expected versus actual) showing what percent of the requested take was actually used according to reporting data.

Species	Life Stage	Origin	Authorized Handling Take	Actual Handling Take	Authorized Lethal Take	Actual Lethal Take	Handling Take Used (%)	Lethal Take Used (%)
Puget Sound Chinook salmon	Adult	Natural	2,521	28	115	13	1.11	11.30
		LHIA	4,043	2	49	0	0.05	0.00
		LHAC	4,559	117	357	82	2.57	22.97
	Juvenile	Natural	138,247	24,530	20,149	3,744	17.74	18.58
		LHIA	47,868	1,999	3,821	285	4.18	7.46
		LHAC	114,977	9,345	21,114	1,859	8.13	8.80
Puget Sound steelhead	Adult	Natural	70	0	35	0	0.00	0.00
		LHIA	20	0	0	0	0.00	0.00
		LHAC	70	0	35	0	0.00	0.00
	Juvenile	Natural	5,991	147	205	0	2.45	0.00
		LHIA	2,448	6	68	0	0.25	0.00
		LHAC	4,872	3	194	0	0.06	0.00
	Adult	Natural	74	4	27	0	5.41	0.00

Species	Life Stage	Origin	Authorized Handling Take	Actual Handling Take	Authorized Lethal Take	Actual Lethal Take	Handling Take Used (%)	Lethal Take Used (%)
Puget Sound/Georgia Basin DPS bocaccio	Juvenile	Natural	154	0	45	0	0.00	0.00
		Natural	87	0	39	0	0.00	0.00
Puget Sound/Georgia Basin DPS yelloweye rockfish	Adult	Natural	434	76	161	0	17.51	0.00
	Juvenile	Natural	343	2	84	0	0.58	0.00
		Natural	91	0	39	0	0.00	0.00
Hood Canal summer-run chum salmon	Adult	Natural	75	0	47	0	0.00	0.00
	Juvenile	Natural	3,046	148	119	0	4.86	0.00
		LHIA	1,140	55	57	0	4.82	0.00
		LHAC	170	10	36	0	5.88	0.00
Ozette Lake sockeye salmon	Adult	Natural	43	0	39	0	0.00	0.00
		LHIA	4	0	0	0	0.00	0.00
		LHAC	4	0	0	0	0.00	0.00
	Juvenile	Natural	4	0	0	0	0.00	0.00
		LHIA	4	0	0	0	0.00	0.00
		LHAC	4	0	0	0	0.00	0.00

Species	Life Stage	Origin	Authorized Handling Take	Actual Handling Take	Authorized Lethal Take	Actual Lethal Take	Handling Take Used (%)	Lethal Take Used (%)
Upper Columbia River spring-run Chinook salmon	Adult	Natural	47	2	27	2	4.26	7.41
		LHAC	47	3	39	3	6.38	7.69
	Juvenile	Natural	498	11	141	11	2.21	7.80
		LHIA	593	6	127	2	1.01	1.57
		LHAC	265	45	157	44	16.98	28.03
Upper Columbia River steelhead	Adult	Natural	35	0	19	0	0.00	0.00
		LHIA	16	0	0	0	0.00	
		LHAC	39	0	19	0	0.00	0.00
	Juvenile	Natural	158	3	80	3	1.90	3.75
		LHIA	197	4	102	4	2.03	3.92
		LHAC	206	11	155	9	5.34	5.81
Middle Columbia River steelhead	Adult	Natural	51	0	19	0	0.00	0.00
		LHAC	51	0	19	0	0.00	0.00
	Juvenile	Natural	854	7	542	7	0.82	1.29
		LHIA	63	2	12	2	3.17	16.67

Species	Life Stage	Origin	Authorized Handling Take	Actual Handling Take	Authorized Lethal Take	Actual Lethal Take	Handling Take Used (%)	Lethal Take Used (%)
		LHAC	157	10	105	7	6.37	6.67
Snake River spring/summer-run Chinook salmon	Adult	Natural	86	7	39	6	8.14	15.38
		LHAC	95	10	39	3	10.53	7.69
	Juvenile	Natural	671	46	370	32	6.86	8.65
		LHIA	582	69	127	20	11.86	15.75
		LHAC	1,180	340	995	331	28.81	33.27
Snake River fall-run Chinook salmon	Adult	Natural	90	3	39	3	3.33	7.69
		LHAC	174	11	73	10	6.32	13.70
	Juvenile	Natural	604	76	256	40	12.58	15.62
		LHIA	678	154	173	52	22.71	30.06
		LHAC	753	65	486	61	8.63	12.55
Snake River Basin steelhead	Adult	Natural	51	0	19	0	0.00	0.00
		LHIA	12	0	0	0	0.00	-
		LHAC	57	0	16	0	0.00	0.00
	Juvenile	Natural	583	20	230	19	3.43	8.26

Species	Life Stage	Origin	Authorized Handling Take	Actual Handling Take	Authorized Lethal Take	Actual Lethal Take	Handling Take Used (%)	Lethal Take Used (%)
		LHIA	257	8	111	8	3.11	7.21
		LHAC	557	68	424	63	12.21	14.86
Snake River sockeye salmon	Adult	Natural	31	0	27	0	0.00	0.00
		LHIA	4	0	0	0	0.00	-
		LHAC	16	0	12	0	0.00	0.00
	Juvenile	Natural	317	3	13	0	0.95	0.00
		LHIA	4	0	0	0	0.00	
		LHAC	66	31	54	31	46.97	57.41
Lower Columbia River Chinook salmon	Adult	Natural	386	23	53	9	5.96	16.98
		LHIA	83	0	0	0	0.00	
		LHAC	631	78	87	14	12.36	16.09
	Juvenile	Natural	6,293	1,162	1,652	540	18.46	32.69
		LHIA	1,358	117	412	47	8.62	11.41
		LHAC	14,244	1,731	4,288	1,058	12.15	24.67
	Adult	Natural	325	44	39	0	13.54	0.00

Species	Life Stage	Origin	Authorized Handling Take	Actual Handling Take	Authorized Lethal Take	Actual Lethal Take	Handling Take Used (%)	Lethal Take Used (%)
Lower Columbia River coho salmon		LHIA	286	34	0	0	11.89	
		LHAC	2,629	323	264	0	12.29	0.00
	Juvenile	Natural	2,418	265	1,024	248	10.96	24.22
		LHIA	2,169	167	1,072	166	7.70	15.49
		LHAC	17,845	2,209	8,563	2,137	12.38	24.96
Lower Columbia River steelhead	Adult	Natural	39	0	19	0	0.00	0.00
		LHAC	39	0	19	0	0.00	0.00
	Juvenile	Natural	472	8	225	8	1.69	3.56
		LHIA	83	0	12	0	0.00	0.00
		LHAC	308	19	230	14	6.17	6.09
Columbia River chum salmon	Adult	Natural	43	0	39	0	0.00	0.00
		LHIA	4	0	0	0	0.00	
	Juvenile	Natural	14,064	961	565	188	6.83	33.27
		LHIA	128	77	108	77	60.16	71.30
		LHAC	50	0	1	0	0.00	0.00

Species	Life Stage	Origin	Authorized Handling Take	Actual Handling Take	Authorized Lethal Take	Actual Lethal Take	Handling Take Used (%)	Lethal Take Used (%)
Upper Willamette River Chinook salmon	Adult	Natural	90	7	39	4	7.78	10.26
		LHAC	238	34	104	22	14.29	21.15
	Juvenile	Natural	2,392	299	791	212	12.50	26.80
		LHIA	199	5	58	2	2.51	3.45
		LHAC	1,963	619	1,007	466	31.53	46.28
Upper Willamette River steelhead	Adult	Natural	19	0	19	0	0.00	0.00
	Juvenile	Natural	147	4	54	4	2.72	7.41
Oregon Coast coho salmon	Adult	Natural	394	17	120	1	4.31	0.83
		LHAC	36	0	27	0	0.00	0.00
	Juvenile	Natural	908	90	908	90	9.91	9.91
		LHAC	90	5	90	5	5.56	5.56
Southern Oregon/Northern California Coast coho salmon	Adult	Natural	70	1	39	0	1.43	0.00
		LHAC	54	1	27	0	1.85	0.00
	Juvenile	Natural	98	9	98	9	9.18	9.18
		LHAC	90	11	90	11	12.22	12.22

Species	Life Stage	Origin	Authorized Handling Take	Actual Handling Take	Authorized Lethal Take	Actual Lethal Take	Handling Take Used (%)	Lethal Take Used (%)
Northern California steelhead	Adult	Natural	19	0	19	0	0.00	0.00
California Coastal Chinook salmon	Adult	Natural	54	2	39	2	3.70	5.13
	Juvenile	Natural	16	0	8	0	0.00	0.00
Sacramento River winter-run Chinook salmon	Adult	Natural	47	2	39	2	4.26	5.13
	Juvenile	Natural	25	0	17	0	0.00	0.00
		LHAC	9	0	9	0	0.00	0.00
Central Valley spring-run Chinook salmon	Adult	Natural	61	2	39	2	3.28	5.13
		LHAC	39	2	39	2	5.13	5.13
	Juvenile	Natural	26	1	18	1	3.85	5.56
		LHAC	16	3	16	3	18.75	18.75
California Central Valley steelhead	Adult	Natural	19	0	19	0	0.00	0.00
		LHAC	19	0	19	0	0.00	0.00
Central California Coast coho salmon	Adult	Natural	43	0	39	0	0.00	0.00
	Juvenile	Natural	8	0	8	0	0.00	0.00

Species	Life Stage	Origin	Authorized Handling Take	Actual Handling Take	Authorized Lethal Take	Actual Lethal Take	Handling Take Used (%)	Lethal Take Used (%)
Central California Coast steelhead	Adult	Natural	19	0	19	0	0.00	0.00
		LHAC	19	0	19	0	0.00	0.00
South-Central California Coast steelhead	Adult	Natural	19	0	19	0	0.00	0.00
Southern DPS eulachon	Adult	Natural	242,329	23,363	240,860	23,361	9.64	9.70
	Subadult	Natural	14,000	0	14,000	0	0.00	0.00
	Juvenile	Natural	240	0	16	0	0.00	0.00
Southern DPS green sturgeon	Adult	Natural	93	1	0	0	1.08	0.00

Table A4. Total Chinook (listed and unlisted) and eulachon requested to be taken annually as part of NWFSC research activities.

	Estimated Annual Mortalities			
	Adult	**Juvenile**	**Subadult**	**Total**
Chinook Salmon				
California Coastal	1	3	12	16
Central Valley spring-run	1	14	24	39
Lower Columbia River	6	1115	32	1153
Puget Sound	11	4889	59	4959
Sacramento River winter-run	1	5	13	19
Snake River fall-run	4	294	28	326
Snake River spring/summer-run	4	366	22	392
Upper Columbia River spring-run	2	87	22	111
Upper Willamette River	2	259	29	290
Unlisted	258	2192	647	3097
Chinook Salmon Total	**291**	**9664**	**888**	**10867**
Eulachon				
Southern DPS	36499	4	1000	37503