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

Consultation on the Evaluation and Determination of Research Programs Submitted for Consideration Under the Endangered Species Act Section 4(d) Rule's Scientific Research Limit [50 CFR 223.203(b)(7)] and Scientific Research Exemptions [50 CFR 223.210(c)(1)]

NMFS Consultation Number: WCRO-2021-03145
ARN 151422WCR2021PR00247

Action Agencies: The National Marine Fisheries Service (NMFS)
The Bonneville Power Administration (BPA)
The United States Army Corps of Engineers (ACOE)
The United States Bureau of Land Management (BLM)
The United States Bureau of Reclamation (BOR)
The United States Department of Defense (USDOD)
The United States Environmental Protection Agency (EPA)
The United States Fish and Wildlife Service (USFWS)
The United States Forest Service (USFS)
The United States Geological Survey (USGS)
The United States National Park Service (NPS)

Affected Species and NMFS's Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species or Critical Habitat?	Is Action Likely To Jeopardize the Species?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*)	Threatened	Yes	No	No
Snake River fall Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No
Snake River spring/summer Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No
Lower Columbia River Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No
Upper Willamette River Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No
California Coastal Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No
Central Valley spring-run Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No

ESA-Listed Species	**Status**	**Is Action Likely to Adversely Affect Species or Critical Habitat?**	**Is Action Likely To Jeopardize the Species?**	**Is Action Likely To Destroy or Adversely Modify Critical Habitat?**
Hood Canal summer-run chum salmon (*O. keta*)	Threatened	Yes	No	No
Columbia River chum salmon (*O. keta*)	Threatened	Yes	No	No
Lower Columbia River coho salmon (*O. kisutch*)	Threatened	Yes	No	No
Oregon Coast coho salmon (*O. kisutch*)	Threatened	Yes	No	No
Southern Oregon/Northern California Coasts coho salmon (*O. kisutch*)	Threatened	Yes	No	No
Puget Sound steelhead (*O. mykiss*)	Threatened	Yes	No	No
Upper Columbia River steelhead (*O. mykiss*)	Threatened	Yes	No	No
Snake River steelhead (*O. mykiss*)	Threatened	Yes	No	No
Middle Columbia River steelhead (*O. mykiss*)	Threatened	Yes	No	No
Lower Columbia River steelhead (*O. mykiss*)	Threatened	Yes	No	No
Upper Willamette River steelhead (*O. mykiss*)	Threatened	Yes	No	No
Northern California steelhead (*O. mykiss*)	Threatened	Yes	No	No
California Central Valley steelhead (*O. mykiss*)	Threatened	Yes	No	No
Central California Coast steelhead (*O. mykiss*)	Threatened	Yes	No	No
South-Central California Coast steelhead (*O. mykiss*)	Threatened	Yes	No	No
Southern Distinct Population Segment of North American green sturgeon (*Acipenser medirostris*)	Threatened	Yes	No	No
Southern Distinct Population Segment of Pacific eulachon (*Thaleichthys pacificus*)	Threatened	Yes	No	No
Southern Resident killer whales (*Orcinus orca*)	Endangered	No	No	No

Fishery Management Plan That Describes EFH in the Project Area	Does Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Pacific Coast Salmon	No	No

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

Issued By: Chris E Yates

Chris Yates
Assistant Regional Administrator for Protected Resources

Date: June 2, 2022

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List of Acronyms

ARN – Administrative Record Number
BPA – Bonneville Power Administration
CC – California Coastal
CCC – Central California Coast
CDFW – California Department of Fish and Wildlife
CFR – Code of Federal Regulation
CH – Critical Habitat
CHART – Critical Habitat Analytical Review Teams
CR – Columbia River
CVS – Central Valley spring-run
CWT – Coded Wire Tag
DC – Direct Current
DPS – Distinct Population Segment
DQA – Data Quality Act
EFH – Essential Fish Habitat
EPA – Environmental Protection Agency
ESA – Endangered Species Act
ESU – Evolutionarily Significant Unit
FR – Federal Register
HCS – Hood Canal summer-run
HUC5 – Hydrologic Unit Code (fifth-field)
ICTRT – Interior Columbia Technical Recovery Team
IDFG – Idaho Department of Fish and Game
IM – Intentional Mortality
ITS – Incidental Take Statement
LCR – Lower Columbia River
MCR – Middle Columbia River
MPG – Major Population Group
MSA – Magnuson-Stevens Fishery Conservation and Management Act
NMFS – National Marine Fisheries Service
NOAA – National Oceanic and Atmospheric Administration
OC – Oregon Coast
ODFW – Oregon Department of Fish and Wildlife
PBF – Physical or Biological Features
PCE – Primary Constituent Element
PIT – Passive Integrated Transponder
PS – Puget Sound
SDPS – Southern Distinct Population Segment
SRF – Snake River fall-run
SRSS – Snake River spring/summer-run
SRB – Snake River Basin
SONCC – Southern Oregon/Northern California Coast

SR – Southern Resident
TRT – Technical Recovery Team
UCR – Upper Columbia River
USFWS – United States Fish and Wildlife Service
USGS –United States Geological Survey
UWR – Upper Willamette River
VSP – Viable Salmonid Population
WCR – West Coast Region
WDFW – Washington Department of Fish and Wildlife

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 USC 1531 et seq.), as amended, and implementing regulations at 50 CFR 402.

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

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

1.2 Consultation History

The four state fishery agencies on the West Coast— Idaho Department of Fish and Game (IDFG), Oregon Department of Fish and Wildlife (ODFW), Washington Department of Fish and Wildlife (WDFW), and California Department of Fish and Wildlife (CDFW)—have submitted scientific research programs (Programs) for review under the salmon and steelhead 4(d) rule's Limit 7 for scientific research (see below for an explanation of the 4(d) rules). On December 2, 2021, the IDFG submitted their Program, which contains 17 projects in Idaho. On December 4, 2021, the WDFW submitted their Program, which contains 33 projects in Washington. On December 7, 2021, the ODFW submitted their Program, which contains 65 projects in Oregon. On December 16, 2021, the CDFW submitted their Program, which contains 88 projects in California. Shortly after receipt of the final request, we initiated consultation on December 20, 2021. The Programs are for scientific research on threatened salmon, steelhead, eulachon, and green sturgeon. The Programs do not request approval for take of endangered species.

Since 2001, the West Coast Region's (WCR's) Protected Resources Division (PRD) has approved Programs submitted under the salmon and steelhead 4(d) rules limit 7 by four state fishery agencies in the WCR— WDFW, IDFG, and ODFW. In 2008, the approval was extended to include CDFW. And in 2010, the approval was extended to the include the green sturgeon 4(d) rules exception for scientific research. Over the years, these Programs have comprised projects affecting green sturgeon, eulachon, and threatened salmon and steelhead. PRD has included eulachon in its section 7 consultation, but has not promulgated protective regulations via section

4(d) of the ESA for eulachon. Accordingly, the Programs do not need approval for the take of eulachon.

Since the first year implementing the 4(d) rules for scientific Programs, PRD has annually conducted an ESA section 7(a)(2) consultation, prepared a biological opinion, and completed an EFH consultation. For 21 years, we have annually reviewed and analyzed the effects of the Programs and prepared a biological opinion that expired at the end of each calendar year. Considering the large workload that the annual review of the Programs, including the ESA Section 7(a)(2) consultation, require, and the redundancy in terms of the types of research activities (including their effects on listed species) that have routinely been part of the Programs, the PRD has determined that it would be appropriate to have a biological opinion in place that does not have an end date. This consultation therefore evaluates the Programs as continuing in perpetuity.

The affected species are:

- Chinook salmon
  - Puget Sound (PS)
  - Snake River fall-run (SRF)
  - Snake River spring/summer run (SRSS)
  - Lower Columbia River (LCR)
  - Upper Willamette River (UWR)
  - California Coastal (CC)
  - Central Valley spring-run (CVS)
- Chum salmon
  - Hood Canal summer-run (HCS)
  - Columbia River (CR)
- Coho salmon
  - Lower Columbia River (LCR)
  - Oregon Coast (OC)
  - Southern Oregon/Northern California Coast (SONCC)
- Steelhead
  - Puget Sound (PS)
  - Upper Columbia River (UCR)
  - Middle Columbia River (MCR)
  - Snake River Basin (SRB)
  - Lower Columbia River (LCR)
  - Upper Willamette River (UWR)
  - Northern California (NC)
  - California Central Valley (CCV)
  - Central California Coast (CCC)
  - South-Central California Coast (SCCC)
- Southern DPS (SDPS) of Pacific eulachon
- SDPS of North American green sturgeon

The proposed actions also have the potential to affect Southern Resident (SR) killer whales and their critical habitat by diminishing the whales’ prey base. We concluded that the proposed activities are not likely to adversely affect SR killer whales or their critical habitat and the full analysis for that conclusion is found in the "Not Likely to Adversely Affect" Determination section (2.11).

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 (50 CFR 402.02). The proposed actions here are NMFS's annual approval of the Programs under Limit 7 of the salmon and steelhead 4(d) rule and Exemption 1 of the green sturgeon 4(d) rule. In addition to our proposed actions of annually approving the Programs, some of the research projects in the programs may be funded or carried out by NMFS, BPA, ACOE, BLM, BOR, USDOD, EPA, USFWS, USFS, USGS, and NPS. We also considered whether or not the proposed actions would cause any other activities and determined that it would not.

The PRD has authorized 21 years (2001-2021) of annual research programs submitted under the salmon and steelhead Limit 7 4(d) rule by four state fishery agencies. As described above in the Consultation History section, the biological opinions from previous years evaluated the effects of the amount of take requested annually in the state Programs. In a change from that approach, this opinion evaluates the range of actual effects (reported take) of the state Programs based on the research conducted over the past 21 years. Since the salmon and steelhead Limit 7 4(d) rule does not have a definitive sunset (or expiration) date, there is no pre-determined end date on this opinion. Under this opinion, the PRD will be responsible for ensuring that submitted state Programs, and the projects in the programs, that fall within the scope of this biological opinion are processed in accordance with the requirements of the opinion.

Our approval of the Programs is based on a determination that the Programs (1) meet the factors described in the 4(d) rules, (2) fulfill additional considerations germane to research projects, (3) act to conserve the affected threatened species, and (4) meet the requirements of this biological opinion. The factors in the 4(d) rules are described below in sections 1.3.1 Salmon and Steelhead 4(d) Rules and 1.3.2 Green Sturgeon 4(d) Rules. The Programs, and considerations germane to research projects, are described in section 1.3.3 Annual State Research Program Submittal. And our annual review process is described in section 1.3.4 Scope and Structure of NMFS's Annual Evaluation.

1.3.1 Salmon and Steelhead 4(d) Rules

On July 10, 2000, NMFS adopted a rule prohibiting the take of 14 groups of salmon and steelhead listed as threatened under the ESA (65 FR 42422, 50 CFR 223.203). On June 28, 2005, January 5, 2006, February 11, 2008, and September 25, 2008 NMFS issued final listing determinations and protective regulations for 26 threatened and endangered salmon and steelhead species (70 FR 37160, 71 FR 834, 73 FR 7816, 73 FR 55451). The protective regulations extended the 4(d) rule to all threatened salmonid species considered in this evaluation.

The salmon and steelhead rule applies the prohibitions of section 9(a)(1) of the ESA to the threatened salmonid species listed in the rule, but imposed certain limits on those prohibitions. Limit 7 states that the prohibitions of section 9(a)(1) of the ESA (16 U.S.C. 1538(a)(1)) do not apply to scientific research activities (50 CFR 223.203(b)(7)) that are submitted by a state fishery agency as a "research program," provided that the program complies with the four factors specified in the rule and is authorized in writing by NMFS's West Coast Regional Administrator. Under the rule, states are required to submit a new program each year. The Programs that NMFS authorizes are exempt from the prohibitions of section 9(a)(1) for one year—at the end of which annual reports documenting research-related take for that year must be submitted to NMFS.

The protective regulations apply the prohibitions of section 9(a)(1) of the ESA to threatened natural and listed hatchery salmon and steelhead with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed. The four factors in the salmon and steelhead 4(d) rule limit 7 are as follows.

> *(7) The prohibitions of paragraph (a) of this section relating to threatened species of salmonids listed in § 223.102(a) do not apply to scientific research activities provided that:*
>
> *(i) Scientific research activities that may take (intentionally or unintentionally) threatened salmonids are conducted by employees or contractors of the Agency or as a part of a monitoring and research program overseen by or coordinated with that Agency. As an additional and related standard, NMFS has notified the affected state fishery agencies that research must be conducted by professional biologists or individuals with fisheries expertise.*
>
> *(ii) The Agency provides for NMFS' review and approval a list of all scientific research activities planned for the coming year that may take (intentionally or unintentionally) threatened salmonids, including an estimate of the total direct take that is anticipated, a description of the study design, including a justification for taking the species and a description of the techniques to be used, and a point of contact.*
>
> *(iii) The Agency annually provides to NMFS the results of the approved scientific research activities, including a report of the actual take resulting from the studies and a summary of the results of such studies.*
>
> *(iv) Electrofishing in any body of water known or suspected to contain threatened salmonids is conducted in accordance with NMFS' Guidelines for Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act. As an additional and related standard, NMFS has notified the affected state fishery agencies that research activities must comply with other relevant state and Federal guidelines.*

1.3.2 Green Sturgeon 4(d) Rules

On June 2, 2010 NMFS issued final rules establishing prohibitions for the threatened Southern Distinct Population Segment of North American green sturgeon (75 FR 30714, 50 CFR

223.210). The rule applies the prohibitions of section 9(a)(1) of the ESA to green sturgeon, but imposed certain exemptions on those prohibitions. Exemption 1 states that the prohibitions of section 9(a)(1) of the ESA (16 U.S.C. 1538(a)(1)) do not apply to ongoing or future state-sponsored scientific research or monitoring activities that are part of a NMFS-approved, ESA-compliant state 4(d) research program, provided that the program complies with the four factors specified in the rule. Under the rule, states are required to submit a new Program each year. The programs that NMFS authorizes are exempt from the prohibitions of section 9(a)(1) for one year—at the end of which reports documenting each project's take must be submitted to NMFS.

The four factors in the green sturgeon 4(d) rule exemption 1 are as follows.

> *(i) Descriptions of the ongoing and future 4(d) research or monitoring activity, as described in paragraph (c)(1)(ii) of this section, must be received by the NMFS Southwest Regional Office in Long Beach during the mid-September through mid-October 2010 application period. This exception to the section 9 take prohibitions expires if the proposal is rejected as insufficient or is denied. If the state 4(d) research program package is received during the mid-September to mid-October application period, ongoing state-supported scientific research activities may continue until NMFS issues a written decision of approval or denial. If approved, the state 4(d) program authorization will cover one calendar year and state-supported researchers would have to renew authorizations annually during subsequent application periods.*
>
> *(ii) Descriptions of ongoing and future state-supported research activities must include the following information and should be submitted to NMFS by the State: an estimate of total direct or incidental take; a description of the study design and methodology; a justification for take and the techniques employed; and a point of contact.*
>
> *(iii) NMFS will provide written approval of a state 4(d) research program.*
>
> *(iv) The State agency will provide an annual report to NMFS that, at a minimum, summarizes the number of Southern DPS green sturgeon taken directly or incidentally, and summarizes the results of the project.*

1.3.3 Annual State Research Program Submittal

In the fall of each year, WDFW, IDFG, ODFW, and CDFW uses NMFS's online application process to submit their Programs for consideration (https://apps.nmfs.noaa.gov/). The Programs address green sturgeon and 22 of the 23 threatened salmon and steelhead in Washington, Idaho, Oregon, and California covered by 4(d) rules. Since 2001, no projects affecting Ozette Lake sockeye salmon have been included in Programs and we do not anticipate there to be any going forward. The Programs also address threatened eulachon. However, we have not promulgated 4(d) rules for eulachon. Accordingly, the prohibitions of section 9 of the ESA does not apply to eulachon.

On average, more than 200 projects are annually submitted for consideration under the 4(d) rules. Almost without exception, those projects are very comparable to those NMFS has approved in ESA section 10(a)(1)(A) permits and other authorizations, and typify the vast array of salmonid research activities conducted for decades throughout the West Coast. And on the very rare occasion that a project is not comparable, it is usually rejected. Over the past 21 years, NMFS's WCR staff have reviewed thousands of similar activities under sections 4 and 10 of the ESA. We have used this experience to help develop state fishery agency programs that support the recovery of listed salmon, steelhead, green sturgeon, and eulachon. The following provides a brief summary of these Programs and sets the context for NMFS's review in this biological opinion.

The Programs are coordinated by the state fishery agencies: WDFW, IDFG, ODFW, and CDFW. The state fishery agencies determine the scope of the programs—including who can participate. In Washington, the WDFW has limited the scope of the state research program to projects that only they conduct. In Oregon, Idaho, and California, the Programs are open to all federal, state, tribal, and non-governmental agencies. The annual reapproval of the 4(d) program starts with an open application period every September. Each year, researchers (a) apply for reapproval of ongoing projects, and/or (b) approval for new projects. Following the open application window, NMFS and Northwest Fisheries Science Center (NWFSC) staff meet with the state fishery agencies to discuss the programs and provide questions and comments on the merits of individual projects. Following those meetings, the state fishery agencies work with the individual researchers to address NMFS's comments. Before the end of the year, and after all comments have been addressed, the state fishery agencies submit their final list of projects to NMFS for approval.

The number of research projects included in WDFW's program has ranged from a low of 30 to a high of 56 (2002-2021). All of the projects in WDFW's Program would be conducted by the WDFW. The WDFW submittal of projects details their forecast of calendar year research activities that may affect 12 threatened species of salmon and steelhead covered by the 4(d) rule in the state of Washington (Table 1).

The number of projects in IDFG's program has ranged from a low of 14 to a high of 25 (2002-2021). The IDFG annual submittal of projects details their forecast of calendar year research activities that may affect three threatened species of Snake River salmon and steelhead covered by the 4(d) rule in the state of Idaho (Table 1).

The number of research projects in ODFW's annual program has ranged from a low of 69 to a high of 221 (2002-2021). ODFW's program started out with 221 projects and by 2008 had dropped to 83. The primary reason for the wide range in the number of projects is that over half of the projects in the early years of the 4(d) program were eventually covered by hatchery and harvest approvals—or were subsumed by the consultation on the continuing operation of the Federal Columbia River Power System—and thus no longer required approval under Limit 7. The ODFW annual submittal details their forecast of calendar year research activities that may affect green sturgeon, eulachon, and 12 threatened salmon and steelhead covered by the 4(d) rule in the state of Oregon (Table 1).

The number of projects in CDFW's program has ranged from a low of 74 to a high of 95 (2009-2021). The CDFW annual submittal of projects details their forecast of calendar year research activities that may affect green sturgeon, eulachon, and seven threatened species of salmon and steelhead covered by the 4(d) rule in the state of California (Table 1).

Table 1. Listed Salmon, Steelhead, and Sturgeon Included in State Fishery Agency Programs.

Listed Species/State Fishery Agencies	WDFW	IDFG	ODFW	CDFW
PS Chinook salmon (*Oncorhynchus tshawytscha*)	X			
SRF Chinook salmon (*O. tshawytscha*)	X	X	X	
SRSS Chinook salmon (*O. tshawytscha*)	X	X	X	
LCR Chinook salmon (*O. tshawytscha*)	X		X	
UWR Chinook salmon (*O. tshawytscha*)			X	
CC Chinook salmon (*O. tshawytscha*)				X
CVS Chinook salmon (*O. tshawytscha*)				X
LCR coho salmon (*O. kisutch*)	X		X	
OC coho salmon (*O. kisutch*)			X	
SONCC coho salmon (*O. kisutch*)			X	X
HCS chum salmon (*O. keta*)	X			
CR chum salmon (*O. keta*)	X		X	
PS steelhead (*O. mykiss*)	X			
UCR steelhead (O. mykiss)	X			
SRB steelhead (*O. mykiss*)	X	X	X	
MCR steelhead (*O. mykiss*)	X		X	
LCR steelhead (*O. mykiss*)	X		X	
UWR steelhead (*O. mykiss*)			X	
NC steelhead (*O. mykiss*)				X
CCV steelhead (*O. mykiss*)				X
CCC steelhead (*O. mykiss*)				X
SCCC steelhead (*O. mykiss*)				X
SDPS green sturgeon (*Acipenser medirostris*)	X		X	X

SDPS eulachon (*Thaleichthys pacificus*)	X	X	X

1.3.3.1 Research Activities in the Programs

The four state fishery agencies would annually conduct, oversee, or coordinate research projects that could take threatened eulachon, green sturgeon, salmon, and steelhead. The research projects are distributed throughout the listed species' ranges. The specific projects and related take estimates are described in detail in the annual state fishery agency submittals. The projects, which are incorporated herein, include activities such as: (1) capturing fish with egg mats, traps, nets, hook and line, backpack electrofishing, and at fishways, diversion screens, and weirs; (2) anesthetizing fish to minimize the stress of handling; (3) handling fish to count them, obtain length or weight measurements, assess general condition, and check for marks and tags, external signs of disease, and sex; (4) marking and tagging fish; (5) non-lethal tissue sampling for genetic and diet studies; and (6) purposefully killing fish for pathogen analysis, diet analysis, life history studies, and contaminant accumulation analysis. Not all projects include all these activities but each would include at least one of them.

The purposes for the research projects vary considerably and are described in the annual state fishery agency submittals. Most projects would specifically target listed species while some are more general in nature (e.g., fish presence/absence surveys). The state fishery agency Programs detail a diverse set of research objectives, generally, these are:

- Determining the abundance, distribution, growth rate, and condition of adult and juvenile fish.
- Conducting disease and genetic studies.
- Determining diet composition.
- Evaluating salmonid production (i.e., smolt-to-adult survival rates).
- Determining stock composition, population trends, and life history patterns.
- Evaluating habitat restoration projects.
- Evaluating the effects artificial production and supplementation have on listed species.
- Investigating migration timing and migratory patterns.
- Evaluating fish passage facilities, screens and other bypass systems.
- Investigating fish behaviors in reservoirs and off channel areas.
- Evaluating salmon spawning below dams.
- Monitoring effects of dam removal.
- Assessing point-source discharge effects on fish communities.

Many of the research projects focus on monitoring and evaluating management actions and tasks recommended for conserving listed salmonid populations. As such, research is often considered an essential part of salmon and steelhead recovery efforts.

1.3.3.2 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). Researchers will use a sterilized needle for each individual fish when injecting PIT tags.
- Barbless hooks will be used when hook-and-line angling equipment is employed for sampling purposes.
- NMFS's electrofishing guidelines (https://media.fisheries.noaa.gov/dam-migration/electro2000.pdf) 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 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: https://apps.nmfs.noaa.gov/docs/NOAA-WCR_Weir_Guidelines_Sept_2015.pdf).
- No fish will be captured or handled if the instantaneous water temperature exceeds 70 degrees Fahrenheit at the capture site where any NOAA Fisheries ESA-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. Tagging and tissue sampling may exceed 3% but may not exceed 5%.[1]

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

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[1] An evaluation of annual reports from the Programs indicates that the annual average unintentional mortality for any capture method is less than 3%. And when procedures such as tissue sampling and tagging are included, the average unintentional mortality is only slightly higher.

unintentional mortality are founded in our analysis of annual report data from the 4(d) Programs and ESA Section 10(a)(1)(A) permits for scientific research activities.

1.3.3.3 Terms and Conditions for Research Projects

NMFS's annual approval of the Programs includes conditions to be followed before, during, and after the annual research projects/activities are conducted. These conditions are intended to minimize the impacts of research activities on listed species and ensure that NMFS receives information about the effects the approved activities have on the species concerned. NMFS's annual approval requires that researchers conduct their research, monitoring and evaluation activities according to the following terms and conditions:

1. Each Researcher must ensure that the listed species are taken only at the levels, by the means, in the areas, and for the purposes set forth in the Programs and consistent with the conditions in this opinion.
2. Each Researcher must not intentionally kill or cause to be killed any listed species—unless their particular project in the approved Program specifically includes intentional lethal take.
3. Each Researcher 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 gear is used that captures a mix of species, listed species must be processed first to minimize handling stress.
4. Each researcher must stop handling listed fish if the water temperature exceeds 70 degrees Fahrenheit at the capture site. Under these conditions, listed fish may only be identified and counted. Additionally, electrofishing is not permitted if water temperatures exceed 64 degrees Fahrenheit.
5. If the Researcher must anesthetize listed fish to keep from injuring or killing them while they are handled, the fish must be allowed to recover before being released. Fish that are only counted must remain in water and not be anesthetized.
6. Each Researcher must use a sterilized needle for each individual injection when passive integrated transponder tags (PIT-tags) are inserted into listed fish.
7. If the Researcher 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. Each Researcher must exercise due caution during spawning ground surveys to avoid disturbing listed adult salmonids when they are spawning and to avoid trampling redds.
9. Any Researcher using backpack electrofishing equipment must comply with NMFS's Backpack Electrofishing Guidelines (NMFS 2000).
10. If any Researcher violates the stated terms and conditions they will be subject to any and all penalties the ESA provides. NMFS may revoke project and Program approval if projects are not conducted in accordance with the annual approval, the 4(d) rule, and the requirements of the ESA or if we determine that the findings made under section 4(d) of the ESA are no longer valid.
11. NMFS's WCR may amend the provisions of our annual approval after giving the Researcher reasonable notice of the amendment.

12. Each Researcher must possess a copy of the relevant letter from NMFS approving the Program under which the project is conducted, these terms and conditions, and their project description (copy of submitted application) when engaging in their project activities.
13. No researcher may transfer or assign their approval to any other person. The approval ceases to be in effect if transferred or assigned to any other person without proper approval from NMFS.
14. Each Researcher must obtain all other Federal, state, and local permits/authorizations necessary for conducting the approved projects.
15. Each Researcher must allow any NMFS employee or representative to accompany field personnel while they conduct the approved activities. The Researchers must also allow such NMFS representatives to inspect any records or facilities relevant to the activities covered by the approval.
16. Each Researcher must obtain approval from NMFS before changing sampling locations or research protocols.
17. Each Researcher 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. Researchers must submit a written report detailing why the approved take level was exceeded or is likely to be exceeded.
18. On or before January 31 of 2022, researchers must submit to NMFS an annual report on any projects conducted under the Programs. The report must be submitted online using the NOAA APPS website (https://apps.nmfs.noaa.gov/). Approval for subsequent years' research activities will be contingent upon NMFS's acceptance of an annual report. Falsifying annual reports or records related to the research is a violation of the approval.
19. Each Researcher is responsible for any biological samples collected from listed species as long as they are used for research purposes. The Researcher may not transfer biological samples to anyone not listed in their application without prior written approval from NMFS.
20. Researchers are required to contact the USFWS regarding listed bull trout and other species under their jurisdiction that may be taken during this research.

1.3.3.4 In-season Modification Process

Requests to modify projects conducted by (or in cooperation with) the WDFW, IDFG, ODFW, and CDFW may be considered before the end of the annual period. Requests for any research project modifications must be submitted to NMFS by the state fishery agency at least 30 days before the activity is due to commence and must meet the standard operating protocols and terms and conditions listed above.

1.3.3.5 Annual Reports

As specified in the 4(d) rules, researchers must provide an annual report of the results of the approved scientific research activities, including a report of the actual take resulting from the studies and a summary of the results of such studies. Specific reporting requirements are included in the terms and conditions each state places on their own staff and on associated researchers. 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.

1.3.3.6 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 will take to avoid such issues in the future. The state fishery agencies and NMFS staff review incident reports and determine if the remedies are sufficient. NMFS also reviews the incident report to determine if the Programs have triggered any of the reevaluation factors below.

1.3.4 Scope and Structure of NMFS's Annual Evaluation and Determination

The research projects in the Programs are reviewed by the state fishery agencies and NOAA Fisheries. The state fishery agencies are responsible for reviewing the projects and ensuring that they are following the standard operating protocols outlined above. Following the state's review, staff from the WCR and NOAA Fisheries' science centers review the projects and consider, among other criteria, the following:

1. Whether the project application was applied for in good faith;
2. Whether the project will operate to the disadvantage of the threatened 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.

Before promulgating the research limits for salmon, steelhead, and green sturgeon, the WCR Region developed a program for evaluating applications for scientific research permits under section 10(a)(1)(A). When we began implementing the 4(d) rule's research limits, we determined that it would be appropriate to use the same criteria when we review applications for research approvals under the salmon and steelhead and green sturgeon ESA 4(d) rules. The criteria listed above were adopted from section 10(d) of the ESA (Permit And Exemption Policy) and from NMFS's regulations for implementing section 10(a)(1)(A) of the ESA [50 CFR 223.308(c)].

The first step in NMFS's annual 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 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.

One of the more common issues related to these criteria arises when a proponent is seeking to get an approval for a project that monitors the effects of another action. In these instances, the project is generally designed either to (a) monitor the amount and/or extent of incidental take associated with an action or (b) determine the effectiveness of activities intended to mitigate the effects of such an action. Projects that monitor the effects of an action or the effectiveness of mitigation are not considered to meet the intent of the salmon and steelhead or green sturgeon scientific research limits. These types of projects are normally incorporated in ESA section 7 consultations for Federal actions that cause incidental take, though they may also sometimes appear as requests for incidental take permits under ESA section 10(a)(1)(B) for non-Federal actions.

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 when evaluating requests for an exemption. 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 listed above are one way

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[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.

that NMFS ensures that individual projects, and the programs as a whole, do not operate to the disadvantage of the listed species.

Another factor that we look at is the requested level of lethal take in the Programs. Because the majority of the fish that would be captured for research purposes are expected to recover with no adverse physiological, behavioral, or reproductive effects, the true effects of the Programs are best seen in the context of the fish that are likely to be killed. To determine the potential effects of these losses, NMFS compares the combined requested levels of lethal take from the Programs to the estimated abundance of the 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 ESA-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 the research permit and program 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, the Programs are generally able to stay under this amount.

Finally, NMFS annually reviews the status of all species subject to the 4(d) approvals and incorporates new information in its yearly evaluation of the Programs. The annual review looks both at the individually-submitted projects and the Programs as a whole, and it closely examines requested and reported take in the context of shifting species abundance and previously approved research. Annual reports are due on January 31. NMFS staff reviews the reports to ensure that researchers followed the standard operating protocols and terms and conditions. NMFS staff also review the annual reports to ensure that the Programs meet the 4(d) rule's factors. Lastly, NMFS staff will evaluate the total reported lethal take from all the projects in the Programs and determine if it is within the range of effects analyzed in this biological opinion. In the annual evaluation of the Programs, NMFS will document the reported take by species, life stage, and origin (hatchery vs. natural). Thus, the annual reports act as a yearly checkpoint for the Programs, and a sustained increase in the relative (i.e., proportional) annual maximum mortality for natural-origin fish could trigger a reinitiation of consultation (see Section 2.10 Reinitiation of Consultation).

In summary, NMFS will annually review the Programs in the fall and annual reports in the winter to determine if the Programs (1) meet the factors described in the 4(d) rules, (2) fulfill additional considerations germane to research projects, (3) act to conserve the affected threatened species, and (4) meet the requirements of this biological 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 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 actions of annually approving the four state Programs:

- May adversely affect PS, SRF, SRSS, LCR, UWR, CC, and CVS Chinook salmon; CR and HCS chum salmon; LCR, OC, and SONCC coho salmon; PS, UCR, SRB, MCR, LCR, UWR, NC, CCC, CCV, and SCCC steelhead, SDPS eulachon, and SDPS green sturgeon; but would not jeopardize their continued existence.
- May adversely affect designated critical habitat for PS, SRF, SRSS, LCR, UWR, CC, and CVS Chinook salmon; CR and HCS chum salmon; LCR, OC, and SONCC coho salmon; PS, UCR, SRB, MCR, LCR, UWR, NC, CCC, CCV, and SCCC steelhead, SDPS eulachon, and SDPS green sturgeon; but would not destroy or adversely their designated critical habitat.
- Is not likely to adversely affect SR killer whales or their designated critical habitat. This conclusion is documented in the "Not Likely to Adversely Affect" Determinations section (Section 2.11).

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 CFR402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

This biological opinion also relies on the 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 critical habitat designations for many of the species considered here use the term primary constituent element (PCE) or essential features. The 2016 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''

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

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 regulations define effects of the action using the term "consequences" (50 CFR 402.02). As explained in the preamble to the regulations (84 FR 44977), that definition 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 actions 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 actions on species and their 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 actions are 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.

2.2 Rangewide Status of the Species and Critical Habitat

This opinion examines the status of each species that would 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, viability assessments, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' current "reproduction, numbers, or distribution" for the jeopardy analysis. The opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and the function of the PBFs that are essential for the conservation of the species.

Climate Change

Climate change 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 Pacific Northwest. These changes will not be spatially homogeneous across the Pacific Northwest. The largest hydrologic responses are expected to occur in basins with significant snow accumulation, where warming decreases snow pack, increases winter flows, and advances the timing of spring melt (Mote et al. 2014, Mote et al. 2016). Rain-dominated watersheds and those with significant contributions from groundwater may be less sensitive to predicted changes in climate (Tague et al. 2013, Mote et al. 2014).

During the last century, average regional air temperatures in the Pacific Northwest increased by 1-1.4°F as an annual average, and up to 2°F in some seasons (based on average linear increase per decade; Abatzoglou et al. 2014, Kunkel et al. 2013). Warming is likely to continue during the next century as average temperatures are projected to increase another 3 to 10°F, with the largest increases predicted to occur in the summer (Mote et al. 2014). Decreases in summer precipitation of as much as 30% by the end of the century are consistently predicted across climate models (Mote et al. 2014). Precipitation is more likely to occur during October through March, less during summer months, and more winter precipitation will be rain than snow (ISAB 2007, Mote et al. 2013, Mote et al. 2014). Earlier snowmelt will cause lower stream flows in late spring, summer, and fall, and water temperatures will be warmer (ISAB 2007, Mote et al. 2014). 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 (Dominguez et al. 2012). The largest increases in winter flood frequency and magnitude are predicted in mixed rain-snow watersheds (Mote et al. 2014).

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 (ISAB 2007). Reduced flows will make 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). Temperature increases shift timing of key life cycle events for salmonids and species forming the base of their aquatic foodwebs (Crozier et al. 2011, Tillmann and Siemann 2011, Winder and Schindler 2004). Higher stream temperatures will also 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 likely to cause several species to become more susceptible to parasites, disease, and higher predation rates (Crozier et al. 2008; Wainwright and Weitkamp 2013; Raymondi et al. 2013).

As more basins become rain-dominated and prone to more severe winter storms, higher winter stream flows may 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).

In addition to changes in freshwater conditions, predicted changes for coastal waters in the Pacific Northwest as a result of climate change include increasing surface water temperature, increasing but highly variable acidity, and increasing storm frequency and magnitude (Mote et al. 2014). Elevated ocean temperatures already documented for the Pacific Northwest are highly likely to continue during the next century, with sea surface temperature projected to increase by

1.0-3.7°C (1.8-6.7°F) by the end of the century (IPCC 2014). Habitat loss, shifts in species' ranges and abundances, and altered marine food webs could have substantial consequences to anadromous, coastal, and marine species in the Pacific Northwest (Tillmann and Siemann 2011, Reeder et al. 2013).

In California, average summer air temperatures are expected to increase according to modeling of climate change impacts (Lindley et al. 2007). Heat waves are expected to occur more often, and heat wave temperatures are likely to be higher (Hayhoe et al. 2004). Total precipitation in California may decline; critically dry years may increase (Lindley et al. 2007, Schneider 2007). Events of both extreme precipitation and intense aridity are projected for California, increasing climactic volatility throughout the state. Snow pack is a major contributor to stored and distributed water in the state (Diffenbaugh et al. 2015), but this important water source is becoming increasingly threatened. The Sierra Nevada snow pack 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 et al. 2006). California wildfires are expected to increase in frequency and magnitude, with 77% more area burned by 2099 under a high emission scenario model. 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, some models show large increases in precipitation (75 to 200 percent) while other models show decreases of 15 to 30 percent (Hayhoe et al. 2004). 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, nutrient cycling, and sedimentation (Scavia et al. 2002). In marine environments, ecosystems and habitats important to subadult and adult green sturgeon and salmonids are likely to experience changes in temperatures, circulation and chemistry, and food supplies (Feely et al. 2004, Osgood 2008), 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. In shorter time frames, climate conditions not caused by the human addition of carbon dioxide to the atmosphere are more likely to predominate (Cox and Stephenson 2007).

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 (Feely et al. 2012, Sunda and Cai 2012).

Global sea levels are expected to continue rising throughout this century, reaching likely predicted increases of 10-32 inches by 2081-2100 (IPCC 2014). These changes will likely result in increased erosion and more frequent and severe coastal flooding, and shifts in the composition of nearshore habitats (Tillmann and Siemann 2011, Reeder et al. 2013). 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 (Glick et al. 2007).

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 (Scheuerell and Williams 2005; Zabel et al. 2006). This is supported by the recent observation that anomalously warm sea surface temperatures off the coast of Washington from 2013 to 2019 resulted in poor coho and Chinook salmon body condition for juveniles caught in those waters (Ford 2022). 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 (Tillmann and Siemann 2011, Reeder et al. 2013).

The adaptive ability of these threatened and endangered species is depressed due to reductions in population size, habitat quantity and diversity, and loss of behavioral and genetic variation. Without these natural sources of resilience, systematic changes in local and regional climatic conditions will likely reduce long-term viability and sustainability of populations in many of these ESUs (Ford 2022). New stressors generated by climate change, or existing stressors with effects that have been amplified by climate change, may also have synergistic impacts on species and ecosystems (Doney et al. 2012). These conditions will possibly intensify the climate change stressors inhibiting recovery of ESA-listed species in the future.

2.2.1 Status of the Species

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.

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).

The summaries that follow describe the status of the 24 ESA-listed species, and their designated critical habitats, that occur within the geographic area of the proposed actions and are considered in this opinion. More detailed information on the status and trends of these listed resources, and their biology and ecology, are in the listing regulations and critical habitat designations published in the Federal Register (Table 2).

Table 2. Listing Status, Status of Critical Habitat Designations and Protective Regulations, and Relevant Federal Register (FR) Decision Notices for ESA-listed Species Considered in this Opinion.

Species	Listing Status	Critical Habitat	Protective Regulations
Chinook salmon *(Oncorhynchus tshawytscha)*			
Puget Sound	6/28/05; 70 FR 37160	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Snake River fall-run	6/28/05; 70 FR 37160	12/28/93; 58 FR 68543	6/28/05; 70 FR 37160
Snake River spring/summer-run	6/28/05; 70 FR 37160	10/25/99; 64 FR 57399	6/28/05; 70 FR 37160
Lower Columbia River	6/28/05; 70 FR 37160	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Upper Willamette River	6/28/05; 70 FR 37160	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160
California Coastal	6/28/05; 70 FR 37160	9/02/05; 70 FR 52488	6/28/05; 70 FR 37160
Central Valley spring-run	6/28/05; 70 FR 37160	9/02/05; 70 FR 52488	6/28/05; 70 FR 37160
Chum salmon (*O. keta*)			
Hood Canal summer-run	6/28/05; 70 FR 37160	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Columbia River	6/28/05; 70 FR 37160	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Coho salmon (*O. kisutch*)			
Lower Columbia River	6/28/05; 70 FR 37160	2/24/16; 81 FR 9252	6/28/05; 70 FR 37160
Oregon Coast	6/20/11; 76 FR 35755	2/11/08; 73 FR 7816	2/11/08; 73 FR 7816
Southern Oregon/Northern California Coasts	6/28/05; 70 FR 37160	5/5/99; 64 FR 24049	6/28/05; 70 FR 37160
Steelhead (*O. mykiss*)			
Puget Sound	5/11/07; 72 FR 26722	2/24/16; 81 FR 9252	2/7/07; 72 FR 5648
Upper Columbia River	1/5/06; 71 FR 834	9/02/05; 70 FR 52630	2/1/06; 71 FR 5178
Snake River Basin	1/5/06; 71 FR 834	9/02/05; 70 FR 52630	1/5/06; 71 FR 834
Middle Columbia River	1/5/06; 71 FR 834	9/02/05; 70 FR 52630	1/5/06; 71 FR 834
Lower Columbia River	1/5/06; 71 FR 834	9/02/05; 70 FR 52630	1/5/06; 71 FR 834
Upper Willamette River	1/5/06; 71 FR 834	9/02/05; 70 FR 52630	1/5/06; 71 FR 834
Northern California	1/5/06; 71 FR 834	9/02/05; 70 FR 52488	1/5/06; 71 FR 834
California Central Valley	1/5/06; 71 FR 834	9/02/05; 70 FR 52488	1/5/06; 71 FR 834
Central California Coast	1/5/06; 71 FR 834	9/02/05; 70 FR 52488	1/5/06; 71 FR 834
South-Central California Coast	1/5/06; 71 FR 834	9/02/05; 70 FR 52488	1/5/06; 71 FR 834
Green sturgeon (*Acipenser medirostris*)			
Southern DPS	4/07/06; 71 FR 17757	10/09/09; 74 FR 52300	6/2/10; 75 FR 30714

Species	Listing Status	Critical Habitat	Protective Regulations
Eulachon (*Thaleichthys pacificus*)			
Southern DPS	3/18/10; 75 FR 13012	10/20/11; 76 FR 65324	Not applicable

2.2.1.1 Puget Sound Chinook Salmon

The PS Chinook salmon ESU is composed 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 Puget Sound Chinook salmon ESU is composed of 31 historically quasi-independent populations, 22 of which are extant. The populations are distributed in 5 geographic regions, or major population groups, identified by the Puget Sound Technical Recovery Team (PSTRT 2002) based on similarities in hydrographic, biogeographic, and geologic characteristics of the Puget Sound basin. The ESU also includes Chinook salmon from twenty-five artificial propagation programs (85 FR 81822).

We adopted a recovery plan for this ESU in January 2007 (SSDC 2007, NMFS 2006). The recovery plan adopts ESU and population level viability criteria recommended by the Puget Sound Technical Recovery Team (Ruckelshaus et al. 2006). The recovery plan and 5-year reviews have identified factors limiting the recovery of the species. Limiting factors for this species include:

- Degraded floodplain and in-river channel structure
- Degraded estuarine conditions and loss of estuarine habitat
- Riparian area degradation 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
- Altered flow regime

<u>Abundance and Productivity</u>

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 2015 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 natural-origin spawner abundances since the 2015 viability assessment (Ford 2022). Fifteen of the remaining 20 populations with positive % change in the 5-year geometric mean natural-origin spawner abundances since the prior viability assessment 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-1980's. In recent years, only 5 populations have had productivities above zero (Ford 2022). These are Lower Skagit, Upper Skagit, Lower Sauk, Upper Sauk, and Suiattle, all Skagit River populations in the Whidbey Basin MPG. The overall pattern is consistent with, and continues the decline reported in the 2015 viability assessment (Ford 2022).

The average abundance (2015-2019) for PS Chinook salmon populations is 23,370 natural-origin and 23,233 hatchery-origin adult spawners (Ford 2022). No populations are meeting minimum viability abundance targets, and only three of 22 populations average greater than 20% of the minimum viability abundance target for natural-origin spawner abundance (all of which are in the Skagit River watershed). The populations closest to 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.

Juvenile PS Chinook salmon abundance estimates come from escapement data, the percentage of females in the population, and fecundity. 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.

Spatial Structure and Diversity

One of the ways in which spatial structure and diversity can be evaluated is by assessing the proportion of natural-origin spawners vs. hatchery-origin spawners on the spawning grounds (Ford 2022). We can see a declining trend in the proportion of natural-origin spawners across the ESU starting approximately in 1990 and extending through the present (2018). Considering populations by their major population groups, the Whidbey Basin is the only major population group with consistently high fraction natural-origin spawner abundance, in 6 of 10 populations. All other major population groups have either variable or declining spawning populations that have high proportions of hatchery-origin spawners.

Status Summary

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 2015 viability assessment, but have small negative trends over the past 15 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. Bi-annual four year work plans document the many completed habitat actions that were initially identified and in the Puget Sound Chinook salmon recovery plan. The expected benefits will take years or decades to produce significant improvement in natural population viability parameters. Overall, the Puget Sound Chinook salmon ESU remains at "moderate" risk of extinction, and viability is largely unchanged from the prior review.

2.2.1.2 Snake River Fall-run Chinook Salmon

The SRF Chinook salmon ESU is composed of naturally spawned fall-run Chinook salmon originating from the mainstem Snake River below Hells Canyon Dam and from the Tucannon River, Grande Ronde River, Imnaha River, Salmon River, and Clearwater River subbasins. The ICTRT identified three populations of this species, although only the lower mainstem population exists at present, and it spawns in the lower main stem of the Clearwater, Imnaha, Grande Ronde, Salmon and Tucannon rivers (ICTRT 2008). The ESU also includes fall-run Chinook salmon from four artificial propagation programs (85 FR 81822).

NMFS adopted a recovery plan for this species in November 2017 (NMFS 2017b). The long term recovery goal for natural-origin fish is 14,360 average annual returns of natural-origin fall Chinook salmon (adults and jacks) above Lower Monumental Dam. The long term goal for hatchery origin fish is average annual return goal is 24,750 hatchery-origin fish above Lower Monumental Dam.

The recovery plan and 5-year reviews have identified factors limiting the recovery of the species. Limiting factors for this species include:

- Degradation of floodplain connectivity and function and channel structure and complexity
- 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.

Abundance and Productivity

The geometric mean of abundance for the most recent 5 years (2015-2019) is 7,252 natural-origin and 14,889 hatchery-origin adult spawners (Ford 2022). This is lower than the 5-year geomean reported in the previous viability assessment, and it amounts to a 29% reduction in natural-origin 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-origin adults (ICTRT 2008). 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.

To estimate abundance of juvenile natural- and hatchery-origin SRF Chinook salmon, 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). The geometric mean of abundance for juvenile natural- and hatchery-origin SRF Chinook salmon is 742,699 and 5,541,897 respectively.

Spatial Structure and Diversity

The lower mainstem population consists of one population that is made up largely of hatchery spawners and the integrated extinction risk for factors relating to structure and diversity is considered to be moderate. Furthermore, 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)

Status Summary

The SRF Chinook salmon ESU is therefore considered to be at moderate-to-low risk of extinction, with viability largely unchanged from the 2015 viability assessment (Ford 2022).

2.2.1.3 Snake River Spring/Summer-run Chinook Salmon

The SRSS Chinook salmon ESU is composed of naturally spawned spring/summer-run Chinook salmon originating from the mainstem Snake River and the Tucannon River, Grande Ronde River, Imnaha River, and Salmon River subbasins. The SRSS Chinook salmon ESU consists of 27 extant and four extirpated populations aggregated into five major population groups that correspond to ecological subregions (ICTRT 2003; McClure et al. 2005). The ESU also includes spring/summer-run Chinook salmon from thirteen artificial propagation programs (85 FR 81822).

NMFS adopted a final recovery plan for this species in November of 2017 (NMFS 2017c). The recovery plan recommends that at least one-half of the populations historically present (minimum of two populations) should meet viability criteria (5 percent or less risk of extinction over 100 years). The recovery plan also recommends that at least one population should be highly viable (less than 1 percent risk of extinction).

The recovery plan and 5-year reviews have identified factors limiting the recovery of the species. Limiting factors for this species include:

- Degradation of floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream flow, and water quality.
- Effects related to the hydropower system in the mainstem Columbia River, including reduced upstream and downstream fish passage, altered ecosystem structure and function, altered flows, and degraded water quality.
- Harvest-related effects
- Predation

Abundance and Productivity

Low abundance and poor productivity remain the primary obstacles to viability for populations in this ESU. The most recent five-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, fresh water productivity remains 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 2008).

The 5-year geometric means for naturally produced and artificially propagated adult SRSS Chinook salmon are 4,419 and 2,822 respectively (Ford 2022). To estimate current abundance of juvenile natural and hatchery SRSS Chinook 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). 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, parental-based-tagging, redd counts, weir counts, and other methods (Ford 2022). The 5-year geometric means for naturally produced and artificially propagated juvenile SRSS Chinook salmon are 822,632 and 5,475,655 respectively.

Spatial Structure and Diversity

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. 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.

Status Summary

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 (Ford 2022).

2.2.1.4 Lower Columbia River Chinook Salmon

The LCR Chinook salmon ESU is composed of naturally spawned Chinook salmon originating from the Columbia River and its tributaries downstream of a transitional point east of the Hood and White Salmon Rivers, and any such fish originating from the Willamette River and its tributaries below Willamette Falls. The ESU also includes Chinook salmon from eighteen artificial propagation programs(85 FR 81822).

Recovery plan targets for this species are tailored for each life history type, and within each type, specific population targets are identified (NMFS 2013b). For spring Chinook salmon, all populations are affected by aspects of habitat loss and degradation. Four of the nine populations require significant reductions in every threat category. Protection and improvement of tributary and estuarine habitat are specifically noted.

The recovery plan and 5-year reviews have identified factors limiting the recovery of the species. Limiting factors for this species include:

- 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
- Contaminants

Spatial Structure and Diversity

The LCR Chinook salmon ESU comprises 32 historic populations from among six major population groups (though we have limited information about the viability of many of them). In terms of spatial 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). A common concern in terms of diversity is the effects of past and present hatchery programs. 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).

Abundance and Productivity

The geometric mean of abundance for the most recent 5 years (2015-2019) is 29,240 natural-origin and 18,872 hatchery-origin adult spawners (Ford 2022). The most recent five-year geometric mean abundance estimates for the ESU's 32 demographically independent populations are highly variable. We only have recent natural and hatchery fish abundance data for 23 of the populations, and about half of them have seen decreases in natural spawners and about half have seen increases. However, all but two populations (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 populations, only seven are at or near their recovery viability goals (NMFS 2013b)—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) likely fell within the high to very-high risk categories for abundance and productivity. Similarly, with the exception of the Sandy River spring-run, all of the spring-run populations in the Cascade and Gorge major population groups 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).

To estimate abundance of juvenile natural and hatchery LCR Chinook, 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). The geometric mean of abundance for juvenile natural- and hatchery-origin LCR Chinook salmon is 11,216,357 and 31,876,209, respectively. 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).

Status Summary

Overall, there has been modest change since the last viability assessment in the biological status of Chinook salmon populations in the Lower Columbia River ESU (Ford 2022), 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 2013b), 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. Overall, LCR Chinook viability has increased somewhat since the last viability assessment, but the ESU remains at moderate risk of extinction (Ford 2022).

2.2.1.5 Upper Willamette River Chinook Salmon

The UWR Chinook salmon ESU is composed of naturally spawned spring-run Chinook salmon originating from the Clackamas River and from the Willamette River and its tributaries above Willamette Falls. Also included in the ESU are spring-run Chinook salmon from six artificial propagation programs (85 FR 81822).

NMFS and ODFW jointly adopted a recovery plan for this species in August 2011 (ODFW and NMFS 2011). The recovery plan for UWR Chinook salmon identified a number of threats to the species conservation and recovery including high levels of prespawning mortality, lack of access to historical habitat, high levels of total dissolved gases (TDG), and a reduction in returning adult abundance between Willamette Falls and census points in the main tributaries. Prespawn mortality levels are generally a problem in the lower tributary reaches where water temperatures and fish densities are the highest. Access to historical spawning and rearing areas is restricted by large dams in the four historically most productive tributaries, and in the absence of effective passage programs will continue to confine spawning to more lowland reaches where land development, water temperatures, and water quality may be limiting.

The recovery plan and 5-year reviews have identified factors limiting the recovery of the species. Limiting factors for this species include:

- Degraded freshwater habitat, including floodplain connectivity and function, channel structure and complexity, incubation gravels, riparian areas, and gravel and large wood recruitment
- Degraded water quality including elevated water temperature and toxins
- Increased disease incidence
- Altered stream flows
- Reduced access to spawning and rearing habitats due to migration barriers, impaired fish passage, and increased pre-spawn mortality associated with conditions below dams
- Altered food web due to reduced inputs of microdetritus
- Predation by native and non-native species, including hatchery fish
- Competition related to introduced races of salmon and steelhead
- Altered population traits due to fisheries, bycatch, and natural-origin fish interbreeding with hatchery origin fish

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 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, specifically 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, this is turn has limited the potential for fry and subyearling "movers" emigrating to the estuary (Schroeder et al. 2016).

Abundance and Productivity

Abundance levels for all but one of seven populations remain well below their recovery goals. The Clackamas River currently exceeds its abundance recovery goal. Alternatively, the Calapooia River may be functionally extinct and the Molalla River remains critically low (there is considerable uncertainty in the level of natural production in the Molalla River). Abundances in the North and South Santiam rivers have declined since the 2015 viability assessment update (Ford 2022), 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 is well below those identified in the recovery goals. 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.

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 (2016-2020) by using annual abundance estimates provided by the NWFSC (Zabel 2017a, 2017b, 2018, 2020, 2021). The geometric mean of abundance for juvenile natural- and hatchery-origin UWR Chinook salmon is 1,164,252 and 4,548,251 respectively. 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). The geometric mean of abundance for the most recent 5 years (2015-2019) is 10,533 natural-origin and 25,378 hatchery-origin adult spawners (Ford 2022).

Status Summary

Overall, there has likely been a declining trend in the viability of the Upper Willamette Chinook salmon ESU since the 2015 viability assessment. 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.

2.2.1.6 California Coastal Chinook Salmon

The CC Chinook salmon ESU is composed of naturally spawned Chinook salmon originating from rivers and streams south of the Klamath River to and including the Russian River. NMFS did not include artificial propagation program in this ESU. Historically there were seven artificial propagation programs for CC Chinook salmon, however all seven programs were terminated prior to 2011 (Williams et al. 2011).

In October of 2016, NMFS adopted a coastal multispecies recovery plan that includes CC Chinook salmon (NMFS 2016c). In the recovery plan, NMFS evaluated current habitat conditions and ongoing and future threats and concluded that all life stages of Chinook salmon are impaired by degraded habitat conditions. These impairments are due to a lack of complexity and shelter formed by instream wood, high sediment loads, lack of refugia during winter, low summer flows, reduced quality and extent of coastal estuaries and lagoons, and reduced access to historic spawning and rearing habitat. The major sources of these impairments are roads, water diversions and impoundments, logging, residential and commercial development, severe weather patterns, and channel modification.

The recovery plan and 5-year reviews have identified factors limiting the recovery of the species. Limiting factors for this species include:

- 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

Spatial Structure and Diversity

Spence et al. (2008) concluded that the CC Chinook salmon ESU historically supported 16 independent populations of fall-run Chinook salmon, six independent populations of spring-run Chinook, and an unknown number of dependent populations. CC Chinook salmon populations remain widely distributed throughout much of the ESU. Notable exceptions include the area between the Navarro River and Russian River and the area between the Mattole and Ten Mile River populations (Lost Coast area). The lack of Chinook salmon populations both north and south of the Russian River (the Russian River is at the southern end of the species' range) makes it one of the most isolated populations in the ESU. Myers et al. (1998) reports no viable populations of Chinook salmon south of San Francisco, California.

Because of their prized status in the sport and commercial fishing industries, CC Chinook salmon have been the subject of many artificial production efforts, including out-of-basin and out-of-ESU stock transfers (Bjorkstedt et al. 2005). It is therefore likely that CC Chinook salmon genetic diversity has been adversely affected despite the relatively wide distribution of populations in the ESU. An apparent loss of the spring-run Chinook life history in the Eel River Basin and elsewhere in the ESU also indicates risks to the diversity of the ESU. CC Chinook salmon populations remain widely distributed throughout much of the ESU. Notable exceptions include the area between the Navarro River and Russian River and the area between the Mattole and Ten Mile River populations (Lost Coast area).

Abundance and Productivity

The availability of data for CC-Chinook salmon has improved since the previous viability assessment. Adult Chinook salmon abundance estimates include (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. Prior viability assessments 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.

Although data availability data for CC-Chinook has improved since the previous viability assessment, there is limited population-level estimates of abundance for CC Chinook salmon populations. Based on limited population-level estimates of abundance for CC Chinook salmon populations, we estimate the current average run size for CC Chinook salmon ESU is 13,169 adults.

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 escapement data, the percentage of females in the population, and fecundity. Average fecundity for female CC Chinook salmon is not available. 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 an average fecundity of 3,634 eggs per female 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 2,392,807 natural outmigrants annually.

Status Summary

Monitoring programs in the Mad and Eel Rivers indicate that populations in these watersheds are doing better than believed in prior assessments, with the Mad River population currently at levels above recovery targets. Likewise, monitoring in 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 showing a significant decline and Van Arsdale 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. In summary, the new information available indicates that the status of the CC-Chinook salmon ESU has not changed appreciably since the last assessment (Williams 2016).

2.2.1.7 Central Valley Spring-run Chinook Salmon

The CVS Chinook salmon ESU is composed of naturally spawned spring-run Chinook salmon originating from the Sacramento River and San Joaquin rivers and their tributaries. The Feather River Fish Hatchery spring-run Chinook salmon stock has been included as part of the CVS Chinook salmon ESU. The San Joaquin component of the ESU, previously extirpated, has been reintroduced and designated as a nonessential experimental population under Section 10(j) of the ESA.

NMFS adopted a recovery plan for CVS Chinook salmon in July of 2014 (NMFS 2014b). In the recovery plan we found that the CVS Chinook salmon ESU is facing three primary threats: (1) loss of most historic spawning habitat; (2) degradation of the remaining habitat; and (3) genetic introgression with the Feather River Fish Hatchery spring-run Chinook salmon strays. Factors effecting the habitat of CVS Chinook salmon include inadequate instream flows caused by small hydropower dams and water diversions, unscreened or inadequately screened water diversions, excessively high water temperatures, and predation by non-native species. The recovery plan also identified the potential effects of climate change as a factor that is likely to adversely affect spring-run Chinook salmon and their recovery.

Spatial 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, all within four distinct geographic regions, or diversity groups (Lindley et al. 2004). Of these 18 populations, only three populations currently exist (Mill, Deer, and Butte creeks tributary to the upper Sacramento River) and they represent only the northern Sierra Nevada diversity group.

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 unfavorable. Off-site releases of FRH spring-run Chinook salmon have resulted in increased straying of hatchery fish into other spring-run populations and if continued, could result in a moderate risk of extinction to other spring-run

Chinook salmon populations. However, beginning in 2014, and expected to continue, the FRH has begun releasing spring-run production into the Feather River rather than releasing in the San Francisco Bay which is hypothesized to reduce straying (California HSRG 2012; Huber and Carlson 2015; Palmer-Zwahlen et al. 2019; Sturrock et al. 2019).

At the ESU level, the spatial diversity within the CVS Chinook is increasing and spring-run Chinook salmon are present (albeit at low numbers in some cases) in all diversity groups. The reestablishment of CVS Chinook to Battle Creek and increasing abundance of CVS Chinook on Clear Creek observed in some years is benefiting the viability of CVS Chinook. 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 on the mainstem San Joaquin River show promise and will be necessary to make the ESU viable (Boughton et al. 2018; Volk et al. 2020). The CVS Chinook is trending in a positive direction towards achieving at least two populations in each of the four historical diversity groups necessary for recovery with the Northern Sierra Nevada region necessitating four populations (NMFS 2014b).

Abundance and Productivity

The viability of CVS Chinook ESU has deteriorated on balance since the 2015 viability assessment with weakening of all populations. The total abundance (hatchery- and natural-origin spawners) of CVS Chinook in the Sacramento River basin in 2019 was 26,553, approximately half of the population size in 2014 (N=56,023), and close to the decadal lows of ~14,000 which occurred as recently as the last two years (Azat 2021). The Butte Creek spring-run population has become the backbone of CVS Chinook in part due to extensive habitat restoration and the accessibility of floodplain habitat in the Butte Sink and Sutter Bypass for juvenile rearing in the majority of years. Butte Creek remains at low risk, yet all viability metrics are trending in a negative direction relative to 2015. Most dependent spring-run populations have been experiencing continued and in some cases drastic declines. For example, while adults were observed in Big Chico Creek between 2014–2018, they likely didn’t survive to spawn due to high summer temperatures resulting in zeros (0) in the escapement estimates (Williams et al. 2021; Azat 2021). No adults were observed in Cottonwood Creek in 2015–2018, resulting in a 100% decline in recent catastrophic declines during the drought cohorts (Williams et al. 2021). Newly re-established populations in Battle and Clear creeks continue to fluctuate on an annual basis but previous total population estimates from 2015 suggest they have the potential to establish a self-sustaining population without significant hatchery supplementation (Johnson and Lindley 2016).

To estimate annual abundance of adult spawners (natural- and hatchery-origin), we calculate the average of the most recent five years of adult escapement estimates (Azat 2021). The total average adult escapement for spring-run Chinook salmon is 8,839.

The Feather River Hatchery is the only hatchery that produces Central Valley spring-run Chinook salmon (with the exception of the San Joaquin Salmon Conservation and Research Facility). Therefore, the annual number of hatchery-origin spring-run Chinook salmon produced is calculated by averaging the releases from the Feather River Hatchery during recent years (DWR and CDFW 2018). The Feather River Hatchery (79 FR 20802) has released, on average, 2,000,000 CVS Chinook salmon smolts (all adipose-clipped) (California HSRG 2012).

By applying the average fecundity of 4,161 eggs per female to the estimated 4,420 females returning (half of the most recent five-year average of spawners), and applying an estimated survival rate from egg to smolt of 10 percent, the Sacramento River basin portion of the ESU could produce roughly 1,838,954 natural outmigrants annually.

Status Summary

The viability of CVS Chinook has deteriorated on balance since the 2015 viability assessment with weakening of all independent CVS Chinook populations (Williams et al. 2021). The Butte Creek spring-run population has become the backbone of CVSRC ESU in part due to extensive habitat restoration and the accessibility of floodplain habitat in the Butte Sink and Sutter Bypass for juvenile rearing in the majority of years. Most dependent spring-run populations have been experiencing continued and in some cases drastic declines (Williams et al. 2021).

2.2.1.8 Hood Canal Summer-run Chum Salmon

On June 28, 2005, NMFS listed HCS chum salmon—both natural and some artificially-propagated fish—as a threatened species (70 FR 37160). 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. Under the final listing in 2005, the section 4(d) protections (and limits on them) apply to natural-origin and hatchery HCS chum salmon with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed. Four artificial propagation programs were listed as part of the ESU (79 FR 20802): Hamma Hamma Fish Hatchery Program, Lilliwaup Creek Fish Hatchery Program, Tahuya River Program; and Jimmycomelately Creek Fish Hatchery Program. Three of the four programs have been discontinued. The production goals of the remaining program are listed in the Table 13.

We adopted a recovery plan for HC summer-run chum salmon in May of 2007. The recovery plan consists of two documents: the Hood Canal and Eastern Strait of Juan de Fuca Summer Chum Salmon Recovery Plan (HCCC 2005) and a supplemental plan by NMFS (2007). The recovery plan adopts ESU and population level viability criteria recommended by the Puget Sound Technical Recovery Team (PSTRT) (Sands et al. 2007). The PSTRT's biological recovery criteria will be met when the following conditions are achieved:

- Spatial Structure: 1) Spawning aggregations are distributed across the historical range of the population. 2) Most spawning aggregations are within 20 km of adjacent aggregations. 3) Major spawning aggregations are distributed across the historical range of the population and are not more than approximately 40 km apart. Further, a viable population has spawning, rearing, and migratory habitats that function in a manner that is consistent with population persistence

- Diversity: Depending on the geographic extent and ecological context of the population, a viable population includes one or more persistent spawning aggregations from each of the two to four major ecological diversity groups historically present within the two populations (see also McElhany et al. 2000).
- Abundance and Productivity: Achievement of minimum abundance levels associated with persistence of Hood Canal Summer Chum ESU populations that are based on two assumptions about productivity and environmental response.

Abundance and Productivity

Productivity had increased at the time of the 2015 review 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). 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).

The current average run size of 28,117 natural-origin and 881 hatchery-origin adult spawners is largely the result of aggressive reintroduction and supplementation programs throughout the ESU. We can derive an estimate of juvenile abundance using average adult spawner abundance and estimates of the percentage of females in the population and average fecundity. Fecundity estimates for chum salmon average 2,500 eggs per female and the proportion of female spawners is approximately 45% of escapement in most populations (WDFW/PNPTT 2000). By applying fecundity estimates to the expected escapement of females (both natural-origin and hatchery-origin spawners – 13,049 females), the ESU is estimated to produce approximately 32.6 million eggs annually. For HCS chum salmon, freshwater mortality rates are high with no more than 13% of the eggs expected to survive to the juvenile migrant stage (Quinn 2005). With an estimated survival rate of 13%, the ESU should produce roughly 4.24 million natural-origin outmigrants annually. The combined hatchery production goal for listed HCS chum salmon is 150,000 unmarked juvenile chum salmon.

Spatial Structure and Diversity

The ESU includes all naturally spawning populations of summer-run chum salmon in Hood Canal tributaries as well as populations in Olympic Peninsula rivers between Hood Canal and Dungeness Bay, Washington, as well as several artificial propagation programs. 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.

The CV for the Hood Canal population was considerably lower in the more recent analysis (Lestelle et al. 2018). Results of 2017 VRAP 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. The Strait of Juan de Fuca population had a much higher risk of extinction, even with a zero exploitation rate (Lestelle et al.

2018). As noted above, since 2017, both populations have experienced much lower returns, and a 2020 update of the VRAP analysis resulted in considerably reduced population performance under a changing ocean climate.

2.2.1.9 Columbia River Chum Salmon

The CR chum salmon ESU is composed of all naturally-spawned populations of chum salmon in the Columbia River and its tributaries in Washington and Oregon. Three artificial propagation programs are 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.

Columbia River chum salmon are included in the Lower Columbia River recovery plan (NMFS 2013b). Recovery targets for this species focus on improving tributary and estuarine habitat conditions, and re-establishing populations where they may have been extirpated, in order to increase all four viability parameters.

The recovery plan and 5-year reviews have identified factors limiting the recovery of the species. Limiting factors for this species include:

- 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

Spatial Structure and Diversity

The Willamette/Lower Columbia River Technical Recovery Team identified 17 historical populations divided into three major population groups. Chum salmon generally spawn in the mainstem Columbia River (in areas of groundwater seeps) and the lower reaches of both large and small tributaries, with the exception of the Cowlitz River (Myers et al. 2006). 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 ability of chum salmon to expand and recolonize historical habitat. Presently, detectable numbers of chum salmon persist in only 4 of the 17 demographically independent populations, a fraction of their historical range.

Abundance and Productivity

Of the 17 historical populations identified, on three currently exceed the abundance targets in the recovery plan (NMFS 2013b). 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 goal. 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.

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 (2016-2020) by using annual abundance estimates provided by the NWFSC (Zabel 2017a, 2017b, 2018, 2020, 2021). The geometric mean of abundance for juvenile natural- and hatchery-origin CR chum salmon is 7,533,081 and 523,500 respectively. 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). The geometric mean of abundance for the most recent 5 years (2015-2019) is 17,302 natural-origin and 1,148 hatchery-origin adult spawners (Ford 2022).

Status Summary

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 to 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 seems 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. This Lower Columbia River chum salmon ESU therefore remains at moderate risk of extinction, and the viability is largely unchanged from the prior review.

2.2.1.10 Lower Columbia River Coho Salmon

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 and are also listed (85 FR 81822).

This species is included in the Lower Columbia River recovery plan (NMFS 2013b). Specific recovery goals are to improve all four viability parameters to the point that the Coast, Cascade, and Gorge strata achieve high probability of persistence. Protection of existing high functioning habitat and restoration of tributary habitat are noted needs, along with reduction of hatchery and harvest impacts. Large improvements are needed in the persistence probability of most populations of this ESU.

The recovery plan and 5-year reviews have identified factors limiting the recovery of the species. Limiting factors for this species include:

- Degraded estuarine and near-shore marine habitat
- Fish passage barriers
- 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

Spatial Structure and Diversity

Prior to the ESA listing, 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 been incremental improvements in spatial structure during this review period. Poor ocean and freshwater conditions have been such as to mask any benefits from these activities. 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.

Abundance and Productivity

In contrast to the 2015 viability assessment, which occurred at a time of near record returns for several populations, the ESU abundance has declined 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 6 of the 23 populations for which we have data appear to be above their recovery goals. 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, 7 DIPs are at 10-50% of their recovery goals, and 7 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).

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 (2016-2020) by using annual abundance estimates provided by the NWFSC (Zabel 2017a, 2017b, 2018, 2020, 2021). The geometric mean of abundance for juvenile natural- and hatchery-origin LCR coho salmon is 776,286 and 7,894,039 respectively. 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). The geometric mean of abundance for the most recent 5 years (2015-2019) is 18,709 natural-origin and 15,954 hatchery-origin adult spawners (Ford 2022).

Status Summary

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 Lower Columbia River coho salmon ESU remains at moderate risk, and viability is largely unchanged from the prior viability assessment.

2.2.1.11 Oregon Coast Coho Salmon

The OC coho salmon ESU is composed of all naturally spawned populations of coho salmon in coastal streams south of the Columbia River and north of Cape Blanco. The ESU also includes the Cow Creek hatchery coho stock, produced at the Rock Creek Hatchery.

NMFS adopted a recovery plan for OC coho salmon on December 1, 2016 (NMFS 2016d). Oregon Coast coho salmon are primarily affected by threats that reduce the quantity and quality of coho salmon rearing habitat. According to the recovery plan, climate change is one of the primary factors threatening habitat. The main predicted effects in terrestrial and freshwater habitats include warmer, drier summers, reduced snowpack, lower summer flows, higher summer stream temperatures, and increased winter floods, which would affect coho salmon by reducing available summer rearing habitat, increasing potential scour and egg loss in spawning habitat, increasing thermal stress, and increasing predation risk. In estuarine habitats, the main physical effects are predicted to be rising sea level and increasing water temperatures, which would lead to a reduction in intertidal wetland habitats, increasing thermal stress, increasing predation risk, and unpredictable changes in biological community composition.

The recovery plan and 5-year reviews have identified factors limiting the recovery of the species. Limiting factors for this species include:

- 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

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 within the ESU 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 within 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). 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 in size 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.

Abundance and Productivity

The spawner abundance of coho salmon within 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 within the ESU generally increased between 1999 and 2014, before dropping in 2015 and remaining low. The 2014 Oregon Coast coho salmon return (355,600 wild and hatchery spawners) was the highest since at least the 1950’s (2011 was the 2nd highest with 352,200; ODFW 2015), 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, indicating the overriding importance of marine survival to returns of Oregon Coast coho salmon (Ford 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). The geometric mean of abundance for the most recent 5 years (2015-2019) is 60,633 natural-origin and 629 hatchery-origin adult spawners (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. The three-year average of natural-origin spawners for the years 2015-2019 is estimated at 61,262 total spawners. 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 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 juvenile coho salmon are produced annually by the Oregon Coast ESU. The combined hatchery production goal for listed OC coho salmon is 60,000 marked juvenile coho salmon.

Status Summary

The latest ESU scores for persistence (high certainty of ESU persistence) and sustainability (low to moderate certainty of ESU sustainability) demonstrate the biological status of the ESU has decreased slightly since the 2015 viability assessment (Ford 2022), which covered a period of favorable ocean conditions and high marine survival rates. However, current ESU scores have improved relative to the 2015 assessment (Ford 2022). This improvement occurred despite similar or better abundances and marine survival rates during the earlier period, suggesting continued benefits due to management decisions to reduce both harvest and hatchery releases. 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 Oregon coast coho salmon ESU is therefore at moderate-to-low risk of extinction, with viability largely unchanged from the prior review.

2.2.1.12 Southern Oregon/Northern California Coast Coho Salmon

The SONCC coho salmon ESU is composed of all naturally spawned populations of coho salmon in coastal streams between Cape Blanco, Oregon, and Punta Gorda, California. The ESU includes coho salmon from three hatchery programs in Oregon and California (85 FR 81822).

NMFS adopted a recovery plan for SONCC coho salmon on January 1, 2014 (NMFS 2014c). The recovery plan identifies drought and water use for domestic and farm purposes, as well as poor ocean conditions as leading factors for concern in most areas of the ESU. The recovery plan uses “stresses” to describe the physical, biological, or chemical conditions and associated ecological processes that may be impeding SONCC coho salmon recovery (NMFS 2014c). Stresses for this species include:

- Lack of floodplain and channel structure
- Impaired water quality
- Altered hydrologic function (timing of volume of water flow)
- Impaired estuary/mainstem function
- Degraded riparian forest conditions
- Altered sediment supply
- Increased disease/predation/competition
- Barriers to migration
- Fishery-related effects
- Hatchery-related effects

Spatial Structure and Diversity

Williams et al. (2006) identified 36 independent and 9 dependent populations of coho salmon in the SONCC coho salmon ESU. 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 relative 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 effects 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 is likely very low and is inadequate to contribute to a viable ESU.

Abundance and Productivity

Population-level estimates of abundance are limited to seven of the 26 independent populations in this ESU. The available data indicate that the seven 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 2014c). 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.

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. The geometric mean of abundance for the most recent 3 years (2017-2019) is 12,641 natural- and hatchery-origin adult spawners.

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. The three-year average of natural-origin spawners for the years 2017-2019 is estimated at 12,641 total spawners. 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 6,320 females returning (half of 12,641) to this ESU, one may expect approximately 12,641,000 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 884,870 juvenile coho salmon are produced annually by the SONCC coho ESU. The combined hatchery production goal for listed SONCC coho salmon is 575,000 marked and 75,000 unmarked juvenile coho salmon.

Status Summary

In summary, data availability for this ESU remains generally poor, new information available since Williams et al. (2016) suggests little improvement over the five years since the last viability assessment (Williams et al. 2021). 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. 2006). Five of the seven have negative trends in abundance including two (Shasta and Mattole rivers) that are at high-risk based on viability criteria (Williams et al. 2006). 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 2014c); both the Elk River and Scott River are at moderate-risk of extinction based on the spawner density criterion (Williams et al. 2006). Based on the available data, the extinction risk of the SONCC Coho Salmon ESU has increased (i.e., less viable) since previous assessment.

2.2.1.13 Puget Sound Steelhead

The PS steelhead DPS is composed of naturally spawned anadromous *O. 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).

On December 27, 2019, we published a final recovery plan for PS steelhead (84 FR 71379) (NMFS 2019b). The recovery plan and 5-year reviews have identified factors limiting the recovery of the species. Limiting factors for this species include:

- The continued destruction and modification of steelhead habitat
- Widespread declines in adult abundance (total run size), despite significant reductions in harvest in recent years
- Threats to diversity posed by use of two hatchery steelhead stocks (Chambers Creek and Skamania)
- Declining diversity in the DPS, including the uncertain but weak status of summer run fish
- A reduction in spatial structure
- Reduced habitat quality through changes in river hydrology, temperature profile, downstream gravel recruitment, and reduced movement of large woody debris
- In the lower reaches of many rivers and their tributaries in Puget Sound where urban development has occurred, increased flood frequency and peak flows during storms and reduced groundwater-driven summer flows, with resultant gravel scour, bank erosion, and sediment deposition
- Dikes, hardening of banks with riprap, and channelization, which have reduced river braiding and sinuosity, increasing the likelihood of gravel scour and dislocation of rearing juveniles

Spatial Structure and Diversity

Although Puget Sound DPS 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 major population groups 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 ten 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, demands on water allocation all continue to degrade the quantity and quality of available fish habitat.

The Recovery Plan for Puget Sound Steelhead (NMFS 2019b) 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, whereas competition and predation by hatchery-origin fish can be readily diminished, it is unclear how long it will take to remove the genetic legacy of introgression by natural selection.

Abundance and Productivity

Abundance information is unavailable for approximately one-third of the populations, disproportionately so for summer-run populations. In most cases where no information is available it is assumed that abundances are very low. Increases in spawner abundance were observed in a number of populations over the last five years (Ford 2022). These improvements were disproportionately found within the South and Central Puget Sound and 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 abated somewhat the demographic risks facing those populations. 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. Additionally, the decline in the Tolt River summer-run steelhead population was especially of concern given that it is the only population for which we have abundance estimates.

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). The geometric mean of abundance for the most recent 5 years (2015-2019) is 19,814 natural- and hatchery-origin adult spawners (Ford 2022). Juvenile PS steelhead abundance estimates are calculated from the estimated abundance of adult spawner and estimates of fecundity. For the species, 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 (9,907 females), 34.67 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 2.25 million natural-origin outmigrants annually.

Juvenile listed hatchery PS steelhead 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 steelhead is roughly 270 thousand juvenile steelhead annually.

Status Summary

Ford (2022) found that the viability of the Puget Sound Steelhead DPS has improved somewhat since the Puget Sound Steelhead TRT concluded that the DPS was at very low viability, as were all three of its constituent MPGs, and many of its 32 DIPs (Hard et al. 2015). However, in spite of improvements in some areas, most populations are still at relatively low abundance levels, with about a third of the populations unmonitored and presumably at very low levels.

2.2.1.14 Upper Columbia River Steelhead

The UCR steelhead DPS is composed of naturally spawned anadromous *O. mykiss* (steelhead) originating below natural and manmade impassable barriers from the Columbia River and its tributaries upstream of the Yakima River to the U.S.-Canada border. This region includes several rivers that drain the east slopes of the Cascade Mountains and several that originate in Canada (only U.S. populations are included in the listed species). Dry habitat conditions in this area are less conducive to steelhead survival than those in many other parts of the Columbia River basin (Mullen et al. 1992a). Although the life history of these fish is similar to that of other inland steelhead, smolt ages are some of the oldest on the West Coast (up to seven years old), probably due to the ubiquitous cold water temperatures (Mullen et al. 1992b). Adults spawn later than in most downstream populations—remaining in fresh water up to a year before spawning. Most current natural production occurs in the Wenatchee and Methow River systems, with a smaller run returning to the Entiat River (WDF et al. 1993). Very limited spawning also occurs in the Okanagan River basin. Most of the fish spawning in natural production areas are of hatchery origin. The DPS also includes steelhead from five artificial propagation programs (85 FR 81822).

NOAA Fisheries adopted a recovery plan for upper Columbia River spring Chinook salmon and steelhead in 2007 (UCSRB 2007). The plan identified the following factors that were limiting the recovery of the species:

- Adverse effects related to the mainstem Columbia River hydropower system
- Impaired tributary fish passage
- Degradation of 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

Spatial Structure and Diversity

The UCR steelhead DPS is made up of four population corresponding to the following river basins: Methow, Wenatchee, Entiat, and Okanogan. With the exception of the Okanogan population, the upper Columbia River populations were rated as low risk for spatial structure in NMFS's recent viability assessment (Ford 2022). However, the viability assessment found that high levels of hatchery spawners within natural spawning areas and a lack of genetic diversity among the populations continues to pose a high risk to diversity. There are currently direct releases of hatchery origin juveniles in three of the four populations, the exception being the Entiat River. However, naturally spawning fish in the Entiat River hatchery include stray hatchery fish from the Wenatchee River (Hillman et al. 2015). The estimated proportion of natural-origin spawners has increased consistently since the late 1990s for all four populations, but remains well below the targets in the recovery plan. Natural-origin proportions were the highest in the Wenatchee River but constituted on 58% of total spawners. Hatchery-origin returns continue to constitute a high fraction of total spawners in natural spawning areas for this DPS (Ford 2022).

Genetics samples taken in the 1980s indicated little differentiation within populations in the upper Columbia River DPS (UCSRB 2007). More recent studies within the Wenatchee River basin have found differences between samples from the Peshastin River, believed to be relatively isolated from hatchery spawning, and those from other reaches within the Wenatchee. This suggests that there may have been a higher level of within and among population diversity prior to the advent of major hatchery releases (Seamons et al. 2012). Genetic studies based on sampling in the Wenatchee as well as other Upper Columbia River steelhead population tributaries are underway and should allow for future analyses of current genetic structure and any impacts of changing hatchery release practices.

Abundance and Productivity

Recent trends in abundance represent substantial reductions from levels seen in the last viability assessment (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 2008). 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.

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). The geometric mean of abundance for the most recent 5 years (2015-2019) is 1,464 natural-origin and 2,894 hatchery-origin adult spawners (Ford 2022).

To estimate abundance of juvenile natural and hatchery UCR steelhead, 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). The geometric mean of abundance for juvenile natural- and hatchery-origin UCR steelhead is 161,936 and 875,910 respectively.

Status Summary

The integrated spatial structure and diversity risk ratings for the populations are high for all four populations (Ford 2022). Because the risk 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.

2.2.1.15 Snake River Basin Steelhead

The SRB steelhead DPS is composed of all naturally spawned anadromous *O. mykiss* (steelhead) originating below natural and manmade impassable barriers in the Snake River basin. This DPS includes steelhead from six artificial propagation programs (85 FR 81822).

In November 2017, NOAA Fisheries adopted the final Snake River Spring/Summer Chinook Salmon and Steelhead Recovery Plan (NMFS 2017c). The overall viability ratings for natural populations in the Snake River Basin Steelhead DPS range from moderate to high risk. Four out of the five MPGs are not meeting the specific objectives in the Recovery Plan; the Grande Ronde MPG is tentatively rated as viable.

The recovery plan identified the following factors limiting recovery of the species (NMFS 2017c):

- Adverse effects related to the mainstem Columbia River hydropower system
- Impaired tributary fish passage
- Degradation of d floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream flow, and water quality
- Increased water temperature
- Harvest-related effects, particularly for B-run steelhead
- Predation
- Genetic diversity effects from out-of-population hatchery releases

Spatial Structure and Diversity

The SRB steelhead DPS comprises five major population groups with 23 extant populations combined. 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. In the most recent viability assessment, 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.

Abundance and Productivity

The recent trends in abundance for all the populations in this DPS show significant declines in the past 15 years (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 15 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 opposed to productivity measured in the ocean environment, has remained above 1.0 for the five major population groups 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.

To estimate abundance of juvenile natural and hatchery SRB steelhead, 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). The geometric mean of abundance for juvenile natural- and hatchery-origin SRB steelhead is 790,184 and 3,631,675 respectively. 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 geometric mean of abundance for the most recent 5 years (2015-2019) is 9,967 natural-origin and 3,283 hatchery-origin adult spawners (Ford 2022).

Status Summary

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 SRB steelhead DPS remains at moderate risk of extinction, with viability essentially unchanged from the last review.

2.2.1.16 Middle Columbia River Steelhead

The MCR steelhead DPS is composed of naturally spawned anadromous *O. mykiss* (steelhead) originating below natural and manmade impassable barriers from the Columbia River and its tributaries upstream of the Wind and Hood Rivers (exclusive) to and including the Yakima River; excludes such fish originating from the Snake River basin. This DPS includes steelhead from the four artificial propagation programs (FR 85 81822). This DPS does not include steelhead that are designated as part of an experimental population.

NMFS adopted a recovery plan for MCR steelhead on November 30, 2009 (NMSS 2009a). Recovery strategies outlined in the Recovery Plan recommend a viable (low risk) status for the four major population groups, as well as representation of all the major life history strategies present historically (e.g. early and late run-types). The Recovery Plan recognizes that at the major population group level there may be several specific combinations of population viability ratings that could satisfy the above criteria.

The recovery plan identified the following factors limiting recovery of the species (NMFS 2009a; NOAA Fisheries 2011):

- Degradation of floodplain connectivity and function, channel structure and complexity, riparian areas, fish passage, stream substrate, stream flow, and water quality
- Mainstem Columbia River hydropower-related impacts
- Degraded estuarine and nearshore marine habitat
- Hatchery-related effects
- Harvest-related effects
- Effects of predation, competition, and disease.

Spatial 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). 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 viability assessment.

Abundance and Productivity

In all but one population (Klickitat R.), the average annual adult return represents substantial reductions from levels seen in the last viability assessment (Ford 2022). 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 3-5 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 2008) 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).

To calculate an estimate for the abundance of for 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). The geometric mean of abundance for the most recent 5 years (2015-2019) is 13,599 natural-origin and 712 hatchery-origin adult spawners (Ford 2022). To estimate abundance of juvenile natural and hatchery MCR steelhead, 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). The geometric mean of abundance for juvenile natural- and hatchery-origin MCR steelhead is 375,923 and 547,613 respectively.

Status Summary

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.

2.2.1.17 Lower Columbia River Steelhead

The LCR steelhead DPS is composed of naturally spawned anadromous *O. mykiss* (steelhead) originating below natural and manmade impassable barriers from rivers between the Cowlitz and Wind Rivers (inclusive) and the Willamette and Hood Rivers (inclusive); excludes such fish originating from the upper Willamette River basin above Willamette Falls. This DPS includes steelhead from eight artificial propagation programs (FR 85 81822).

Recovery plan targets for this species are tailored for each life history type, and within each type, specific population targets are identified (NMFS 2013b). For steelhead, all populations are affected by aspects of habitat loss and degradation. Most of the populations require significant reductions in every threat category. Protection and improvement of tributary and estuarine habitat are specifically noted.

The recovery plan and 5-year reviews have identified factors limiting the recovery of the species. Limiting factors for this species include:

- Degraded estuarine and near-shore marine habitat
- Fish passage barriers
- 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

Spatial Structure and Diversity

The LCR steelhead DPS comprises 23 populations in four major population groups—two winter-run and two summer-run. All of the populations 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 populations 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).

Abundance and Productivity

Total spawner counts are available for 17 of 21 populations, 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 (Ford 2022), and of the six populations 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 populations. We do not have any productivity data for the rest of the LCR steelhead populations 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 populations, the changes in 5-year abundances have been not substantial, however recent negative trends are of concern here as well (Ford 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). The geometric mean of abundance for the most recent 5 years (2015-2019) is 8,151 natural-origin and 6,383 hatchery-origin adult spawners (Ford 2022). To estimate abundance of juvenile natural and hatchery LCR steelhead, 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). The geometric mean of abundance for juvenile natural- and hatchery-origin LCR steelhead is 371,241 and 1,193,743 respectively.

Status Summary

Of the 23 populations in the Lower Columbia River steelhead DPS, 10 are nominally at or above the goals set in the recovery plan (NMFS 2013b); 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).

2.2.1.18 Upper Willamette River Steelhead

The UWR steelhead DPS includes all naturally spawned populations of winter-run steelhead in the Willamette River, Oregon, and its tributaries upstream from Willamette Falls to the Calapooia River, inclusive. 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.

NMFS and ODFW jointly adopted a recovery plan for this species in August 2011 (ODFW and NMFS 2011). The recovery plan identifies the factors limiting recovery as habitat access, physical habitat quality/quantity, water quality, competition, disease, food web, population traits, and predation (ODFW 2011). The primary threats to UWR steelhead are human impacts, including flood control/hydropower system operations, land use practices (e.g., road building, riparian development, etc.), harvest, hatchery operations, and other species.

Limiting factors for this species include (ODFW and NMFS 2011):

- Degraded freshwater habitat, including floodplain connectivity and function, channel structure and complexity, incubation gravels, riparian areas, and gravel and large wood recruitment
- Degraded water quality including elevated water temperature and toxins
- Increased disease incidence
- Altered stream flows
- Reduced access to spawning and rearing habitats due to migration barriers and impaired fish 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 races of salmon and steelhead
- Altered population traits due to natural-origin fish interbreeding with hatchery origin fish.

Spatial Structure and Diversity

The recovery plan identifies four demographically independent populations of steelhead: Molalla, North Santiam, South Santiam, and Calapooia. 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.

Abundance and Productivity

Populations in this DPS have experienced long-term declines in spawner abundance. The underlying cause(s) of these declines is 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, continued declines would be a cause for concern.

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 (2016-2020) by using annual abundance estimates provided by the NWFSC (Zabel 2017a, 2017b, 2018, 2020, 2021). The geometric mean of abundance for juvenile natural-origin UWR steelhead is 136,980. 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). The geometric mean of abundance for the most recent 5 years (2015-2019) is 2,628 natural-origin adult spawners (Ford 2022).

Status Summary

Overall, the UWR steelhead DPS continued to decline in abundance since the previous viability assessment 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 proscribed timetable, 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).

2.2.1.19 Northern California Steelhead

The NC steelhead DPS includes all naturally spawned populations of steelhead in rivers and streams from Redwood Creek (Humboldt County) south to the Gualala River (Mendocino

County). The DPS does not currently include artificially propagated fish. Two artificial propagation programs were originally listed as part of the DPS, but both programs were terminated in the mid-2000's.

In October of 2016, NMFS adopted a coastal multispecies recovery plan that includes NC steelhead (NMFS 2016c). In the recovery plan, NMFS evaluated current habitat conditions and ongoing and future threats and concluded that all life stages of steelhead are impaired by degraded habitat conditions. These impairments are due to a lack of complexity and shelter formed by instream wood, high sediment loads, lack of refugia during winter, low summer flows, reduced quality and extent of coastal estuaries and lagoons, and reduced access to historic spawning and rearing habitat. The major sources of these impairments are roads, water diversions and impoundments, logging, residential and commercial development, severe weather patterns, and channel modification.

The recovery plan and 5-year reviews have identified factors limiting the recovery of the species. Limiting factors for this species include:

- Logging and road construction altering substrate composition, increasing sediment load, and reducing riparian cover
- 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)

Spatial Structure and Diversity

The NC steelhead DPS is composed of both winter- and summer-run steelhead populations. Extant summer-run populations are found in Redwood Creek, Mad River, Eel River (Middle Fork), and Mattole River. 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 described above.

NC steelhead remain broadly distributed throughout their range, with the exception of habitat upstream of dams on both the Mad River and Eel River, which has 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 to be part of the DPS, CDFW continues to operate the hatchery.

Abundance and Productivity

Williams et al. (2021) 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. And there appears to be a downward (but non-significant) trend in abundance for smaller populations. Overall, the data suggest that the status of winter-run populations has not changed appreciably since the 2016 viability assessment (Williams et al. 2021).

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.

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 10-year average as an estimate for abundance (2009-2018). The data collected from the recent SWFSC viability assessment indicates that there may be as many as 13, 906 adult steelhead returning to spawn each year (Williams et al. 2021). 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. For the species, 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 –6,953 females), 24 million eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS could produce roughly 1,581,784 natural outmigrants annually.

Status Summary

In summary, the available information for winter-run and summer-run populations of NC Steelhead do not suggest an appreciable increase or decrease in extinction risk since the 2016 viability assessment (Williams et al. 2021). 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.

2.2.1.20 California Central Valley Steelhead

The CCV steelhead DPS is composed of naturally spawned anadromous *O. mykiss* (steelhead) originating below natural and manmade impassable barriers from the Sacramento and San Joaquin Rivers and their tributaries; excludes such fish originating from San Francisco and San Pablo Bays and their tributaries. This DPS includes steelhead from the three artificial propagation programs (FR 85 81822).

In July 2014, NOAA Fisheries released a Recovery Plan for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead. The recovery plan draws on the expertise of the Central Valley Technical Recovery Team, agency co-managers, and many public entities and individuals dedicated to recovering these fish. It is based on a sound scientific foundation and is a key decision-making resource for improving and sustaining the health of California's natural environment.

The recovery plan and 5-year reviews have identified factors limiting the recovery of the species. Limiting factors for this species include:

- Major dams
- Water diversions
- Barriers
- Levees and bank protection
- Dredging and sediment disposal
- Mining
- Contaminants
- Alien species
- Fishery-related effects
- Hatchery-related effects

Spatial Structure and Diversity

Steelhead are well-distributed throughout the Central Valley below impassable dams (Good et al. 2005, NMFS 2014b). However, about 80 percent of the historical spawning and rearing habitat once used by anadromous O. mykiss in the Central Valley is located upstream of dams (Lindley et al. 2006). Many historical populations of CCV steelhead are entirely above impassable barriers and may persist as resident or adfluvial rainbow trout, although they are presently not considered part of the DPS.

Steelhead in the Central Valley historically consisted of both summer-run and winter-run migratory forms, based on their state of sexual maturity at the time of river entry and the duration of their time in freshwater before spawning. Only winter-run (ocean maturing) steelhead currently are found in California Central Valley rivers and streams (Moyle 2002, McEwan and Jackson 1996). Summer-run steelhead have been extirpated due to a lack of suitable holding and staging habitat, such as cold-water pools in the headwaters of CCV streams, presently located above impassible dams (Lindley et al. 2006).

Hatchery stocks within the DPS include Coleman National Fish Hatchery, Feather River Hatchery, Mokelumne River Hatchery, and Nimbus Hatchery. Steelhead produced from the first three programs are considered to be genetically similar to the natural spawning DPS. The

Nimbus Hatchery stock is not included in the DPS because they are genetically divergent from the Central Valley DPS lineages, having been founded from Eel and Mad river populations (Pearse and Garza 2015). Thus, potential straying of Nimbus Hatchery broodstock and continued introgression with natural-origin steelhead poses a risk to the overall DPS (California HSRG 2012). Furthermore, hatchery programs are intended to mitigate for the loss of steelhead habitat caused by dam construction, but hatchery origin fish constitute a major proportion of naturally spawning adult steelhead and in such they pose a risk to the genetic diversity of the DPS.

Abundance and Productivity

Population trend data remain extremely limited for the California Central Valley Steelhead DPS. However, the available information indicates that the vast majority of steelhead in the Central Valley are from hatchery programs. The abundance of hatchery origin adult spawners has significantly increased since the 2010 and 2015 viability assessments (Williams et al. 2021). However, abundance of natural-origin fish has decreased over the same time period. The lack of improved natural production and low abundances coupled with large hatchery influence is cause for concern and an indication that risks to abundance and productivity have not improved since the last viability assessment (Williams et al. 2021).

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. 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. The average number of hatchery- and natural-origin adult CCV steelhead returning to spawn each year is 11,494 (Williams et al. 2021).

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. Juvenile CCV steelhead abundance estimates can be derived from the adult escapement data. For the species, 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 –5,747 females), 20 million eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS could produce roughly 1,307,442 natural outmigrants annually. In addition, hatchery managers could produce approximately 1,050,000 million listed hatchery juvenile CCV steelhead each year.

Status Summary

The viability of Central Valley steelhead appears to have slightly improved since the 2010 and 2015 viability assessments. The modest improvement is driven by the increase in adult returns to hatcheries from their recent lows, but the state of naturally-origin fish remains poor and largely unknown. Improvements to the sizes of the largely hatchery populations does not warrant a downgrading of the DPS extinction risk. In fact, 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 is cause for concern.

2.2.1.21 Central California Coast Steelhead

The CCC steelhead DPS is composed of naturally spawned anadromous *O. mykiss* (steelhead) originating below natural and manmade impassable barriers from the Russian River to and including Aptos Creek, and all drainages of San Francisco and San Pablo Bays eastward to Chipps Island at the confluence of the Sacramento and San Joaquin Rivers. This DPS includes steelhead from two artificial propagation programs (FR 85 81822).

In October of 2016, NMFS adopted a coastal multispecies recovery plan that includes CCC steelhead (NMFS 2016c). In the recovery plan, NMFS evaluated current habitat conditions and ongoing and future threats and concluded that all life stages of steelhead are impaired by degraded habitat conditions. These impairments are due to a lack of complexity and shelter formed by instream wood, high sediment loads, lack of refugia during winter, low summer flows, reduced quality and extent of coastal estuaries and lagoons, and reduced access to historic spawning and rearing habitat. The major sources of these impairments are roads, water diversions and impoundments, logging, residential and commercial development, severe weather patterns, and channel modification.

The recovery plan and 5-year reviews have identified factors limiting the recovery of the species. Limiting factors for this species include:

- Logging and road construction altering substrate composition, increasing sediment load, and reducing riparian cover
- 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)

Spatial 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 comprised of 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 viability assessment about potential genetic consequences of interbreeding between hatchery and wild fish appear well founded (Williams et al. 2021).

Abundance and Productivity

The scarcity of information on steelhead abundance in the CCC-Steelhead DPS continues to make it difficult to assess trends in abundance and productivity (Williams et al. 2021). The implementation of the Coastal Monitoring Plan 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 800–2000 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 primarily targeting Chinook salmon (but occasionally steelhead) have been conducted in recent years in selected portions of the Napa River watershed and its tributaries. Additionally, a rotary screw trap operated near the upper limit of tidal influence has resulted in capture of 31 to 242 smolts annually since 2009. Smolt trap efficiency has averaged about 12% during this period, suggesting that total smolt production has generally ranged from a few hundred to perhaps 2,000 fish. These efforts 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 viability assessment. Likewise, limited spawner surveys in selected tributaries of the Petaluma River produced 6 live steelhead, 2 carcasses, and 6 redds, all in Adobe Creek during the 2013–2014 spawning season. Again, these limited surveys confirm steelhead presence in the watershed, but do not allow conclusions to be drawn about current viability.

In the Santa Cruz Mountain diversity stratum, 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 (Williams et al. 2021). 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.

Data for both adult and juvenile abundance are limited for 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 10-year average as an estimate for abundance (2009-2018). The data collected from the recent SWFSC viability assessment indicates that there may be as many as 3,864 adult steelhead returning to spawn each year (Williams et al. 2021). 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 natural-origin spawners – 1,932 females), roughly 6.8 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 439,485 natural outmigrants annually. In addition, hatchery managers could produce 520,000 listed hatchery juvenile CCC steelhead each year.

Status Summary

In summary, while data availability for this DPS remains generally poor, we do not find compelling evidence to suggest that the extinction risk for this DPS has changed appreciably since publication of the last viability assessment (Williams et al. 2021).

2.2.1.22 South-Central California Coast Steelhead

SCCC steelhead occupy rivers from the Pajaro River (Santa Cruz County, California), inclusive, south to, but not including, the Santa Maria River (San Luis Obispo County, California). Most rivers in this DPS drain from the San Lucia Mountain range, the southernmost section of the California Coast Ranges. Many stream and rive mouths in this area are seasonally closed by sand berms that form during the low water flows of summer. The climate is drier than for the more northern DPSs with vegetation ranging from coniferous forest to chaparral and coastal scrub.

In December 2013, NMFS adopted a coastal multispecies recovery plan for S-CCC steelhead (NMFS 2013c). In the recovery plan, NMFS determined that the S-CCC steelhead DPS experienced substantial declines as a result of human activities such as water development, flood control programs, forestry practices, agricultural activities, mining, and urbanization that have degraded, simplified, and fragmented aquatic and riparian habitats. Restoring flows, access to spawning and rearing habitats, and instream habitat conditions (including estuarine conditions) necessary to support steelhead are the principal recovery actions.

The recovery plan and 5-year reviews have identified factors limiting the recovery of the species. Limiting factors for this species include:

- 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

Spatial Structure and Diversity

The S-CCC 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 2013c).

Although steelhead are present in most of the streams in the S-CCC 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 the some populations pose a serious risk to the survival and recovery of the S-CCC 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.

Abundance and Productivity

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 (Williams et al. 2021). However, since the end of the drought in 2017 all indicators have ticked upward, 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 provision viability criterion of 0.3 fish/m2.

Data for both adult and juvenile abundance are limited for 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 10-year average as an estimate for abundance (2009-2018). The data collected from the recent SWFSC viability assessment indicates that there may be as many as 466 adult steelhead returning to spawn each year (Williams et al. 2021). While we currently lack data on naturally produced juvenile S-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 natural-origin spawners – 233 females), roughly 815,000 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 52,982 natural outmigrants annually.

Status Summary

There is little new evidence to indicate that the status of the S-CCC steelhead DPS has changed appreciably in either direction since the last viability assessment (Williams et al. 2016, Capelli 2016). Although the recent drought resulted in negative trends in abundance, since the drought ended there is evidence of improvement. Monitoring of status and trends continues to be unsatisfactory in this DPS. A draft plan to update the monitoring strategy is in progress (Williams et al. 2021).

2.2.1.23 Southern DPS Eulachon

Eulachon are endemic to the northeastern Pacific Ocean; they range from northern California to southwest and south-central Alaska and into the southeastern Bering Sea. The southern DPS of eulachon is composed of fish that spawn in rivers south of the Nass River in British Columbia to, and including, the Mad River in California.

In September 2017, NMFS adopted a recovery plan for eulachon (NMFS 2017d). In the recovery plan, NMFS determined the primary threat to be climate change and its impacts on ocean conditions. Climate change impacts on freshwater habitat and eulachon bycatch in offshore shrimp fisheries were 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 (Gustafson et al. 2010). The recovery plan does not identify limiting factors.

Spatial Structure and Diversity

At the time the species was evaluated for listing the Biological Review Team (BRT) partitioned the southern DPS of eulachon into geographic areas (subpopulations) for their threats 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 2017d). 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.

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 (Beecham 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 2016, NMFS 2017d). A 2015 study of SNP markers in eulachon from several regions concluded their results suggest there may 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).

Abundance and Productivity

Prior to 2011, few direct estimates of eulachon abundance existed. Escapement counts and spawning stock biomass estimates are only available for a small number of systems. Catch statistics from commercial and First Nations fisheries are available for some systems in which no direct estimates of abundance are available. However, inferring population status or even trends from yearly catch statistic changes requires making certain assumptions that are difficult to corroborate (e.g., assuming that harvest effort and efficiency are similar from year to year, assuming a consistent relationship among the harvested and total stock portion, and certain statistical assumptions, such as random sampling). Unfortunately, these assumptions cannot be verified, few fishery-independent sources of eulachon abundance data exist, and in the United States, eulachon monitoring programs have only been operating since 2011. However, the combination of catch records and anecdotal information indicates that there were large eulachon runs in the past and that eulachon populations have severely declined (Gustafson et al. 2010).

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 2017d). 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).

In recent years abundance estimates of eulachon in the Columbia and Fraser rivers have fluctuated from just under a million to nearly 40 million (Tables 3 and 4). The geometric mean spawner abundance over the past five years for the Columbia River is just over 23.5 million, though this is almost certainly an underestimate as surveys were cut short in 2020. These recent estimates are an improvement over abundance estimates at the time of listing, but a decline from the average abundances at the time of the last viability assessment (Gustafson et al 2010, Gustafson et al 2016). Since 2018 annual estimates have 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 viability assessment 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).

Table 3. Southern DPS Eulachon Spawning Estimates for the Fraser River, British Columbia, Canada (Fisheries and Oceans Canada 2021).

Year	Biomass estimate (metric tons)	Estimated spawner population[a]
2016	44	1,086,437
2017	35	864,211
2018	408	10,074,232
2019	108	2,666,708
2020	624	15,407,648
2016-2020[b]		3,295,411

[a] Estimated population numbers are calculated as 11.2 eulachon per pound.

[b] Five-year geometric mean of mean eulachon biomass estimates (2014-2018).

Table 4. Columbia River Southern DPS Eulachon Spawning Stock Biomass Survey Estimates (R. Anderson, personal communication, February 25, 2022).

Year	MAX	MEAN	MIN
2017	34,071,100	18,307,100	8,148,600
2018	9,200,000	4,100,000	1,300,000
2019	89,137,289	46,684,765	19,285,087
2020[a,b]	40,644,800	21,280,000	8,724,800
2021[b]	184,115,810	96,395,712	39,522,242
2017-2021[c]		**23,513,733**	

[a] Abbreviated estimate; sampling stopped mid-March of 2020
[b] Data are provisional and subject to change
[c] Five-year geometric mean of mean eulachon biomass estimates (2017-2021)

Status Summary

The Biological Review Team (BRT) concluded that, starting in 1994, the southern DPS of eulachon experienced an abrupt decline in abundance throughout its range (Gustafson et al. 2010). Efforts to estimate abundance in the Columbia and Fraser rivers increased following the listing of the species. The improvement in abundance of the species, relative to the time of listing, reflects both changes in biological status and improved monitoring.

2.2.1.24 Southern DPS Green Sturgeon

The southern DPS consists of coastal and Central Valley populations south of the Eel River (exclusive), with the only known spawning population in the Sacramento River. Information on their oceanic distribution and behavior indicates that green sturgeon make generally northern migrations—even occurring in numbers off Vancouver Island (NMFS 2005). A mixed stock assessment assigned about 70% to 90% of the green sturgeon present in the Columbia River estuary and Willapa Bay to the southern DPS. The stock composition in Grays Harbor is about 40% southern DPS (Israel et al. 2009).

The recovery plan for this DPS was finalized in August, 2018 (NMFS 2018c). The objective of the recovery plan is to increase green sturgeon abundance, distribution, productivity, and diversity by alleviating significant threats. To determine when these threats have been alleviated and the green sturgeon population has recovered, the recovery plan includes a set of demographic- and threat-based recovery criteria. The demographic criteria focus on maintaining abundance of the species above specific targets, viable spawning stocks in at least two rivers, positive trends in juvenile and subadult abundance, a broad distribution of size classes in adults, and no net loss of diversity from 2018 levels. The threats criteria focus on improving access to spawning habitat, maintaining appropriate in-stream temperatures and flows, reducing adult contaminant levels, and reducing the threat of illegal harvest.

NMFS recently completed a 5-year review for green sturgeon and provided the following summary of threats and limiting factors (NMFS 2021a).

> *Impassible barriers and flood bypass systems continue to be identified as a primary threat limiting recovery of Southern DPS green sturgeon. The decommissioning of RBDD has resulted in additional spawning habitat availability and utilization, and fish passage improvement at Fremont Weir has reduced entrainment into the Yolo Bypass. However, entrainment, as well as stranding in flood diversions during high water events, continue to negatively impact Southern DPS green sturgeon. Confirmation of spawning in the Feather and Yuba rivers is encouraging, although Southern DPS green sturgeon still encounter impassable barriers in the Sacramento, Feather, and Yuba rivers that limit their spawning range.*
>
> *Altered flow and temperature regimes in the Sacramento River are also a potential threat to S green sturgeon. Hydrological and thermal regimes in spawning habitats are altered as compared to historic profiles due to the operation of dams as well as climate change impacts. The relationship between altered flows and temperatures in spawning and rearing habitat and Southern DPS green sturgeon population productivity is uncertain. S green sturgeon are now spawning in higher reaches of the Sacramento River and more influenced by cold water releases from Keswick Dam, although at the uppermost reaches cold water may deter spawning and temperatures may not be suitable for egg and larval development. Drought conditions during 2012 to 2015 resulted in substantial reductions in spawning habitat in the Sacramento River, and increased frequency of droughts as predicted under climate change may impact S green sturgeon occupation in these areas.*
>
> *Prohibiting retention of S green sturgeon in commercial and recreational fisheries has reduced the threat of harvest, although some bycatch mortality still occurs. The inadequacy of regulatory mechanisms to address other threats such as water diversions and management remains a threat to the persistence of the DPS. The emerging threat posed by nearshore and offshore energy development requires continued attention into the future to understand how S green sturgeon may be impacted.*

Spatial Structure and Diversity

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 (NMFS 2021a). Adult and subadult Southern DPS 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 the 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). In California, Miller et al. (2020) recorded adult and subadult Southern DPS 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 Southern DPS 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.

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 (NMFS 2021a). Applying the same demographic proportions as prior previous estimates (Beamesderfer et al. 2007) to this total, we calculated abundance estimates of adults, juveniles, and sub-adults that would be expected as portions of this updated total (Table 5).

Table 5. Green Sturgeon Estimated Total Population Size Based on Data from 2016 to 2018, and Life Stage-specific Abundance Estimates Derived from the Total (NMFS 2021a).

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 Southern DPS 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 (NMFS 2021a). 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).

Status Summary

The southern DPS of North American green sturgeon remains vulnerable due to having only one small spawning population, potential growth-limiting and lethal temperatures, harvest concerns, loss of spawning habitat, and entrainment by water projects. There will have to be substantial changes in this species' status before it can recover.

2.2.2 Status of the Species' Critical Habitat

2.2.2.1 Salmon ESUs and Steelhead DPSs

We review the status of designated critical habitat affected by the proposed actions by examining the condition and trends of essential physical and biological features throughout the designated area. These features are essential to the conservation of the listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration and foraging).

For salmon and steelhead, NMFS 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 listed species they support[4]; the conservation rankings are high, medium, or low. To determine the conservation value of each watershed to species viability, NMFS's critical habitat analytical review teams (CHARTs; NOAA Fisheries 2005a, 2005b, 2007; NMFS 2015c) evaluated the quantity and quality of habitat features (for example, spawning gravels, wood and water condition, side channels), the relationship of the area compared to other areas within the species' range, and the significance to the species of the population occupying that area. Thus, even a location that has poor quality of habitat could be ranked with a high conservation value if it were essential due to factors such as limited availability (e.g., one of a very few spawning areas), a unique contribution of the population it served (e.g., a population at the extreme end of geographic distribution), or the fact that it serves another important role (e.g., obligate area for migration to upstream spawning areas).

The CHARTs identified habitat-related human activities that affect the quantity or quality of the physical or biological habitat features that are essential to the conservation of the species. The primary categories of habitat-related activities identified by the CHART are (1) forestry, (2)

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[4] The conservation value of a site depends upon "(1) the importance of the populations associated with a site to the ESU [or DPS] conservation, and (2) the contribution of that site to the conservation of the population through demonstrated or potential productivity of the area" (NOAA Fisheries 2005).

agriculture, (3) channel modifications/diking, (4) road building/maintenance, (5) urbanization, (6) dams, (7) irrigation impoundments and withdrawals, and (8) wetland loss/removal. All of these activities have physical or biological habitat features related impacts because they have altered one or more of the following: stream hydrology, flow and water-level modifications, fish passage, geomorphology and sediment transport, temperature, dissolved oxygen, vegetation, soils, nutrients and chemicals, physical habitat structure, and stream/estuarine/marine biota and forage. And the degrees to which these alterations have affected the region's watersheds are the main factors that lead to the CHART teams' high-, medium-, and low conservation value ratings.

Over time, critical habitat for a species may need to be revised based on new information that has become available since the publication of the critical habitat designation. However, we have not re-evaluated the conservation value of the habitat nor revised the original critical habitat rules for the threatened species of salmon, steelhead, green sturgeon, or eulachon included in this Opinion.

Puget Sound Chinook

We designated critical habitat for PS Chinook salmon on September 2, 2005 (70 FR 52630). There are 61 watersheds and nineteen nearshore marine areas within the range of this ESU. The CHART rated twelve watersheds as having low, nine as having medium, and 40 as having high rating for their conservation value to the ESU. The nearshore marine areas also received a rating of high conservation value. Habitat areas eligible for designation for this ESU included 2,216 miles of stream and 2,376 miles of nearshore marine areas. We excluded some areas that overlap military lands or Indian lands and other areas where the economic impacts outweighed the benefits of designation. We designated approximately 1,683 miles of stream habitats and 2,182 miles of nearshore marine as critical habitat. The designation includes 926 miles of spawning/rearing sites, 215 miles of rearing/migration sites, and 542 miles of migration corridors. The 2,182 miles of designated nearshore marine habitats also contain rearing and migration sites.

Snake River Spring/summer Chinook

We designated critical habitat for the SR spr/sum Chinook salmon on December 28, 1993 (58 FR 68543) and revised the designation on October 25, 1999 (64 FR 14308). Critical habitat includes river reaches presently or historically accessible (except reaches above impassable natural falls, and Dworshak and Hells Canyon Dams). Included are adjacent riparian zones, as well as mainstem river reaches and estuarine areas in the Columbia River from a straight line connecting the west end of the Clatsop jetty (south jetty, Oregon side) and the west end of the Peacock jetty (north jetty, Washington side) upstream to the confluence of the Columbia and Snake Rivers and all Snake River reaches from the confluence of the Columbia River upstream to Hells Canyon Dam. Major river basins containing spawning and rearing habitat for this ESU comprise approximately 22,390 square miles in Idaho, Oregon, and Washington. The following counties lie partially or wholly within these basins: Idaho - Adams, Blaine, Custer, Idaho, Lemhi, Lewis, Nez Perce, and Valley; Oregon - Baker, Umatilla, Union, and Wallowa; Washington - Adams, Asotin, Columbia, Franklin, Garfield, Walla Walla, and Whitman.

The critical habitat for this species was designated before we had implemented the CHART team process, so no determination has been made regarding the various conservation values of the habitat areas the fish inhabit. Nonetheless, the great majority of the habitat that the SR spr/sum Chinook use overlaps with that of SR steelhead. Thus, nearly all of the ratings applied to the steelhead would apply here as well.

Snake River Fall Chinook

We designated critical habitat for SR fall Chinook salmon on December 28, 1993 (58 FR 68543). It includes river reaches presently or historically accessible (except reaches above impassable natural falls, and Dworshak and Hells Canyon Dams). Included are adjacent riparian zones, as well as mainstem river reaches and estuarine areas in the Columbia River from a straight line connecting the west end of the Clatsop jetty (south jetty, Oregon side) and the west end of the Peacock jetty (north jetty, Washington side) upstream to the confluence of the Columbia and Snake Rivers; the Snake River including all river reaches from the confluence of the Columbia River upstream to Hells Canyon Dam; the Palouse River from its confluence with the Snake River upstream to Palouse Falls; the Clearwater River from its confluence with the Snake River upstream to its confluence with Lolo Creek; and the North Fork Clearwater River from its confluence with the Clearwater River upstream to Dworshak Dam. Major river basins containing spawning and rearing habitat for this ESU comprise approximately 13,679 square miles in Idaho, Oregon, and Washington. The following counties lie partially or wholly within these basins: Idaho - Adams, Clearwater, Idaho, Latah, Lemhi, Lewis, and Nez Perce; Oregon - Baker, Union, and Wallowa; Washington - Adams, Asotin, Columbia, Franklin, Garfield, Walla Walla, and Whitman.

The critical habitat for this species was designated before we had implemented the CHART team process, so no determination has been made regarding the various conservation values of the habitat areas the fish inhabit. Nonetheless, nearly all the habitat that the SR fall Chinook use overlaps with that of SR steelhead—at least for the mainstems of the Clearwater, Snake, and Columbia Rivers and lower-river tributary habitat. The biggest area of overlap is the lower Snake/ Columbia River rearing/migration corridor, and it is rated as having a high conservation value, but many of the other ratings applied to steelhead critical habitat would apply here as well.

Lower Columbia River Chinook

We designated critical habitat for LCR Chinook salmon on September 2, 2005 (70 FR 52630). Critical habitat for LCR Chinook includes 1,293 miles of streams and lakes in 47 watersheds in Oregon and Washington. There are 440 miles of spawning/rearing sites, 164 miles of rearing/migration sites, and 688 miles of migration corridors. The CHART rated four watersheds as having low, 13 as having medium, and 30 as having high conservation value to the ESU. Of the 47 watersheds considered for designation, we excluded four low-value and five medium-value watersheds in their entirety, and excluded tributary habitat in one medium-value watershed. Also, we excluded approximately 162 miles of stream covered by two habitat conservation plans because the benefits of exclusion outweigh the benefits of designation. As a result of these considerations, 344 miles of stream habitats were excluded from the designation.

Upper Willamette River Chinook

We designated critical habitat for UWR Chinook salmon on September 2, 2005 (70 FR 52630). Critical habitat for UWR Chinook includes approximately 1,796 miles of streams in Oregon and Washington. There are 644 miles of spawning/rearing sites, 722 miles of rearing/migration sites, and 106 miles of migration corridors. The CHART rated nineteen watersheds as having low, 18 as having medium, and 22 as having high rating for their conservation value to the ESU. Of the 60 watersheds considered for designation, we excluded 11 low conservation value and four medium-value watersheds in their entirety, and the tributary-only portions of eight low-value watersheds. As a result of these considerations, 324 miles of stream habitats were excluded from the designation.

California Coastal Chinook Salmon

We designated critical habitat for CC Chinook salmon on September 2, 2005 (70 FR 52488); it includes all river reaches and estuarine areas accessible to listed Chinook salmon from Redwood Creek (Humboldt County, California) to the Russian River (Sonoma County, California), inclusive. Excluded are areas above specific dams or above longstanding, naturally impassable barriers (i.e., natural waterfalls in existence for at least several hundred years). Critical habitat for CC Chinook salmon includes 1,634 miles of stream habitat. The CHART rated 27 watersheds as having high, 10 as having medium, and 8 as having low conservation value to the ESU.

Our assessment of the condition of CC Chinook critical habitat shows physical or biological features that are essential to the conservation of the species for spawning and rearing habitat in the two major rivers within this ESU—the Eel River and the Russian River—to be severely degraded by the persistence of highly turbid flows during the winter and spring, persisting even at low flows. Migration and rearing habitat physical or biological features that are essential to the conservation of the species in the Eel River (both riverine and estuarine) are degraded by diminished flows resulting from water storage in Lake Pillsbury (Scott Dam) and by interbasin diversions to the Russian River through the Potter Valley Project tunnel. Rearing habitat in the Russian River, both riverine and estuarine, is considered to be degraded as a result of land use patterns changing the channel configuration limiting available habitat, and a program of keeping the Russian River estuary breached open to the ocean throughout the year. Within the smaller coastal streams of the ESU which support populations of Chinook, the status of critical habitat physical or biological features that are essential to the conservation of the species for rearing, spawning, and migration are considered degraded to a lesser extent.

Central Valley Spring-run Chinook Salmon

Critical habitat was designated for CVS Chinook salmon on September 2, 2005, when NMFS published a final rule in the Federal Register (70 FR 52488). There are approximately 1,373 miles of stream habitats and 427 square miles of estuary habitats designated as critical habitat for CVS Chinook salmon. NMFS determined that marine areas did not warrant consideration as critical habitat for this ESU.

In determining the areas eligible for critical habitat designation, the CHART identified the physical or biological features that are essential to the conservation of the species. CVS Chinook physical or biological features that are essential to the conservation of the species are those 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 37 watersheds within the range of this ESU. Seven watersheds received a low rating, three received a medium rating, and 27 received a high rating of 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.

Hood Canal Summer-run Chum

We designated critical habitat for HCS chum salmon on September 2, 2005 (70 FR 52630). There are 12 watersheds within the range of this ESU. The CHART rated three watersheds as having medium and nine as having high conservation value to the ESU (NMFS, 2005a). Five nearshore marine areas also received a rating of high conservation value. Habitat areas eligible for designation for this ESU include 88 miles of stream and 402 miles of nearshore marine areas. We excluded some areas where the benefits of exclusion outweighed the benefits of designation. There are approximately 79 miles of stream habitats and 377 miles of nearshore marine habitats designated as critical habitat for HCS chum salmon. Of the areas designated as critical habitat, there are 34 miles of spawning/rearing sites, one mile of rearing/migration sites, 36 miles of migration corridors, and eight miles of habitat that is unoccupied but essential to conservation of the ESU. The 377 miles of designated nearshore marine habitats contain rearing and migration sites.

Columbia River Chum

We designated critical habitat for CR chum salmon on September 2, 2005 (70 FR 52630). There are 20 watersheds within the range of this ESU. The CHART rated three watersheds as having medium and 17 as having high conservation value to the ESU. Habitat areas eligible for designation as critical habitat for this ESU included 725 miles of streams. We excluded 7 stream miles of streams where the economic benefits of exclusion outweigh the benefits of designation. Critical habitat for CR chum includes approximately 19 miles of spawning/rearing sites, 55 miles of rearing/migration sites, and 634 miles of migration corridors.

Lower Columbia River Coho

We designated critical habitat for LCR coho salmon on February 24, 2016 (81 FR 9251). Critical habitat for LCR Coho includes approximately 2,300 miles of streams in Oregon and Washington. There are 805 miles of spawning/rearing sites, 1,436 miles of rearing/migration sites, and 46 miles of migration corridors. There are 55 watersheds within the range of this ESU. The CHART rated three of the watersheds as having low, eighteen as having medium, and thirty-four as having high conservation value to the ESU (NMFS 2015c). As a result of the economic and other relevant impacts weighed against the conservation value, approximately 1,000 miles of stream habitats were excluded from the designation.

Oregon Coast Coho

We designated critical habitat for OC coho salmon on February 11, 2008 (73 FR 7816). Critical habitat for OC coho includes approximately 6,565 miles of streams and 15 square miles of lake habitat in Oregon. There are 4,494 miles of spawning/rearing sites, 1,851 miles of rearing/migration sites, and 223 miles of migration corridors. The CHART rated four watersheds as having low, 13 as having medium, and 30 as having high conservation value to the ESU. Of the 80 watersheds considered for designation, we excluded five low conservation value watersheds in their entirety. As a result of these considerations, 84 miles of stream habitats were excluded from the designation.

Southern Oregon/Northern California Coasts Coho

We designated critical habitat for SONCC coho salmon on May 5, 1999 (64 FR 24049). Critical habitat includes all river reaches accessible to listed coho salmon in coastal streams south of Cape Blanco, Oregon, and north of Punta Gorda, California. Critical habitat consists of the water, substrate, and adjacent riparian zone of estuarine and riverine reaches (including off-channel habitats) in the following counties: Klamath, Jackson, Douglas, Josephine, and Curry in Oregon, and Humbolt, Mendocino, Trinity, Glenn, and Del Norte in California. Major rivers, estuaries, and bays known to support SONCC coho salmon include the Rogue River, Smith River, Klamath River, Mad River, Humboldt Bay, Eel River, and Mattole River. Many smaller coastal rivers and streams also provide essential estuarine habitat for coho salmon, but access is often constrained by seasonal fluctuations in hydrologic conditions. Within these areas, essential features of coho salmon critical habitat include adequate; (1) substrate, (2) water quality, (3) water quantity, (4) water temperature, (5) water velocity, (6) cover/shelter, (7) food, (8) riparian vegetation, (9) space, and (10) safe passage conditions. The critical habitat for this species was designated before we had implemented the CHART team process, so no determination has been made regarding the various conservation values of the habitat areas the fish inhabit.

Puget Sound Steelhead

We designated critical habitat for PS steelhead on February 24, 2016 (81 FR 9251). Critical habitat for PS steelhead includes approximately 1,879 miles of streams and lakes in 66 watersheds in Washington. There are 759 miles of spawning/rearing sites, 200 miles of rearing/migration sites, and 921 miles of migration corridors. There are 66 watersheds within the PS steelhead DPS. The CHART rated nine watersheds as having low, 16 as having medium, and 41 as having high conservation value to the ESU. Of the 66 watershed within the range of the species we excluded three low conservation value watershed in their entirety, as well as many stream segments which intersected tribal lands, military lands, and private forest lands. As a result of the economic and other relevant impacts weighed against the conservation value, approximately 1,600 miles of stream habitats were excluded from the designation.

Upper Columbia River Steelhead

We designated critical habitat for UCR steelhead on September 2, 2005 (70 FR 52630). There are 42 watersheds within the range of this ESU. The CHART rated three watersheds as having low, 8 as having medium, and 31 as having high conservation value to the ESU. The Columbia River rearing/migration corridor downstream of the spawning range is considered to have a high conservation value and is the only habitat area designated in 11 of the high value watersheds identified above. Habitat areas for this ESU include 1,332 miles of stream. Of these, approximately 70 stream miles were not designated because they either overlap military or Indian lands, or the economic benefits of exclusion outweigh the benefits of designation. Of the areas designated as critical habitat, there are 360 miles of spawning/rearing sites, 71 miles of rearing/migration sites, and 831 miles of migration corridors.

Snake River Steelhead

We designated critical habitat for SR steelhead on September 2, 2005 (70 FR 52630). There are 289 watersheds within the range of this ESU. The CHART rated fourteen watersheds as having low, 44 as having medium, and 231 as having high rating of conservation value to the ESU. The lower Snake/ Columbia River rearing/migration corridor downstream of the spawning range is considered to have a high conservation value and is the only habitat area designated in 15 of the 231 identified high-value watersheds. Of the 8,225 miles of habitat areas eligible for designation, approximately 134 miles of stream were excluded because the economic benefits of exclusion outweigh the benefits of designation. Also, we excluded approximately 39 miles of stream because they overlap with Indian lands. In the final critical habitat designation, there are 6,844 miles of spawning/rearing sites, 324 miles of rearing/migration sites, and 884 miles of migration corridors.

Middle Columbia River Steelhead

We designated critical habitat for MCR steelhead on September 2, 2005 (70 FR 52630). There are 114 watersheds within the range of this ESU. The CHART rated nine watersheds as having low, 24 as having medium, and 81 as having high conservation value to the ESU. The lower Columbia River rearing/migration corridor downstream of the spawning range is considered to have a high conservation value and is the only habitat area designated in three of the high value watersheds identified above. Of the 6,529 miles of habitat areas eligible for designation, approximately 714 miles of stream were excluded because the overlap with Indian lands or the economic benefits of exclusion outweigh the benefits of designation. In the areas designated critical habitat, there are 3,732 miles of spawning/rearing sites, 551 miles of rearing/migration sites, and 1,532 miles of migration corridors.

Lower Columbia River Steelhead

We designated critical habitat for LCR steelhead on September 2, 2005 (70 FR 52630). Critical habitat for LCR steelhead includes approximately 2,338 square miles of streams in Oregon and Washington. There are 1,114 miles of spawning/rearing sites, 165 miles of rearing/migration sites, and 1,059 miles of migration corridors. The CHART rated two watersheds as having low, 11 as having medium, and 28 as having high rating for their conservation value to the DPS. Of the 41 watersheds considered for designation, we excluded one low conservation value and three medium-value watersheds in their entirety, and the tributary-only portions of one low-value watershed. Also, we are excluding approximately 125 miles of stream covered by two habitat conservation plans because the benefits of exclusion outweigh the benefits of designation. As a result of the considerations, 335 miles of stream habitats were excluded from the designation.

Upper Willamette River Steelhead

We designated critical habitat for UWR steelhead on September 2, 2005 (70 FR 52630). Critical habitat for UWR steelhead includes approximately 1,277 miles of streams in Oregon and Washington. There are 560 miles of spawning/rearing sites, 613 miles of rearing/migration sites, and 104 miles of migration corridors. The CHART rated two watersheds as having low, 11 as having medium, and 28 as having high rating for their conservation value to the DPS. Of the 41 watersheds within the range of this DPS, we excluded nine low conservation value watersheds in their entirety and the tributary-only portions of eight low-value watersheds. Also, we are excluding approximately 11 miles of stream overlapping Indian Land. As a result of these considerations, 335 miles of stream habitats were excluded from the designation.

Northern California Steelhead

Critical habitat was designated for NC steelhead on September 2, 2005, when NMFS published a final rule in the Federal Register (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.

In determining the areas eligible for critical habitat designation, the CHART identified the physical or biological features that are essential to the conservation of the species. NC steelhead physical or biological features that are essential to the conservation of the species are those 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 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, received a high conservation value rating.

NC steelhead inhabit coastal river basins from Redwood Creek south to, and including, the Gualala River. Major watersheds include Redwood Creek, Mad River, Eel River, and several smaller coastal watersheds southward to the Gualala River. Steelhead from both summer and winter run types are found.

California Central Valley Steelhead

Critical habitat was designated for CV steelhead on September 2, 2005, when NMFS published a final rule in the Federal Register (70 FR 52488). There are approximately 2,308 miles of stream habitats and 254 square miles of estuary habitats designated as critical habitat for CV steelhead. NMFS determined that marine areas did not warrant consideration as critical habitat for this DPS.

In determining the areas eligible for critical habitat designation, the CHART identified the physical or biological features that are essential to the conservation of the species. CV steelhead physical or biological features that are essential to the conservation of the species are those 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 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.

Central California Coast Steelhead

Critical habitat was designated for CCC steelhead on September 2, 2005, when NMFS published a final rule in the Federal Register (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.

In determining the areas eligible for critical habitat designation, the CHART identified the physical or biological features that are essential to the conservation of the species. CCC steelhead physical or biological features that are essential to the conservation of the species are those 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. Fourteen watersheds received a low rating, 13 received a medium rating, and 19 received a high rating of conservation value to the DPS.

CCC steelhead inhabit coastal river basins from the Russian River southward to, and including, Aptos Creek as well as naturally spawned populations from the San Francisco/San Pablo bays west of the Sacramento/San Joaquin Delta.

South-Central California Coast Steelhead

Critical habitat was designated for SCCC steelhead on September 2, 2005, when NMFS published a final rule in the Federal Register (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.

In determining the areas eligible for critical habitat designation, the CHART identified the physical or biological features that are essential to the conservation of the species. SCCC steelhead physical or biological features that are essential to the conservation of the species are those 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. Six watersheds received a low rating, 11 received a medium rating, and 13 received a high rating of conservation value to the DPS. 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 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.

2.2.2.2 Eulachon

We designated critical habitat for eulachon on October 20, 2011 (76 FR 65324). Critical habitat for eulachon includes 16 specific areas in California, Oregon, and Washington. The designated areas are a combination of freshwater creeks and rivers and their associated estuaries, comprising approximately 335 miles of habitat. In our biological report, we found that all of the areas considered for critical habitat designation have a high conservation value. The designated critical habitat areas contain at least one of the following physical and biological features essential to conservation of the species: (1) freshwater spawning and incubation sites; (2) freshwater and estuarine migration corridors; and (3) nearshore and offshore marine foraging sites. Freshwater spawning and incubation sites are essential for successful spawning and offspring production; essential environmental components include specific water flow, quality, and temperature conditions; spawning and incubation substrates; and migratory access. Freshwater and estuarine migration corridors, associated with spawning and incubation sites, are essential for allowing adult fish to swim upstream to reach spawning areas and allowing larval fish to proceed downstream and reach the ocean. Essential environment components include waters free of obstruction; specific water flow, quality, and temperature conditions (for supporting larval and adult mobility), and abundant prey items (for supporting larval feeding after the yolk sac depletion). Nearshore and offshore marine foraging habitat are essential for juvenile and adult survival; essential environmental components include water quality and available prey.

We identified a number of activities that may affect the physical and biological features essential to the southern DPS of eulachon such that special management considerations or protection may be required. Major categories of such activities include: (1) Dams and water diversions; (2) dredging and disposal of dredged material; (3) inwater construction or alterations; (4) pollution and runoff from point and non-point sources; (5) tidal, wind, or wave energy projects; (6) port and shipping terminals; and (7) habitat restoration projects. All of these activities may have an effect on one or more of the essential physical and biological features via their alteration of one or more of the following: stream hydrology; water level and flow; water temperature; dissolved oxygen; erosion and sediment input/transport; physical habitat structure; vegetation; soils; nutrients and chemicals; fish passage; and estuarine/marine prey resources.

2.2.2.3 Green Sturgeon

We designated critical habitat for green sturgeon on October 9, 2009 (74 FR 52300). We designated approximately 320 miles of freshwater river habitat, 897 square miles of estuarine habitat, 11,421 square miles of marine habitat, 487 miles of habitat in the Sacramento-San

Joaquin Delta, and 135 square miles of habitat within the Yolo and Sutter bypasses (Sacramento River, CA) as critical habitat for the Southern DPS of green sturgeon. Of the areas considered for critical habitat, the Critical Habitat Review Team rated 18 areas as having high, twelve as having medium, and eleven as having low rating for their conservation value to the DPS. Areas designated for critical habitat include coastal U.S. marine waters within 60 fathoms depth from Monterey Bay, California north to Cape Flattery, Washington, including the Strait of Juan de Fuca, Washington, to its United States boundary; the lower Columbia River estuary; and certain coastal bays and estuaries in Washington (Willapa Bay and Grays Harbor).

Based on the best available scientific information about the habitat needs for green sturgeon, we identified PBFs for freshwater riverine systems, estuarine areas, and nearshore marine waters (74 FR 52300). For freshwater riverine systems, the specific PBFs for species conservation are (1) food resources, (2) substrate type or size, (3) water flow, (4) water quality, (5) migratory corridor, (6) water depth, and (7) sediment quality. For estuarine areas, the specific PBFs for species conservation are (1) food resources, (2) water flow, (3) water quality, (4) migratory corridor, (5) water depth, and (6) sediment quality. For coastal marine areas, the specific PBFs for species conservation are (1) migratory corridor, (2) water quality, and (3) food resources.

From analyses of the identified PBFs and examination of economic activities, NMFS verified that at least one activity in each specific area may threaten at least one PBF such that special management considerations or protection may be required (NMFS 2009b). Major categories of habitat-related activities include: (1) dams, (2) water diversions, (3) dredging and disposal of dredged material, (4) in-water construction or alterations, (5) National Pollutant Discharge Elimination System (NPDES) activities and activities generating non-point source pollution, (6) power plants, (7) commercial shipping, (8) aquaculture, (9) desalination plants, (10) proposed alternative energy hydrokinetic projects, (11) Liquefied Natural Gas (LNG) projects, (12) habitat restoration, and (13) bottom trawl fisheries.

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). As the Programs describe, the research actions will occur throughout much of Washington, Idaho, Oregon, and California. For the purposes of this opinion, the action area includes all river reaches and estuarine habitats accessible to listed Chinook salmon, chum salmon, coho salmon, steelhead, eulachon, and green sturgeon in all sub-basins of Washington, Oregon, California and much of Idaho. Additionally, the action area includes shallow-water nearshore habitats (habitat areas shallow enough to deploy a beach seine) in the Puget Sound and Strait of Juan de Fuca, Washington.

The research projects are distributed throughout much of the listed species' ranges. The specific projects and related take estimates are described in detail in the annual state fishery agency submittals. In all cases, individual research activities would take place on very small sites. For example, researchers may anchor a rotary screw trap in the stream channel, deploy seines and nets covering tens of feet of stream, or wade a few hundred feet of stream while backpack electrofishing. Most of the proposed research activities would take place in designated critical habitat. As noted earlier, the proposed actions could affect the killer whales' prey base (Chinook salmon) and those effects are described in the Not Likely to Adversely Affect section (2.11).

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 consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

As described above in the Status of the Species and Critical Habitat sections, factors that limit the recovery of species considered in this opinion vary with the overall condition of aquatic habitats on surrounding lands. Within the action area, many stream and riparian areas have been degraded by the effects of land and water use, including road construction, forest management, agriculture, mining, transportation, urbanization, and water development. Each of these economic activities has contributed to the myriad factors for the decline of species in the action area. Among the most important of these are changes in stream channel morphology, degradation of spawning substrates, reduced instream roughness and cover, loss and degradation of estuarine rearing habitats, loss of wetlands, loss and degradation of riparian areas, water quality (e.g., temperature, sediment, dissolved oxygen, contaminants) degradation, blocked fish passage, direct take, and loss of habitat refugia. Climate change is likely to play an increasingly important role in determining the abundance of ESA-listed species, and the conservation value of designated critical habitats, in the Pacific Northwest.

Within the habitat currently accessible by species considered in this opinion, dams have negatively affected spawning and rearing habitat. Floodplains have been reduced, off-channel habitat features have been eliminated or disconnected from the main channel, and the amount of large wood in mainstem rivers has been greatly reduced. Remaining habitats often are affected by flow fluctuations associated with reservoir water management for power peaking, flood control, and other operations.

Stream habitats and riparian areas below the heads of tide in the action area have been degraded by loss of mature riparian forests, increased sediment inputs, removal of large woody debris, urbanization, agriculture, alteration of floodplain and stream morphology, riparian vegetation disturbance, wetland draining and conversion, dredging, armoring of shorelines, marina and port development, and road construction. These activities have resulted in loss of available habitat, reduced habitat quality, altered forage species communities, reduced stream complexity, and altered stream flow and sediment load. Coastal marsh lands have been extensively altered by the installation of dikes, levees, and tide/flood gates to protect developments or to create pasturelands or land for development. In addition to the loss of these wetlands, fish passage into waterways has been adversely affected. Water quality has also been degraded from stormwater, municipal discharges, and agriculture and non-point source conveyances associated with the aforementioned activities. The negative impacts of these activities to aquatic habitat have contributed to the decline in abundance, productivity, diversity, and distribution and are limiting the recovery of the listed species.

The existing highway system contributes to a poor environmental baseline condition in several significant ways. Many miles of highway that parallel streams have degraded stream bank conditions by armoring the banks with rip rap, degraded floodplain connectivity by adding fill to floodplains, and discharge untreated or marginally treated highway runoff to streams. Culvert and bridge stream crossings have similar effects, and create additional problems for fish when they act as physical or hydraulic barriers that prevent fish access to spawning or rearing habitat, or contribute to adverse stream morphological changes upstream and downstream of the crossing itself.

Water quality throughout most of the program action area is degraded to various degrees because of contaminants that are harmful to species considered in this consultation. Aerial deposition, discharges of treated effluents, and stormwater runoff from residential, commercial, industrial, agricultural, recreational, and transportation land uses are all source of these contaminants. For example, 4.7 million pounds of toxic chemicals were discharged into surface waters of the Columbia River Basin (a 39% decrease from 2003) and another 91.7 million pounds were discharged in the air and on land in 2011 (USEPA 2011). This reduction can be attributed, in part, to significant state, local and private efforts to modernize and strengthen tools available to treat and manage stormwater runoff (USEPA 2009; USEPA 2011).

ESA-listed fish considered in this opinion are exposed to high rates of predation during all lifestages. Fish, birds, and marine mammals, including harbor seals, sea lions, and killer whales all prey on juvenile and adult salmon and eulachon. The various river basins throughout the action area have a diverse assemblage of native and introduced fish species, some of which prey on salmon, steelhead, and eulachon. The primary resident fish predators of salmonids in many parts of the action area are northern pikeminnow (native), smallmouth bass (introduced), striped bass (introduced), and walleye (introduced). Other predatory resident fish include channel catfish (introduced), Pacific lamprey (native), yellow perch (introduced), largemouth bass (introduced), and bull trout (native). Increased predation by non-native predators has and continues to decrease population abundance and productivity.

The environmental baseline includes the anticipated impacts of all Federal actions in the action area that have already undergone formal consultation. The PRD has consulted on the issuance of numerous scientific research permits and approvals, including the Programs that are the subject of this biological opinion. Although not identified as a factor for decline or a threat preventing recovery, scientific research activities have the potential to affect the species' survival and recovery by killing listed salmonids—whether intentionally or not. Over the ten-year period 2011-2020, NMFS has issued many hundreds of section 10(a)(1)(A) scientific research permits and many hundreds of projects under the salmon, steelhead, and green sturgeon 4(d) rules for state research programs and tribal resource management plans (Puget Sound Tribal Salmonid

Research Plan)—all of these have allowed listed species to be lethally and non-lethally taken. Over the ten-year period 2011-2020 we conducted 52 formal consultations for section 10(a)(1)(A) permits and one formal consultation for the Puget Sound Tribal Salmonid Research Plan. We also conducted 16 formal consultations for the Programs that are the subject of this biological opinion. As with the state research program, section 10(a)(1)(A) scientific research permits and the Puget Sound Tribal Salmon Research Plan approval require researchers to report on actual take for each calendar year. Reported annual take from the various permits and programs is displayed in Appendix Tables A.1 and A.2. Our analysis, in the formal consultations noted above, 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 was expected to be minor compared to overall population abundance. We also noted that scientific research has never been identified as a threat and the research projects were designed to benefit the species' survival in the long term.

Research activities conducted on anadromous salmonids in the Pacific Northwest have provided resource managers with a wealth of important and useful information regarding anadromous fish 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 fish passage studies have enhanced our understanding of how fish behave and survive when moving past dams and through reservoirs. By issuing research approvals—including many of those being contemplated again in this opinion—NMFS 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.

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. 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 402.17). In our analysis, which describes the effects of the proposed action, we considered 50 CFR 402.17(a) and (b).

2.5.1 Effects on Critical Habitat

Full descriptions of effects of the proposed research activities are given in the following sections. In general, the permitted activities would be (1) electrofishing, (2) capturing fish with angling equipment, traps, and nets of various types, (3) collecting biological samples from live fish, and (4) collecting fish for biological sampling. Many of the techniques used to capture fish would have minimal effects on habitat. Examples of capture methods that involve some level of habitat disturbance includes beach seines, fyke nets, and rotary screw traps (all discussed in more detail in the Effects on the Species section below). In the first example, researchers use beach seines to capture juvenile and adult fish in deep water habitats. One end of the seine is anchored to shore while the other end is deployed by boat circling and trapping the fish in the seine. As the seine is closed around the fish researchers drag the seine towards the shore and remove fish from the seine with dip nets. The top of the beach seine floats while the bottom hangs down and makes contact with the substrate. Beach seines affect small spatial areas of habitat, are brief in duration, and involve very little disturbance of habitat. The second example is the fyke net, a method that is designed to capture migrating juvenile and adult fish and consists of a temporary fence and trap installed in the stream channel. The fence is installed at an angle to the current and serves to direct fish into the trap. The trap and fencing are secured by stakes driven into the substrate. These types of traps are temporary and only used part of the year, typically installed during the adult or juvenile migration window. The trap is checked regularly and capture fish are released either upstream (adults) or downstream (juveniles). The third method is a rotary screw trap which consists of a funnel and a trap attached to pontoons. The trap floats in the current and is anchored to the shore by cables. All of these methods would have minor effects on riparian habitat and similarly minor, ephemeral, rapidly attenuated effects on in-water habitat. All of the techniques utilized by researchers are minimally intrusive in terms of their effect on habitat because they would involve very little, if any, disturbance of streambeds or adjacent riparian zones. Therefore, the activities analyzed in this opinion would have minimal effects on the function or value of the habitat PBFs described earlier (see section 2.2.2).

2.5.2 Effects on the Species

As discussed above, the proposed research activities would have minimal affect on the listed species' habitat (critical or otherwise). The actions are therefore not likely to diminish the conservation value of the specie's habitat.

The primary effect the proposed research would have on the listed species would be in the form of capturing and handling the fish. Such activity 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 approvals. 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 an approval unless the activities (e.g., electrofishing) incorporate NMFS's standard operating procedures and terms and conditions. These measures are described in Section 1.3 of this opinion. They are incorporated (where relevant) into every approval as part of the conditions to which a researcher must adhere.

2.5.2.1 Capture/handling

The primary effect of the proposed research on the listed species would be in the form of capturing and handling fish. We discuss effects from handling and anesthetizing fish, and the general effects of capture using seines and traps here. We discuss effects from other capture methods in more detail in the subsections below.

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. Stress on salmonids increases rapidly from handling if the water temperature exceeds 18ºC or dissolved oxygen is below saturation. 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. Decreased survival of fish can result when stress levels are high because stress can be immediately debilitating and may also increase the potential for vulnerability to subsequent challenges (Sharpe et al. 1998). 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 fairly rapidly from handling.

2.5.2.2 Electrofishing

Electrofishing is a process by which an electrical current is passed through water containing fish in order to stun them, which makes them easy to capture. It can cause a suite of effects ranging from disturbing the fish to killing them. The percentage of fish that are unintentionally killed by electrofishing varies widely depending on the equipment used, the settings on the equipment, and the expertise of the technician (Sharber and Carothers 1988, McMichael 1993, Dalbey et al. 1996; Dwyer and White 1997). Research indicates that using continuous direct current (DC) or low-frequency (30 Hz) pulsed DC waveforms produce lower spinal injury rates, particularly for salmonids (Fredenberg 1992, McMichael 1993, Sharber et al. 1994, Snyder 1995).

Most studies on the effects of electrofishing on fish have been conducted on adult fish greater than 300 mm in length (Dalbey et al. 1996). Electrofishing can have severe effects on adult salmonids. Adult salmonids can be injured or killed due to spinal injuries that can result from forced muscle contractions. Sharber and Carothers (1988) reported that electrofishing killed 50 percent of the adult rainbow trout in their study.

Spinal injury rates are substantially lower for juvenile fish than for adults. Smaller fish are subjected to a lower voltage gradient than larger fish (Sharber and Carothers 1988) and may, therefore, be subject to lower injury rates (e.g., Hollender and Carline 1994, Dalbey et al. 1996, Thompson et al. 1997). McMichael et al. (1998) reported a 5.1% injury rate for juvenile Middle Columbia River steelhead captured by electrofishing in the Yakima River subbasin.

When using appropriate electrofishing protocols and equipment settings, shocked fish normally revive quickly. Studies on the long-term effects of electrofishing indicate that even with spinal injuries, salmonids can survive long-term; however, severely injured fish may have stunted growth (Dalbey et al. 1996, Ainslie et al. 1998).

Permit conditions would require that all researchers follow NMFS's 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's electrofishing guidelines.

2.5.2.3 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.

2.5.2.4 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. As a result, NOAA Fisheries expects steelhead hook and release mortality to be in the lower range discussed above.

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 steelhead sampling via angling must be carried out using barbless artificial flies and lures.

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 associated with 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 unintentional mortality in fisheries (TAC 2008). Nonetheless, given the fact that no ESA section 10 permit or 4(d) approval may "operate to the disadvantage of the species," we allow 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.

2.5.2.5 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's pre-established mitigation measures (included in state fishery agency submittals), would not be walked on. Harassment is the primary form of take associated with these observation activities, and few if any injuries (and no deaths) are 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.

2.5.2.6 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 after they spawn, there is very little overall effect. Essentially, it amounts to removing the nutrients their bodies would have provided to the spawning grounds. 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. And, in almost every instance where it is allowed, the adults are stripped of sperm and eggs so their progeny can be raised in a controlled environment such as a hatchery—thereby greatly decreasing the potential harm posed by sacrificing the adults. As a general rule, adults are not sacrificed for scientific purposes and no such activity is considered in this opinion.

2.5.2.7 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 approvals, we would expect the mortality rates for fish captured at rotary screw type traps to be one percent or less.

The trapping, capturing, or collecting and handling of juvenile fish using traps is likely to cause some stress on listed fish. However, fish typically recover rapidly from handling procedures. The primary factors that contribute to stress and mortality from handling are excessive doses of anesthetic, differences in water temperature, dissolved oxygen conditions, the amount of time that fish are held out of water, and physical trauma. Stress on salmonids increases rapidly from handling if the water temperature exceeds 64.4 degrees F (18 degrees C) or if dissolved oxygen is below saturation. Additionally, stress can occur if there are more than a few degrees difference in water temperature between the stream/river and the holding tank.

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.

2.5.2.8 Gillnet and Tangle Net

A gillnet is a wall of netting that hangs in the water column, typically made of monofilament or multifilament nylon. Mesh sizes are designed to allow fish to get only their head through the netting but not their body. The fish's gills then get caught in the mesh as the fish tries to back out of the net. As the fish struggles to free itself, it becomes more and more entangled. There are two main types of gillnets. Set gillnets are attached to poles fixed in the substrate or an anchor system to prevent movement of the net. Drift gillnets are kept afloat at the proper depth using a system of weights and buoys attached to the headrope, footrope, or floatline.

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. Ashbrook 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. Ashbrook 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.

2.5.2.9 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 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).

The other primary method for tagging fish is to implant them with acoustic tags, radio tags, or archival loggers. There are two main ways to accomplish this and they differ in both their characteristics and consequences. First, a tag can be inserted into a fish's stomach by pushing it past the esophagus with a plunger. Stomach insertion does not cause a wound and does not interfere with swimming. This technique is benign when salmon are in the portion of their spawning migrations during which they do not feed (Nielsen 1992). In addition, for short-term studies, stomach tags allow faster post-tagging recovery and interfere less with normal behavior than do tags attached in other ways.

The second method for implanting tags is to place them within the body cavities of (usually juvenile) salmonids. These tags do not interfere with feeding or movement. However, the tagging procedure is difficult, requiring considerable experience and care (Nielsen 1992). Because the tag is placed within the body cavity, it is possible to injure a fish's internal organs. Infections of the sutured incision and the body cavity itself are also possible, especially if the tag and incision are not treated with antibiotics (Chisholm and Hubert 1985; Mellas and Haynes 1985).

Fish with internal tags often die at higher rates than fish tagged by other means because tagging is a complicated and stressful process. Mortality is both acute (occurring during or soon after tagging) and delayed (occurring long after the fish have been released into the environment). Acute mortality is caused by trauma induced during capture, tagging, and release. It can be reduced by handling fish as gently as possible. Delayed mortality occurs if the tag or the tagging procedure harms the animal in direct or subtle ways. Tags may cause wounds that do not heal properly, may make swimming more difficult, or may make tagged animals more vulnerable to predation (Howe and Hoyt 1982; Matthews and Reavis 1990; Moring 1990). Tagging may also reduce fish growth by increasing the energetic costs of swimming and maintaining balance. As with the other forms of tagging and marking, researchers will keep the harm caused by tagging to a minimum by following the conditions in the permits as well as any other permit-specific requirements.

2.5.2.10 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.

2.5.2.11 Trawls

Trawls are cone-shaped, mesh nets that are towed, often, along benthic habitat (1983, Hayes et al. 1996). Rectangular doors, attached to the towing cables, keep the mouth of the trawl open. Most trawls are towed behind a boat, but small trawls can be operated by hand. As fish enter the trawl, they tire and fall to the codend of the trawl. Mortality and injury rates associated with trawls can be high, particularly for small or fragile fish. Fish can be crushed by debris or other fish caught in the net. However, all of the trawling considered in this opinion is midwater trawling which may be less likely to capture heavy debris loads than benthic or demersal trawl sampling. Depending on mesh size, some small fish 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. Short duration trawl hauls (5 to 10 minutes maximum) may reduce injuries (Hayes 1983, Hayes et al. 1996).

2.5.2.12 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 intended to help improve fish weir design and operation in ways which will limit fish passage delays and increase weir efficiency.

2.5.3 Species-specific Effects of the Programs

In the Rangewide Status of the Species and Critical Habitat section, we estimated the annual abundance of adult and juvenile listed salmonids, eulachon, and green sturgeon. Because the proposed activities—even in total—would have minimal effects on habitat, the analysis will consist primarily of examining directly measurable impacts that the Programs would have on abundance. Abundance effects are themselves relevant to extinction risk, are directly related to productivity effects, and are relevant (but less directly tied) to structure and diversity effects.

The analysis process relies on multiple sources of data. In Section 2.2.1 (Status of the Species), we estimated the average annual abundance for the species considered in this document. For most of the listed species, we estimated abundance for adult returning fish and outmigrating smolts. These data come from estimates compiled by NOAA Fisheries' science centers for the species viability assessment, which are updated every five years. Additional data sources include state agencies (i.e. WDFW, IDFW, ODFW, and CDFW), county and local agencies, and educational and non-profit institutions. These sources are vetted for scientific accuracy before their use. For hatchery propagated juvenile salmonids, we use hatchery production goals. Appendix Table A.2 displays the estimated annual abundance of hatchery-propagated and naturally produced listed fish.

In conducting the following analyses, we have tied the effects of the Programs to their impacts on the listed species. Due to the nature of the Programs (i.e., it includes broadly distributed research projects throughout Washington, Idaho, Oregon, and California), the take cannot reliably be assigned to any individual population or group of populations. Furthermore, many of the projects are located in migration corridors for multiple upstream populations, ESUs, and DPSs. In these instances, we cannot reliable determine what proportion of the fish that are captured come from each of the various upstream populations. Therefore, the effects of the Programs are measured in terms of how they are expected to affect each listed unit at the species scale, rather than at the population scale. However, it should be noted that through our annual reviews of the Programs, we make sure that we keep overlap/repetition of research activities to a minimum and ensure that both the proposed and reported effects are not concentrated on individual populations (see section 1.3.4 Scope and Structure of NMFS's Annual Evaluation and Determination)—at least to the extent we can reasonably do so.

2.5.3.1 Requested and Reported Take in the Research Programs

The specific projects and related take estimates are described in detail in the annual project applications and year-end reports. Over the past ten years (2011-2020) the number of projects submitted by WDFW has ranged from 33 to 52. The projects contained in WDFW's program are conducted by WDFW staff in the state of Washington. The WDFW program submittals detail their forecast of calendar year research activities that may affect 14 threatened species of salmon and steelhead, as well as green sturgeon and eulachon in the state of Washington.

Over the past ten years (2011-2020) the number of projects submitted by IDFG has ranged from 14 to 24. The IDFG Program contains applications for work to be conducted by the IDFG and by other researchers and coordinated with the IDFG. The IDFG annually submits their forecast of research activities that may affect three threatened species of salmon and steelhead covered by the 4(d) rule in the state of Idaho.

The ODFW research program has ranged from 69 to 95 projects each year for work to be conducted in the state of Oregon (2011-2020). On average, more than half of the projects are conducted by the ODFW and the rest by other researchers and coordinated with the ODFW. The ODFW annual program submittal details their forecast of calendar year research activities that may affect eulachon, green sturgeon, and 12 threatened salmon and steelhead in the state of Oregon.

The CDFW research program has ranged from 74 to 86 projects each year for work to be conducted in the state of California (2011-2020). The CDFW Program contains projects conducted by the CDFW and projects conducted by other researchers and coordinated with the CDFW. The CDFW submittals detail their forecast of calendar year research activities that may affect threatened species of salmon and steelhead, as well as green sturgeon and eulachon in the state of California.

Researchers submit a new application each year detailing the purpose and objectives of their project as well as the amount and extent of take that could occur, but the anticipated take for each project is intentionally overestimated. The project application requires the researcher fill out a “take table” estimating the anticipated take for each species, life stage, origin (natural or hatchery), take action (capture/handle/release, capture/mark, tag, tissue sample/release, intentional mortality, observe, collect tissue dead animal), and capture method (e.g. net, trap, hook and line, electrofishing). Researchers are also required to provide a take table for each sampling site. Abundance of the species juvenile and adult life stages can vary greatly from one year to the next and influence the numbers of fish that researchers observe or capture. Environmental conditions, such as fluctuations in stream flow resulting from rain and snow melt, can also influence the numbers of fish captured. For these reasons, researchers are instructed to provide a modest take overestimate to accommodate unforeseen environmental conditions, greater than expected abundance of the species, or complications with the research equipment. The detailed information required in the take table and the intentional modest overestimation of take results in far more take requested than needed.

At the end of the year, researchers are required to report the annual take for each project. As illustrated above, the requested take is often greater than the amount of take reported at the end of the year. The average amount of take the state programs have requested and reported annually is displayed in Appendix Table A.2.

Under the research projects in the Programs juvenile salmon and steelhead would be observed via stream or snorkel surveys and captured using backpack electrofishing equipment, traps, nets, seines, and hook and line angling. Most of the juvenile salmon and steelhead would be released shortly after capture. A subsample of captured juvenile salmon and steelhead may be anesthetized, checked for tags/marks, tissue sampled, stomach sampled, and/or tagged/marked prior to release. A small number of juvenile salmon and steelhead may be sacrificed for tissue analysis.

Adult salmon and steelhead would be observed via snorkel surveys, spawning surveys, or underwater video/sonar and captured using fish ladders, hook and line angling, nets, seines, and traps. Tissues would be collected from any carcasses encountered during snorkel and spawning surveys. Most of the adult salmon and steelhead would be released shortly after capture. A subsample of captured adult salmon and steelhead may be anesthetized, checked for tags/marks, tissue sampled, and/or tagged/marked prior to release.

Larval, juvenile, subadult, and adult green sturgeon would be observed via underwater video or sonar, stream surveys and snorkel surveys, and captured using backpack electrofishing equipment, traps, nets, seines, and hook and line. Researchers would release most of the green sturgeon shortly after capture. A subsample of captured green sturgeon may be anesthetized, checked for tags/marks, tissue sampled, and tagged/marked prior to release. Researchers may also collect green sturgeon eggs.

Adult eulachon may also be captured using nets, seines, and traps. Researchers would handle and quickly release the majority of the eulachon captured. A small number of eulachon may be sacrificed for tissue analysis.

With the exception of a small number of intentional mortalities annually, researchers in the programs generally do not intend to kill any of the fish being captured, but a small number of fish may be killed as an inadvertent result of these activities. Researchers are directed to substitute inadvertent mortalities for planned intentional lethal sacrifice individuals whenever possible to minimize the total mortality associated with these studies. 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 actions considered herein are best seen in the context of the fish that are likely to be killed. To determine the effects of these losses, it is necessary to compare the numbers of fish that may be killed to the total abundance numbers expected for the species. In the table below (Table 6) we have identified the maximum annual impact of the Program over the ten-year period 2011-2020. The maximum percent of the species annual abundance taken and killed is derived by dividing the reported take and mortalities (Appendix Tables A.4 and A.5) by the estimated annual abundance for that same year (Appendix Table A.3). Annual abundance estimates are as reported in the biological opinion for that year’s 4(d) approval.

Table 6. Maximum annual reported take in the Programs compared to the estimated abundance of each component of the ESU/DPS (2011-2020). See APPENDIX A for the annual abundance estimates, and reported take and mortalities.

Species	Life Stage	Origin	Maximum Percent of ESU/DPS Component Taken	Maximum Percent of ESU/DPS Component Killed
PS Chinook	Adult	Natural	0.0165%	0.0056%
PS Chinook	Adult	Hatchery	0.0454%	0.0124%
PS Chinook	Juvenile	Natural	4.8052%	0.0491%
PS Chinook	Juvenile	Hatchery	0.1108%	0.0131%
SRSS Chinook	Adult	Natural	26.4481%	0.0314%
SRSS Chinook	Adult	Hatchery	13.5358%	0.0000%
SRSS Chinook	Juvenile	Natural	17.9537%	0.0581%
SRSS Chinook	Juvenile	Hatchery	2.3960%	0.1714%
SRF Chinook	Adult	Natural	0.0402%	0.0000%
SRF Chinook	Adult	Hatchery	0.0000%	0.0000%
SRF Chinook	Juvenile	Natural	0.0443%	0.0005%
SRF Chinook	Juvenile	Hatchery	0.0000%	0.0000%
LCR Chinook	Adult	Natural	2.4055%	0.0000%
LCR Chinook	Adult	Hatchery	2.1521%	0.0433%
LCR Chinook	Juvenile	Natural	2.5834%	0.0410%
LCR Chinook	Juvenile	Hatchery	0.0606%	0.0015%
UWR Chinook	Adult	Natural	0.5021%	0.0000%
UWR Chinook	Adult	Hatchery	0.3244%	0.0068%
UWR Chinook	Juvenile	Natural	1.5699%	0.0210%
UWR Chinook	Juvenile	Hatchery	0.0085%	0.0002%
CC Chinook	Adult	Natural	49.0342%	0.0140%
CC Chinook	Juvenile	Natural	39.4738%	0.0624%
CVS Chinook	Adult	Natural	24.3435%	0.0134%
CVS Chinook	Adult	Hatchery	290.7390%	0.8419%
CVS Chinook	Juvenile	Natural	58.7509%	0.5256%
CVS Chinook	Juvenile	Hatchery	0.1411%	0.0025%

Species	Life Stage	Origin	Maximum Percent of ESU/DPS Component Taken	Maximum Percent of ESU/DPS Component Killed
HCS chum	Adult	Natural	42.4926%	0.0776%
HCS chum	Juvenile	Natural	15.5018%	0.0300%
HCS chum	Juvenile	Hatchery	0.0585%	0.0000%
CR chum	Adult	Natural	0.0167%	0.0000%
CR chum	Juvenile	Natural	0.2379%	0.0012%
CR chum	Juvenile	Hatchery	0.0000%	0.0000%
LCR coho	Adult	Natural	9.3717%	0.0274%
LCR coho	Adult	Hatchery	1.2954%	0.0217%
LCR coho	Juvenile	Natural	8.8118%	0.0575%
LCR coho	Juvenile	Hatchery	0.2997%	0.0094%
OC coho	Adult	Natural	5.8736%	0.0276%
OC coho	Adult	Hatchery	0.0000%	0.0000%
OC coho	Juvenile	Natural	2.6459%	0.0266%
OC coho	Juvenile	Hatchery	0.0017%	0.0000%
SONCC coho	Adult	Natural	18.5150%	0.0319%
SONCC coho	Adult	Hatchery	136.3755%	0.2608%
SONCC coho	Juvenile	Natural	7.5060%	0.0695%
SONCC coho	Juvenile	Hatchery	0.0945%	0.0015%
PS steelhead	Adult	Natural	2.6524%	0.0000%
PS steelhead	Adult	Hatchery	0.0603%	0.0000%
PS steelhead	Juvenile	Natural	1.1180%	0.0295%
PS steelhead	Juvenile	Hatchery	6.0243%	0.1649%
UCR steelhead	Juvenile	Natural	0.0340%	0.0000%
SRB steelhead	Adult	Natural	6.6324%	0.0431%
SRB steelhead	Adult	Hatchery	0.6293%	0.0006%
SRB steelhead	Juvenile	Natural	5.8498%	0.0351%
SRB steelhead	Juvenile	Hatchery	0.0305%	0.0001%
MCR steelhead	Adult	Natural	8.5444%	0.0733%

Species	Life Stage	Origin	Maximum Percent of ESU/DPS Component Taken	Maximum Percent of ESU/DPS Component Killed
MCR steelhead	Adult	Hatchery	51.9885%	0.0974%
MCR steelhead	Juvenile	Natural	8.0637%	0.1071%
MCR steelhead	Juvenile	Hatchery	2.0414%	0.0151%
LCR steelhead	Adult	Natural	9.8228%	0.0509%
LCR steelhead	Adult	Hatchery	0.5882%	0.0098%
LCR steelhead	Juvenile	Natural	6.0184%	0.0710%
LCR steelhead	Juvenile	Hatchery	0.9934%	0.3059%
UWR steelhead	Adult	Natural	0.2512%	0.0000%
UWR steelhead	Juvenile	Natural	0.8338%	0.0012%
NC steelhead	Adult	Natural	22.7718%	0.0000%
NC steelhead	Juvenile	Natural	33.3826%	0.0718%
CCV steelhead	Adult	Natural	29.6215%	0.0728%
CCV steelhead	Adult	Hatchery	103.9595%	0.0000%
CCV steelhead	Juvenile	Natural	1.2099%	0.0112%
CCV steelhead	Juvenile	Hatchery	0.0064%	0.0002%
CCC steelhead	Adult	Natural	0.6401%	0.1372%
CCC steelhead	Juvenile	Natural	2.3950%	0.0111%
SCCC steelhead	Adult	Natural	1.0072%	0.0000%
SCCC steelhead	Juvenile	Natural	5.0103%	0.0253%
Eulachon	Adult	Natural	0.0151%	0.0007%
Green sturgeon	Adult	Natural	3.8462%	0.0000%
Green sturgeon	Egg	Natural	#N/A	#N/A
Green sturgeon	Juvenile	Natural	0.6838%	0.0000%
Green sturgeon	Larvae	Natural	#N/A	#N/A

Thus, the Programs have caused the death of a very small number of juvenile and adult fish. Over the 10-year period (2011-2020), the Programs have killed no more than 0.14% and 0.53% of the expected annual abundance of naturally produced adult and juvenile (respectively) listed salmon, steelhead, sturgeon, or eulachon. The Programs have also killed a maximum of 0.84% and 0.31% of the expected annual abundance of hatchery produced adult and juvenile (respectively) listed salmon and steelhead. The small numbers of juvenile and adult fish that have been killed by the Programs was spread out over tributary, estuarine, and nearshore marine habitats in Washington, Idaho, Oregon, and California. Thus, it is very probable that no population experienced a disproportionate amount of these small losses. As a result, the activities likely had only a minimal impact on species abundance (and therefore productivity) and no appreciable impact on structure or diversity. This finding is consistent with the sixteen biological opinions that were completed for the annual approval of the Programs during the same time period. In those analyses we evaluated the potential effect of the requested annual take and mortality, and arrived at the same conclusion. And the submittals for the years 2021 and 2022 indicate that the trend continues—and we therefore believe it is very likely to continue to be true for the foreseeable future.

In some instances, the maximum number of fish that were taken represents a significant portion of the estimated annual abundance of the species, and in a few cases exceeds the estimated abundance for that year. The most plausible explanation for this is that we underestimated the abundance of the species. In many cases we are estimating abundance from samples that only represent a portion of the populations within each ESU/DPS. As a result, our abundance estimates are sometimes much lower than actual abundance. This is especially apparent in the case of the California ESUs/DPSs, where efforts to monitor abundance do not exist or have only recently begun in some populations. Hence, the maximum annual take for some of the species in the table above may appear to be disproportionately large in comparison to other species for which there are reliable long-term abundance estimates (e.g. Columbia River and Oregon coastal basins).

We have every reason to believe that the submittals in the coming years will be similar in magnitude to those over the time period 2011-2020, and may be even smaller in some cases. Some of the research we permit is tied directly to ongoing actions that will eventually undergo formal consultation. As those formal consultations are completed some of the research we have approved in the Programs will be folded into those consultations. We also continue to look for opportunities to reduce the impact of research through collaboration and alternative and less invasive methods for gathering information about the species. Our annual review allows us to take a big picture look at the scope and scale of research across the landscape and identify opportunities for researchers to collaborate. Through collaboration researchers can share their samples and data, hence reducing the numbers of fish they might individually capture and kill. We also will continue to explore alternatives to capturing fish. One promising alternative is environmental DNA. With this method researchers are able to identify species presence and relative abundance through water samples instead of using intrusive sampling methods that may impact the listed species.

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 and 402.17(a)). 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.

Because essentially all of the action area would continue to fall within designated critical habitat, the vast majority of future actions in the region 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 almost all instances, proponents of future actions will need government funding or authorization to carry out a project that may affect salmonids, sturgeon, eulachon, or their habitat, and therefore the effects such a project may have on listed species will be analyzed when the need arises.

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 species status/environmental baseline vs. cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the status section (Section 2.2).

In developing this opinion, we considered several efforts being made at the local, tribal, state, and national levels to conserve listed species—recovery plans and efforts laid out in the 5-year reviews for Pacific salmon and steelhead listed under the Endangered Species Act.[5] The recovery plans, status summaries, and limiting factors that are part of the analysis of this Opinion are discussed in detail in Section 2.2.1.

The result of that review was that take of the ESA listed fish included in this opinion 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.

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 the species included in this opinion, 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.

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[5] NOAA Fisheries – West Coast Region - 2016 5-Year Reviews for 28 Listed Species of Pacific Salmon, Steelhead, and Eulachon (https://www.fisheries.noaa.gov/action/2016-5-year-reviews-28-listed-species-pacific-salmon-steelhead-and-eulachon)

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 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. 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 in the Pacific Northwest and elsewhere that will not undergo ESA consultation. Although many 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 certain to occur" in its analysis of cumulative effects.

We can, however, make some generalizations based on population trends.

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 2016, the population in Puget Sound has increased from 1.77 to 4.86 million people (Source: WA state Office of Financial Management homepage). 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). Scholz et al. (2011) 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 certain" 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.

Idaho and Eastern Oregon and Washington

According to the U.S. Census bureau, the State of Idaho's population has been increasing at about 1% per year over the last several years, but that increase has largely been confined to the State's urban areas. The rural population—the areas where the proposed actions would take place--saw a 14% decrease in population between 1990 and 2012.[6] This signifies that in the action areas, if this trend continues, there is likely to be a reduction in competing demands for resources such as water. Also, it is likely that streamside development will decrease. However, given the overall increase in population, recreation demand for resources such as the fish themselves may go up—albeit slowly.

The situation is similar for Eastern Oregon and Washington. Both states have seen population increases between 0.5% and 1.5% per year for Oregon between 2000 and 2010[7], an overall 12% for Washington between 2000 and 2010, and a 2.7% increase for rural, eastern Oregon for the past five years (2013-2018).[8] And, though Eastern Washington has also seen some population increase, it has largely been restricted to the population centers rather than the rural areas.[9] This signifies that, as with Idaho, there is little likelihood that there will be increasing competing demands for primary resources like water, but recreational demand for the species themselves will probably increase along with the human population.

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 showing year-by-year population increases of about 0.5% to 1.5% over the last several years.[6] 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 6.1% from 2010 to 2019 (source: Census Bureau California Quick Facts). If this trend in population growth continues, there will be an increase in competing demands for water resources. Water withdrawals, diversions, and other hydrological modifications to regulate water bodies are likely to continue. Urbanization and rural development are limiting factors for many of the listed salmonids within the State of California and these factors are likely to increase with continued population growth. Therefore, 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.

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[6] Idaho State Journal June 2, 2013 "Idaho's rural population continues to shrink"

[7] Portland State University "Annual Oregon Population Report"

[8] State of Oregon Employment Department Dec 20, 2018 "A Quick Look at Population Trends in Eastern Oregon"

[9] Cashmere Valley Record March 9, 2011 "Population growth slowed during last decade, but state is more diversified"

2.7 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we first summarize the relevant components of the proposed Programs designed to mitigate risks associated with the proposed actions (our annual approvals). We then 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 actions are 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.

2.7.1 Scientific Research Programs: Summary

The Programs are coordinated by the state fishery agencies: WDFW, IDFG, ODFW, and CDFW. The annual reapproval of the 4(d) program involves an open application period every September. Researchers submit an application each year requesting reapproval for ongoing projects, as well as approval for new projects. NMFS and state fishery agency staff review the applications for compliance with (1) the factors identified in section 1.3.4 of this Opinion, (2) standard protocols and well-understood practices, and (3) the factors in the 4(d) rules for salmon and steelhead and green sturgeon. Unless the researcher requests an exception, and the exception is granted by NMFS, researchers must follow the standard sampling practices listed above in section 1.3.2.1.

In addition to the standard practices, NMFS's annual approval of the Programs includes conditions to be followed before, during, and after the annual research projects/activities are conducted. These conditions are intended to (a) manage the interaction between scientists and listed salmonids by requiring that research activities be coordinated between researchers, the state fishery agencies, and NMFS; (b) minimize impacts on listed species; and (c) ensure that NMFS receives information about the effects the permitted activities have on the species concerned.

During the review process, NMFS staff also consider whether the projects will benefit the listed species. The Programs submitted by the state fishery agencies should clearly demonstrate that the proposed projects will promote the conservation of the species, enhance the species' survival, or add significantly to NMFS's and state agencies' knowledge of the listed species.

Following the open application window, NMFS meets with the state fishery agencies to discuss the programs and address any comments on individual projects. Following those meetings, the state fishery agencies work with researchers to address comments. Prior to the end of the year, and after all comments have been addressed, the state fishery agencies submit their final list of projects to NMFS for approval.

On average, more than 200 projects are annually submitted for consideration under the 4(d) rules. Almost without exception, those projects are very comparable to those NMFS has approved in ESA section 10(a)(1)(A) permits and other approvals, and typify the vast array of salmonid research activities conducted for decades throughout the West Coast. And on the very rare occasion that a project is not comparable, it is usually rejected. Over the past 21 years, NMFS's WCR staff have reviewed thousands of similar activities under sections 4 and 10 of the ESA. NMFS has used this experience to help develop state fishery agency programs that support the recovery of listed salmon, steelhead, and green sturgeon.

NMFS will use annual reports to monitor the actual number of listed fish taken each year in the Programs and will reduce approved take levels if they are deemed to be excessive or if cumulative take levels rise to the point where they are detrimental to the listed species. In addition, NMFS will reevaluate the research program approval if: (1) the amount or extent of approved take is exceeded; (2) the projects are modified in a way that causes an effect on the listed species that was not previously considered in NMFS's evaluation; (3) new information or project monitoring reveals effects not previously considered, and (4) a new species is listed or critical habitat is designated that may affect NMFS's evaluation of the Programs. In the event that there is a reevaluation of the Programs, NMFS would follow the procedures described in section 2.10 Reinitiation of Consultation to determine if reinitiation is warranted.

2.7.2 Species Discussion

As described above, our assessment of whether the Programs would reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild is made in consideration of the other research that has been authorized and that may affect the various listed species. The reasons we integrate the proposed take in the programs considered here with the take from previous (but ongoing) research approvals and permits are that they are similar in nature and we have good information on what the effects are, and thus it is possible to determine the overall effect of all research in the region on the species considered here. The following table therefore combines the annual reported take for the Programs considered in this opinion with the annual reported take from other research permits and authorizations in the region and compares those totals to the estimated annual abundance of each species under consideration (Table 7). In the table below we combine the annual reported take from the Programs (Appendix Table A.2) with the annual reported take from section 10(a)(1)(A) permits and the Puget Sound Tribal Salmon Research Plan (Appendix Table A.1). We next evaluate the range of values and determine the maximum annual take and mortality for the years 2011-2020. The final step is to divide the maximum annual take and mortality by the estimated annual abundance for the year in which the maximum occurred. In this final step we are estimating the maximum impact that the Programs, in combination with the other research permits and approvals, has had on the species. The maximum impact is reported as percent of abundance for each component (life stage and origin) of the species.

Table 7. Comparison of the maximum reported take in the Programs and the other research permits and approvals identified in the baseline to the abundance of the ESA listed species covered in this Opinion (2011-2020).

Species	Life Stage	Origin	Maximum Percent of ESU/DPS Component Taken	Maximum Percent of ESU/DPS Component Killed
PS Chinook	Adult	Natural	0.7223%	0.0260%
PS Chinook	Adult	Hatchery	2.2536%	0.1059%
PS Chinook	Juvenile	Natural	7.2443%	0.1261%
PS Chinook	Juvenile	Hatchery	0.1584%	0.0150%
SRSS Chinook	Adult	Natural	64.1895%	0.0377%
SRSS Chinook	Adult	Hatchery	13.5885%	0.0000%
SRSS Chinook	Juvenile	Natural	47.5205%	0.1647%
SRSS Chinook	Juvenile	Hatchery	2.8401%	0.1724%
SRF Chinook	Adult	Natural	2.5703%	0.0000%
SRF Chinook	Adult	Hatchery	0.0335%	0.0000%
SRF Chinook	Juvenile	Natural	0.3740%	0.0065%
SRF Chinook	Juvenile	Hatchery	0.0236%	0.0009%
LCR Chinook	Adult	Natural	2.4275%	0.0071%
LCR Chinook	Adult	Hatchery	2.1521%	0.0433%
LCR Chinook	Juvenile	Natural	2.5897%	0.0412%
LCR Chinook	Juvenile	Hatchery	0.0611%	0.0020%
UWR Chinook	Adult	Natural	0.5021%	0.0000%
UWR Chinook	Adult	Hatchery	0.3244%	0.0068%
UWR Chinook	Juvenile	Natural	1.5754%	0.0221%
UWR Chinook	Juvenile	Hatchery	0.0093%	0.0018%
CC Chinook	Adult	Natural	49.0342%	0.0140%
CC Chinook	Juvenile	Natural	42.2497%	0.0670%
CVS Chinook	Adult	Natural	25.4019%	0.0134%
CVS Chinook	Adult	Hatchery	290.7390%	0.8419%
CVS Chinook	Juvenile	Natural	61.5380%	0.5158%
CVS Chinook	Juvenile	Hatchery	0.1748%	0.0554%

Species	Life Stage	Origin	Maximum Percent of ESU/DPS Component Taken	Maximum Percent of ESU/DPS Component Killed
HCS chum	Adult	Natural	42.4926%	0.0776%
HCS chum	Juvenile	Natural	15.5085%	0.0313%
HCS chum	Juvenile	Hatchery	0.0585%	0.0000%
CR chum	Adult	Natural	0.0167%	0.0000%
CR chum	Adult	Hatchery	0.0000%	0.0000%
CR chum	Juvenile	Natural	0.2381%	0.0014%
CR chum	Juvenile	Hatchery	0.0017%	0.0017%
LCR coho	Adult	Natural	9.8822%	0.0340%
LCR coho	Adult	Hatchery	1.7026%	0.0217%
LCR coho	Juvenile	Natural	9.0979%	0.0600%
LCR coho	Juvenile	Hatchery	0.3061%	0.0127%
OC coho	Adult	Natural	5.8757%	0.0276%
OC coho	Adult	Hatchery	0.2183%	0.0000%
OC coho	Juvenile	Natural	2.6469%	0.0268%
OC coho	Juvenile	Hatchery	0.0950%	0.0950%
SONCC coho	Adult	Natural	18.5150%	0.0319%
SONCC coho	Adult	Hatchery	136.3755%	0.2608%
SONCC coho	Juvenile	Natural	22.4260%	0.1385%
SONCC coho	Juvenile	Hatchery	2.2175%	0.3095%
PS steelhead	Adult	Natural	3.0585%	0.0068%
PS steelhead	Adult	Hatchery	0.0603%	0.0000%
PS steelhead	Juvenile	Natural	1.3787%	0.0304%
PS steelhead	Juvenile	Hatchery	6.0351%	0.1649%
UCR steelhead	Adult	Natural	2.2613%	0.0000%
UCR steelhead	Adult	Hatchery	0.0630%	0.0000%
UCR steelhead	Juvenile	Natural	2.4981%	0.0617%
UCR steelhead	Juvenile	Hatchery	0.2151%	0.0011%
SRB steelhead	Adult	Natural	14.3949%	0.1008%

Species	Life Stage	Origin	Maximum Percent of ESU/DPS Component Taken	Maximum Percent of ESU/DPS Component Killed
SRB steelhead	Adult	Hatchery	0.7246%	0.0047%
SRB steelhead	Juvenile	Natural	7.7326%	0.0501%
SRB steelhead	Juvenile	Hatchery	0.6836%	0.0059%
MCR steelhead	Adult	Natural	10.5319%	0.0733%
MCR steelhead	Adult	Hatchery	52.0364%	0.0974%
MCR steelhead	Juvenile	Natural	9.6861%	0.1242%
MCR steelhead	Juvenile	Hatchery	2.0446%	0.0158%
LCR steelhead	Adult	Natural	10.9755%	0.0509%
LCR steelhead	Adult	Hatchery	0.7156%	0.0098%
LCR steelhead	Juvenile	Natural	7.0277%	0.0775%
LCR steelhead	Juvenile	Hatchery	0.9934%	0.3064%
UWR steelhead	Adult	Natural	0.2680%	0.0000%
UWR steelhead	Juvenile	Natural	1.1635%	0.0194%
NC steelhead	Adult	Natural	23.4251%	0.0233%
NC steelhead	Juvenile	Natural	36.9050%	0.1054%
CCV steelhead	Adult	Natural	34.5706%	2.3290%
CCV steelhead	Adult	Hatchery	103.9595%	0.4149%
CCV steelhead	Juvenile	Natural	4.1678%	0.1964%
CCV steelhead	Juvenile	Hatchery	0.1481%	0.0007%
CCC steelhead	Adult	Natural	15.6753%	0.2099%
CCC steelhead	Adult	Hatchery	0.1293%	0.0000%
CCC steelhead	Juvenile	Natural	34.6462%	0.3642%
CCC steelhead	Juvenile	Hatchery	0.0088%	0.0005%
SCCC steelhead	Adult	Natural	1.0072%	0.0000%
SCCC steelhead	Juvenile	Natural	13.0526%	0.0759%
Eulachon	Adult	Natural	0.0233%	0.0232%
Green sturgeon	Adult	Natural	3.8462%	0.0000%
Green sturgeon	Egg	Natural	#N/A	#N/A

Species	Life Stage	Origin	Maximum Percent of ESU/DPS Component Taken	Maximum Percent of ESU/DPS Component Killed
Green sturgeon	Juvenile	Natural	6.1807%	0.6001%
Green sturgeon	Larvae	Natural	#N/A	#N/A

Thus, the activities in the Programs in combination with all the previously authorized research has killed as much as 2.3% of the annual abundance from any component of any listed species; that component is adult natural-origin CCV steelhead. In all other instances found in the table above, the effect is (at most) about one-third of that figure and, in many cases, the effect is an order of magnitude smaller (or more). In these instances, the total mortalities are so small and so spread out across each listed unit that they are unlikely to have any lasting detrimental effect on the species' numbers, reproduction, or distribution.

In some instances, the maximum number of fish that were taken represents a significant portion of the estimated annual abundance of the species, and in a few cases exceeds the estimated abundance for that year. The most plausible explanation for this is that we underestimated the abundance of the species. In many cases we are estimating abundance from samples that only represent a portion of the populations within each ESU/DPS. As a result, our abundance estimates are sometimes much lower than actual abundance. This is especially apparent in the case of the California ESUs/DPSs, where efforts to monitor abundance do not exist or have only recently begun in some populations. Hence, the maximum annual take for some of the species in the table above may appear to be disproportionately large in comparison to other species for which there are reliable long-term abundance estimates (e.g. Columbia River and Oregon coastal basins).

As noted in section 1.3.4 Scope and Structure of NMFS's Annual Evaluation and Determination, when we conduct our annual evaluation of the Programs we look for instances where requested lethal take exceeds one half of one percent (0.5%) of the estimated annual abundance of any life stage of naturally produced ESA-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 the research permit and program 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, the Programs are generally able to stay under this amount. In four cases involving three species, the total annual mortality has amounted to more than 0.5% of an ESU/DPS component (i.e., life stage and origin). As a result, below we will review the potential mortality in these instances in more detail.

2.7.3 Salmonid Species

As Table 7 illustrates, in most instances, the research—even in total—has had only very small effects on any species' abundance (and therefore productivity) and no discernible effect on structure or diversity because the effects would be attenuated across each entire species. Nonetheless, there are some instances where closer scrutiny of the effects on a particular component is warranted. The Programs, when considered together with research that has previously been authorized have killed 0.5% or more of the estimated abundance of an adult or juvenile component of the following listed species: CVS Chinook salmon and CCV steelhead.

General descriptions of these effects follow in the paragraphs below with detailed discussions regarding CVS Chinook salmon and CCV steelhead discussed in the subsections that follow.

A few considerations apply generally to our analyses of the total mortalities that would be permitted (i.e., take considered in this opinion added to the rest of the research take that has been authorized in the West Coast Region; Table 7). First, we do not expect the potential mortality of hatchery-origin fish contemplated in this opinion to have any genuine effect on the species' survival and recovery in the wild because, while they are listed, they are generally considered surplus to the recovery needs of threatened species included in 4(d) rules. In most instances, these hatchery-origin fish are easily identifiable because nearly 90% of the listed juvenile hatchery fish included in this opinion will have their adipose fin removed prior to release in the wild. The salmon and steelhead 4(d) rules apply the take prohibitions of ESA section 9 to naturally produced and unmarked hatchery-produced fish. Marked hatchery fish are generally produced to supplement harvest and are considered to be surplus to recovery needs.

A second consideration is how we ask researchers to report take of fish where there may be unlisted natural-origin fish. In those instances where a non-listed fish cannot be differentiated from a listed fish of the same species, we ask that researchers err on the side of caution and treat all unmarked fish as if they were part of the listed ESU/DPS. For example, Willamette Falls on the Willamette River was historically a seasonal barrier that limited fish passage during the lower river levels encountered in the summer and fall. With the construction of a fish ladder at Willamette Falls, fall-run Chinook salmon and summer-run steelhead were introduced to the upper basin. There is also a hatchery program for summer-run steelhead in the upper basin. While researchers can differentiate between adult fish based on run-timing (e.g. spring vs. fall in adult Chinook salmon, and winter vs. summer in adult steelhead) the same does not hold true for juvenile fish in the upper Willamette River basin. Naturally produced juvenile Chinook salmon and steelhead from the early and late run-timing populations are so similar in appearance and in habitat use that researchers are unable to differentiate between them. Hence, all unmarked juvenile Chinook salmon and steelhead in the upper Willamette River basin are treated as if they were part of the listed ESU/DPS.

Another factor to consider is unmarked hatchery-origin fish. In those instances where a non-marked hatchery-origin fish cannot be differentiated from a natural-origin fish, we ask that researchers err on the side of caution and treat all unmarked fish as if they were natural-origin fish. For instance, for the MCR steelhead unclipped hatchery fish make up approximately 39% of the animals with intact adipose fins. It is undoubtedly the case that some unclipped fish would be taken by program activities and counted as natural-origin fish. Therefore, in most cases, the natural-origin component would in actuality be affected to a lesser degree than the percentages displayed above. It is not possible to know how much smaller the take figures would be, but that they are smaller is not in doubt.

Lastly, the research being conducted in the region adds critical knowledge about the species' status—knowledge that we are required to compile to perform viability assessments and 5-year reviews for all listed species. 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 species survive and recover.

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

1. The research activities' expected detrimental effects on the species' annual abundance and productivity would be small, even in combination with all the rest of the research authorized in the basin; 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.

Thus, we determined that the impact of the research program—even in its entirety—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 listed species recover.

2.7.1.1 Juveniles

One figure for natural-origin juvenile fish that bears closer scrutiny is the maximum annual mortality of CVS Chinook salmon. For CVS Chinook salmon, the Programs combined with the baseline have had a maximum mortality of approximately 0.5% of the estimated abundance of natural-origin juvenile fish. In this particular instance, a CDFW research project operating a rotary screw trap in Butte Creek, a tributary to the Sacramento River in California, captured more fish than anticipated. The CDFW researchers noted that in 2019 there was a large return of adult spring-run Chinook and a subsequently large outmigration of juvenile fish in 2020. An estimated 14,863 adult spring-run Chinook salmon returned to spawn in 2019, a six-fold increase from the previous year. Thus, when combined with the existing authorized research take of juvenile salmonids, the effects from the Programs were still found to incur losses that are very small, the effects are only seen in reductions in abundance and productivity and, as described above, the estimates of mortalities are almost certainly much greater than the actual numbers are likely to be.

2.7.1.2 Adults

The two instances where estimated adult mortality met or exceeded 0.5% are hatchery produced adult CVS Chinook salmon and naturally produced adult CCV steelhead. In 2013, CDFW captured a record 18,625 adult spring-run Chinook salmon at the Feather River Hatchery weir and unintentionally killed 54 of them. It should be noted that the mortality rate for this project was only 0.3% of the total number of adult spring-run Chinook captured, well within the allowable limit of 1% we authorized for this project in 2013. It should also be noted that as of 2017 this project is no longer included in CDFW's state research program. The operation of the Feather River hatchery weir is an inseparable part of the hatchery program for spring-run Chinook salmon. Since 2017, the operation of the Feather River hatchery weir has been included in the approval for the hatchery program.

In 2008, we issued an ESA section 10(a)(1)(A) permit authorizing the intentional mortality of up to 100 naturally produced adult CCV steelhead annually for up to five years. In 2011 and 2012 researchers operating under the permit sacrificed 31 and 32 (respectively) naturally produced adult CCV steelhead. The purpose of the project was to collect information on parentage of CCV steelhead for use in an ongoing hatchery program. The information collected was subsequently used to develop minimization measures for a hatchery genetic management plan. Although the intentional mortality amounted to more than 2% of the estimated abundance of naturally produced adult steelhead, the information gathered benefitted the species by allowing managers to determine appropriate minimization measures.

Currently, we rarely authorize intentional mortality of naturally produced adult salmon or steelhead in the Programs. Furthermore, aside from the one project mentioned above, we have authorized no more than two naturally produced adult salmon or steelhead in total per year in section 10(a)(1)(A) permits. We do not anticipate authorizing more than a few intentional mortalities of naturally produced adult fish in either the state research program or the other programs included in the baseline. Setting those two years of reported take aside, the maximum number of naturally produced adult fish killed in the Programs is less than three-tenths of a percent.

Thus, the overall situation for natural-origin adult fish is effectively the same as it is for juvenile fish: the losses are very small and the effects are only seen in reductions in abundance and productivity. Therefore, the effects of the Programs and the baseline on natural-origin adult fish is minor, restricted to abundance and productivity reductions, and to some degree the negative effects would be offset by the information to be gained—information that in all cases would be used to protect listed fish or promote their recovery.

One further thing to note for the species above: some of the discussed impacts are ascribed to the natural-origin component of each listed unit, which means that in actuality the effects are in most cases very likely to be smaller than the displayed percentages. The reason for this is that when in doubt—in those instances where an unmarked hatchery fish or a fish of the same species but from an unlisted population cannot be differentiated from a natural-origin fish—we ask that researchers err on the side of caution and treat all fish as if they were listed fish. So, for instance, given that for the SRF Chinook salmon ESU, unmarked hatchery fish make up approximately 47% of the juvenile fish that are unmarked, it is undoubtedly the case that some unmarked fish would be taken and counted as natural-origin fish. As another example, that figure is 21% for the SONCC coho salmon ESU. Therefore, in some cases, the natural-origin component would in actuality be affected to a lesser degree than the percentages displayed above. It is not possible to know how much smaller the take figures would be, but that they are smaller is not in doubt.

Thus, we expect the research activities' detrimental effects on the species' abundance and productivity to be very small—even in combination with the entirety of the research authorized in the WCR. And because that slight impact would be distributed throughout the entire listing units' ranges, it would be so attenuated as to have no appreciable effect on spatial structure or diversity. Moreover, we expect all the research actions to generate lasting benefits for the listed fish.

2.7.4 Other species

Beyond the 22 salmonid ESUs and DPSs discussed above, are the two additional DPSs of eulachon and green sturgeon. Both of these species only have a natural-origin component to their DPS. Of these two, the effects on green sturgeon merit additional discussion.

For green sturgeon, scientific research in the baseline combined with the Programs has resulted in (at most) the mortality of approximately 0.6% of the estimated abundance of juvenile green sturgeon in a given year. First, note that that total is entirely from one ESA section 10(a)(1)(A) permit in the baseline, the Programs have reported zero juvenile green sturgeon mortalities in the ten-year period 2011-2020. In 2016, the USFWS operating under a section 10(a)(1)(A) permit captured 77 juvenile green sturgeon in the Sacramento River and unintentionally killed 10 of them. Second, we did not have reliable estimates of abundance of green sturgeon in the first half of this ten-year time period and our estimates were much smaller than those recently calculated by Dudley (2021). Therefore, the maximum effect of the research in the baseline has likely been much smaller than 0.6% and the effect of the research in the Programs negligible.

We also must call attention to the take of green sturgeon eggs and larvae. When combined with the baseline, research approvals have killed as many as 270 eggs and 391 larvae annually. The annual abundance of green sturgeon eggs and larvae is currently unknown due to a lack of knowledge of the survival rate of early life history stages of green sturgeon. However, given an annual adult estimate of 2,106 individuals, and a mean green sturgeon fecundity of 142,000 (Van Eenennaam et al. 2006), it can be safely assumed that 270 egg and 391 larvae mortalities would represent a very small fraction of the annual abundance of those life stages for the DPS.

When the reported mortality from the Programs is combined with the baseline, the maximum loss of eulachon compared to the species estimated abundance amounts to no more than 0.2% over the 10-year period of 2011-2020. Thus, the maximum total loss reported for all research activities represent only fractions of a percent of the species' total abundance.

Thus, the effects of the Programs combined with the baseline represent only a small reduction in overall abundance and productivity and very little (if any) effect on structure or diversity. And finally, regardless of its relative magnitude, all the negative effect associated with the research program on this species is to some extent offset by gaining information that would be used to help the species survive and recover.

2.7.5 Critical Habitat Discussion

As previously discussed, we expect the scientific research projects in the Programs, section 10(a)(1)(A) permits, and the Puget Sound Tribal Salmonid Plan, to have minimal effect on any listed species' critical habitat. This is true for all the proposed permit actions in combination as well: the actions' short durations, minimal intrusion, and general lack of measurable effects signify that even when taken together they would have no discernible impact on critical habitat.

2.7.6 Summary

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 Programs meaningfully exacerbate any of the negative cumulative effects discussed (habitat alterations, etc.) and in all cases the research in the Programs 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, but we will monitor that—largely by keeping track of abundance changes and what is causing them—and will adjust or reanalyze the programs as the need arises. However, the Programs would in no way contribute to climate change (even locally) and, in any case, many of the research actions in the Programs would actually help monitor the effects of climate change by noting stream temperatures, flows, etc. So, while we can expect both cumulative effects and climate change to continue their negative trends, it is unlikely that the Programs 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 stream temperatures or continuing land development).

To this picture, it is necessary to add the increment of effect represented by the Programs. Our analysis shows that the Programs have had 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 two decades, research activities conducted on anadromous salmonids in the Pacific Northwest have provided resource managers with a wealth of important and useful information regarding anadromous fish 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 fish passage studies have enhanced our understanding of how fish behave and survive when moving past dams and through reservoirs. By issuing research approvals—including many of those being contemplated again in this opinion—NMFS 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 approval, 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 endangered to threatened, or (c) have its status changed from threatened to endangered. As a result, it is legally incumbent upon us to monitor the status of every species considered here, and the research program, as a whole, is 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 Programs—even in combination with the baseline—would have no appreciable effect on the species' diversity or structure. Moreover, we expect the Programs to provide lasting benefits for the listed fish and that all habitat effects would be negligible. And finally, we expect the Programs and the permit actions in the baseline to generate information we need to fulfill our mandate under the ESA.

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, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS's biological opinion that the proposed actions are not likely to jeopardize the continued existence of PS Chinook salmon, PS steelhead, HCS chum salmon, UCR steelhead, MCR steelhead, SRF Chinook salmon, SRSS Chinook salmon, SR steelhead, CR chum salmon, LCR Chinook salmon, LCR coho salmon, LCR steelhead, UWR Chinook salmon, UWR steelhead, OC coho salmon, SONCC coho salmon, CC Chinook salmon, NC steelhead, CCC steelhead, CVS Chinook salmon, CCV steelhead, SCCC steelhead, Southern DPS eulachon, Southern DPS green sturgeon, or to destroy or adversely modify any designated critical habitat.

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). "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.

In this instance, and for the actions considered in this opinion, there is no incidental take. The reason for this is that all the take contemplated in this document would be carried out under approvals that allow the researchers to directly take the animals in question. The actions are considered to be direct take rather than incidental take because in every case their actual purpose is to take the animals while carrying out a lawfully approved activity. Thus, the take cannot be considered "incidental" under the definition given above.

2.10 Reinitiation of Consultation

This concludes formal consultation for WCR proposal to implement the annual approval of the Programs under the ESA section 4(d) rule's scientific research limit [50 CFR 223.203(b)(7)] and scientific research exemptions [50 CFR 223.210(c)(1)]. Because there is no definitive sunset (or expiration) date for the state research program approvals, there is no pre-determined end date on this opinion. As discussed above (see Sections 1.3.2.1 and 1.3.2.2 and the Integration and Synthesis Section 2.7.1), the standard sampling practices, terms and conditions, and annual review of the Programs are critically important for reducing risk and avoiding jeopardy or adverse modification over time. The standard reinitiation triggers, which 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 Federal agency or by the Service where discretionary Federal 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."

In the context of this opinion, there is no incidental take anticipated and the reinitiation trigger set out in (1) is not applicable. Furthermore, given the annual review and reapproval approach that is built into the proposed action, we anticipate that reinitiation trigger #2 (above) will have limited application in the context of this consultation. That is, the proposed Programs are structured such that new information regarding the effects of research activities on ESA-listed species and/or critical habitat can be incorporated into the Programs without the need for reinitiation, assuming such changes are designed to be more protective, or at least as protective as the status quo. Some examples may include changes in general permit conditions to improve the monitoring of take or administration of the Programs, or adding new mitigation measures to further minimize adverse effects on ESA-listed species.

Reinitiation trigger #3 (above) could be invoked if the state fishery agencies modify their Programs such that the adverse effects to ESA-listed species or designated critical habitat are greater than those effects considered in this opinion under the proposed action. For example, a one-year maximum mortality greater than 1% of the abundance or a sustained increase of five or more years in the relative (i.e., proportional) annual maximum mortality for natural-origin fish, could result in adverse effects to the species beyond those considered in this opinion. We will calculate a running 5-year average for mortality for each species and consider a 5-year average of more than 0.5% to be an indicator of a sustained increase. Such changes to the Programs, therefore, would trigger reinitiation of formal consultation on the effected species.

As discussed in the Description of the Proposed Action (Section 1.3), the WCR would work closely with the state fishery agencies throughout implementation of their Programs. The WCR and state fishery agencies will annually check-in on how the Programs are functioning overall, and determine whether new information indicates that the WCR should re-initiate this consultation.

2.11 "Not Likely to Adversely Affect" Determination

NMFS's determination that an action "is not likely to adversely affect" listed species or critical habitat is based on our finding that the effects are expected to be discountable, insignificant, or completely beneficial (USFWS and NMFS 1998). Insignificant effects relate to the size of the impact and should never reach the scale where take occurs; discountable effects are those that are extremely unlikely to occur; and beneficial effects are contemporaneous positive effects without any adverse effects on the species or their critical habitat.

Southern Resident Killer Whales Determination

The Southern Resident killer whale (SRKW) DPS was listed as endangered under the ESA in 2005 (70 FR 69903) and a recovery plan was completed in 2008 (NMFS 2008). 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 2021b). Because NMFS determined the action is not likely to adversely affect SRKWs, this document does not provide detailed discussion of environmental baseline or cumulative effects for the SRKW portion of the action area.

Several factors identified in the final recovery plan for SRKWs may be limiting recovery including 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 2008).

SRKWs consist of three pods (J, K, and L) and inhabit coastal waters off Washington, Oregon, and Vancouver Island and are known to travel as far south as central California and as far north as Southeast Alaska (NMFS 2008; Hanson et al. 2013; Carretta et al. 2017, 2021). 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 1982; Ford et al. 2000; Krahn et al. 2002; Hauser et al. 2007; Hanson and Emmons 2010). By late fall, all three pods are seen less frequently in inland waters. 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 (Hanson and Emmons 2010; Whale Museum unpublished data). 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, NWFSC unpubl. data). Satellite-linked tag deployments have also provided more data on SRKW movements in the winter indicating that K and L pods use the coastal waters along Washington, Oregon, and California during non-summer months (Hanson et al. 2017), 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. In 2021, NMFS published a rule to revise SRKW critical habitat and designate six additional coastal critical habitat areas (86 Fed. Reg. 41668, August 2, 2021). 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 2021c).

SRKWs consume a variety of fish species (22 species) and one species of squid (Ford et al. 1998; Ford et al. 2000; Ford and Ellis 2006; Hanson et al. 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). 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 waters during October through December indicate Chinook salmon and chum salmon are primary contributors of the whale’s diet (Hanson et al. 2021).

Observations of whales overlapping with salmon runs (Wiles 2004; Zamon et al. 2007; Krahn et al. 2007) and collection of prey and fecal samples have also occurred in the winter months. 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 2021 population census, there were 74 SRKWs counted in the population, which includes three calves born between the 2020 and 2021 censuses, and all three surviving at the time of this report (CWR 2021). Since the latest census, one additional whale is presumed dead: K21, an adult male. The NWFSC continues to evaluate changes in fecundity and mortality rates, and has updated the work on population viability analyses for Southern Resident killer whales and a science panel review of the effects of salmon fisheries (Krahn et al. 2004; Hilborn et al. 2012; Ward et al. 2013). Following that work, population estimates, including data from the last five years (2017-2021), project a downward trend over the next 25 years. The population projection is most pessimistic if future fecundity rates are assumed to be similar to the last five years, and higher but still declining if average fecundity and survival rates over all years (1985-2021) are used for the projections. Only 25 years were selected for projections because as the model projects out over a longer time frame (e.g., 50 years), there is increased uncertainty around the estimates (also see Hilborn et al. 2012). Recently, Lacy et al. (2017) developed a population viability assessment (PVA) model that attempts to quantify and compare the three primary threats affecting the whales (e.g., prey availability, vessel noise and disturbance, and high levels of contaminants). This model relies on previously published correlations of SRKW demographic rates with Chinook salmon abundance using a prey index for 1979 – 2008, and models SRKW demographic trajectories assuming that the relationship is constant over time. They found that over the range of scenarios tested, the effects of prey abundance on fecundity and survival had the largest impact on the population growth rate (Lacy et al. 2017).

The proposed actions may affect SRKWs indirectly by reducing availability of their preferred prey, Chinook salmon. This analysis focuses on effects to Chinook salmon availability in the ocean because the best available information indicates that salmon are the preferred prey of SRKWs year round, including in coastal waters, and that Chinook salmon are the preferred salmon prey species. To assess the indirect effects of the proposed actions on the Southern Resident killer whale DPS, we considered the geographic area of overlap in the marine distribution of Chinook salmon affected by the action, and the range of Southern Resident killer whales. We also considered the importance of the affected Chinook salmon ESUs compared to other Chinook salmon runs in Southern Resident diet composition, and the influence of hatchery mitigation programs. As described in section 2.5.3 Species-Specific Effects of the Program, a maximum of 14,106 juvenile and 60 adult Chinook salmon have been killed during the ten year period 2011-2020. As the previous effects analysis 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 spatial structure for any Chinook salmon ESUs. The affected Chinook salmon species are:

Puget Sound
Snake River spring-summer run
Snake River fall-run
Lower Columbia River
Upper Willamette River
California Coastal
Central Valley spring-run

For the adult take, the 60 fish that were killed from these ESUs were taken by research after they return to shallower bays, estuaries and their natal rivers, and are therefore very unlikely to have been available as prey to the whales that typically feed in coastal offshore areas. This portion of the proposed work would very probably therefore have minimal, if any, effect on prey availability for Southern Resident killer whales.

Because SRKW mainly consume adult salmon (see above), for the juveniles, the most recent ten-year average smolt-to-adult ratio (SAR) from PIT-tagged Chinook salmon returns is from the Snake River, and indicates that SARs are less than 1% (BPA 2018). If one percent of 14,106 juvenile Chinook salmon that were killed in one year by the Programs were to have otherwise survived to adulthood, this would translate to the effective loss of about 141 adult Chinook salmon annually. Given that the number of adult Chinook (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 have intercepted and fed on many (if any) of those salmon.

If SRKWs consume only large adult Chinook salmon (16,386 kcal/fish), adult female killer whales would consume up to approximately 13 Chinook salmon per day and adult male killer whales would consume up to approximately 16 Chinook salmon per day (Noren 2011, NMFS 2019c). Noren (2011) estimated the daily consumption rate of a population with 82 individuals over the age of 1 that consumes solely Chinook salmon would consume 289,131–347,000 fish/year by assuming the caloric density of Chinook was 16,386 kcal/fish (i.e., the average value for adults from Fraser River).

Using methods described in NMFS 2021d, we combined the sex and age specific maximum daily prey energy requirement information with the population census data to estimate daily energetic requirements for all members of the SRKW population, based on the population size as of summer 2021 (74 whales) and using ages for the year 2021. Assuming a Chinook caloric density of 16,386 kcal/fish, the SRKW population of 74 whales, ≥1 year of age, need 755-906 fish/day. Based on this simple calculation, the research contemplated in this opinion could kill, in its entirety and at a maximum, about 19% of one day's worth of the fish that the SRKWs need to survive. Moreover, that figure would only hold if the SRKWs could somehow intercept all the fish that might otherwise reach maturity without the permitted take. So even the maximum effect of a loss of 19% of one day's worth of SRKW food could only occur under circumstances so unlikely as to effectively be impossible. However, because there is no available information on the whales' foraging efficiency, it is unknown how much more fish need to be available in order for the whales to capture and consume enough prey to meet their needs.

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 actions may affect, but are not likely to adversely affect, SR killer whales or their critical habitat.

3. MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT CONSULTATION

Section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. Under the MSA, this consultation is intended to promote the conservation of EFH as necessary to support sustainable fisheries and the managed species' contribution to a healthy ecosystem. For the purposes of the MSA, EFH means "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity", and includes the physical, biological, and chemical properties that are used by fish (50 CFR 600.10). Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on

EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) of the MSA also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH. Such recommendations may include measures to avoid, minimize, mitigate, or otherwise offset the adverse effects of the action on EFH [CFR 600.905(b)].

This analysis is based, in part, on the EFH assessment provided by the NMFS and descriptions of EFH for Pacific coast salmon (PFMC 2014) contained in the fishery management plans developed by the Pacific Fishery Management Council (PFMC) and approved by the Secretary of Commerce.

3.1 Essential Fish Habitat Affected by the Project

In the estuarine and marine areas, salmon EFH extends from the nearshore and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone (370.4 km) offshore of Washington, Oregon, and California north of Point Conception. The EFH identified within the action areas are identified in the Pacific coast salmon fishery management plan (PFMC 2014). Freshwater EFH for Pacific salmon includes all those streams, lakes, ponds, wetlands, and other water bodies currently, or historically accessible to salmon in Washington, Oregon, Idaho, and California, except areas upstream of certain impassable man-made barriers (as identified by the PFMC), and longstanding, naturally-impassable barriers (i.e., natural waterfalls in existence for several hundred years).

3.2 Adverse Effects on Essential Fish Habitat

As the Biological Opinion above describes, the proposed research actions are not likely, individually or in combination, to adversely affect the habitat upon which Pacific salmon, groundfish, and coastal pelagic species, depend; the research is therefore not likely to affect EFH. All the actions are of limited duration, minimally intrusive, and are entirely discountable in terms of their effects, short-or long-term, on any habitat parameter important to the fish.

3.3 Essential Fish Habitat Conservation Recommendations

No adverse effects upon EFH are expected; therefore, no EFH conservation recommendations are necessary.

3.4 Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, the Federal agency must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation from NMFS. Given that there are no conservation recommendations, there is no statutory response requirement.

3.5 Supplemental Consultation

The Action Agency must reinitiate EFH consultation with NMFS if the proposed actions are substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS's EFH Conservation Recommendations [50 CFR 600.920(l)].

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this consultation are the state fishery agencies and funding/action agencies listed on the first page. Individual copies of this opinion are provided to the state agency Program managers upon request. The document will be available within two weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. The format and naming adhere to conventional standards for style.

This ESA section 7 consultation on our approval of the state fishery research programs concluded that the actions will not jeopardize the continued existence of any species. Therefore, the funding/action agencies may carry out the research actions and NMFS may approve them. Pursuant to the MSA, NMFS determined that no conservation recommendations were needed to conserve EFH.

4.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

4.3 Objectivity

Information Product Category: Natural Resource Plan

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA regulations, 50 CFR 402.01 et seq., and the MSA implementing regulations regarding EFH, 50 CFR 600.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this opinion [*and EFH consultation, if applicable*] 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.

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6. APPENDIX

Table A.1. Ten-year Average Annual Take and Mortality (Range of Annual Take in Parenthesis) of the ESA Listed Species for Scientific Research Authorized in Section 10(a)(1)(A) Scientific Research Permits and the Puget Sound Tribal Salmonid Research Plan (2011-2020).

Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality	Reported Take	Reported Mortality
PS Chinook salmon	Adult	Natural	Capture	316 (208 - 438)	21 (7 - 27)	79 (11 - 186)	2 (0 - 10)
			Intentional Mortality	0 (0 - 2)	0 (0 - 2)	0 (0 - 0)	0 (0 - 0)
			Observe/Harass	180 (0 - 1,800)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	782 (217 - 1,989)	43 (21 - 75)	260 (0 - 1,039)	3 (0 - 14)
			Intentional Mortality	0 (0 - 2)	0 (0 - 2)	0 (0 - 0)	0 (0 - 0)
			Observe/Harass	20 (0 - 200)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Juvenile	Natural	Capture	123,434 (76,871 - 189,414)	1,727 (1,377 - 2,061)	48,961 (17,014 - 118,798)	409 (65 - 967)
			Intentional Mortality	4,595 (2,601 - 6,564)	4,595 (2,601 - 6,564)	909 (45 - 2,508)	909 (45 - 2,508)
			Observe/Harass	115 (0 - 430)	0 (0 - 0)	13 (0 - 129)	0 (0 - 0)
		Hatchery	Capture	98,209 (65,184 - 167,777)	1,378 (951 - 1,962)	36,738 (24,903 - 55,778)	537 (130 - 1,227)
			Intentional Mortality	10,132 (3,650 - 14,459)	10,132 (3,650 - 14,459)	1,468 (176 - 3,464)	1,468 (176 - 3,464)
			Observe/Harass	70 (0 - 200)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
SRSS Chinook salmon	Adult	Natural	Capture	4,174 (1,868 - 5,701)	21 (9 - 30)	426 (0 - 1,681)	1 (0 - 1)
			Observe/Harass	1,889 (30 - 4,100)	12 (0 - 18)	881 (0 - 2,544)	0 (0 - 0)
			Sample Tissue Dead Animal	5 (0 - 15)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)

Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality	Reported Take	Reported Mortality
		Hatchery	Capture	2,111 (1,203 - 2,799)	11 (1 - 20)	19 (0 - 58)	0 (0 - 0)
			Observe/Harass	178 (0 - 260)	2 (0 - 2)	0 (0 - 0)	0 (0 - 0)
	Juvenile	Natural	Capture	592,796 (363,986 - 746,660)	4,981 (2,947 - 7,083)	138,842 (14,813 - 413,900)	709 (10 - 1,454)
			Intentional Mortality	695 (51 - 1,259)	695 (51 - 1,259)	60 (1 - 79)	60 (1 - 79)
			Observe/Harass	25,470 (0 - 36,900)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	99,342 (40,032 - 123,917)	1,055 (426 - 1,349)	9,786 (11 - 40,772)	22 (0 - 166)
			Intentional Mortality	89 (44 - 196)	89 (44 - 196)	37 (11 - 94)	37 (11 - 94)
			Observe/Harass	540 (0 - 1,800)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
SRF Chinook salmon	Adult	Natural	Capture	281 (177 - 396)	5 (2 - 7)	19 (0 - 63)	0 (0 - 0)
			Observe/Harass	9 (0 - 30)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	342 (12 - 431)	5 (0 - 9)	1 (0 - 3)	0 (0 - 0)
			Observe/Harass	18 (0 - 60)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Juvenile	Natural	Capture	4,402 (728 - 17,475)	75 (30 - 196)	380 (1 - 1,977)	3 (0 - 14)
			Intentional Mortality	22 (13 - 42)	22 (13 - 42)	7 (0 - 21)	7 (0 - 21)
			Observe/Harass	450 (0 - 1,500)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
			Sample Tissue Dead Animal	7 (0 - 36)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	9,579 (455 - 43,110)	117 (20 - 408)	179 (1 - 1,328)	1 (0 - 3)
			Intentional Mortality	46 (16 - 128)	46 (16 - 128)	15 (3 - 47)	15 (3 - 47)

Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality	Reported Take	Reported Mortality
			Observe/Harass	900 (0 - 3,000)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
			Sample Tissue Dead Animal	8 (0 - 38)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
LCR Chinook salmon	Adult	Natural	Capture	162 (111 - 225)	1 (0 - 2)	6 (0 - 31)	0 (0 - 1)
			Intentional Mortality	0 (0 - 1)	0 (0 - 1)	0 (0 - 0)	0 (0 - 0)
			Observe/Harass	29 (0 - 40)	0 (0 - 0)	2 (0 - 14)	0 (0 - 0)
		Hatchery	Capture	149 (88 - 188)	1 (0 - 2)	18 (0 - 74)	0 (0 - 0)
			Observe/Harass	8 (0 - 15)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Juvenile	Natural	Capture	12,902 (4,310 - 17,172)	293 (107 - 466)	229 (35 - 589)	10 (0 - 35)
			Intentional Mortality	239 (138 - 362)	239 (138 - 362)	93 (16 - 328)	93 (16 - 328)
			Sample Tissue Dead Animal	81 (0 - 405)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	4,081 (1,735 - 6,362)	78 (40 - 117)	199 (2 - 695)	1 (0 - 4)
			Intentional Mortality	510 (295 - 655)	510 (295 - 655)	165 (32 - 367)	165 (32 - 367)
			Sample Tissue Dead Animal	89 (0 - 444)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
UWR Chinook salmon	Adult	Natural	Capture	54 (28 - 102)	1 (0 - 1)	1 (0 - 3)	0 (0 - 0)
		Hatchery	Capture	58 (33 - 111)	0 (0 - 1)	2 (0 - 4)	0 (0 - 0)
			Observe/Harass	2 (0 - 5)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Juvenile	Natural	Capture	5,018 (2,230 - 8,640)	134 (75 - 241)	157 (61 - 263)	8 (1 - 22)
			Intentional Mortality	107 (12 - 280)	107 (12 - 280)	26 (0 - 163)	26 (0 - 163)

Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality	Reported Take	Reported Mortality
			Observe/Harass	540 (0 - 1,800)	0 (0 - 0)	1 (0 - 10)	0 (0 - 0)
			Sample Tissue Dead Animal	91 (0 - 454)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	2,883 (1,887 - 4,042)	87 (61 - 115)	30 (0 - 95)	1 (0 - 8)
			Intentional Mortality	120 (81 - 142)	120 (81 - 142)	53 (11 - 106)	53 (11 - 106)
			Sample Tissue Dead Animal	9 (0 - 43)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
CC Chinook salmon	Adult	Natural	Capture	645 (232 - 1,202)	11 (5 - 21)	0 (0 - 0)	0 (0 - 0)
			Intentional Mortality	0 (0 - 1)	0 (0 - 1)	0 (0 - 0)	0 (0 - 0)
			Observe/Harass	3,701 (0 - 9,133)	0 (0 - 0)	150 (0 - 433)	0 (0 - 0)
			Sample Tissue Dead Animal	40 (0 - 200)	0 (0 - 0)	3 (0 - 16)	0 (0 - 0)
		Hatchery	Observe/Harass	0 (0 - 0)	0 (0 - 0)	10 (0 - 102)	0 (0 - 0)
	Juvenile	Natural	Capture	259,984 (39,714 - 655,823)	3,552 (980 - 7,822)	9,240 (172 - 36,032)	36 (2 - 80)
			Intentional Mortality	108 (70 - 179)	108 (70 - 179)	0 (0 - 2)	0 (0 - 2)
			Observe/Harass	6,799 (140 - 17,060)	5 (0 - 14)	180 (0 - 672)	0 (0 - 0)
		Hatchery	Capture	0 (0 - 0)	0 (0 - 0)	0 (0 - 1)	0 (0 - 1)
CVS Chinook salmon	Adult	Natural	Capture	426 (100 - 644)	19 (10 - 30)	33 (2 - 79)	0 (0 - 0)
			Intentional Mortality	0 (0 - 1)	0 (0 - 1)	0 (0 - 0)	0 (0 - 0)
			Observe/Harass	19,531 (0 - 28,351)	0 (0 - 0)	506 (0 - 1,581)	0 (0 - 0)
		Hatchery	Capture	226 (0 - 425)	6 (0 - 13)	2 (0 - 5)	0 (0 - 1)

Species	**Life Stage**	**Origin**	**Take Activity**	**Requested Take**	**Requested Mortality**	**Reported Take**	**Reported Mortality**
			Intentional Mortality	108 (0 - 240)	108 (0 - 240)	0 (0 - 0)	0 (0 - 0)
			Observe/Harass	189 (0 - 361)	0 (0 - 0)	1 (0 - 7)	0 (0 - 0)
	Juvenile	Natural	Capture	282,800 (2,150 - 404,482)	8,408 (101 - 12,143)	16,657 (112 - 61,953)	226 (4 - 689)
			Intentional Mortality	84 (20 - 182)	84 (20 - 182)	2 (0 - 9)	2 (0 - 9)
			Observe/Harass	63,668 (0 - 112,500)	0 (0 - 0)	1,043 (0 - 10,290)	0 (0 - 0)
			Sample Tissue Dead Animal	448 (0 - 2,769)	0 (0 - 0)	0 (0 - 4)	0 (0 - 0)
		Hatchery	Capture	3,550 (215 - 5,647)	72 (4 - 115)	358 (0 - 791)	2 (0 - 11)
			Intentional Mortality	1,743 (0 - 2,845)	1,743 (0 - 2,845)	376 (0 - 1,552)	376 (0 - 1,552)
			Observe/Harass	40 (0 - 80)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
HCS chum salmon	Adult	Natural	Capture	26 (19 - 33)	4 (0 - 5)	0 (0 - 0)	0 (0 - 0)
			Intentional Mortality	0 (0 - 2)	0 (0 - 2)	0 (0 - 0)	0 (0 - 0)
			Observe/Harass	0 (0 - 2)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Juvenile	Natural	Capture	23,257 (4,497 - 39,288)	274 (68 - 464)	5,583 (22 - 24,703)	11 (0 - 38)
			Intentional Mortality	2,567 (0 - 7,027)	242 (0 - 770)	1,578 (0 - 14,042)	3 (0 - 25)
		Hatchery	Capture	112 (80 - 142)	2 (2 - 3)	3 (0 - 10)	0 (0 - 0)
CR chum salmon	Adult	Natural	Capture	60 (19 - 194)	1 (0 - 5)	0 (0 - 0)	0 (0 - 0)
			Observe/Harass	1 (0 - 5)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	0 (0 - 1)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)

Species	**Life Stage**	**Origin**	**Take Activity**	**Requested Take**	**Requested Mortality**	**Reported Take**	**Reported Mortality**
	Juvenile	Natural	Capture	3,341 (2,164 - 4,067)	83 (42 - 134)	115 (0 - 517)	1 (0 - 3)
			Intentional Mortality	29 (12 - 36)	29 (12 - 36)	7 (0 - 33)	7 (0 - 33)
			Sample Tissue Dead Animal	131 (0 - 656)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	4 (0 - 15)	0 (0 - 1)	0 (0 - 0)	0 (0 - 0)
			Intentional Mortality	12 (12 - 12)	12 (12 - 12)	3 (0 - 11)	3 (0 - 11)
LCR coho salmon	Adult	Natural	Capture	668 (130 - 822)	9 (0 - 16)	191 (6 - 570)	1 (0 - 4)
			Observe/Harass	10 (0 - 20)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	633 (341 - 836)	10 (4 - 14)	45 (8 - 94)	0 (0 - 0)
			Observe/Harass	8 (0 - 15)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Juvenile	Natural	Capture	19,950 (7,344 - 43,250)	355 (132 - 737)	1,052 (0 - 2,311)	10 (0 - 25)
			Intentional Mortality	119 (105 - 145)	119 (105 - 145)	29 (6 - 90)	29 (6 - 90)
			Sample Tissue Dead Animal	2 (0 - 9)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	3,657 (1,325 - 4,448)	68 (47 - 89)	33 (0 - 232)	2 (0 - 18)
			Intentional Mortality	1,095 (990 - 1,181)	1,095 (990 - 1,181)	237 (40 - 743)	237 (40 - 743)
			Sample Tissue Dead Animal	7 (0 - 34)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
OC coho salmon	Adult	Natural	Capture	164 (36 - 644)	2 (0 - 10)	12 (0 - 87)	0 (0 - 0)
			Observe/Harass	51 (0 - 500)	0 (0 - 0)	3 (0 - 33)	0 (0 - 0)
		Hatchery	Capture	38 (11 - 101)	0 (0 - 1)	2 (0 - 12)	0 (0 - 0)

Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality	Reported Take	Reported Mortality
	Juvenile	Natural	Capture	3,171 (2,195 - 6,899)	81 (64 - 102)	47 (1 - 253)	2 (0 - 14)
			Intentional Mortality	100 (100 - 102)	100 (100 - 102)	14 (0 - 49)	14 (0 - 49)
			Observe/Harass	100 (0 - 1,000)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	305 (175 - 550)	11 (7 - 18)	0 (0 - 0)	0 (0 - 0)
			Intentional Mortality	97 (10 - 300)	97 (10 - 300)	13 (0 - 57)	13 (0 - 57)
SONCC coho salmon	Adult	Natural	Capture	815 (69 - 2,273)	10 (1 - 25)	0 (0 - 1)	0 (0 - 0)
			Observe/Harass	2,935 (0 - 6,430)	0 (0 - 0)	73 (0 - 379)	0 (0 - 0)
		Hatchery	Capture	21 (7 - 76)	0 (0 - 1)	0 (0 - 1)	0 (0 - 0)
			Observe/Harass	80 (0 - 220)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Juvenile	Natural	Capture	295,965 (68,775 - 890,892)	6,411 (1,258 - 19,619)	15,196 (6,181 - 29,839)	66 (9 - 161)
			Intentional Mortality	350 (12 - 910)	350 (12 - 910)	16 (0 - 131)	16 (0 - 131)
			Observe/Harass	19,788 (120 - 40,115)	4 (0 - 12)	2,538 (0 - 6,933)	0 (0 - 0)
		Hatchery	Capture	11,279 (8,646 - 20,630)	356 (82 - 1,020)	1,016 (61 - 3,821)	8 (0 - 21)
			Intentional Mortality	813 (390 - 1,730)	813 (390 - 1,730)	245 (88 - 614)	245 (88 - 614)
			Observe/Harass	356 (0 - 1,300)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
			Sample Tissue Dead Animal	300 (0 - 600)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
PS steelhead	Adult	Natural	Capture	200 (46 - 337)	8 (0 - 12)	44 (0 - 182)	0 (0 - 1)
			Observe/Harass	0 (0 - 0)	0 (0 - 0)	0 (0 - 1)	0 (0 - 0)

Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality	Reported Take	Reported Mortality
		Hatchery	Capture	37 (27 - 50)	4 (0 - 5)	0 (0 - 3)	0 (0 - 0)
	Juvenile	Natural	Capture	21,769 (4,564 - 38,825)	373 (85 - 621)	5,450 (611 - 12,141)	77 (8 - 192)
			Intentional Mortality	28 (0 - 55)	28 (0 - 55)	2 (0 - 12)	2 (0 - 12)
			Observe/Harass	845 (0 - 1,530)	0 (0 - 0)	56 (0 - 321)	0 (0 - 0)
		Hatchery	Capture	8,084 (1,450 - 18,764)	220 (56 - 505)	3,254 (11 - 16,629)	60 (0 - 209)
			Intentional Mortality	2 (0 - 10)	2 (0 - 10)	0 (0 - 0)	0 (0 - 0)
			Observe/Harass	10 (0 - 20)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
UCR steelhead	Adult	Natural	Capture	532 (112 - 1,424)	17 (0 - 90)	96 (0 - 802)	2 (0 - 16)
			Observe/Harass	101 (0 - 504)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	444 (16 - 821)	12 (0 - 24)	1 (0 - 5)	0 (0 - 0)
			Observe/Harass	60 (0 - 300)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Juvenile	Natural	Capture	24,501 (2,297 - 36,332)	646 (70 - 902)	3,004 (18 - 7,003)	49 (0 - 153)
			Intentional Mortality	119 (3 - 263)	119 (3 - 263)	1 (0 - 2)	1 (0 - 2)
			Observe/Harass	1,508 (0 - 7,502)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
			Sample Tissue Dead Animal	18 (0 - 60)	1 (0 - 3)	3 (0 - 30)	0 (0 - 0)
		Hatchery	Capture	20,253 (9,928 - 29,236)	527 (207 - 838)	452 (18 - 1,983)	2 (0 - 6)
			Intentional Mortality	39 (8 - 100)	39 (8 - 100)	2 (0 - 9)	2 (0 - 9)
			Observe/Harass	416 (0 - 2,000)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)

Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality	Reported Take	Reported Mortality
SRB steelhead	Adult	Natural	Capture	7,723 (2,222 - 12,036)	84 (22 - 124)	898 (0 - 3,339)	2 (0 - 11)
			Observe/Harass	98 (0 - 160)	1 (0 - 1)	0 (0 - 1)	0 (0 - 0)
			Sample Tissue Dead Animal	1,200 (0 - 1,500)	0 (0 - 0)	4 (0 - 23)	0 (0 - 4)
		Hatchery	Capture	9,733 (189 - 19,953)	111 (1 - 218)	26 (0 - 133)	1 (0 - 7)
			Observe/Harass	232 (0 - 440)	2 (0 - 2)	0 (0 - 0)	0 (0 - 0)
			Sample Tissue Dead Animal	2,200 (0 - 3,000)	2 (0 - 6)	1 (0 - 4)	0 (0 - 0)
	Juvenile	Natural	Capture	205,328 (128,611 - 278,206)	2,088 (1,352 - 2,935)	17,429 (2,618 - 27,364)	142 (40 - 271)
			Intentional Mortality	733 (17 - 1,534)	733 (17 - 1,534)	42 (0 - 77)	42 (0 - 77)
			Observe/Harass	3,549 (0 - 5,170)	0 (0 - 1)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	100,687 (21,624 - 143,838)	1,121 (341 - 1,589)	9,527 (633 - 27,096)	40 (0 - 240)
			Intentional Mortality	62 (43 - 78)	62 (43 - 78)	10 (0 - 47)	10 (0 - 47)
			Observe/Harass	180 (0 - 600)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
MCR steelhead	Adult	Natural	Capture	859 (32 - 1,447)	6 (0 - 14)	86 (0 - 264)	0 (0 - 0)
			Observe/Harass	80 (0 - 200)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	110 (22 - 238)	4 (0 - 11)	0 (0 - 1)	0 (0 - 0)
			Observe/Harass	80 (0 - 200)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Juvenile	Natural	Capture	40,819 (23,201 - 56,472)	852 (563 - 1,182)	6,224 (141 - 11,999)	91 (0 - 197)
			Intentional Mortality	70 (17 - 101)	70 (17 - 101)	1 (0 - 6)	1 (0 - 6)

Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality	Reported Take	Reported Mortality
			Observe/Harass	1,072 (0 - 2,680)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
			Sample Tissue Dead Animal	200 (0 - 500)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	5,164 (568 - 11,732)	90 (19 - 181)	12 (0 - 102)	0 (0 - 0)
			Intentional Mortality	11 (4 - 16)	11 (4 - 16)	2 (0 - 5)	2 (0 - 5)
			Observe/Harass	32 (0 - 80)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
LCR steelhead	Adult	Natural	Capture	851 (125 - 1,163)	13 (1 - 17)	165 (0 - 330)	0 (0 - 0)
		Hatchery	Capture	77 (41 - 89)	2 (0 - 2)	6 (0 - 15)	0 (0 - 0)
	Juvenile	Natural	Capture	9,816 (8,098 - 10,240)	304 (266 - 331)	3,427 (1,750 - 6,739)	48 (14 - 110)
			Intentional Mortality	53 (12 - 74)	53 (12 - 74)	1 (0 - 7)	1 (0 - 7)
		Hatchery	Capture	1,129 (584 - 1,721)	42 (24 - 61)	4 (0 - 15)	0 (0 - 0)
			Intentional Mortality	24 (14 - 29)	24 (14 - 29)	2 (0 - 5)	2 (0 - 5)
UWR steelhead	Adult	Natural	Capture	27 (15 - 51)	0 (0 - 0)	1 (0 - 3)	0 (0 - 0)
	Juvenile	Natural	Capture	1,482 (945 - 2,012)	42 (27 - 64)	20 (0 - 99)	1 (0 - 6)
			Intentional Mortality	7 (4 - 8)	7 (4 - 8)	1 (0 - 3)	1 (0 - 3)
			Observe/Harass	162 (0 - 540)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
NC steelhead	Adult	Natural	Capture	741 (300 - 1,450)	9 (4 - 18)	46 (0 - 129)	0 (0 - 1)
			Observe/Harass	1,555 (0 - 3,450)	0 (0 - 0)	86 (0 - 363)	0 (0 - 0)
	Juvenile	Natural	Capture	146,979 (89,132 - 248,680)	3,019 (2,063 - 5,248)	21,819 (11,161 - 38,536)	83 (20 - 180)

Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality	Reported Take	Reported Mortality
			Intentional Mortality	544 (476 - 1,000)	544 (476 - 1,000)	0 (0 - 0)	0 (0 - 0)
			Observe/Harass	15,107 (25 - 31,500)	6 (1 - 10)	3,134 (0 - 7,215)	0 (0 - 0)
CCV steelhead	Adult	Natural	Capture	1,881 (672 - 2,486)	54 (13 - 79)	72 (0 - 159)	1 (0 - 7)
			Intentional Mortality	40 (0 - 200)	40 (0 - 200)	6 (0 - 32)	6 (0 - 32)
			Observe/Harass	9,792 (500 - 14,045)	0 (0 - 0)	375 (0 - 2,101)	0 (0 - 0)
			Sample Tissue Dead Animal	80 (0 - 400)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	906 (0 - 1,801)	19 (0 - 43)	77 (0 - 210)	2 (0 - 16)
			Intentional Mortality	48 (0 - 240)	48 (0 - 240)	0 (0 - 0)	0 (0 - 0)
			Observe/Harass	57 (0 - 115)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Juvenile	Natural	Capture	38,844 (14,009 - 49,836)	1,164 (317 - 1,560)	2,596 (626 - 4,713)	42 (4 - 78)
			Intentional Mortality	388 (283 - 700)	388 (283 - 700)	37 (0 - 300)	37 (0 - 300)
			Observe/Harass	925,803 (50 - 1,368,700)	1 (0 - 2)	24,740 (0 - 200,038)	0 (0 - 0)
			Sample Tissue Dead Animal	130 (100 - 314)	0 (0 - 0)	0 (0 - 1)	0 (0 - 0)
		Hatchery	Capture	15,242 (379 - 22,539)	572 (13 - 849)	1,034 (0 - 2,369)	5 (0 - 11)
			Intentional Mortality	325 (17 - 592)	325 (17 - 592)	0 (0 - 1)	0 (0 - 1)
			Observe/Harass	127 (0 - 255)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
			Sample Tissue Dead Animal	2 (0 - 12)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
CCC steelhead	Adult	Natural	Capture	3,208 (1,315 - 5,994)	48 (25 - 77)	114 (4 - 251)	0 (0 - 3)

Species	**Life Stage**	**Origin**	**Take Activity**	**Requested Take**	**Requested Mortality**	**Reported Take**	**Reported Mortality**
			Observe/Harass	4,211 (0 - 9,005)	0 (0 - 0)	262 (0 - 678)	0 (0 - 0)
			Sample Tissue Dead Animal	330 (0 - 1,220)	0 (0 - 0)	6 (0 - 42)	1 (0 - 7)
		Hatchery	Capture	192 (0 - 485)	4 (0 - 10)	1 (0 - 5)	0 (0 - 0)
			Observe/Harass	905 (0 - 3,430)	0 (0 - 0)	40 (0 - 145)	0 (0 - 0)
			Sample Tissue Dead Animal	140 (0 - 600)	0 (0 - 0)	3 (0 - 18)	0 (0 - 0)
	Juvenile	Natural	Capture	256,107 (203,548 - 313,594)	5,955 (4,617 - 7,933)	31,651 (21,292 - 52,424)	268 (150 - 574)
			Intentional Mortality	456 (234 - 920)	456 (234 - 920)	2 (0 - 22)	2 (0 - 22)
			Observe/Harass	78,365 (2,650 - 162,600)	1 (0 - 2)	21,557 (83 - 57,656)	0 (0 - 0)
			Sample Tissue Dead Animal	402 (0 - 1,000)	0 (0 - 0)	25 (0 - 253)	0 (0 - 0)
		Hatchery	Capture	8,250 (1,512 - 19,100)	181 (47 - 400)	15 (0 - 53)	0 (0 - 0)
			Intentional Mortality	72 (0 - 150)	72 (0 - 150)	0 (0 - 3)	0 (0 - 3)
SCCC steelhead	Adult	Natural	Capture	178 (130 - 260)	4 (2 - 6)	0 (0 - 0)	0 (0 - 0)
			Observe/Harass	50 (0 - 100)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Juvenile	Natural	Capture	34,335 (27,722 - 54,780)	710 (520 - 1,118)	5,390 (2,273 - 7,930)	29 (7 - 58)
			Intentional Mortality	270 (200 - 400)	270 (200 - 400)	0 (0 - 0)	0 (0 - 0)
			Observe/Harass	2,070 (1,740 - 2,540)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
SDPS eulachon	Adult	Natural	Capture	8,620 (2,802 - 20,481)	7,915 (1,900 - 20,075)	2,191 (0 - 6,502)	2,172 (0 - 6,483)
		Natural	Intentional Mortality	100 (100 - 100)	100 (100 - 100)	0 (0 - 0)	0 (0 - 0)

Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality	Reported Take	Reported Mortality
	Juvenile	Natural	Capture	906 (220 - 2,220)	874 (220 - 2,220)	1 (0 - 5)	1 (0 - 5)
		Natural	Observe/Harass	42 (30 - 50)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
SDPS green sturgeon	Adult	Natural	Capture	247 (114 - 536)	9 (4 - 22)	14 (0 - 51)	0 (0 - 0)
		Natural	Observe/Harass	11 (10 - 13)	0 (0 - 0)	0 (0 - 2)	0 (0 - 0)
	Egg	Natural	Intentional Mortality	1,321 (1,250 - 1,350)	1,321 (1,250 - 1,350)	0 (0 - 0)	0 (0 - 0)
	Juvenile	Natural	Capture	1,223 (2 - 2,155)	78 (0 - 121)	65 (0 - 165)	3 (0 - 10)
		Natural	Observe/Harass	41 (10 - 70)	0 (0 - 0)	0 (0 - 2)	0 (0 - 0)
		Natural	Sample Tissue Dead Animal	182 (28 - 304)	0 (0 - 0)	1 (0 - 2)	0 (0 - 0)
	Larvae	Natural	Capture	6,880 (10 - 11,000)	763 (0 - 1,000)	1,629 (0 - 4,901)	99 (0 - 391)
		Natural	Intentional Mortality	15 (15 - 15)	15 (15 - 15)	0 (0 - 0)	0 (0 - 0)

Table A.2. Ten-year (2011-2020) average annual requested take and actual (reported) take at the ESU/DPS scale under the Programs (minimum and maximum in parentheses).

Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality	Reported Take	Reported Mortality
PS Chinook salmon	Adult	Natural	Capture	114 (47 - 141)	3 (0 - 16)	1 (0 - 5)	0 (0 - 2)
		Hatchery	Capture	110 (67 - 214)	7 (0 - 44)	1 (0 - 6)	0 (0 - 2)
	Juvenile	Natural	Capture	295,273 (258,613 - 367,025)	3,020 (2,436 - 4,084)	83,607 (38,266 - 132,657)	593 (167 - 1,152)
			Intentional Mortality	705 (100 - 1,546)	705 (100 - 1,546)	261 (0 - 778)	261 (0 - 778)

Species	**Life Stage**	**Origin**	**Take Activity**	**Requested Take**	**Requested Mortality**	**Reported Take**	**Reported Mortality**
		Hatchery	Capture	117,062 (48,926 - 169,030)	1,410 (535 - 2,453)	16,741 (8,354 - 31,833)	70 (7 - 329)
			Intentional Mortality	1,183 (0 - 4,009)	1,183 (0 - 4,009)	728 (0 - 2,990)	728 (0 - 2,990)
	Spawned Adult	Natural	Capture	7 (0 - 10)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
			Sample Tissue Dead Animal	752 (0 - 2,170)	0 (0 - 0)	221 (0 - 1,082)	0 (0 - 0)
		Hatchery	Sample Tissue Dead Animal	618 (0 - 1,960)	0 (0 - 0)	121 (0 - 478)	0 (0 - 0)
SRSS Chinook salmon	Adult	Natural	Capture	2,103 (29 - 3,463)	18 (2 - 26)	697 (0 - 1,644)	1 (0 - 5)
			Sample Tissue Dead Animal	0 (0 - 1)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	1,295 (31 - 3,191)	4 (0 - 9)	325 (0 - 851)	0 (0 - 0)
	Juvenile	Natural	Capture	517,511 (223,583 - 675,869)	4,766 (2,721 - 6,660)	130,914 (31,468 - 254,498)	445 (104 - 803)
			Intentional Mortality	43 (3 - 120)	43 (3 - 120)	2 (0 - 12)	2 (0 - 12)
			Observe/Harass	757 (0 - 1,750)	0 (0 - 0)	95 (0 - 438)	0 (0 - 0)
			Sample Tissue Dead Animal	4 (0 - 20)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	105,903 (8,858 - 188,025)	1,124 (162 - 1,934)	51,244 (393 - 114,647)	992 (0 - 9,157)
			Observe/Harass	4 (0 - 10)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Spawned Adult	Natural	Capture	34 (0 - 75)	0 (0 - 2)	1 (0 - 12)	0 (0 - 0)
			Sample Tissue Dead Animal	3,424 (1,535 - 4,370)	0 (0 - 1)	612 (61 - 1,605)	12 (0 - 124)
		Hatchery	Capture	30 (0 - 50)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
			Sample Tissue Dead Animal	1,241 (300 - 1,745)	0 (0 - 0)	241 (17 - 717)	11 (0 - 108)

Species	**Life Stage**	**Origin**	**Take Activity**	**Requested Take**	**Requested Mortality**	**Reported Take**	**Reported Mortality**
SRF Chinook salmon	Adult	Natural	Capture	39 (6 - 65)	1 (0 - 3)	0 (0 - 1)	0 (0 - 0)
		Hatchery	Capture	35 (4 - 75)	2 (0 - 3)	0 (0 - 0)	0 (0 - 0)
	Juvenile	Natural	Capture	1,391 (845 - 1,750)	32 (21 - 46)	64 (0 - 370)	1 (0 - 3)
			Intentional Mortality	15 (3 - 60)	15 (3 - 60)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	734 (465 - 1,130)	21 (13 - 33)	0 (0 - 0)	0 (0 - 0)
	Spawned Adult	Natural	Capture	2 (0 - 5)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
LCR Chinook salmon	Adult	Natural	Capture	533 (181 - 833)	8 (4 - 12)	196 (46 - 328)	0 (0 - 0)
			Observe/Harass	196 (160 - 210)	0 (0 - 0)	0 (0 - 1)	0 (0 - 0)
		Hatchery	Capture	333 (0 - 775)	4 (0 - 9)	118 (0 - 295)	0 (0 - 1)
			Intentional Mortality	8 (0 - 15)	8 (0 - 15)	2 (0 - 6)	2 (0 - 6)
			Observe/Harass	1,597 (405 - 4,060)	0 (0 - 0)	48 (0 - 275)	0 (0 - 0)
	Juvenile	Natural	Capture	1,418,720 (684,673 - 2,049,327)	15,510 (9,123 - 21,595)	186,196 (85,448 - 314,270)	2,841 (1,069 - 5,091)
			Intentional Mortality	144 (70 - 340)	144 (70 - 340)	6 (0 - 50)	6 (0 - 50)
			Observe/Harass	1,130 (750 - 1,950)	0 (0 - 0)	242 (10 - 612)	0 (0 - 0)
		Hatchery	Capture	50,156 (2,000 - 96,845)	805 (42 - 1,491)	6,819 (0 - 21,108)	114 (0 - 543)
			Observe/Harass	400 (0 - 2,000)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Spawned Adult	Natural	Capture	17 (5 - 20)	0 (0 - 1)	0 (0 - 0)	0 (0 - 0)
			Sample Tissue Dead Animal	2 (0 - 20)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)

Species	**Life Stage**	**Origin**	**Take Activity**	**Requested Take**	**Requested Mortality**	**Reported Take**	**Reported Mortality**
		Hatchery	Sample Tissue Dead Animal	2 (0 - 20)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
UWR Chinook salmon	Adult	Natural	Capture	147 (126 - 209)	3 (1 - 8)	4 (0 - 35)	0 (0 - 0)
			Observe/Harass	78 (30 - 285)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	105 (61 - 145)	4 (2 - 9)	53 (4 - 118)	0 (0 - 2)
			Observe/Harass	194 (110 - 550)	0 (0 - 0)	7 (0 - 35)	0 (0 - 0)
	Juvenile	Natural	Capture	58,811 (33,735 - 101,771)	814 (404 - 1,229)	20,338 (1,935 - 40,414)	168 (19 - 381)
			Intentional Mortality	63 (24 - 180)	63 (24 - 180)	1 (0 - 5)	1 (0 - 5)
			Observe/Harass	1,020 (300 - 1,500)	0 (0 - 0)	95 (0 - 426)	0 (0 - 0)
		Hatchery	Capture	12,793 (6,115 - 22,540)	173 (94 - 366)	133 (0 - 507)	1 (0 - 10)
			Observe/Harass	250 (250 - 250)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Spawned Adult	Natural	Capture	10 (10 - 10)	0 (0 - 1)	4 (0 - 41)	0 (0 - 0)
			Observe/Harass	18 (0 - 180)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
			Sample Tissue Dead Animal	1 (0 - 5)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	30 (0 - 50)	1 (0 - 1)	5 (0 - 51)	0 (0 - 0)
			Observe/Harass	33 (0 - 330)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
			Sample Tissue Dead Animal	1 (0 - 5)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
CC Chinook salmon	Adult	Natural	Capture	2,443 (145 - 4,435)	2 (0 - 3)	735 (1 - 3,503)	0 (0 - 1)
			Observe/Harass	14,374 (270 - 30,396)	0 (0 - 0)	4,158 (168 - 11,337)	0 (0 - 0)

Species	**Life Stage**	**Origin**	**Take Activity**	**Requested Take**	**Requested Mortality**	**Reported Take**	**Reported Mortality**
			Sample Tissue Dead Animal	0 (0 - 2)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Juvenile	Natural	Capture	281,674 (216,040 - 458,578)	2,929 (2,175 - 4,191)	147,298 (7,010 - 512,396)	314 (40 - 810)
			Observe/Harass	3,594 (0 - 9,190)	0 (0 - 0)	310 (0 - 1,000)	0 (0 - 0)
	Spawned Adult	Natural	Observe/Harass	8 (0 - 80)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
			Sample Tissue Dead Animal	1,829 (595 - 2,715)	0 (0 - 0)	193 (37 - 519)	0 (0 - 0)
CVS Chinook salmon	Adult	Natural	Capture	2,523 (64 - 5,885)	39 (0 - 60)	537 (0 - 1,817)	0 (0 - 1)
			Observe/Harass	40,933 (22,710 - 56,050)	0 (0 - 3)	7,434 (1,967 - 14,716)	0 (0 - 0)
			Sample Tissue Dead Animal	10 (0 - 100)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	16,074 (38 - 29,055)	134 (0 - 275)	4,502 (0 - 18,648)	13 (0 - 54)
			Observe/Harass	11,196 (5,400 - 29,900)	1 (0 - 10)	1,468 (395 - 5,572)	0 (0 - 0)
			Sample Tissue Dead Animal	2 (0 - 15)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Juvenile	Natural	Capture	438,035 (35,870 - 537,241)	4,453 (450 - 5,406)	113,800 (197 - 455,598)	1,186 (1 - 4,076)
			Intentional Mortality	10 (0 - 100)	10 (0 - 100)	0 (0 - 0)	0 (0 - 0)
			Observe/Harass	19,935 (3,100 - 35,775)	0 (0 - 0)	1,189 (0 - 6,511)	0 (0 - 0)
		Hatchery	Capture	14,909 (1,000 - 26,920)	148 (7 - 267)	409 (0 - 3,035)	5 (0 - 29)
			Intentional Mortality	61 (0 - 160)	61 (0 - 160)	14 (0 - 43)	14 (0 - 43)
			Observe/Harass	715 (250 - 1,675)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Spawned Adult	Natural	Observe/Harass	7,700 (0 - 19,250)	0 (0 - 0)	1,942 (0 - 14,860)	0 (0 - 0)

Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality	Reported Take	Reported Mortality
			Sample Tissue Dead Animal	13,812 (3,930 - 23,430)	0 (0 - 0)	4,739 (83 - 16,900)	0 (0 - 0)
		Hatchery	Sample Tissue Dead Animal	5,227 (0 - 7,195)	0 (0 - 0)	942 (0 - 4,081)	0 (0 - 0)
HCS chum salmon	Adult	Natural	Capture	4,133 (500 - 10,120)	24 (5 - 35)	1,981 (29 - 7,460)	3 (0 - 12)
	Juvenile	Natural	Capture	523,894 (302,062 - 656,274)	2,552 (1,823 - 3,722)	171,122 (39,063 - 417,928)	458 (184 - 825)
			Intentional Mortality	6 (0 - 31)	6 (0 - 31)	0 (0 - 1)	0 (0 - 1)
		Hatchery	Capture	150 (0 - 555)	1 (0 - 4)	17 (0 - 161)	0 (0 - 0)
	Spawned Adult	Natural	Sample Tissue Dead Animal	280 (0 - 800)	0 (0 - 0)	130 (0 - 300)	0 (0 - 0)
CR chum salmon	Adult	Natural	Capture	21 (0 - 50)	1 (0 - 3)	0 (0 - 1)	0 (0 - 0)
	Juvenile	Natural	Capture	17,087 (3,635 - 33,595)	222 (37 - 441)	2,455 (2 - 10,565)	11 (0 - 75)
			Intentional Mortality	4 (0 - 12)	4 (0 - 12)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	500 (500 - 500)	5 (4 - 5)	0 (0 - 0)	0 (0 - 0)
	Spawned Adult	Natural	Capture	1 (0 - 5)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
LCR coho salmon	Adult	Natural	Capture	2,152 (485 - 3,436)	23 (7 - 37)	676 (10 - 2,203)	2 (0 - 5)
			Observe/Harass	465 (100 - 1,020)	0 (0 - 0)	3 (0 - 22)	0 (0 - 0)
		Hatchery	Capture	2,002 (75 - 3,009)	36 (1 - 53)	188 (1 - 675)	2 (0 - 11)
			Intentional Mortality	6 (0 - 10)	6 (0 - 10)	0 (0 - 0)	0 (0 - 0)
			Observe/Harass	924 (200 - 2,010)	0 (0 - 0)	23 (0 - 154)	0 (0 - 0)
	Juvenile	Natural	Capture	190,282 (151,174 - 289,683)	2,431 (1,924 - 5,047)	38,133 (20,304 - 73,941)	217 (80 - 351)

Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality	Reported Take	Reported Mortality
			Intentional Mortality	139 (44 - 310)	139 (44 - 310)	15 (0 - 89)	15 (0 - 89)
			Observe/Harass	13,800 (8,550 - 22,500)	0 (0 - 0)	4,923 (1,493 - 8,259)	0 (0 - 0)
		Hatchery	Capture	50,457 (14,240 - 89,780)	682 (146 - 1,116)	7,344 (8 - 22,898)	99 (0 - 825)
			Intentional Mortality	11 (0 - 50)	11 (0 - 50)	0 (0 - 0)	0 (0 - 0)
	Spawned Adult	Natural	Capture	19 (10 - 25)	0 (0 - 2)	0 (0 - 0)	0 (0 - 0)
			Sample Tissue Dead Animal	2 (0 - 20)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Sample Tissue Dead Animal	2 (0 - 20)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
OC coho salmon	Adult	Natural	Capture	10,974 (5,412 - 14,262)	111 (54 - 143)	3,679 (1,346 - 11,432)	12 (3 - 30)
			Observe/Harass	14,315 (12,750 - 15,950)	0 (0 - 0)	1,215 (176 - 2,432)	0 (0 - 0)
		Hatchery	Capture	6 (0 - 13)	0 (0 - 1)	0 (0 - 0)	0 (0 - 0)
			Observe/Harass	120 (0 - 200)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Juvenile	Natural	Capture	625,663 (478,555 - 734,241)	13,661 (10,830 - 16,162)	157,114 (74,621 - 356,411)	1,404 (457 - 3,692)
			Intentional Mortality	222 (0 - 436)	222 (0 - 436)	14 (0 - 62)	14 (0 - 62)
			Observe/Harass	152,978 (135,470 - 178,470)	0 (0 - 0)	74,951 (41,103 - 103,602)	0 (0 - 0)
		Hatchery	Capture	277 (0 - 2,185)	8 (0 - 62)	0 (0 - 1)	0 (0 - 0)
	Spawned Adult	Natural	Sample Tissue Dead Animal	930 (50 - 2,250)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Sample Tissue Dead Animal	50 (0 - 100)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
SONCC coho salmon	Adult	Natural	Capture	1,296 (1,110 - 1,555)	10 (8 - 12)	354 (189 - 601)	0 (0 - 2)

Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality	Reported Take	Reported Mortality
			Observe/Harass	5,713 (1,643 - 10,649)	0 (0 - 0)	2,724 (1,429 - 4,370)	0 (0 - 0)
			Sample Tissue Dead Animal	6 (0 - 60)	0 (0 - 0)	9 (0 - 90)	0 (0 - 0)
		Hatchery	Capture	1,782 (1,345 - 2,171)	9 (8 - 11)	331 (11 - 1,046)	0 (0 - 2)
			Observe/Harass	3,339 (0 - 14,935)	0 (0 - 0)	62 (0 - 437)	0 (0 - 0)
	Juvenile	Natural	Capture	88,274 (59,590 - 105,480)	1,008 (701 - 1,251)	24,159 (10,203 - 37,928)	114 (31 - 393)
			Intentional Mortality	3 (0 - 10)	3 (0 - 10)	0 (0 - 1)	0 (0 - 1)
			Observe/Harass	43,552 (24,100 - 64,722)	0 (0 - 0)	27,561 (5,345 - 161,664)	0 (0 - 0)
			Sample Tissue Dead Animal	3 (0 - 25)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	1,424 (1,250 - 1,700)	23 (6 - 131)	19 (0 - 189)	0 (0 - 3)
			Intentional Mortality	25 (0 - 125)	25 (0 - 125)	0 (0 - 0)	0 (0 - 0)
			Observe/Harass	4 (0 - 30)	0 (0 - 0)	0 (0 - 2)	0 (0 - 0)
			Sample Tissue Dead Animal	1 (0 - 5)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Spawned Adult	Natural	Capture	1 (0 - 5)	0 (0 - 0)	1 (0 - 14)	0 (0 - 0)
			Sample Tissue Dead Animal	1,872 (1,320 - 2,137)	0 (0 - 0)	406 (98 - 940)	0 (0 - 0)
		Hatchery	Sample Tissue Dead Animal	153 (0 - 230)	0 (0 - 0)	5 (0 - 32)	0 (0 - 0)
PS steelhead	Adult	Natural	Capture	1,082 (902 - 1,552)	18 (14 - 27)	215 (56 - 376)	0 (0 - 0)
		Hatchery	Capture	6 (0 - 15)	0 (0 - 4)	3 (0 - 11)	0 (0 - 0)
	Juvenile	Natural	Capture	35,684 (21,211 - 60,869)	501 (362 - 786)	8,747 (4,851 - 12,345)	52 (29 - 83)

Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality	Reported Take	Reported Mortality
			Intentional Mortality	167 (0 - 510)	167 (0 - 510)	33 (0 - 326)	33 (0 - 326)
		Hatchery	Capture	6,180 (3,363 - 10,499)	92 (40 - 178)	523 (126 - 2,169)	1 (0 - 3)
			Intentional Mortality	13 (0 - 120)	13 (0 - 120)	6 (0 - 60)	6 (0 - 60)
	Spawned Adult	Natural	Capture	35 (17 - 82)	2 (0 - 4)	4 (0 - 14)	0 (0 - 0)
UCR steelhead	Juvenile	Natural	Capture	1,070 (500 - 2,500)	12 (5 - 25)	10 (0 - 60)	0 (0 - 0)
SRB steelhead	Adult	Natural	Capture	2,475 (1,338 - 3,905)	35 (21 - 60)	651 (25 - 1,976)	3 (0 - 15)
			Observe/Harass	8 (0 - 25)	0 (0 - 0)	3 (0 - 22)	0 (0 - 0)
			Sample Tissue Dead Animal	0 (0 - 1)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	621 (205 - 1,075)	17 (6 - 24)	168 (1 - 878)	0 (0 - 1)
	Juvenile	Natural	Capture	167,563 (139,761 - 193,655)	2,132 (1,677 - 2,696)	46,942 (13,335 - 82,893)	190 (31 - 401)
			Intentional Mortality	84 (3 - 180)	84 (3 - 180)	11 (0 - 50)	11 (0 - 50)
			Observe/Harass	536 (0 - 1,250)	0 (0 - 0)	119 (0 - 465)	0 (0 - 0)
			Sample Tissue Dead Animal	5 (0 - 25)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	11,941 (3,235 - 24,305)	167 (70 - 294)	487 (0 - 1,293)	0 (0 - 3)
			Observe/Harass	30 (0 - 75)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Spawned Adult	Natural	Capture	813 (505 - 1,185)	14 (7 - 26)	84 (6 - 271)	1 (0 - 5)
			Sample Tissue Dead Animal	81 (0 - 120)	0 (0 - 0)	4 (0 - 17)	0 (0 - 0)
		Hatchery	Capture	18 (0 - 75)	2 (0 - 10)	0 (0 - 3)	0 (0 - 1)

Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality	Reported Take	Reported Mortality
MCR steelhead	Adult	Natural	Capture	2,702 (1,144 - 4,875)	24 (12 - 37)	698 (107 - 1,490)	3 (0 - 9)
			Observe/Harass	449 (285 - 650)	0 (0 - 0)	209 (43 - 336)	0 (0 - 0)
		Hatchery	Capture	1,120 (850 - 2,350)	13 (10 - 25)	572 (153 - 1,085)	1 (0 - 5)
			Observe/Harass	2 (0 - 15)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Juvenile	Natural	Capture	94,788 (54,610 - 159,996)	1,566 (930 - 2,577)	30,667 (12,091 - 48,872)	340 (70 - 665)
			Intentional Mortality	347 (206 - 820)	347 (206 - 820)	39 (0 - 152)	39 (0 - 152)
			Observe/Harass	5,410 (2,500 - 14,500)	2 (0 - 10)	661 (0 - 1,955)	0 (0 - 0)
		Hatchery	Capture	16,800 (580 - 34,835)	420 (14 - 833)	1,856 (0 - 10,699)	13 (0 - 79)
			Observe/Harass	3 (0 - 25)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Spawned Adult	Natural	Capture	574 (165 - 1,070)	14 (10 - 31)	86 (7 - 195)	1 (0 - 3)
			Sample Tissue Dead Animal	316 (0 - 450)	0 (0 - 0)	18 (0 - 50)	0 (0 - 0)
		Hatchery	Capture	40 (25 - 150)	10 (2 - 75)	3 (0 - 22)	0 (0 - 0)
LCR steelhead	Adult	Natural	Capture	2,278 (1,595 - 2,542)	23 (18 - 26)	625 (248 - 1,092)	3 (0 - 5)
			Observe/Harass	156 (100 - 260)	0 (0 - 0)	1 (0 - 5)	0 (0 - 0)
		Hatchery	Capture	60 (0 - 106)	2 (0 - 5)	18 (0 - 60)	0 (0 - 1)
			Observe/Harass	18 (0 - 100)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Juvenile	Natural	Capture	54,296 (49,115 - 62,785)	719 (616 - 891)	15,931 (10,470 - 26,942)	50 (15 - 172)
			Intentional Mortality	193 (133 - 310)	193 (133 - 310)	41 (0 - 235)	41 (0 - 235)

Species	**Life Stage**	**Origin**	**Take Activity**	**Requested Take**	**Requested Mortality**	**Reported Take**	**Reported Mortality**
			Observe/Harass	3,020 (1,350 - 7,300)	0 (0 - 0)	673 (59 - 1,717)	0 (0 - 0)
		Hatchery	Capture	35,985 (18,410 - 50,560)	596 (362 - 991)	6,194 (1,180 - 10,832)	316 (0 - 3,031)
			Observe/Harass	100 (0 - 500)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Spawned Adult	Natural	Capture	86 (45 - 105)	2 (1 - 4)	8 (0 - 26)	0 (0 - 0)
			Observe/Harass	2 (0 - 20)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
			Sample Tissue Dead Animal	2 (0 - 20)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	35 (33 - 35)	1 (0 - 4)	1 (0 - 4)	0 (0 - 0)
			Sample Tissue Dead Animal	2 (0 - 20)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
UWR steelhead	Adult	Natural	Capture	220 (185 - 237)	2 (2 - 4)	2 (0 - 15)	0 (0 - 0)
			Observe/Harass	33 (5 - 210)	0 (0 - 0)	0 (0 - 3)	0 (0 - 0)
	Juvenile	Natural	Capture	5,626 (3,655 - 9,510)	113 (83 - 167)	113 (5 - 349)	0 (0 - 2)
			Intentional Mortality	30 (0 - 150)	30 (0 - 150)	0 (0 - 1)	0 (0 - 1)
			Observe/Harass	1,505 (1,505 - 1,505)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Spawned Adult	Natural	Observe/Harass	18 (0 - 180)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
			Sample Tissue Dead Animal	1 (0 - 5)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
NC steelhead	Adult	Natural	Capture	2,291 (375 - 2,976)	3 (0 - 7)	333 (81 - 976)	0 (0 - 0)
			Observe/Harass	7,224 (200 - 16,860)	0 (0 - 0)	2,115 (26 - 5,871)	0 (0 - 0)
			Sample Tissue Dead Animal	2 (0 - 10)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)

Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality	Reported Take	Reported Mortality
		Hatchery	Capture	20 (0 - 100)	0 (0 - 1)	0 (0 - 0)	0 (0 - 0)
	Juvenile	Natural	Capture	199,635 (112,060 - 264,611)	1,793 (978 - 2,233)	73,473 (4,352 - 162,751)	217 (41 - 350)
			Observe/Harass	8,394 (0 - 17,050)	0 (0 - 0)	1,104 (0 - 2,020)	0 (0 - 0)
	Spawned Adult	Natural	Capture	3 (0 - 30)	0 (0 - 0)	2 (0 - 17)	0 (0 - 0)
			Observe/Harass	12 (0 - 120)	0 (0 - 0)	6 (0 - 62)	0 (0 - 0)
			Sample Tissue Dead Animal	563 (170 - 835)	0 (0 - 0)	9 (0 - 28)	0 (0 - 0)
CCV steelhead	Adult	Natural	Capture	1,314 (601 - 2,246)	18 (10 - 29)	262 (4 - 407)	0 (0 - 1)
			Observe/Harass	5,019 (2,088 - 7,479)	0 (0 - 1)	1,303 (123 - 3,595)	0 (0 - 0)
			Sample Tissue Dead Animal	1 (0 - 8)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Capture	2,702 (178 - 6,515)	14 (3 - 28)	1,363 (0 - 3,492)	0 (0 - 0)
			Observe/Harass	3,189 (1,145 - 4,835)	0 (0 - 1)	326 (23 - 866)	0 (0 - 0)
	Juvenile	Natural	Capture	14,066 (12,296 - 18,333)	216 (170 - 298)	1,309 (232 - 3,131)	9 (0 - 19)
			Intentional Mortality	5 (0 - 25)	5 (0 - 25)	0 (0 - 0)	0 (0 - 0)
			Observe/Harass	45,861 (9,155 - 73,520)	0 (0 - 0)	6,008 (364 - 16,781)	0 (0 - 0)
		Hatchery	Capture	2,016 (770 - 5,775)	18 (10 - 41)	24 (0 - 102)	0 (0 - 1)
			Intentional Mortality	20 (0 - 200)	20 (0 - 200)	0 (0 - 3)	0 (0 - 3)
			Observe/Harass	2,649 (1,030 - 5,030)	0 (0 - 0)	1 (0 - 4)	0 (0 - 0)
	Spawned Adult	Natural	Sample Tissue Dead Animal	218 (76 - 367)	0 (0 - 0)	32 (1 - 92)	0 (0 - 0)

Species	**Life Stage**	**Origin**	**Take Activity**	**Requested Take**	**Requested Mortality**	**Reported Take**	**Reported Mortality**
		Hatchery	Sample Tissue Dead Animal	27 (0 - 77)	0 (0 - 0)	0 (0 - 3)	0 (0 - 0)
CCC steelhead	Adult	Natural	Capture	27 (14 - 51)	0 (0 - 1)	3 (0 - 14)	0 (0 - 3)
			Observe/Harass	356 (0 - 915)	0 (0 - 0)	4 (0 - 26)	0 (0 - 0)
			Sample Tissue Dead Animal	4 (0 - 22)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
		Hatchery	Observe/Harass	2 (0 - 20)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Juvenile	Natural	Capture	12,246 (2,284 - 18,913)	206 (45 - 313)	1,108 (515 - 3,893)	6 (0 - 18)
			Observe/Harass	1,963 (520 - 2,630)	0 (0 - 0)	129 (0 - 428)	0 (0 - 0)
	Spawned Adult	Natural	Capture	19 (0 - 49)	0 (0 - 2)	0 (0 - 0)	0 (0 - 0)
			Observe/Harass	2 (0 - 20)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
			Sample Tissue Dead Animal	147 (10 - 630)	0 (0 - 0)	1 (0 - 4)	0 (0 - 0)
		Hatchery	Sample Tissue Dead Animal	2 (0 - 20)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
SCCC steelhead	Adult	Natural	Capture	157 (10 - 887)	1 (0 - 4)	1 (0 - 7)	0 (0 - 0)
			Observe/Harass	2,308 (693 - 4,020)	0 (0 - 0)	545 (0 - 3,886)	0 (0 - 0)
	Juvenile	Natural	Capture	13,822 (9,730 - 16,640)	141 (88 - 233)	1,580 (62 - 3,961)	5 (0 - 20)
			Observe/Harass	2,101 (1,300 - 3,395)	0 (0 - 0)	3 (0 - 15)	0 (0 - 0)
			Recondition and release	1,200 (0 - 12,000)	12 (0 - 120)	251 (0 - 2,507)	1 (0 - 14)
	Spawned Adult	Natural	Capture	8 (0 - 17)	0 (0 - 1)	0 (0 - 0)	0 (0 - 0)
			Observe/Harass	1 (0 - 7)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)

Species	Life Stage	Origin	Take Activity	Requested Take	Requested Mortality	Reported Take	Reported Mortality
			Sample Tissue Dead Animal	64 (40 - 85)	0 (0 - 0)	0 (0 - 2)	0 (0 - 0)
SDPS eulachon	Adult	Natural	Capture	1,638 (913 - 2,165)	85 (44 - 185)	20 (1 - 67)	2 (0 - 15)
			Intentional Mortality	0 (0 - 2)	0 (0 - 2)	0 (0 - 0)	0 (0 - 0)
			Observe/Harass	0 (0 - 1)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Spawned Adult	Natural	Capture	1,160 (0 - 2,200)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
SDPS green sturgeon	Adult	Natural	Capture	57 (16 - 197)	1 (0 - 4)	11 (0 - 81)	0 (0 - 0)
			Observe/Harass	349 (206 - 750)	0 (0 - 0)	106 (12 - 300)	0 (0 - 0)
	Egg	Natural	Intentional Mortality	345 (60 - 1,310)	345 (60 - 1,310)	37 (0 - 270)	37 (0 - 270)
	Larvae	Natural	Capture	231 (59 - 859)	69 (15 - 330)	66 (0 - 643)	11 (0 - 110)
	Juvenile	Natural	Capture	47 (2 - 239)	3 (0 - 25)	0 (0 - 0)	0 (0 - 0)
			Observe/Harass	8 (0 - 29)	0 (0 - 0)	0 (0 - 0)	0 (0 - 0)
	Subadult	Natural	Capture	19 (0 - 154)	0 (0 - 3)	3 (0 - 30)	0 (0 - 0)

Table A.3: Estimated annual abundance of the species from previous biological opinions for the Programs (NMFS 2011, NMFS 2012, NMFS 2013a, NMFS 2014a, NMFS 2015a, NMFS 2015b, NMFS 2016a, NMFS 2016b, NMFS 2017, NMFS 2018, NMFS 2019, NMFS 2020).

Species	Life Stage	Origin	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
PS Chinook	Adult	Natural	35,894	25,928	25,928	19,750	18,127	19,258	19,258	18,413	18,413	22,398
PS Chinook	Adult	Hatchery	16,125	12,206	12,206	11,205	11,089	13,223	13,223	13,227	13,227	15,543

Species	Life Stage	Origin	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
PS Chinook	Juvenile	Natural	8,600,000	3,050,000	3,050,720	2,476,383	2,337,280	2,600,000	2,598,480	2,531,163	2,531,163	3,035,288
PS Chinook	Juvenile	Hatchery	25,174,000	24,074,000	24,074,000	42,819,650	42,609,650	41,809,650	41,809,650	43,269,740	43,269,740	43,568,630
SRSS Chinook	Adult	Natural	11,393	4,454	15,911	15,911	20,422	23,801	11,347	11,347	18,270	12,798
SRSS Chinook	Adult	Hatchery	45,570	3,096	11,221	11,221	60,058	62,799	5,696	5,696	4,010	2,808
SRSS Chinook	Juvenile	Natural	1,331,541	1,268,554	1,290,830	1,290,830	1,454,727	1,416,621	1,420,448	1,383,142	1,201,631	1,007,526
SRSS Chinook	Juvenile	Hatchery	4,458,293	4,620,205	4,784,913	4,784,913	5,545,380	5,343,039	5,409,936	5,460,651	5,571,748	5,228,968
SRF Chinook	Adult	Natural	5,977	2,490	3,646	3,646	14,438	11,254	11,254	11,254	12,029	10,337
SRF Chinook	Adult	Hatchery	8,966	8,830	15,373	15,373	30,475	37,812	26,558	26,558	97,325	29,059
SRF Chinook	Juvenile	Natural	555,332	769,148	835,652	835,652	570,821	605,921	544,134	585,720	788,775	692,819
SRF Chinook	Juvenile	Hatchery	5,769,614	6,052,580	6,882,446	6,882,446	6,856,771	6,397,599	5,974,592	5,586,538	5,715,434	5,346,131
LCR Chinook	Adult	Natural	14,130	17,961	17,961	17,961	13,594	29,469	29,469	29,469	29,469	29,469
LCR Chinook	Adult	Hatchery	15,980	13,847	13,847	13,847	22,868	38,594	38,594	38,594	38,594	38,594
LCR Chinook	Juvenile	Natural	23,063,840	20,631,535	18,186,523	18,186,523	13,271,270	12,866,892	12,427,062	12,164,845	11,906,946	11,745,027
LCR Chinook	Juvenile	Hatchery	39,346,269	37,875,617	37,013,538	37,013,538	36,407,748	36,449,211	35,477,813	34,836,856	34,130,756	32,315,853
UWR Chinook	Adult	Natural	6,971	8,527	9,572	9,572	11,061	11,443	11,443	11,443	11,443	10,203
UWR Chinook	Adult	Hatchery	61,828	30,641	29,596	29,596	38,135	34,454	34,454	34,454	34,454	31,476
UWR Chinook	Juvenile	Natural	3,847,481	3,345,117	2,842,534	2,842,534	1,813,726	1,299,323	1,287,502	1,275,681	1,275,681	1,211,863
UWR Chinook	Juvenile	Hatchery	5,884,376	5,914,826	5,981,932	5,981,932	6,049,133	5,829,027	5,886,848	5,559,649	5,259,090	4,709,202
CC Chinook	Adult	Natural	7,144	7,144	7,144	7,144	7,144	7,034	7,034	7,034	7,034	7,034

Species	**Life Stage**	**Origin**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
CC Chinook	Juvenile	Natural	1,298,065	1,298,065	1,298,065	1,298,065	1,298,065	1,278,078	1,278,078	1,278,078	1,278,078	1,278,078
CVS Chinook	Adult	Natural	7,464	7,464	7,464	7,464	7,464	7,151	11,468	11,468	11,468	3,727
CVS Chinook	Adult	Hatchery	6,414	6,414	6,414	6,414	6,414	6,414	8,213	8,213	8,213	2,273
CVS Chinook	Juvenile	Natural	1,552,885	1,552,885	1,552,885	1,552,885	1,552,885	1,487,974	2,386,000	2,386,000	2,386,000	775,474
CVS Chinook	Juvenile	Hatchery	2,178,601	2,178,601	2,178,601	2,178,601	2,178,601	2,178,601	2,878,601	2,878,601	2,878,601	2,169,329
HCS Chum	Adult	Natural	24,711	15,608	15,608	15,463	17,556	17,556	20,855	25,538	25,538	25,146
HCS Chum	Adult	Hatchery	9,352	3,226	3,226	2,971	3,452	3,452	2,179	1,935	1,935	1,452
HCS Chum	Juvenile	Natural	4,400,000	2,750,000	2,754,473	2,696,003	3,072,420	3,072,420	3,368,592	4,017,929	4,017,929	3,889,955
HCS Chum	Juvenile	Hatchery	415,996	275,000	275,000	275,000	275,000	275,000	150,000	150,000	150,000	150,000
CR Chum	Adult	Natural	6,000	6,000	6,000	6,000	12,239	10,644	10,644	10,644	10,644	10,644
CR Chum	Adult	Hatchery	14,000	14,000	14,000	14,000	428	426	426	426	426	426
CR Chum	Juvenile	Natural	7,000,950	4,653,450	4,129,560	4,129,560	2,978,550	3,462,120	4,093,920	5,362,740	6,081,120	6,626,218
CR Chum	Juvenile	Hatchery	311,800	270,200	321,200	321,200	391,973	544,214	662,814	654,559	734,059	601,503
LCR Coho	Adult	Natural	20,765	23,507	23,507	23,507	10,957	32,986	32,986	32,986	32,986	29,866
LCR Coho	Adult	Hatchery	394,539	446,634	446,634	446,634	208,192	23,082	23,082	23,082	23,082	8,791
LCR Coho	Juvenile	Natural	1,178,205	1,187,042	1,069,927	1,069,927	839,118	729,256	619,576	639,015	652,672	661,468
LCR Coho	Juvenile	Hatchery	10,840,453	10,859,430	9,860,073	9,860,073	8,937,124	8,747,510	7,753,864	7,640,458	7,487,722	7,537,431
OC Coho	Adult	Natural	124,379	194,632	194,632	194,632	192,431	234,203	234,203	234,203	135,705	94,320
OC Coho	Adult	Hatchery	5,498	4,238	4,238	4,238	1,753	2,046	2,046	2,046	1,201	559

Species	Life Stage	Origin	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
OC Coho	Juvenile	Natural	11,000,000	14,000,000	11,000,000	11,000,000	13,470,170	16,000,000	16,394,210	16,394,210	16,394,210	6,641,564
OC Coho	Juvenile	Hatchery	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000
SONCC Coho	Adult	Natural	5,900	3,138	3,138	3,138	10,193	9,056	9,056	9,056	8,161	9,065
SONCC Coho	Adult	Hatchery	3,489	767	767	767	7,894	10,934	10,934	10,934	8,288	10,934
SONCC Coho	Juvenile	Natural	950,000	200,000	950,000	950,000	1,026,707	2,000,000	1,101,382	1,101,382	1,656,908	2,013,593
SONCC Coho	Juvenile	Hatchery	200,000	200,000	200,000	200,000	775,000	775,000	775,000	775,000	775,000	775,000
PS Steelhead	Adult	Natural and Hatchery	18,914	14,866	11,577	11,525	14,615	13,422	13,422	18,257	18,257	19,313
PS Steelhead	Juvenile	Natural	4,300,000	1,700,000	1,104,171	1,310,969	1,668,371	1,526,753	1,526,753	2,076,734	2,076,734	2,196,901
PS Steelhead	Juvenile	Hatchery	84,500	52,000	52,000	37,000	219,897	244,897	244,897	223,730	223,730	222,500
UCR Steelhead	Adult	Natural	2,954	1,592	1,592	1,592	2,728	2,728	2,846	2,846	3,618	1,931
UCR Steelhead	Adult	Hatchery	11,815	6,165	6,165	6,165	7,936	7,936	6,579	6,579	12,112	6,472
UCR Steelhead	Juvenile	Natural	209,931	247,969	298,447	298,447	286,452	280,338	245,890	176,213	181,772	199,380
UCR Steelhead	Juvenile	Hatchery	921,928	893,226	841,696	841,696	834,220	807,617	774,709	802,009	830,657	826,168
SRB Steelhead	Adult	Natural	34,821	18,847	31,344	31,344	46,336	35,553	33,340	33,340	29,289	10,547
SRB Steelhead	Adult	Hatchery	118,974	143,476	168,633	168,633	139,528	116,648	300,060	300,060	263,601	95,647
SRB Steelhead	Juvenile	Natural	1,159,152	1,307,703	1,417,531	1,417,531	1,399,511	1,142,126	890,596	804,571	834,970	798,341
SRB Steelhead	Juvenile	Hatchery	3,973,685	4,188,360	4,236,020	4,236,020	4,046,223	4,444,395	4,203,771	4,094,093	4,100,653	4,005,642
MCR Steelhead	Adult	Natural	23,610	12,277	12,277	12,277	24,127	23,872	23,872	23,872	9,242	5,052

Species	Life Stage	Origin	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
MCR Steelhead	Adult	Hatchery	10,083	2,087	2,155	2,155	2,724	1,842	1,842	1,842	1,027	560
MCR Steelhead	Juvenile	Natural	858,865	762,513	665,584	665,584	540,850	479,860	448,242	417,206	415,760	407,697
MCR Steelhead	Juvenile	Hatchery	524,100	642,880	770,380	770,380	773,669	639,606	550,426	453,864	512,190	555,442
LCR Steelhead	Adult	Natural	11,483	7,863	10,422	10,422	11,117	12,920	12,920	12,920	12,920	12,920
LCR Steelhead	Adult	Hatchery	17,378	10,201	10,201	10,201	23,000	22,297	22,297	22,297	22,297	22,297
LCR Steelhead	Juvenile	Natural	607,900	591,043	573,063	573,063	447,659	393,641	351,966	323,607	335,102	352,146
LCR Steelhead	Juvenile	Hatchery	967,344	953,744	990,944	990,944	1,028,157	1,129,744	1,147,193	1,216,950	1,289,093	1,206,294
UWR Steelhead	Adult	Natural	5,642	4,838	236,869	236,869	6,030	5,971	5,971	5,971	3,657	2,912
UWR Steelhead	Juvenile	Natural	229,168	231,332	5,157	5,157	215,847	207,853	163,084	143,898	143,898	140,396
NC Steelhead	Adult	Natural	4,286	4,286	4,286	4,286	4,286	7,221	7,221	7,221	7,221	7,221
NC Steelhead	Juvenile	Natural	487,533	487,533	487,533	487,533	487,533	821,389	821,389	821,389	821,389	821,389
CCV Steelhead	Adult	Natural	1,374	1,374	1,374	1,374	1,374	1,486	1,686	1,686	1,686	1,686
CCV Steelhead	Adult	Hatchery	3,359	3,359	3,359	3,359	3,359	3,822	3,856	3,856	3,856	3,856
CCV Steelhead	Juvenile	Natural	156,293	156,293	156,293	156,293	156,293	169,033	630,403	630,403	630,403	630,403
CCV Steelhead	Juvenile	Hatchery	1,600,653	1,600,653	1,600,653	1,600,653	1,600,653	1,600,653	1,600,653	1,600,653	1,600,653	1,600,653
CCC Steelhead	Adult	Natural	1,429	1,429	1,429	1,429	1,429	2,187	2,187	2,187	2,187	2,187
CCC Steelhead	Adult	Hatchery	3,866	3,866	3,866	3,866	3,866	3,866	3,866	3,866	3,866	3,866
CCC Steelhead	Juvenile	Natural	162,549	162,549	162,549	162,549	162,549	248,771	248,771	248,771	248,771	248,771

Species	Life Stage	Origin	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
CCC Steelhead	Juvenile	Hatchery	648,891	648,891	648,891	648,891	648,891	648,891	600,000	600,000	600,000	648,891
SCCC Steelhead	Adult	Natural	695	695	695	695	695	695	695	695	695	695
SCCC Steelhead	Juvenile	Natural	79,057	79,057	79,057	79,057	79,057	79,057	79,057	79,057	79,057	79,057
Eulachon	Adult	Natural		442,793	442,793	27,979,254	34,780,000	81,736,000	81,736,000	81,736,000	77,598,015	18,796,090
Green Sturgeon	Adult	Natural		800	800	800	800	800	1,348	1,348	2,106	2,106
Green Sturgeon	Juvenile	Natural		1,666	1,666	1,666	1,666	1,666	2,808	2,808	4,387	4,387
Green Sturgeon	Subadult	Natural		4,199	4,199	4,199	4,199	4,199	7,076	7,076	11,055	11,055

Table A.4: Total reported nonlethal take, in the Programs, for each component of the listed ESU/DPS.

Species	Life Stage	Origin	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
PS Chinook	Adult	Natural	5	0	1	0	3	0	1	0	0	0
PS Chinook	Adult	Hatchery	3	0	0	0	1	6	0	0	0	0
PS Chinook	Juvenile	Natural	77715	102578	132720	83298	38346	51722	124862	70589	115933	40917
PS Chinook	Juvenile	Hatchery	17608	26686	20702	31833	22387	11748	11430	11835	8354	12105
SRSS Chinook	Adult	Natural	1644	1178	1015	1378	830	722	200	0	0	0
SRSS Chinook	Adult	Hatchery	0	2	50	834	745	851	771	0	0	0
SRSS Chinook	Juvenile	Natural	218791	227752	208519	118425	254498	92590	79132	31469	41731	36261
SRSS Chinook	Juvenile	Hatchery	74609	105053	114647	68707	75677	69959	1151	1167	393	1073

Species	Life Stage	Origin	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
SRF Chinook	Adult	Natural	1	1	0	0	0	0	0	0	0	0
SRF Chinook	Adult	Hatchery	0	0	0	0	0	0	0	0	0	0
SRF Chinook	Juvenile	Natural	79	183	370	0	0	0	0	8	0	0
SRF Chinook	Juvenile	Hatchery	0	0	0	0	0	0	0	0	0	0
LCR Chinook	Adult	Natural	191	141	230	328	327	323	217	57	46	96
LCR Chinook	Adult	Hatchery	101	32	251	298	245	121	159	0	0	0
LCR Chinook	Juvenile	Natural	248122	157565	85448	198038	96082	110686	276904	314271	244544	130353
LCR Chinook	Juvenile	Hatchery	23	0	2	2	4950	18750	12997	21108	8338	2021
UWR Chinook	Adult	Natural	35	0	0	0	6	1	0	0	0	0
UWR Chinook	Adult	Hatchery	103	54	59	96	118	16	36	23	21	4
UWR Chinook	Juvenile	Natural	36484	40414	35544	19563	13298	17267	20213	9336	9331	1935
UWR Chinook	Juvenile	Hatchery	133	49	418	507	15	0	127	14	10	59
CC Chinook	Adult	Natural	2451	3503	168	598	109	460	52	1	1	3
CC Chinook	Juvenile	Natural	109280	90933	512396	109673	402279	95456	7010	91937	26823	27188
CVS Chinook	Adult	Natural	1596	1063	1817	546	161	90	96	0	0	1
CVS Chinook	Adult	Hatchery	4485	6431	18648	6742	5206	2830	666	0	11	1
CVS Chinook	Juvenile	Natural	2795	3133	105763	391183	45972	8233	197	109082	16048	455598
CVS Chinook	Juvenile	Hatchery	0	132	202	0	239	212	59	28	298	3061
HCS chum	Adult	Natural	372	4905	3022	2982	7460	474	29	153	357	55

Species	**Life Stage**	**Origin**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
HCS chum	Juvenile	Natural	96390	185305	275975	417928	49625	39063	159467	173068	162407	151989
HCS chum	Juvenile	Hatchery	0	5	0	161	0	0	0	0	0	0
CR chum	Adult	Natural	1	0	0	1	0	0	0	0	0	0
CR chum	Juvenile	Natural	9	89	2	3	321	1229	9740	425	10565	2170
CR chum	Juvenile	Hatchery	0	0	0	0	0	0	0	0	0	0
LCR coho	Adult	Natural	1422	683	710	2203	780	617	280	34	10	19
LCR coho	Adult	Hatchery	209	50	423	675	176	299	41	3	6	1
LCR coho	Juvenile	Natural	52874	39279	37677	46228	73941	27121	28441	25892	29723	20304
LCR coho	Juvenile	Hatchery	8	1133	2853	5710	14856	11788	5751	22898	7463	979
OC coho	Adult	Natural	7282	2103	2912	11432	2463	3127	1346	1665	1940	2523
OC coho	Adult	Hatchery	0	0	0	0	0	0	0	0	0	0
OC coho	Juvenile	Natural	203201	251512	209678	114778	356411	78228	96155	74622	81150	105550
OC coho	Juvenile	Hatchery	0	0	0	1	0	0	0	0	0	0
SONCC coho	Adult	Natural	407	401	268	581	413	189	223	601	223	229
SONCC coho	Adult	Hatchery	370	605	486	1046	427	11	88	46	146	81
SONCC coho	Juvenile	Natural	10203	15012	37928	37855	27595	22258	13643	25028	23310	28759
SONCC coho	Juvenile	Hatchery	0	0	189	0	0	0	0	0	0	0
PS steelhead	Adult	Natural	244	311	304	121	376	356	145	141	98	56
PS steelhead	Adult	Hatchery	0	0	0	0	2	2	1	11	11	4

Species	Life Stage	Origin	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
PS steelhead	Juvenile	Natural	6661	4851	12345	11684	9648	8209	8904	9586	8545	7366
PS steelhead	Juvenile	Hatchery	560	402	423	2229	312	341	523	212	166	126
UCR steelhead	Juvenile	Natural	0	0	0	0	0	0	0	60	40	0
SRB steelhead	Adult	Natural	1976	1250	1169	291	958	517	222	45	25	56
SRB steelhead	Adult	Hatchery	109	84	57	1	878	351	168	23	3	9
SRB steelhead	Juvenile	Natural	59670	60500	82923	43324	64667	64704	38076	24074	18256	13335
SRB steelhead	Juvenile	Hatchery	409	458	1293	52	0	0	376	891	531	856
MCR steelhead	Adult	Natural	1490	969	1049	909	1210	407	107	279	327	234
MCR steelhead	Adult	Hatchery	790	1085	427	643	1009	551	385	460	153	214
MCR steelhead	Juvenile	Natural	48455	49024	35771	30280	30575	23763	36145	25715	15243	12091
MCR steelhead	Juvenile	Hatchery	10699	1617	1930	2354	0	267	308	998	382	0
LCR steelhead	Adult	Natural	918	654	455	755	1092	991	308	397	248	436
LCR steelhead	Adult	Hatchery	30	10	60	58	2	13	11	0	0	0
LCR steelhead	Juvenile	Natural	10940	14781	20152	22078	26942	16556	10470	13915	10547	13345
LCR steelhead	Juvenile	Hatchery	4041	1180	2295	9844	9155	5415	7659	10832	6631	4888
UWR steelhead	Adult	Natural	0	0	0	0	0	15	0	0	0	0
UWR steelhead	Juvenile	Natural	32	18	43	5	349	27	82	162	72	338
NC steelhead	Adult	Natural	147	508	976	715	237	224	115	225	105	81
NC steelhead	Adult	Hatchery	0	0	0	0	0	0	0	0	0	0

Species	Life Stage	Origin	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NC steelhead	Juvenile	Natural	56541	60050	122794	148100	162751	117934	4352	15670	14712	31824
CCV steelhead	Adult	Natural	292	389	402	407	343	349	4	156	126	152
CCV steelhead	Adult	Hatchery	1906	1859	3492	2471	1945	1679	0	100	94	88
CCV steelhead	Juvenile	Natural	824	1891	1068	1801	783	725	232	1608	1023	3131
CCV steelhead	Juvenile	Hatchery	15	100	102	1	1	0	0	4	10	7
CCC steelhead	Adult	Natural	0	2	7	0	0	3	14	3	3	0
CCC steelhead	Juvenile	Natural	773	611	3893	1008	819	515	890	758	1070	746
SCCC steelhead	Adult	Natural	2	7	0	0	0	0	0	0	0	0
SCCC steelhead	Juvenile	Natural	1630	2557	912	634	62	569	783	3961	2634	2056
Eulachon	Adult	Natural	16	1	67	9	31	4	13	27	17	12
Green sturgeon	Adult	Natural	2	0	6	0	2	2	2	13	1	81
Green sturgeon	Egg	Natural	24	58	0	0	0	0	2	270	17	0
Green sturgeon	Juvenile	Natural	0	0	0	0	0	2	1	0	0	30
Green sturgeon	Larvae	Natural	643	0	0	0	0	0	11	2	1	0

Table A.5: Total reported mortality, in the Programs, for each component of the listed ESU/DPS.

Species	Life Stage	Origin	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
PS Chinook	Adult	Natural	2	0	0	0	0	0	0	0	0	0

Species	Life Stage	Origin	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
PS Chinook	Adult	Hatchery	2	0	0	0	0	0	0	0	0	0
PS Chinook	Juvenile	Natural	1029	1066	961	677	247	566	1152	1243	1148	451
PS Chinook	Juvenile	Hatchery	3003	3155	59	26	24	283	46	525	329	529
SRSS Chinook	Adult	Natural	0	0	0	5	0	0	0	0	0	0
SRSS Chinook	Adult	Hatchery	0	0	0	0	0	0	0	0	0	0
SRSS Chinook	Juvenile	Natural	675	737	654	280	803	645	289	105	124	159
SRSS Chinook	Juvenile	Hatchery	77	112	396	141	37	9157	0	0	0	2
SRF Chinook	Adult	Natural	0	0	0	0	0	0	0	0	0	0
SRF Chinook	Adult	Hatchery	0	0	0	0	0	0	0	0	0	0
SRF Chinook	Juvenile	Natural	3	3	2	0	0	0	0	1	0	0
SRF Chinook	Juvenile	Hatchery	0	0	0	0	0	0	0	0	0	0
LCR Chinook	Adult	Natural	0	0	0	0	0	0	0	0	0	0
LCR Chinook	Adult	Hatchery	1	1	6	3	6	4	4	0	0	0
LCR Chinook	Juvenile	Natural	3445	3420	1518	3582	1309	2494	5091	3984	2555	1069
LCR Chinook	Juvenile	Hatchery	1	0	0	0	149	543	190	179	79	2
UWR Chinook	Adult	Natural	0	0	0	0	0	0	0	0	0	0
UWR Chinook	Adult	Hatchery	0	1	0	2	0	0	0	0	0	0
UWR Chinook	Juvenile	Natural	197	294	339	138	381	116	54	27	125	19
UWR Chinook	Juvenile	Hatchery	0	0	0	2	0	0	1	10	0	0

Species	Life Stage	Origin	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
CC Chinook	Adult	Natural	0	0	0	0	1	0	0	0	0	0
CC Chinook	Juvenile	Natural	301	265	810	186	389	159	40	509	337	142
CVS Chinook	Adult	Natural	0	0	0	0	1	0	0	0	0	0
CVS Chinook	Adult	Hatchery	11	29	54	22	9	0	0	0	0	0
CVS Chinook	Juvenile	Natural	20	243	1034	2536	693	105	1	2247	907	4076
CVS Chinook	Juvenile	Hatchery	0	0	0	0	16	38	43	24	9	55
HCS chum	Adult	Natural	3	3	6	12	6	2	0	0	0	0
HCS chum	Juvenile	Natural	263	825	256	798	184	495	362	532	268	593
HCS chum	Juvenile	Hatchery	0	0	0	0	0	0	0	0	0	0
CR chum	Adult	Natural	0	0	0	0	0	0	0	0	0	0
CR chum	Juvenile	Natural	0	0	0	0	0	1	22	3	75	11
CR chum	Juvenile	Hatchery	0	0	0	0	0	0	0	0	0	0
LCR coho	Adult	Natural	3	4	0	5	3	1	0	0	0	0
LCR coho	Adult	Hatchery	2	0	0	11	0	5	0	0	0	0
LCR coho	Juvenile	Natural	341	355	292	159	262	147	356	149	176	80
LCR coho	Juvenile	Hatchery	0	0	4	4	12	825	12	33	104	0
OC coho	Adult	Natural	8	10	6	30	6	10	3	13	3	26
OC coho	Adult	Hatchery	0	0	0	0	0	0	0	0	0	0
OC coho	Juvenile	Natural	2006	3723	1781	1310	2280	534	773	611	457	709

Species	Life Stage	Origin	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
OC coho	Juvenile	Hatchery	0	0	0	0	0	0	0	0	0	0
SONCC coho	Adult	Natural	0	1	0	0	2	0	0	0	0	0
SONCC coho	Adult	Hatchery	0	2	0	1	0	0	0	0	0	0
SONCC coho	Juvenile	Natural	393	139	79	235	45	49	42	61	69	31
SONCC coho	Juvenile	Hatchery	0	0	3	0	0	0	0	0	0	0
PS steelhead	Adult	Natural	0	0	0	0	0	0	0	0	0	0
PS steelhead	Adult	Hatchery	0	0	0	0	0	0	0	0	0	0
PS steelhead	Juvenile	Natural	35	31	29	387	67	80	51	53	29	83
PS steelhead	Juvenile	Hatchery	3	0	0	61	0	1	2	0	0	0
UCR steelhead	Juvenile	Natural	0	0	0	0	0	0	0	0	0	0
SRB steelhead	Adult	Natural	15	8	5	1	0	2	1	0	0	1
SRB steelhead	Adult	Hatchery	0	0	1	0	0	0	0	0	0	0
SRB steelhead	Juvenile	Natural	244	217	409	159	297	401	113	87	52	31
SRB steelhead	Juvenile	Hatchery	0	0	3	0	0	0	0	0	1	0
MCR steelhead	Adult	Natural	5	3	9	3	4	5	1	0	1	0
MCR steelhead	Adult	Hatchery	5	1	0	0	0	0	0	1	1	0
MCR steelhead	Juvenile	Natural	680	817	573	510	287	134	423	163	70	132
MCR steelhead	Juvenile	Hatchery	79	20	1	4	0	1	16	5	1	0
LCR steelhead	Adult	Natural	3	4	1	0	4	3	4	1	1	5

Species	Life Stage	Origin	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
LCR steelhead	Adult	Hatchery	0	0	0	1	0	0	0	0	0	0
LCR steelhead	Juvenile	Natural	55	148	407	115	36	45	32	29	26	15
LCR steelhead	Juvenile	Hatchery	7	8	3031	2	0	87	11	3	6	2
UWR steelhead	Adult	Natural	0	0	0	0	0	0	0	0	0	0
UWR steelhead	Juvenile	Natural	0	0	0	0	0	0	2	1	0	0
NC steelhead	Adult	Natural	0	0	0	0	0	0	0	0	0	0
NC steelhead	Adult	Hatchery	0	0	0	0	0	0	0	0	0	0
NC steelhead	Juvenile	Natural	334	325	350	334	258	288	41	92	52	95
CCV steelhead	Adult	Natural	0	0	1	1	0	0	0	1	0	0
CCV steelhead	Adult	Hatchery	0	0	0	0	0	0	0	0	0	0
CCV steelhead	Juvenile	Natural	3	12	8	14	13	19	0	1	8	11
CCV steelhead	Juvenile	Hatchery	0	0	0	1	0	0	0	0	0	3
CCC steelhead	Adult	Natural	0	0	0	0	0	3	1	0	0	0
CCC steelhead	Juvenile	Natural	13	5	18	13	5	0	1	2	3	0
SCCC steelhead	Adult	Natural	0	0	0	0	0	0	0	0	0	0
SCCC steelhead	Juvenile	Natural	10	5	2	1	0	0	2	20	3	4
Eulachon	Adult	Natural	15	0	3	0	0	0	0	0	0	0
Green sturgeon	Adult	Natural	0	0	0	0	0	0	0	0	0	0

Species	Life Stage	Origin	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Green sturgeon	Egg	Natural	24	58	0	0	0	0	2	270	17	0
Green sturgeon	Juvenile	Natural	0	0	0	0	0	0	0	0	0	0
Green sturgeon	Larvae	Natural	110	0	0	0	0	0	3	1	0	0