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 Issuance of 17 ESA Section 10(a)(1)(A) Scientific Research Permits in Oregon, Washington, Idaho and California affecting Salmon, Steelhead, Eulachon, Green Sturgeon, and Rockfish in the West Coast Region

NMFS Consultation Number: WCRO-2023-00322
ARN: 151422WCR2023PR00064

Action Agencies: The United States Geological Survey (USGS)
The United States Fish and Wildlife Service (USFWS)

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely To Adversely Affect Species?	Is Action Likely To Jeopardize the Species?	Is Action Likely To Adversely Affect Critical Habitat?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Puget Sound (PS) Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No
PS steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Puget Sound/Georgia Basin (PS/GB) bocaccio (*Sebastes paucispinis*)	Endangered	Yes	No	No	No
PS/GB yelloweye rockfish (*S. ruberrimus*)	Threatened	Yes	No	No	No
Hood Canal summer-run (HCS) chum salmon (*O. keta*)	Threatened	Yes	No	No	No
Ozette Lake (OL) sockeye salmon (*O. nerka*)	Threatened	Yes	No	No	No
Upper Columbia River (UCR) spring-run Chinook salmon (*O. tshawytscha*)	Endangered	Yes	No	No	No
Upper Columbia River (UCR) steelhead (*O. mykiss*)	Threatened	Yes	No	No	No

ESA-Listed Species	Status	Is Action Likely To Adversely Affect Species?	Is Action Likely To Jeopardize the Species?	Is Action Likely To Adversely Affect Critical Habitat?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Middle Columbia River (MCR) steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Snake River (SnkR) spring/summer-run (spr/sum) Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No
Snake River (SnkR) fall-run Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No
Snake River (SnkR) steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Snake River (SnkR) sockeye salmon (*O. nerka*)	Endangered	Yes	No	No	No
Lower Columbia River (LCR) Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No
Lower Columbia River (LCR) coho salmon (*O. kisutch*)	Threatened	Yes	No	No	No
Lower Columbia River (LCR) steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Columbia River (CR) chum salmon (*O. keta*)	Threatened	Yes	No	No	No
Upper Willamette River (UWR) Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No
Upper Willamette River (UWR) steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Oregon Coast (OC) coho salmon (*O. kisutch*)	Threatened	Yes	No	No	No
Southern Oregon/Northern California Coast (SONCC) coho salmon (*O. kisutch*)	Threatened	Yes	No	No	No
Northern California (NC) steelhead (*O. mykiss*)	Threatened	Yes	No	No	No

ESA-Listed Species	Status	Is Action Likely To Adversely Affect Species?	Is Action Likely To Jeopardize the Species?	Is Action Likely To Adversely Affect Critical Habitat?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
California Coastal (CC) Chinook salmon (*Oncorhynchus tshawytscha*)	Threatened	Yes	No	No	No
Sacramento River (SacR) winter-run Chinook salmon (*O. tshawytscha*)	Endangered	Yes	No	No	No
Central Valley spring-run (CVS) Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No
California Central Valley (CCV) steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Central California Coast (CCC) coho salmon (*O. kisutch*)	Endangered	Yes	No	No	No
Central California Coast (CCC) steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
South-Central California Coast (SCCC) Steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Southern DPS (SDPS) eulachon (*Thaleichthys pacificus*)	Threatened	Yes	No	No	No
Southern DPS (SDPS) green sturgeon (*Acipenser medirostris*)	Threatened	Yes	No	No	No
Southern Resident killer whale (SRKW) (*Orcinus orca*)	Endangered	No	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: [signature]
For Scott M. Rumsey, Ph.D.
Acting Regional Administrator

Date: March 31, 2023

TABLE OF CONTENTS

List of Acronyms

ARIS – Adaptive Resolution Imaging Sonar
ARN – Administrative Record Number
BPA – Bonneville Power Administration
C/H/R – Capture/Handle/Release
C/M, T, S/R – Capture/Mark, Tag, Sample Tissue/Release Live Animal
CC – California Coastal
CCC – Central California Coast
CCV – California Central Valley
CDFW – California Department of Fish and Wildlife
CFR – Code of Federal Regulation
CH – Critical Habitat
CHART – Critical Habitat Analytical Review Teams
CR – Columbia River
CRITFC – Columbia River Inter-Tribal Fish Commission
CVS – Central Valley spring-run
CWT – Coded Wire Tag
DC – Direct Current
DEQ – Oregon Department of Environmental Quality
DFO – Department of Fisheries and Oceans
DIDSON – Dual Frequency Identification Sonar
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
GCID – Glenn-Colusa Irrigation District
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 (Directed) Mortality
ISAB – Independent Scientific Advisory Board
ISU – Idaho State University
ITS – Incidental Take Statement
LCR – Lower Columbia River
LHAC – Listed Hatchery Adipose Clipped
LHIA – Listed Hatchery Intact Adipose
MCR – Middle Columbia River
MPG – Major Population Group
MSA – Magnuson-Stevens Fishery Conservation and Management Act
NC – Northern California
NFH – National Fish Hatchery

NMFS – National Marine Fisheries Service
NOAA – National Oceanic and Atmospheric Administration
NWFSC – Northwest Fisheries Science Center
O/H – Observe/Harass
OC – Oregon Coast
ODFW – Oregon Department of Fish and Wildlife
OL – Ozette Lake
OSU – Oregon State University
PBF – Physical or Biological Features
PCE – Primary Constituent Element
PFMC – Pacific Fishery Management Council
PIT – Passive Integrated Transponder
PRD – Protected Resources Division
PS – Puget Sound
PS/GB – Puget Sound/Georgia Basin
RK – River Kilometer
ROV – Remotely Operated Vehicle
RPM – Reasonable and Prudent Measure
S – Southern
SacR – Sacramento River
SBT – Shoshone-Bannock Tribes
SnkR – Snake River
SCCC – South-Central California Coast
SDPS – Southern Distinct Population Segment
SONCC – Southern Oregon/Northern California Coast
spr/sum – spring/summer run
SR – Southern Resident
SRKW – Southern Resident Killer Whales
SWFSC – Southwest Fisheries Science Center
SVWID – Snoqualmie Valley Watershed Improvement District
TRT – Technical Recovery Team
UCR – Upper Columbia River
USFWS – United States Fish and Wildlife Service
USGS – United States Geological Survey
UW – University of Washington
UWR – Upper Willamette River
VSP – Viable Salmonid Population
WCR – West Coast Region
WDFW – Washington Department of Fish and Wildlife
WDNR – Washington Department of Natural Resources

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.), and implementing regulations at 50 CFR 402, as amended. It constitutes a review of 17 scientific research permits NMFS is proposing to issue under section 10(a)(1)(A) of the ESA and is based on information provided in the associated applications for the proposed permits, published and unpublished scientific information on the biology and ecology of listed salmonids in the action areas, and other sources of information.

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 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 West Coast Region's (WCR's) Protected Resources Division (PRD) received 17 applications for permits to conduct scientific research in Washington, Oregon, Idaho and California (see Table 1 and the text following it):

- 7 applications were to renew existing permits;
- 1 application was to modify existing permits; and
- 9 applications were for new permits.

Because the permit requests are similar in nature and duration and are expected to affect many of the same listed species, we combined them into a single consultation pursuant to 50 CFR 402.14(c).

The affected species are:

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

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

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).

Table 1. The Applications Considered in this Biological Opinion and Their Associated Applicants.

Permit Number	Applicant
1134-8R	Columbia River Inter-Tribal Fish Commission
15573-4R	Glenn-Colusa Irrigation District
15824-3R	County of Santa Cruz
16303-3R	USGS Western Fisheries Research Center
21061-2R	Windward Environmental
22093-2R	Snoqualmie Valley Watershed Improvement District
22998-2R	U.S. Fish and Wildlife Service
26368-2M	Idaho State University
26714	Oregon Department of Fish and Wildlife
26766	Washington Department of Natural Resources
26968	California Department of Fish and Wildlife
27069	Thomas Gast & Associates Environmental Consultants
27091	Port of Seattle
27098	WA Department of Natural Resources
27129	United States Geological Survey
27162	Washington Department of Natural Resources
27212	Oregon State University

Permit 1134-8R—We received a permit renewal request from the CRITFC on December 5, 2022. Because there had been discussion about the application before it was submitted, the application was deemed complete at that time.

Permit 15573-4R—We received a permit renewal request from the Glenn-Colusa Irrigation District (GCID) on January 16, 2023. Because there had been discussion about the application before it was submitted, the application was deemed complete at that time.

Permit 15824-3R—We received a permit renewal request from the County of Santa Cruz on November 18, 2022. Because there had been discussion about the application before it was submitted, the application was deemed complete at that time.

Permit 16303-3R—We received a permit renewal request from the U.S. Geologic Survey (USGS) on January 24, 2023. Edits and clarifications were requested and discussed and the application was completed on February 2, 2023.

Permit 21061-2R—We received a permit renewal request from Windward Environmental on January 31, 2023. Edits and clarifications were requested and discussed and the application was completed on February 10, 2023.

Permit 22093-2R—We received a permit renewal request from Snoqualmie Valley Watershed Improvement District (SVWID) on December 7, 2022. The application was reviewed and determined to be complete on January 24, 2023.

Permit 22998-2R—We received a permit renewal request from the U.S. Fish and Wildlife Service (FWS) on September 28, 2022. The application was reviewed and determined to be complete on January 24, 2023.

Permit 26368-2M—We received a permit modification request from Tyler Breech (ISU) on January 9, 2023. Because there had been a fair amount of discussion and back-and-forth regarding the application before it was submitted, the application was deemed complete on January 10, 2023.

Permit 26714—We received an application for a new permit from the ODFW on August 18, 2022. Because there had been discussion about the application before it was submitted, the application was deemed complete at that time.

Permit 26766—We received an application for a new permit from the WDNR on August 18, 2022. After a number of discussions and clarifications, the application was deemed complete on January 12, 2023.

Permit 26968—We received a new permit request from the California Department of Fish and Wildlife (CDFW) on November 3, 2022. Because there had been discussion about the application before it was submitted, the application was deemed complete at that time.

Permit 27069—We received a new permit renewal from Thomas Gast & Associates Environmental Consultants on December 5, 2022. Because there had been discussion about the application before it was submitted, the application was deemed complete at that time.

Permit 27091—We were contacted about coverage for this work by the Port of Seattle August 9, 2022, and after discussion with the applicant confirmed an application should be pursued on October 24, 2022. Edits and clarifications were requested and discussed and the application was submitted on December 20, 2022, and determined to be complete on December 21, 2022.

Permit 27098—We were contacted about coverage for this work by the Washington Department of Natural Resources (WDNR) Aquatic Invasive Species team November 1, 2022, and after discussion with the applicant confirmed an application should be pursued on November 22, 2022. Edits and clarifications were requested and discussed and the application was submitted on December 14, 2022, and determined to be complete on December 15, 2022.

Permit 27129—We received an application for a new permit from the USGS on December 27, 2022. After a number of discussions and clarifications, the application was deemed complete on January 27, 2023.

Permit 27162—We received a permit request from the WDNR Olympic Region on December 28, 2022. Edits and clarifications were requested and discussed and the application was completed on January 23, 2023.

Permit 27212—We received an application for a new permit from OSU on January 13, 2023. Because there had been a fair amount of discussion regarding the application before it was submitted, the application was deemed complete on that date.

Most of the requests were deemed incomplete to varying extents when they arrived. After numerous phone calls and e-mail exchanges, the applicants revised and finalized their applications. After the applications were determined to be complete, we published notice in the Federal Register on February 17, 2023 asking for public comment on them (88 FR 10258). The public was given 30 days to comment on the permit applications and, once those periods closed on March 20, 2023 the consultation was formally initiated on March 21, 2023. The full consultation histories for the actions are lengthy and not directly relevant to the analysis for the proposed actions and so are not detailed here. A complete record of this consultation is maintained by the PRD and kept on file in Portland, Oregon.

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). Under the MSA, "Federal action" means any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken by a Federal Agency (50 CFR 600.910).]

The proposed actions here are NMFS' issuance of 17 scientific research permits pursuant to section 10(a)(1)(A) of the ESA. The permits would cover the research activities proposed by the applicants listed in Table 1, above. The permits would variously authorize researchers to take all the species listed on the front page of this document (except southern resident killer whales). "Take" is defined in section 3 of the ESA; it means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect [a listed species] or to attempt to engage in any such conduct.

We considered, under the ESA, whether the proposed action would cause any other activities and determined that it would not.

Permit 1134-8R

The Columbia River Inter-Tribal Fish Commission (CRITFC) is seeking to renew for five years a permit under which they have been conducting research for more than 20 years. The permit would continue covering three study projects that, among them, would annually take adult and juvenile SnkR steelhead and spr/sum Chinook salmon in the Snake River basin. There have been some significant changes in the research over the last ten years, nonetheless, the projects proposed are essentially continuations of ongoing research. They are: Project 1—Cryopreservation of Spring/summer Chinook Salmon and Summer Steelhead Gametes; Project 2—Snorkel, Seine, fyke net, Minnow Trap, and Electrofishing Surveys and Collection of Juvenile Chinook Salmon and Steelhead; and Project 3—Juvenile Anadromous Salmonid Emigration Studies Using Rotary Screw Traps. Under these tasks, listed adult and juvenile salmon would be variously (1) observed/harassed during fish population and production monitoring surveys; (2) captured (using dip nets, seines, trawls, traps, hook-and-line angling equipment, and electrofishing equipment) and anesthetized; (3) sampled for biological information and tissue samples; (4) PIT-tagged or tagged with other identifiers, and (5) released. It should be noted that in the past, this permit covered five projects instead of three and authorized a great deal more adult and juvenile take of both species than it would under this proposed action.

The research has many purposes and would benefit listed salmon and steelhead in different ways. However, in general, the studies are part of ongoing efforts to monitor the status of listed species in the Snake River basin and to use those data to inform decisions about land- and fisheries management actions and to help prioritize and plan listed species recovery measures. Under the proposal, the studies would continue to benefit listed species by generating population abundance estimates; providing information on adult and juvenile salmon and steelhead life histories in the in the Snake, Salmon, Clearwater, Grande Ronde, and Imnaha River subbasins, and helping preserve listed salmon and steelhead genetic diversity. The CRITFC researchers do not intend to kill any of the fish being captured, but a small percentage may die as a result of the research activities.

Permit 15573-4R

The Glenn-Colusa Irrigation District (GCID) is seeking to renew a permit that would authorize them to take juvenile SacR winter-run Chinook salmon, CVS Chinook salmon, CCV steelhead, and SDPS green sturgeon in order to monitor restoration actions and to detect annular and cyclic population changes. The GCID project provides the longest and most complete anadromous fish data set on the Sacramento River. As a result, the research would benefit the affected species by informing operational decisions for state and Federal water facilities and supplementing other out-migrant monitoring projects conducted in the Sacramento River Basin.

Juveniles would be collected via screw trap. A subsample of captured juveniles would be anesthetized, tissue sampled and PIT-tagged prior to release. Juvenile fish would be captured, handled, and released. The researchers are not proposing to kill any of the listed fish being captured, but a small number of fish may be killed as an inadvertent result of these activities.

Permit 15824-3R

The County of Santa Cruz is seeking to renew for five years a research permit that currently allows them to take juvenile CCC coho, CCC steelhead, and SCCC steelhead in the San Lorenzo River and its tributaries, Aptos Creek and its tributaries, Corralitos Creek and its tributaries, and Soquel Creek and its tributaries. The study's purpose is to document habitat conditions and collect data on juvenile salmonid abundance in Santa Cruz County watersheds. The research would benefit the affected species by providing data on salmonid spawning and rearing habitat conditions and thereby help inform habitat restoration and conservation efforts and land and water use decisions.

The researchers at Santa Cruz County propose to use backpack electrofishing and beach seines to capture fish and to observe fish during snorkel surveys. Captured fish would be anesthetized, identified to species, measured, PIT tagged, have a tissue sample taken for genetic analysis (fin clip and scales), and allowed to recover before being released back to the stream. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

Permit 16303-3R

The United States Geological Survey (USGS) is seeking to renew a research permit that allows them to take juvenile PS/GB DPS bocaccio, juvenile HCS chum salmon, juvenile PS steelhead, and juvenile, subadult, and adult PS Chinook salmon throughout the marine waters of Puget Sound, Hood Canal, and the Strait of Juan de Fuca (Washington State). The USGS research may also cause them to take adult SDPS eulachon and juvenile PS/GB DPS yelloweye rockfish—species for which there are currently no ESA take prohibitions. The purpose of the USGS study is to examine salmonid stage-specific growth, as well as bioenergetics, competition, and predation during the early marine growth period. Additionally, unlisted salmonid species, herring, and other forage fish species would be studied for the potential effects arising from fluctuations in temporal-spatial food supplies, temperature, competition, and predation.

This research would benefit the affected species by quantifying key factors limiting survival and production of Chinook salmon (particularly during juvenile outmigration and the first marine growing season) and advancing knowledge of the ecological role and contribution that the little-studied resident Chinook salmon make to Puget Sound Chinook salmon populations as a whole.

The USGS proposes capturing fish by beach seine, purse seine, Lampara seine, and micro-trolling (i.e., hook-and-line angling). All captured, viable subadult or adult salmon and any rockfish would be released as swiftly as possible. Listed rockfish would be released via rapid submergence to their capture depth to reduce the effects from barotrauma, and sub-adult/adult salmonids would be released at the surface. Under all capture methods, the juvenile salmonids would be anesthetized, identified to species, checked for coded wire tags (CWTs), measured to length, gastric-lavaged, tissue-sampled (fin clip and scales), and released. All juvenile, hatchery-origin, CWT fish (marked and unmarked) captured during the seining would be intentionally sacrificed to determine their origins. The researchers also propose to intentionally kill small numbers of hatchery- and natural-origin juvenile Chinook salmon for otolith collection and whole-body chemical analyses. Additionally, a small number of listed fish may die as an unintended result of the activities.

Permit 21061-2R

Windward Environmental is seeking to renew a permit that would authorize them to take juvenile and adult PS steelhead and Chinook salmon and juvenile PS/GB DPS bocaccio in order to establish baseline Lower Duwamish Waterway-wide concentrations of contaminants in non-listed resident fish species and evaluate how well this superfund site is progressing toward meeting the cleanup target tissue concentrations set by the Environmental Protection Agency (EPA). The research may also cause unintentional take of juvenile PS/GB DPS yelloweye rockfish—a species for which there are currently no ESA take prohibitions. The information would be used to determine progress towards cleanup goals for the Lower Duwamish Waterway and inform future sediment remediation efforts. This information would benefit listed species ESA-listed species by confirming where contaminated areas are and how concentrated contaminants continue to be within the Lower Duwamish River, and whether cleanup activities to date have been successful in reducing contaminant concentrations in resident fish species and their invertebrate prey. This information will also inform future sediment remediation efforts in the Puget Sound and elsewhere.

The researchers may unintentionally capture juvenile and adult ESA-listed fish while conducting otter trawls that target sole and surfperch. All captured juvenile or adult ESA-listed fish captured would be identified, enumerated, and immediately released at the location of capture. The researchers would also deploy crab traps targeting Dungeness crab, although neither juvenile nor adult ESA-listed fish are expected to be unintentionally captured by this gear. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the proposed activities.

Permit 22093-2R

The Snoqualmie Valley Watershed Improvement District (SVWID) is seeking to renew a permit that would authorize them to take adult and juvenile PS Chinook salmon and PS steelhead in order to assess the presence or absence of fish in various streams and agricultural drainage ditches within the boundary of the SVWID. This information will better inform plans to improve drainage, minimize flooding, and restore salmon habitat. Data and observations gathered through this research will also benefit ESA-listed species by providing data that will inform researchers about the status of these species in agricultural drainage ditches and small streams that may not otherwise be studied.

Juveniles would be collected via backpack electrofishing, beach seining, and minnow traps. Adults would be collected via beach seine. Fish would be captured, handled (weighed, measured, and checked for marks or tags), and released. The researchers are not proposing to kill any of the listed fish being captured, but a small number of fish may be killed as an inadvertent result of these activities.

Permit 22998-2R

The United States Fish and Wildlife Service (FWS) is seeking to renew a permit that would authorize them to annually take juvenile PS Chinook salmon and steelhead and adult HCS chum salmon in streams and waterbodies on the Kitsap Peninsula (Kitsap County, WA). The purpose of the study is to determine where in those waterbodies ESA-listed salmonids are present. That information would be used help guide future land use management and fulfill requirements in the Navy Base Kitsap's Natural Resource Management Plan. This research would benefit the affected species by helping guide habitat restoration and providing baseline information on species distribution. Currently, there is little information about the distribution of ESA-listed salmonids on Navy Base Kitsap lands.

The FWS would use backpack electrofishing equipment, beach seines, and dip nets to capture the juvenile fish. For electrofishing, the captured fish would be anesthetized with tricaine methanesulfonate (MS-222), identified by species, measured for length, weighed, allowed to recover, and released. For beach seines and dip netting, the captured fish would only be identified by species and swiftly released. The researchers would also conduct snorkel surveys for juvenile PS Chinook salmon and steelhead, and spawner surveys in which adult chum salmon may be observed. The FWS does not intend to kill any of the fish being captured, but a small number of juveniles may die as an unintended consequence of the proposed activities.

Permit 26368-2M

Idaho State University is seeking to modify a permit that currently authorizes them to annually take juvenile MCR steelhead, SnkR spring/summer-run Chinook salmon, SnkR steelhead, UWR Chinook salmon, UWR steelhead, and OC coho salmon at more than a dozen locations from Idaho to western Oregon. The modification would entail adding some sampling locations—particularly in Washington—and therefore would also require adding small amounts of take for SDPS eulachon and sturgeon and UCR and PS Chinook and steelhead. The purpose of the research is to conduct a range-wide comparison of native rainbow trout population genetics and structure across much of western North America. The work would benefit listed fish by providing of information about population and subspecies structure, local biodiversity in a variety of settings, and some measure of how intra- and inter-species variability contribute to ecosystem maintenance. That information, in turn, would be used to monitor and adjust for variances in species diversity and population structure and health across a broad section of the listed species' habitat.

The juvenile fish would be collected via backpack electrofishing and hook-and-line angling. Only juvenile steelhead would be captured, handled (anesthetized, weighed, measured, and checked for marks or tags), sampled, and released. All other listed fish that may be captured would be allowed to recover in aerated water and then released immediately. The researchers are not proposing to kill any listed fish, but a small number may be killed as an inadvertent result of the proposed activities.

Permit 26714

The Oregon Department of Fish and Wildlife (ODFW) is seeking a permit to capture SnkR steelhead and spr/sum Chinook salmon while surveying the Wallowa River, Oregon, to better understand the distribution, relative abundance, movement ecology, and angler exploitation rates of rainbow trout and mountain whitefish in the river. This work is intended to generate important baseline information on the status and trends of native fishes in the Wallowa River and thereby improve managers' ability to conserve and manage them. The study would benefit listed salmonids by giving mangers information on (1) salmonid distribution and general habitat use in the Wallowa River, (2) the distribution and abundance of residualized hatchery steelhead, and (3) the rates at which anglers capture and handle listed juvenile steelhead/rainbow trout. This information, in turn, would be used to set harvest regimes and design recovery actions.

The researchers would use raft-mounted electrofishing equipment to capture the fish. Most of the listed Chinook and steelhead would be measured, scanned for tags and marks and immediately released. However, because they are very difficult to distinguish from non-listed rainbow trout, a small portion of the captured juvenile SnkR steelhead would also be tagged and tissue sampled before being released. In all cases, listed fish would be processed and released before any work is done on non-listed fish. Also, if an adult Chinook or steelhead fish were to be encountered, the electrofishing equipment would be turned off and the electrofishing raft would be moved before the survey is started again. The researchers do not plan to kill any fish they capture, but some may die as an unintended result of the activities.

Permit 26766

The Washington Department of Natural Resources (WDNR) is seeking a new permit to conduct fish presence/absence surveys in small streams across the state of Washington. The permit would authorize them to take juvenile PS Chinook salmon and steelhead; HC summer-run chum salmon; OL sockeye salmon; UCR steelhead and spring-run Chinook salmon; MCR steelhead; SnkR steelhead, sockeye, and spr/sum and fall-run Chinook salmon; LCR Chinook salmon, coho salmon and steelhead; and CR chum salmon. The purpose of the study is to survey small streams on privately held land across the state of Washington and determine what fish are present at each site. The information would be used to (a) inform landowners of the appropriate riparian management zone to follow under the state Forest Regulations and (b) identify potential fish passage barriers. Helping landowners follow the appropriate forest practice regulations would help protect crucial habitats along riparian zones. Identifying fish passage barriers would help mangers determine what barriers could be altered to increase the amount of habitat accessible to listed fish.

The juvenile fish would be collected via backpack electrofishing and the captured fish would be handled (anesthetized, weighed, measured, and checked for marks or tags), and swiftly released near the point of their capture. The researchers are not proposing to kill any listed fish, but a small number from each species may be killed as an inadvertent result of the proposed activities.

Permit 26968

The CDFW is seeking a new permit that would authorize them to take juvenile SONCC coho salmon, NC steelhead, CC Chinook salmon, SacR winter-run Chinook salmon, CVS Chinook salmon, CCV steelhead, CCC coho salmon, CCC steelhead, S-CCC steelhead, SC steelhead, and adult SDPS green sturgeon in streams and rivers throughout California at pre-selected locations. The study's purpose is to assess the condition of the rivers and streams in California and provide a baseline for future comparisons. CDFW is participating in the USEPA National Rivers and Streams Assessment (NRSA), a probability-based survey designed to assess the condition of the Nation's rivers and streams. NRSA is a keystone program in California that provides data for the National

Water Quality Inventory Report to Congress (305(b) report) and fulfills the water quality monitoring requirements of the Clean Water Act.

The researchers at CDFW propose to use kick nets, backpack and boat electrofishing to capture fish. Captured fish would be handled (anesthetized, weighed, measured, and checked for marks or tags), and released. The researchers are not proposing to kill any of the listed fish being captured, but a small number of fish may be killed as an inadvertent result of these activities.

Permit 27069

Thomas Gast & Associates Environmental Consultants is seeking a new permit that would authorize them to take juvenile SacR winter-run Chinook salmon, CVS Chinook salmon, CCV Valley steelhead, and SDPS green sturgeon in a backwater area of the Sacramento River directly downstream of its confluence with Battle Creek. The study's purpose is to characterize seasonal changes and variability within the fish community in the backwater area. Data on the fish community composition will be used to inform the planning and design of an upcoming side-channel restoration project.

Juveniles would be collected via fyke net, beach seine, and minnow trap and observed during snorkel surveys. Juvenile fish would be captured, handled (anesthetized, weighed, measured, and checked for marks or tags), and released. The researchers are not proposing to kill any of the listed fish being captured, but a small number of fish may be killed as an inadvertent result of these activities.

Permit 27091

The Port of Seattle is seeking a permit that would allow them to take juvenile PS steelhead and Chinook salmon while conducting survey work designed to examine ecological response to restoration actions that have been undertaken in the lower Duwamish River waterway in Washington state. The purpose of the work is to fulfill the conditions found in the habitat-restoration component of a Natural Resources Damage Assessment claim made against the Port of Seattle. It would benefit the listed salmon and steelhead by ensuring the habitat they use in the lower Duwamish functions to promote their survival; it would also help the listed species by helping guide similar habitat restoration actions elsewhere in the Puget Sound and beyond.

All captured salmonids would be sedated with MS-222 and identified by species, weighed and measured to the nearest millimeter (fork length). Once measured and weighed, the fish would be placed into a recovery bucket and be transported to the bank of the Duwamish River and released downstream of the capture site. The process would be halted if the fish appear to be overly stressed, or recovery times are unusually long. Any fish with coded wire tags or that have had their adipose fins clipped would be noted in order to calculate the ratio of natural-origin to hatchery fish in the lower Duwamish River. The researchers do not intend to kill any of the fish being captured, but a small number may die as an unintended consequence of the proposed activities.

Permit 27098

The WDNR is seeking a new permit that would authorize them to annually take juvenile UCR steelhead and spring-run Chinook salmon; MCR steelhead; SnkR steelhead, sockeye, and spr/sum and fall-run Chinook salmon; LCR Chinook salmon, coho salmon and steelhead; UWR Chinook salmon and steelhead; and CR chum salmon. The permit would also allow them to take adult and juvenile SDPS eulachon—a species for which there are currently no take prohibitions. Under the permit, the WDNR researchers would monitor, track, trap, and remove invasive European green crabs on WDNR aquatic lands in the Puget Sound and lower Columbia River. The purpose of the research is to explore the best means of locating and eliminating European green crab incursions, and it will benefit listed salmonid (and other) species by guiding long-term management actions designed protect their critical habitat.

The researchers would use modified shrimp and minnow traps placed in the estuarine and marine intertidal and subtidal waters in the Puget Sound and lower Columbia River. The researchers do not actually expect to catch any listed salmonids or eulachon; nonetheless, all traps will be checked very regularly and any listed animals that are captured will be swiftly released without further handling. The researchers do not intend to kill any of the fish being captured, but a small number may die as an unintended consequence of the proposed activities.

Permit 27129

The United States Geological Survey (USGS) is seeking a new permit to monitor toxic chemical contamination levels in resident fish sampled in the Bonneville pool (reservoir) on the Columbia River. The permit would authorize them to take juvenile and adult UCR steelhead and spring-run Chinook salmon; MCR steelhead; SnkR steelhead, sockeye, and spr/sum and fall-run Chinook salmon; LCR Chinook salmon, coho salmon, and steelhead; and CR chum salmon. The purpose of the research is to conduct long-term monitoring to assess the spatial and temporal status and trends of toxics in fish, water, sediment, and other potential media in the Columbia River mainstem—eventually from Bonneville Dam to the Canadian Border. While the work does not target listed fish, it will benefit them by providing information to help state, tribal and federal mangers plan restoration and remediation actions designed to improve ecosystem function and reduce contaminants in all levels of the food chain.

The researchers would use a variety of means to capture the fish. The main methods would be fyke and hoop nets, minnow traps and nets, longlines, and angling. If these methods prove insufficient to gathering the needed resident fish samples, boat electrofishing may possibly be employed. All adult listed fish would be avoided, and any that are captured would immediately be released. Captured juvenile fish Juvenile fish would also be minimally handled and released without any data being collected on them. The researchers are not proposing to kill any listed fish, but a small number from each species may be killed as an inadvertent result of the proposed activities.

Permit 27162

Under permit 27162 the WDNR (Olympic Region) is seeking a new permit that would authorize them to take juvenile PS Chinook salmon, PS steelhead, HCS chum salmon, and OL sockeye salmon in streams on WDNR land on the Olympic Peninsula (Clallam, Jefferson, and Grays Harbor counties in Washington) in order to determine listed fish presence or absence in small streams. The information gathered would be used to determine salmonid presence and distribution and thereby inform land management decisions on WDNR holdings. This information would benefit listed species by helping WDNR identify existing man-made fish barriers that should be removed or replaced with structures that fish can pass over or through, and support a region-wide program of road maintenance and other forest management activities in the vicinity of streams. Confirming which streams currently support ESA-listed fish species would help prioritize those locations for restoration actions.

Juvenile salmonids would be collected via backpack electrofishing, handled (anesthetized, weighed, measured, identified, and checked for marks or tags), and released back to the waters from which they came. In some cases, the researchers may not actually capture any fish but would merely note their presence, however electrofishing where listed species are observed would still be reported as take. The researchers are not proposing to kill any of the listed fish being taken, but a small number may be killed as an inadvertent result of these activities.

Permit 27212

The Oregon State University (OSU) is seeking a new permit to survey waters across the pacific Northwest with the intent of mapping sculpin diversity and distribution across that range. The permit would authorize them to take juvenile PS Chinook salmon and steelhead; HC summer-run chum salmon; UCR steelhead and spring-run Chinook salmon; MCR steelhead; SnkR steelhead, sockeye, and spr/sum and fall-run Chinook salmon; LCR Chinook salmon, coho salmon and steelhead; UWR Chinook salmon; CR chum salmon; and SDPS eulachon. The purpose of the study is to map sculpin diversity and distribution, but it would also benefit listed salmonids. Improved data on the listed species' distribution, movement, and life histories would generate the most important benefit because such information would help direct the efforts recommended in each of the species' recovery plans. Moreover, the project would generate presence/absence data to help fill the need to monitor ecosystem health and the distribution, population status, and migratory movements of all the of listed species that may be encountered.

The fish would be collected via backpack electrofishing and beach seine; with the exception of SDPD eulachon, no adults would be taken. All captured listed fish would be handled briefly (identified and recorded) and immediately released back to the stream of their origin. The researchers would reduce possible harm to listed salmonids by: (1) avoiding sampling in the heat of the day or during spawning times, (2) surveying sample plots in advance for any listed fish, (3) using the lowest feasible settings on the electroshocker, (4) using the gentler seine net when possible, and (5) consulting with district biologists to get their advice on how to minimize harm to endangered and threatened species at each site. The researchers are not proposing to kill any listed fish, but a small number of each species may be killed as an inadvertent result of the proposed activities.

Common Elements among the Proposed Permit Actions

Research permits lay out the conditions to be followed before, during, and after the research activities are conducted. These conditions are intended to (a) manage the interaction between scientists and listed salmonids by requiring that research activities be coordinated among permit holders and between permit holders 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. All research permits the NMFS' WCR issues have the following conditions:

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

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

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

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

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

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

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

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

9. The permit holder using backpack electrofishing equipment must comply with NMFS' Backpack Electrofishing Guidelines (June 2000) (NMFS 2000).

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

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

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

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

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

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

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

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

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

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

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

"Permit holder" means the permit holder or any employee, contractor, or agent of the permit holder. Also, NMFS may include conditions specific to the proposed research in the individual permits.

Finally, NMFS will use the annual reports to monitor the actual number of listed fish taken annually in the scientific research activities and will adjust permitted 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.

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

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.[1] Herein, the NMFS determined that the proposed action of issuing 17 scientific research permits, individually or in aggregate:

- May adversely affect PS, UCR, SnkR spr/sum, SnkR fall-run, LCR, UWR, SacR winter-run, CVS, CC Chinook salmon; LCR, OC, SONCC, CCC coho salmon, HCS and CR chum salmon; OL and SnkR sockeye salmon; PS, UCR, MCR, SnkR, LCR, NC, CCV, CCC, SCCC steelhead, SDPS green sturgeon, SDPS eulachon, PS/GB bocaccio, and PS/GB yelloweye rockfish; but would not jeopardize their continued existence.
- 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 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).

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

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’’ 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 2019 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 action is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Evaluate the rangewide status of the species and critical habitat expected to be adversely affected by the proposed action.
- Evaluate the environmental baseline of the species and critical habitat.
- Evaluate the effects of the proposed action on species and their habitat using an exposure-response approach.
- Evaluate cumulative effects.
- In the integration and synthesis, add the effects of the action and cumulative effects to the environmental baseline, and, in light of the status of the species and critical habitat, analyze whether the proposed action is likely to: (1) directly or indirectly reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species, or (2) directly or indirectly result in an alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species.
- If necessary, suggest a reasonable and prudent alternative to the proposed action.

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, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The 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

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

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

Pacific Northwest

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

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

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

California

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

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

Marine Habitats

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

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

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

Impacts on Salmon and Steelhead

The physical impacts of climate change described above are predicted to cause a variety of impacts to Pacific salmon and their ecosystems (Mote *et al.* 2013; Crozier *et al.* 2008; Martins *et al.* 2012; Wainwright and Weitkamp 2013; Mote *et al.* 2019, Dalton and Fleishman 2021). The adaptive ability of threatened and endangered salmon and steelhead 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 (NWFSC 2015). 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). The primary effects of climate change on Pacific Northwest salmon and steelhead are (Crozier 2016, 2021):

- Direct effects of increased water temperatures on fish physiology and increased susceptibility to disease. 5-Year Review: Snake River Spring/Summer Chinook Salmon NOAA Fisheries
- Temperature-induced changes to stream flow patterns can block fish migration, trap fish in dewatered sections, dewater redds, introduce non-native fish, and degrade water quality.
- Alterations to freshwater, estuarine, and marine food webs can alter the availability and timing of food resources.
- Changes in estuarine and ocean productivity can affect the abundance and productivity of fish resources.

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.

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

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

A species' status thus is a function of how well its biological requirements are being met: the greater the degree to which the requirements are fulfilled, the better the species' status. Information on the status and distribution of all the species considered here can be found in a number of documents, but the most pertinent are the status review updates and recovery plans listed in Table 2 and the specific species sections that follow. These documents and other relevant information may be found on the NOAA Fisheries West Coast Region website; the discussions they contain are summarized in the tables below. For the purposes of our later analysis, all the species considered here require functioning habitat and adequate spatial structure, abundance, productivity, and diversity to ensure their survival and recovery in the wild.

Table 2. Listing classification and date, recovery plan reference, most recent status review, status summary, and limiting factors for each species considered in this opinion.

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Puget Sound Chinook salmon	Threatened 06/28/2005 (70 FR 37160)	SSDC 2007 NMFS 2006	Ford 2022*	This ESU comprises 22 populations distributed over five geographic areas. Most populations within the ESU have declined in abundance over the past 7 to 10 years, with widespread negative trends in natural-origin spawner abundance, and hatchery-origin spawners present in high fractions in most populations outside of the Skagit watershed. Escapement levels for all populations remain well below the Technical Recovery Team (TRT) planning ranges for recovery, and most populations are consistently below the spawner-recruit levels identified by the TRT as consistent with recovery.	• Degraded floodplain and in-river channel structure • Degraded estuarine conditions and loss of estuarine habitat • Degraded riparian areas and loss of in-river large woody debris • Excessive fine-grained sediment in spawning gravel • Degraded water quality and temperature • Degraded nearshore conditions • Impaired passage for migrating fish • Severely altered flow regime
Puget Sound steelhead	Threatened 05/11/2007 (72 FR 26722)	NMFS 2019	Ford 2022*	This DPS comprises 32 populations. The DPS is currently at very low viability, with most of the 32 populations and all three population groups at low viability. Information considered during the most recent status review indicates that the biological risks faced by the Puget Sound Steelhead DPS have not substantively changed since the listing in 2007, or since the 2011 status review. Furthermore, the Puget Sound Steelhead TRT recently concluded that the DPS was at very low viability, as were all three of its constituent MPGs, and many of its 32 populations. In the near term, the outlook for environmental conditions affecting Puget Sound steelhead is not optimistic. While harvest and hatchery production of steelhead in Puget Sound are currently at low levels and are not likely to increase substantially in the foreseeable future, some recent environmental trends not favorable to Puget Sound steelhead survival and production are expected to continue.	• Continued destruction and modification of habitat • Widespread declines in adult abundance despite significant reductions in harvest • Threats to diversity posed by use of two hatchery steelhead stocks • Declining diversity in the DPS, including the uncertain but weak status of summer-run fish • A reduction in spatial structure • Reduced habitat quality • Urbanization • Dikes, hardening of banks with riprap, and channelization
Puget Sound/ Georgia Basin DPS of	Endangered 04/28/2010 (75 FR 22276)	NMFS 2017a	NMFS 2016a	Though bocaccio were never a predominant segment of the multi-species rockfish population within the Puget Sound/Georgia	• Over harvest • Water pollution • Climate-induced changes to rockfish habitat

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Bocaccio				Basin, their present-day abundance is likely a fraction of their pre-contemporary fishery abundance. Most bocaccio within the DPS may have been historically spatially limited to several basins within the DPS. They were apparently historically most abundant in the Central and South Sound with no documented occurrences in the San Juan Basin until 2008. The apparent reduction of populations of bocaccio in the Main Basin and South Sound represents a further reduction in the historically spatially limited distribution of bocaccio, and adds significant risk to the viability of the DPS.	• Small population dynamics
Puget Sound/ Georgia Basin DPS of Yelloweye Rockfish	Threatened 04/28/2010 (75 FR 22276)	NMFS 2017a	NMFS 2016a	Yelloweye rockfish within the Puget Sound/Georgia Basin (in U.S. waters) are very likely the most abundant within the San Juan Basin of the DPS. Yelloweye rockfish spatial structure and connectivity is threatened by the apparent reduction of fish within each of the basins of the DPS. This reduction is probably most acute within the basins of Puget Sound proper. The severe reduction of fish in these basins may eventually result in a contraction of the DPS' range.	• Over harvest • Water pollution • Climate-induced changes to rockfish habitat • Small population dynamics
Hood Canal summer-run chum salmon	Threatened 06/28/2005 (70 FR 37160)	HCCC 2005 NMFS 2007	Ford 2022*	This ESU is made up of two independent populations in one major population group. Natural-origin spawner abundance has increased since ESA-listing and spawning abundance targets in both populations have been met in some years. Productivity was quite low at the time of the last review, though rates have increased in the last five years, and have been greater than replacement rates in the past two years for both populations. However, productivity of individual spawning aggregates shows only two of eight aggregates have viable performance. Spatial structure and diversity viability parameters for each population have increased and nearly meet the viability criteria.	• Reduced floodplain connectivity and function • Poor riparian condition • Loss of channel complexity Sediment accumulation • Altered flows and water quality

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				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.	
Ozette Lake sockeye salmon	Threatened 06/28/2005 (70 FR 37160)	NMFS 2009a	NMFS 2022a	This single population ESU's size remain very small compared to historical sizes. Additionally, population estimates remain highly variable and uncertain, making it impossible to detect changes in abundance trends or in productivity in recent years. Spatial structure and diversity are also difficult to appraise; there is currently no successfully quantitative program to monitor beach spawning or spawning at other tributaries. Assessment methods must improve to evaluate the status of this species and its responses to recovery actions. Abundance of this ESU has not changed substantially from the last status review. The quality of data continues to hamper efforts to assess more recent trends and spatial structure and diversity although this situation is improving.	• Predation by harbor seals, river otters, and predaceous non-native and native species of fish • Reduced quality and quantity of beach spawning habitat in Lake Ozette • Increased competition for beach spawning sites due to reduced habitat availability • Stream channel simplification and increased sediment in tributary spawning areas
Upper Columbia River spring-run Chinook salmon	Endangered 06/28/2005 (70 FR 37160)	UCSRB 2007	NMFS 2022b	This ESU comprises four independent populations. Three are at high risk and one is functionally extirpated. Current estimates of natural origin spawner abundance increased relative to the levels observed in the prior review for all three extant populations, and productivities were higher for the Wenatchee and Entiat populations and unchanged for the Methow population. However, abundance and productivity remained well below the viable thresholds called for in the Upper Columbia Recovery Plan for all three populations.	• Effects related to hydropower system in the mainstem Columbia River • Degraded freshwater habitat • Degraded estuarine and nearshore marine habitat • Hatchery-related effects • Persistence of non-native (exotic) fish species • Harvest in Columbia River fisheries
Upper Columbia River steelhead	Threatened 01/05/2006 (71 FR 834)	UCSRB 2007	NMFS 2022b	This DPS comprises four independent populations. Three populations are at high risk of extinction while 1 population is at moderate risk. Upper Columbia River steelhead populations have increased relative to the low	• Adverse effects related to the mainstem Columbia River hydropower system • Impaired tributary fish passage • Degraded floodplain connectivity and function, channel structure and complexity,

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				levels observed in the 1990s, but natural origin abundance and productivity remain well below viability thresholds for three out of the four populations. The status of the Wenatchee River steelhead population continued to improve based on the additional year's information available for the most recent review. The abundance and productivity viability rating for the Wenatchee River exceeds the minimum threshold for 5% extinction risk. However, the overall DPS status remains unchanged from the prior review, remaining at high risk driven by low abundance and productivity relative to viability objectives and diversity concerns.	riparian areas, large woody debris recruitment, stream flow, and water quality • Hatchery-related effects • Predation and competition • Harvest-related effects
Middle Columbia River steelhead	Threatened 01/05/2006 (71 FR 834)	NMFS	NMFS 2022c	This DPS comprises 17 extant populations. The DPS does not currently include steelhead that are designated as part of an experimental population above the Pelton Round Butte Hydroelectric Project. Returns to the Yakima River basin and to the Umatilla and Walla Walla Rivers have been higher over the most recent brood cycle, while natural origin returns to the John Day River have decreased. There have been improvements in the viability ratings for some of the component populations, but the DPS is not currently meeting the viability criteria in the MCR steelhead recovery plan. In general, the majority of population level viability ratings remained unchanged from prior reviews for each major population group within the DPS.	• Degraded freshwater habitat • Mainstem Columbia River hydropower-related impacts • Degraded estuarine and nearshore marine habitat • Hatchery-related effects • Harvest-related effects • Effects of predation, competition, and disease
Snake River spring/summer-run Chinook salmon	Threatened 06/28/2005 (70 FR 37160)	NMFS 2017b	NMFS 2022d	This ESU comprises 28 extant and four extirpated populations. All expect one extant population (Chamberlin Creek) are at high risk. Natural origin abundance has increased over the levels reported in the prior review for most populations in this ESU, although the increases were not substantial enough to change viability ratings. Relatively high ocean survivals in recent years were a major factor in recent abundance	• Degraded freshwater habitat • Effects related to the hydropower system in the mainstem Columbia River, • Altered flows and degraded water quality • Harvest-related effects • Predation

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				patterns. While there have been improvements in abundance and productivity in several populations relative to prior reviews, those changes have not been sufficient to warrant a change in ESU status.	
Snake River fall-run Chinook salmon	Threatened 06/28/2005 (70 FR 37160)	NMFS 2017c	NMFS 2022e	This ESU has one extant population. Historically, large populations of fall Chinook salmon spawned in the Snake River upstream of the Hells Canyon Dam complex. The extant population is at moderate risk for both diversity and spatial structure and abundance and productivity. The overall viability rating for this population is 'viable.' Overall, the status of Snake River fall Chinook salmon has clearly improved compared to the time of listing and compared to prior status reviews. The single extant population in the ESU is currently meeting the criteria for a rating of 'viable' developed by the ICTRT, but the ESU as a whole is not meeting the recovery goals described in the recovery plan for the species, which require the single population to be "highly viable with high certainty" and/or will require reintroduction of a viable population above the Hells Canyon Dam complex.	• Degraded floodplain connectivity and function • Harvest-related effects • Loss of access to historical habitat above Hells Canyon and other Snake River dams • Impacts from mainstem Columbia River and Snake River hydropower systems • Hatchery-related effects • Degraded estuarine and nearshore habitat.
Snake River basin steelhead	Threatened 01/05/2006 (71 FR 834)	NMFS 2017b	NMFS 2022f	This DPS comprises 24 populations. Two populations are at high risk, 15 populations are rated as maintained, 3 populations are rated between high risk and maintained, 2 populations are at moderate risk, 1 population is viable, and 1 population is highly viable. Four out of the five MPGs are not meeting the specific objectives in the draft recovery plan based on the updated status information available for this review, and the status of many individual populations remains uncertain A great deal of uncertainty still remains regarding the relative proportion of hatchery fish in natural	• Adverse effects related to the mainstem Columbia River hydropower system • Impaired tributary fish passage • Degraded freshwater habitat • Increased water temperature • Harvest-related effects, particularly for B-run steelhead • Predation • Genetic diversity effects from out-of-population hatchery releases

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

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

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				summer-run population is a source of concern, given that this population has been considered one of the healthiest of the summer-runs; however, the most recent abundance estimates suggest that the decline was a single year aberration. Passage programs in the Cowlitz and Lewis basins have the potential to provide considerable improvements in abundance and spatial structure, but have not produced self-sustaining populations to date. Even with modest improvements in the status of several winter-run DIPs, none of the populations appear to be at fully viable status, and similarly none of the MPGs meet the criteria for viability.	• Reduced productivity resulting from sediment and nutrient-related changes in the estuary • Juvenile fish wake strandings • Contaminants
Columbia River chum salmon	Threatened 06/28/2005 (70 FR 37160)	NMFS 2013a	NMFS 2022h	Overall, the status of most chum salmon populations is unchanged from the baseline VSP scores estimated in the recovery plan. A total of 3 of 17 populations are at or near their recovery viability goals, although under the recovery plan scenario these populations have very low recovery goals of 0. The remaining populations generally require a higher level of viability and most require substantial improvements to reach their viability goals. Even with the improvements observed during the last five years, the majority of populations in this ESU remain at a high or very high risk category and considerable progress remains to be made to achieve the recovery goals.	• 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 • Reduced productivity resulting from sediment and nutrient-related changes in the estuary • Juvenile fish wake strandings • Contaminants
Upper Willamette River Chinook salmon	Threatened 06/28/2005 (70 FR 37160)	ODFW and NMFS 2011	Ford 2022*	This ESU comprises seven populations. Five populations are at very high risk, one population is at moderate risk (Clackamas River) and one population is at low risk (McKenzie River). Consideration of data collected since the last status review in 2010 indicates the fraction of hatchery origin fish in all populations remains high (even in Clackamas and McKenzie populations). The proportion of natural origin	• Degraded freshwater habitat • Degraded water quality • Increased disease incidence • Altered stream flows • Reduced access to spawning and rearing habitats • Altered food web due to reduced inputs of microdetritus

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				spawners improved in the North and South Santiam basins, but is still well below identified recovery goals. Abundance levels for five of the seven populations remain well below their recovery goals. Of these, the Calapooia River may be functionally extinct and the Molalla River remains critically low. Abundances in the North and South Santiam rivers have risen since the 2010 review, but still range only in the high hundreds of fish. The Clackamas and McKenzie populations have previously been viewed as natural population strongholds, but have both experienced declines in abundance despite having access to much of their historical spawning habitat. Overall, populations appear to be at either moderate or high risk, there has been likely little net change in the VSP score for the ESU since the last review, so the ESU remains at moderate risk.	• Predation by native and non-native species, including hatchery fish • Competition related to introduced salmon and steelhead • Altered population traits due to fisheries and bycatch
Upper Willamette River steelhead	Threatened 01/05/2006 (71 FR 834)	ODFW and NMFS 2011	Ford 2022*	This DPS has four demographically independent populations. Three populations are at low risk and one population is at moderate risk. Declines in abundance noted in the last status review continued through the period from 2010-2015. While rates of decline appear moderate, the DPS continues to demonstrate the overall low abundance pattern that was of concern during the last status review. The causes of these declines are not well understood, although much accessible habitat is degraded and under continued development pressure. The elimination of winter-run hatchery release in the basin reduces hatchery threats, but non-native summer steelhead hatchery releases are still a concern for species diversity and a source of competition for the DPS. While the collective risk to the persistence of the DPS has not changed significantly in recent years, continued declines and potential negative impacts from	• Degraded freshwater habitat • Degraded water quality • Increased disease incidence • Altered stream flows • Reduced access to spawning and rearing habitats due to impaired passage at dams • Altered food web due to changes in inputs of microdetritus • Predation by native and non-native species, including hatchery fish and pinnipeds • Competition related to introduced salmon and steelhead • Altered population traits due to interbreeding with hatchery origin fish

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				climate change may cause increased risk in the near future.	
Oregon Coast coho salmon	Threatened 06/20/2011 (76 FR 35755)	NMFS 2016b	NMFS 2022i	This ESU comprises 56 populations including 21 independent and 35 dependent populations. The last status review indicated a moderate risk of extinction. Significant improvements in hatchery and harvest practices have been made for this ESU. Most recently, spatial structure conditions have improved in terms of spawner and juvenile distribution in watersheds; none of the geographic area or strata within the ESU appear to have considerably lower abundance or productivity. The ability of the ESU to survive another prolonged period of poor marine survival remains in question.	• 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
Southern Oregon/ Northern California Coast coho salmon	Threatened 06/28/2005 (70 FR 37160)	NMFS 2014a	Ford 2022*	This ESU comprises 31 independent, 9 independent, and 5 ephemeral populations all grouped into 7 diversity strata. Of the 31 independent populations, 24 are at high risk of extinction and 6 are at moderate risk of extinction. The extinction risk of an ESU depends upon the extinction risk of its constituent independent populations; because the population abundance of most independent populations are below their depensation threshold, the SONCC coho salmon ESU is at high risk of extinction and is not viable	• Lack of floodplain and channel structure • Impaired water quality • Altered hydrologic function • Impaired estuary/mainstem function • Degraded riparian forest conditions • Altered sediment supply • Increased disease/predation/competition • Barriers to migration • Fishery-related effects • Hatchery-related effects
Northern California steelhead	Threatened 6/7/2000 (65 FR 36074)	NMFS 2016c	NMFS 2016d	This DPS historically comprised 42 independent populations of winter-run steelhead (19 functionally independent and 23 potentially independent), and up to 10 independent populations (all functionally independent) of summer-run steelhead, with more than 65 dependent populations of winter-run steelhead in small coastal watersheds, and Eel river tributaries. Many populations are considered to be extant. Significant gaps in information exist for the Lower Interior and North Mountain Interior diversity strata. All winter-run	• Dams and other barriers to migration • Logging • Agriculture • Ranching • Fishery-related effects • Hatchery-related effects

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				populations are currently well below viability targets, with most at 5-13% of these goals. Mixed population trends arise depending on time series length; thus, there is no strong evidence to indicate conditions for winter-run populations have worsened appreciably since the last status review. Summer-run populations are of concern. While one run is near the viability target, others are very small or there is a lack of data. Overall, available information for winter- and summer-run populations do not suggest an appreciable increase or decrease in extinction risk since the last status review.	
California Coastal Chinook salmon	Threatened 09/16/1999 (64 FR 50394)	NMFS 2016c	NMFS 2016d	This ESU historically supported 16 Independent populations of fall-run Chinook salmon (11 Functionally Independent and five potentially Independent), six populations of spring-run Chinook salmon, and an unknown number of dependent populations. Based on the data available, eight of the 16 populations were classified as data deficient, one population was classified as being at a Moderate/High risk of extirpation, and six populations were classified as being at a High risk of extirpation. There has been a mix in population trends, with some population escapement numbers increasing and others decreasing. Overall, there is a lack of compelling evidence to suggest that the status of these populations has improved or deteriorated appreciably since the previous status review.	• Logging and road construction altering substrate composition, increasing sediment load, and reducing riparian cover • Estuarine alteration resulting in lost complexity and habitat from draining and diking • Dams and barriers diminishing downstream habitats through altered flow regimes and gravel recruitment • Climate change • Urbanization and agriculture degrading water quality from urban pollution and agricultural runoff • Gravel mining creating barriers to migration, stranding of adults, and promoting spawning in poor locations • Alien species (i.e. Sacramento Pikeminnow) • Small hatchery production without monitoring the effects of hatchery releases on wild spawners
Sacramento River winter-run Chinook salmon	Endangered 09/16/1999 (64 FR 50394)	NMFS 2014b	NMFS 2016e	This ESU historically supported 18 or 19 Independent populations, with some smaller dependent populations, and four diversity groups. Only three populations are extant (Mill, Deer, and Butte creeks on the upper Sacramento River) which only represent one	• Dams block access to 90 percent of historic spawning and summer holding areas along with altering river flow regimes and temperatures. • Diversions • Urbanization and rural development

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				diversity group (Northern Sierra Nevada). Spatial diversity is increasing with presence (at low numbers in some cases) in all diversity groups. Recolonization of the Battle Creek population with increasing abundance of the Clear Creek population is benefiting ESU viability. The reappearance of phenotypic spring-run to the San Joaquin River tributaries may be the beginning of natural recolonization processes in once extirpated rivers. Active reintroduction efforts on the Yuba and San Joaquin rivers show promise. The ESU is trending positively towards achieving at least two populations in each of the four historical diversity groups necessary for recovery.	• Logging • Grazing • Agriculture • Mining – historic hydraulic mining from the California Gold Rush era. • Estuarine modified and degraded, thus reducing developmental opportunities for juvenile salmon • Fisheries • Hatcheries • 'Natural' factors (e.g. ocean conditions)
Central Valley spring-run Chinook salmon	Threatened 09/16/1999 (64 FR 50394)	NMFS 2014b	NMFs 2016f	This ESU historically supported 18 or 19 Independent populations, with some smaller dependent populations, and four diversity groups. Only three populations are extant (Mill, Deer, and Butte creeks on the upper Sacramento River) which only represent one diversity group (Northern Sierra Nevada). Spatial diversity is increasing with presence (at low numbers in some cases) in all diversity groups. Recolonization of the Battle Creek population with increasing abundance of the Clear Creek population is benefiting ESU viability. The reappearance of phenotypic spring-run to the San Joaquin River tributaries may be the beginning of natural recolonization processes in once extirpated rivers. Active reintroduction efforts on the Yuba and San Joaquin rivers show promise. The ESU is trending positively towards achieving at least two populations in each of the four historical diversity groups necessary for recovery.	• Dams block access to 90 percent of historic spawning and summer holding areas along with altering river flow regimes and temperatures. • Diversions • Urbanization and rural development • Logging • Grazing • Agriculture • Mining – historic hydraulic mining from the California Gold Rush era. • Estuarine modified and degraded, thus reducing developmental opportunities for juvenile salmon • Fisheries • Hatcheries • 'Natural' factors (e.g. ocean conditions)
California Central Valley steelhead	Threatened 3/19/1998 (63 FR 13347)	NMFS 2014b	NMFS 2016g	Steelhead are present throughout most of the watersheds in the Central Valley, but often in low numbers, especially in the San Joaquin River	• Major dams • Water diversions • Barriers

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				tributaries. The status of this DPS appears to have changed little since the 2011 status review stating the DPS was in danger of extinction. There is still a paucity of data on the status of wild populations. There are some encouraging signs of increased returns over the last few years. However, the catch of unmarked (wild) steelhead at Chipps Island is still less than 5 percent of the total smolt catch, which indicates natural production of steelhead throughout the Central Valley remains at very low levels. Despite a positive trend on Clear Creek and encouraging signs from Mill Creek, all other concerns raised in the previous status review remain.	• Levees and bank protection • Dredging and sediment disposal • Mining • Contaminants • Alien species • Fishery-related effects • Hatchery-related effects
Central California Coast coho salmon	Endangered 04/02/2012 (77 FR 19552) 06/28/2005 (70 FR 37160) Threatened 10/31/1996 (61 FR 56138)	NMFS 2012a	NMFS 2016h	This ESU comprises approximately 76 populations that are mostly dependent populations. Historically, the ESU had 11 functionally independent populations and one potentially independent population organized into four stratum. Most independent populations remain at critically low levels, with those in the southern Santa Cruz Mountains strata likely extirpated. Data suggests some populations show a slight positive trend in annual escapement, but the improvement is not statistically significant. Overall, all populations remain, at best, a slight fraction of their recovery target levels, and, aside from the Santa Cruz Mountains strata, the continued extirpation of dependent populations continues to threaten the ESU's future survival and recovery.	• Logging • Agriculture • Mining • Urbanization • Stream modifications - including altered stream bank and channel morphology, elevated water temperature, lost spawning and rearing habitat, habitat fragmentation, impaired gravel and wood recruitment from upstream sources, degraded water quality, lost riparian vegetation, and increased erosion into streams from upland areas • Dams • Wetland loss • Water withdrawals (including unscreened diversions for irrigation)
Central California Coast steelhead	Threatened 8/18/1997 (62 FR 43937)	NMFS 2016c	NMFS 2016i	Both adult and juvenile abundance data are limited for this DPS. It was historically comprised of 37 independent populations (11 functionally independent and 26 potentially independent) and perhaps 30 or more dependent populations of winter-run steelhead. Most of the coastal	• Dams and other barriers to migration • Stream habitat degradation • Estuarine habitat degradation • Hatchery-related effects

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				populations are assumed to be extant with other populations (Coastal San Francisco Bay and Interior San Francisco Bay) likely at high risk of extirpation. While data availability for this DPS remains poor, there is little new evidence to suggest that the extinction risk for this DPS has changed appreciably in either direction since the last status review.	
South-Central California Coast steelhead	Threatened 8/18/1997 (62 FR 43937)	NMFS 2013b	NMFS 2016j	Currently, nearly half of this DPS reside in the Carmel River. Most other streams and rivers have small populations that can be stochastically driven to extirpation. The ability to fully assess the status of individual populations and the DPS as whole has been limited. There is little new evidence to indicate that the status of the SCCC Steelhead DPS has changed appreciably since the last status review, though the Carmel River runs have shown a long term decline. Threats to the DPS identified during initial listing have remained largely unchanged, though some fish passage barriers have been removed. Threats to this DPS are likely to exacerbate the factors affecting the continued existence of the DPS. SCCC steelhead recovery will require reducing threats, maintaining interconnected populations across their native range, and preserving the diversity of life history strategies.	• 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
Southern California Steelhead	Endangered 8/18/1997 (62 FR 43937)	NMFS 2012b	NMFS 2016k	This DPS includes steelhead populations along the coast of California from the Santa Maria River system to the border between the U.S. and Mexico. Within this area there are a number of very small (<10 fish) but enduring annual runs. It remains to be seen how these small runs are able to persist. Some populations in different basins are connected by relatively frequent straying. More recent genetic data show a large amount of introgression and extirpation of native fish in the southern portion	• Loss and degradation of estuarine habitats • Dams • Urban Development, roads • Mining, agriculture, ranching, recreation • Predation by and competition with non-native species • Disease • More frequent and extended river mouth closures • Inadequate regulatory mechanisms

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

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				these conditions will persist into the near future suggest that population declines may be widespread in the upcoming return years	
Southern resident killer whale	Endangered 11/18/2005 (70 FR 69903)	NMFS 2008a	Ford 2013	The Southern Resident killer whale DPS is composed of a single population that ranges as far south as central California and as far north as southeast Alaska. The estimated effective size of the population (based on the number of breeding individuals under ideal genetic conditions) is very small — <30 whales, or about 1/3 of the current population size. The small effective population size, the absence of gene flow from other populations, and documented breeding within pods may elevate the risk from inbreeding and other issues associated with genetic deterioration. As of July 1, 2013, there were 26 whales in J pod, 19 whales in K pod and 37 whales in L pod, for a total of 82 whales. Estimates for the historical abundance of Southern Resident killer whales range from 140 whales (based on public display removals to 400 whales, as used in population viability analysis scenarios.	• Quantity and quality of prey • Exposure to toxic chemicals • Disturbance from sound and vessels • Risk from oil spills

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

Species-specific status information is discussed in more detail below. The abundance numbers presented for each should be viewed with caution, however, as they only address one of several juvenile life stages. Moreover, deriving any juvenile abundance estimate for species with no dam/passage counts is complicated by a host of variables, including the facts that: (1) the available data do not include all populations; (2) spawner counts and associated sex ratios and fecundity estimates can vary widely between years; (3) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; (4) it is very difficult to distinguish between non-listed juvenile rainbow trout and listed juvenile steelhead; and (5) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, fishing, etc.).

2.2.1.1 Puget Sound Chinook Salmon

Abundance and Productivity

The current abundance for PS Chinook salmon populations is displayed in Table 3, below. To estimate the abundance of adult spawners, we took the geometric means of the last five years of adult returns—as estimated by dam counts, radio-tag studies, PIT-stag studies, redd counts, and other methods (Ford 2022). Natural-origin juvenile PS Chinook salmon abundance estimates come from applying estimates of the percentage of females in the population and average fecundity to escapement data. Fecundity estimates for the ESU range from 2,000 to 5,500 eggs per female, and the proportion of female spawners in most populations is approximately 40% of escapement. By applying a conservative fecundity estimate (2,000 eggs/female) to the expected female escapement (both natural-origin and hatchery-origin spawners – 18,641 females), the ESU is estimated to produce approximately 37.3 million eggs annually. Smolt trap studies have researched egg to migrant juvenile Chinook salmon survival rates in the following Puget Sound tributaries: Skagit River, North Fork Stillaguamish River, South Fork Stillaguamish River, Bear Creek, Cedar River, and Green River (Beamer et al. 2000; Seiler et al. 2002, 2004, 2005; Volkhardt et al. 2005; Griffith et al. 2004). The average survival rate in these studies was 10%, which corresponds with those reported by Healey (1991). With an estimated survival rate of 10%, the ESU should produce roughly 3.7 million natural-origin outmigrants annually.

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

Table 3. Recent Five-Year Geometric Means for Estimated PS Chinook Juvenile Outmigrations and Adult Returns (Ford 2022) (LHIA=Listed hatchery, intact adipose (fin); LHAC= listed hatchery, adipose-clipped).

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

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

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

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

Spatial Structure and Diversity

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

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

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

2.2.1.2 Puget Sound Steelhead

Abundance and Productivity

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

Juvenile listed hatchery PS steelhead abundance estimates come from the annual hatchery production goals (WDFW 2022). The combined hatchery production goal for listed PS steelhead is roughly 274 thousand juveniles annually (Table 4).

Table 4. Recent Five-Year Geometric Means for Estimated PS Steelhead Juvenile Outmigrations and Adult Returns (Ford 2022).

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

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

Spatial Structure and Diversity

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

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

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

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

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

2.2.1.3 Puget Sound/Georgia Basin Rockfish

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

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

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

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

2.2.1.3.1 Puget Sound/Georgia Basin DPS Bocaccio

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

Abundance and Productivity

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

Table 5. Estimated Adult Boccacio Abundance (Pacunski et al. 2013).

Life Stage	Origin	Abundance
Adult	Natural	4,606

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

Structure and Diversity

The PS/GB bocaccio DPS includes all bocaccio from inland marine waters east of the central Strait of Juan de Fuca and south of the northern Strait of Georgia, collectively known as the Salish Sea. The waters of Puget Sound and Straits of Georgia can be divided into five interconnected basins that are largely hydrologically isolated from each other by relatively shallow sills. The basins within US waters are: (1) San Juan, (2) Main, (3) South Sound, and (4) Hood Canal. The fifth basin consists of Canadian waters east and north of the San Juan Basin into the Straits of Georgia. Although most individuals of the PS/GB bocaccio DPS are believed to remain within the basin of their origin, including larvae and pelagic juveniles, some movement between basins occurs, and the DPS is currently considered a single population (Tonnes et al. 2016). Research intended to assess this assumption using genetic techniques was unable to collect sufficient samples for analysis (Andrews et al. 2018), but is ongoing.

2.2.1.3.2 Puget Sound/Georgia Basin DPS Yelloweye Rockfish

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

Abundance and Productivity

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

Table 6. Estimated Adult Yelloweye Rockfish Abundance (Pacunski et al. 2020).

Life Stage	Origin	Abundance
Adult	Natural	114,494

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

Structure and Diversity

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

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

2.2.1.5 Hood Canal Summer-run Chum Salmon

Abundance and Productivity

Managers have been estimating total spawner and natural spawner returns for this ESU since 1974. The estimates are based on spawning ground surveys and genetic stock identification (Ford 2022). Fifteen-year trends in log natural-origin spawner abundance over two time periods (1990 – 2005 and 2004 – 2019) show strongly positive trends in the two populations in the first time period, but abundance trends for both populations have decreased to close to zero in the most recent 15-year period (Ford 2022). Since 2016, abundances for both populations have sharply decreased. This began in 2017 for the Strait of Juan de Fuca population and in 2018 for the Hood Canal population. Despite substantive gains towards meeting viability criteria in the Hood Canal and Strait of Juan de Fuca summer chum salmon populations, the ESU still does not meet all of the recovery criteria for population viability at this time (Ford 2022). Abundance estimates for the ESU components are listed below (Table 7).

Table 7. Recent 5-Year Geometric Means for Estimated HCS Chum Juvenile Outmigrations and Adult Returns (Ford 2022).

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

*This ESU contains no listed, adipose-fin-clipped fish.

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

Spatial Structure and Diversity

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

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

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

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

2.2.1.6 Ozette Lake Sockeye Salmon

Abundance and Productivity

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

present). Until 2000, all broodstock was taken from beaches. From 2000 on, the broodstock was taken from Umbrella Creek (Ford 2022).

Table 8. Recent Five-Year Geometric Means for Estimated Ozette Lake Sockeye Juvenile Outmigrations and Adult Returns (Ford 2022).

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

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

Structure and Diversity

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

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

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

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

2.2.1.7 Upper Columbia River Spring-run Chinook Salmon

Abundance and Productivity

To estimate abundance of juvenile natural and hatchery UCR spring-run Chinook salmon, we calculate the geometric means for outmigrating smolts over the past five years by using annual abundance estimates provided by the NWFSC (Zabel 2017, 2018, 2020, 2021, 2022). To estimate the abundance figures for adult returns, we used the geometric means of the last five years of adult returns as reported by the NWFSC (Ford 2022). The figures for adults are broken down by natural and hatchery fish, but not into individual hatchery components (i.e., LHAC and LHIA). Abundance estimates for the ESU components are listed below (Table 9).

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

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

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

Structure and Diversity

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

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

2.2.1.8 Upper Columbia River Steelhead

Abundance and Productivity

To estimate abundance of juvenile natural and hatchery UCR steelhead, we calculate the geometric means for outmigrating smolts over the past five years by using annual abundance estimates provided by the NWFSC (Zabel 2017, 2018, 2020, 2021, 2022). To calculate the abundance figures for adult returns, we took the geometric means of the last five years of adult returns—as estimated by expanded redd surveys, carcass counts, dam counts, and run-at-large PIT tag detections (Ford 2022). The figures for adults are broken down by natural and hatchery fish, but not into individual hatchery components (i.e., LHAC and LHIA) (Table 10).

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

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

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

Structure and Diversity

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

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

2.2.1.9 Middle Columbia River Steelhead

Abundance and Productivity

To estimate abundance of juvenile natural and hatchery MCR steelhead, we calculate the geometric means for outmigrating smolts over the past five years by using annual abundance estimates provided by the NWFSC (Zabel 2017, 2018, 2020, 2021, 2022). To estimate the abundance figures for adult returns, we used the geometric means of the last five years of adult returns as reported by the NWFSC (Ford 2022). The figures for adults are broken down by natural and hatchery fish, but not into individual hatchery components (i.e., LHAC and LHIA). Abundance estimates for the DPS components are listed below (Table 11).

Table 11. Recent 5-Year Geometric Means for Estimated MCR Steelhead Juvenile Outmigrations and Adult Returns (Ford 2022; Zabel 2017, 2018, 2020, 2021, 2022).

Life Stage	Origin	Outmigration/Return
Adult	Natural	13,598

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

In all but one population (Klickitat R.), these adult return numbers represent substantial reductions from levels seen in the last status review (NWSFC 2015). Since that time, 16 out of the DPS's 17 extant populations have seen reductions in natural spawners that range from 15% (upper Yakima) R.) to 70% (eastside Deschutes R.). In addition, only four populations show productivity increases over the last 14 years, and all populations in the DPS have demonstrated decreases in productivity during the most recent 3-five years for which we have data (Ford 2022). Thus, both abundance and productivity have been decreasing for essentially all MCR steelhead populations for the last several years; however, five populations remain above the ICTRT's minimum viability thresholds for natural abundance (ICTRT 2007) and several more are near their thresholds. In addition, freshwater productivity indices (FWPIs) are above 1.0 for all populations except the Umatilla—indicating that poor marine survival could be driving most of the downturns. The result is that most of the populations are considered to be at moderate extinction risk with regard to abundance and productivity criteria, but three (Deschutes R. westside, Rock Cr., and Touchet R.) are considered to be at high risk (Ford 2022).

Structure and Diversity

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

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

2.2.1.10 Snake River Spring/Summer-run Chinook Salmon

Abundance and Productivity

To estimate abundance of juvenile natural and hatchery SnkR spr/sum Chinook, we calculate the geometric means for outmigrating smolts over the past five years by using annual abundance estimates provided by the NWFSC (Zabel 2017, 2018, 2020, 2021, 2022). To estimate the abundance figures for adult returns, we used the geometric means of the last five years of adult returns as reported by the NWFSC (Ford 2022). The figures for adults are broken down by natural and hatchery fish, but not into individual hatchery components (i.e., LHAC and LHIA). Abundance estimates for the ESU components are listed below (Table 12).

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

Life Stage	Origin	Outmigration/Return
Adult	Natural	4,419
Adult	Hatchery	2,822
Juvenile	Natural	682,600
Juvenile	LHIA	695,385
Juvenile	LHAC	4,743,977

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

Structure and Diversity

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

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

2.2.1.11 Snake River Fall-run Chinook Salmon

Abundance and Productivity

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

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

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

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

Structure and Diversity

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

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

2.2.1.12 Snake River Basin Steelhead

Abundance and Productivity

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

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

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

The five-year geometric mean abundance estimates for all the populations in this DPS show significant declines in the recent past (Ford 2022). The population decreases ranged from 15% (Lochsa/Selway) to over 70% (Little Salmon/Rapid R.), with most declines somewhere in the 50% range. These declines, following years of general increase, resulted in nearly zero population change over the past 1five years for the three populations with sufficiently long data time series to measure. Overall productivity among every population in the DPS has also declined over the last five years for which we have data. However, the freshwater component of productivity, as measured by FWPIs, has remained above 1.0 for every MPG in the DPS (Ford 2022)—which may indicate low marine survival rates are driving much of the recent declines. Given the abundance and productivity downturns in recent years, the DPS is now generally rated as being at moderate extinction risk for factors relating to abundance and productivity, though three populations are at very low risk and three are at high risk.

Structure and Diversity

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

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

2.2.1.13 Snake River Sockeye Salmon

Abundance and Productivity

To estimate abundance of juvenile natural and hatchery SnkR sockeye, we calculate the geometric means for outmigrating smolts over the past five years (2016-2020) by using annual abundance estimates provided by the NWFSC (Zabel 2017a, 2017b, 2018, 2020, 2021). To estimate the abundance figures for adult returns, we used the geometric means of the last five years of adult returns as reported by the NWFSC (Ford 2022). The figures for adults are broken down by natural and hatchery fish, but not into individual hatchery components (i.e., LHAC and LHIA). In addition, there are no LHIA juvenile fish in this ESU because all hatchery fish have their adipose fins clipped. Abundance estimates for the ESU components are listed below (Table 15).

Table 15. Recent 5-Year Geometric Means for Estimated SnkR Sockeye Juvenile Outmigrations and Adult Returns (Ford 2022; Zabel 2017, 2018, 2020, 2021, 2022).

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

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

After a number of years of small but steady increases, adult sockeye salmon returns to the Sawtooth Basin crashed in 2015 and natural returns have remained low since then (Ford 2022). The low returns of fish collected at the Redfish Lake and Sawtooth weirs have limited anadromous releases into Redfish Lake to a high of 311 hatchery fish in 2016, and no natural anadromous fish have been released since 2014 because they are required to be spawned in the captive broodstock program. Captive adult releases continue to support spawning in Redfish Lake, but productivity for this ESU is almost entirely due to the captive spawning efforts. Given the low returns in recent years, the production occurring almost entirely in hatchery environments, and the persistence of poor climatic conditions during times when the adult sockeye are migrating, the species' extinction risk remains high for factors relating to abundance and productivity.

Structure and Diversity

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

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

2.2.1.14 Lower Columbia River Chinook Salmon

Abundance and Productivity

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

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

Life Stage	Origin	Outmigration/Return
Adult	Natural	29,298
Adult	Hatchery	18,814

Life Stage	Origin	Outmigration/Return
Juvenile	Natural	11,135,315
Juvenile	LHIA	942,328
Juvenile	LHAC	30,923,844

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

Structure and Diversity

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

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

2.2.1.15 Lower Columbia River Coho Salmon

Abundance and Productivity

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

Table 17. Recent Five-Year Geometric Means for Estimated LCR Coho Juvenile Outmigrations and Adult Returns (Ford 2022; Zabel 2017, 2018, 2020, 2021, 2022).

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

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

Spatial Structure and Diversity

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

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

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

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

2.2.1.16 Lower Columbia River Steelhead

Abundance and Productivity

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

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

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

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

Structure and Diversity

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

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

2.2.1.17 Columbia River Chum Salmon

Abundance and Productivity

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

Table 19. Recent Five-Year Geometric Means for Estimated CR Chum Juvenile Outmigrations and Adult Returns (Ford 2022; Zabel 2017, 2018, 2020, 2021, 2022).

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

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

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

Spatial Structure and Diversity

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

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

2.2.1.18 Upper Willamette River Chinook Salmon

Abundance and Productivity

To estimate current abundance of juvenile natural and hatchery UWR Chinook salmon, we calculate the geometric means for outmigrating smolts over the past five years by using annual abundance estimates provided by the NWFSC (Zabel 2017, 2018, 2020, 2021, 2022). To estimate the abundance of adult spawners, we used the geometric means of the last five years of adult returns as reported by the NWFSC (Ford 2022). Abundance estimates for the ESU components are listed below (Table 20).

Table 20. Recent 5-Year Geometric Means for Estimated UWR Chinook Salmon Juvenile Outmigrations and Adult Returns (Ford 2022; Zabel 2017, 2018, 2020, 2021, 2022).

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

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

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

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

Spatial Structure and Diversity

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

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

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

2.2.1.19 Upper Willamette River Steelhead

Abundance and Productivity

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

Table 21. Recent Five-Year Geometric Means for Estimated UWR Steelhead Juvenile Outmigrations and Adult Returns (Ford 2022; Zabel 2017, 2018, 2020, 2021, 2022).

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

*This DPS contains no hatchery fish.

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

Spatial Structure and Diversity

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

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

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

Overall, the UWR steelhead DPS continued to decline in abundance since the previous status review in 2015. While the viability of the ESU appears to be declining, the recent uptick in abundance may provide a short-term demographic buffer. Although the most recent counts at Willamette Falls and the Bennett dams in 2019 and 2020 suggest a rebound from the record 2017 lows, it should be noted that current "highs" are equivalent to past lows. Introgression by non-native summer-run steelhead continues to be a concern. Genetic analysis suggests that there is introgression among native late-winter steelhead and summer-run steelhead (Van Doornik et al. 2015, Johnson et al. 2018, Johnson et al. 2021). Accessibility to historical spawning habitat is still limited, especially in the North Santiam River. Efforts to provide juvenile downstream passage at Detroit are well behind the prescribed timetable (NMFS 2008b), 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).

2.2.1.20 Oregon Coast Coho Salmon

Abundance and Productivity

To estimate the abundance of adult spawners, we used the geometric means of the last five years of adult returns as reported by the NWFSC (Ford 2022). While we currently lack data on how many natural juvenile coho salmon this ESU produces, it is possible to make rough estimates of juvenile abundance from adult return data. By applying a very conservative value of 2,000 eggs per female to an estimated 30,631 females returning (half of 61,262) to this ESU, one may expect approximately 61.3 million eggs to be produced annually. Nickelson (1998) found survival of coho from egg to parr in Oregon coastal streams to be around 7%. Thus, we can estimate that roughly 4.3 million natural-origin juvenile coho salmon are produced annually by the Oregon Coast ESU. In addition, the Cow Creek OC coho salmon artificial propagation program has an annual release target of 60,000 juveniles in the Umpqua River (ODFW 2017). Abundance estimates for the ESU components are listed below (Table 22).

Table 22. Recent 5-Year Geometric Means for Estimated OC Coho Juvenile Outmigrations and Adult Returns (Ford 2022).

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

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

Spatial Structure and Diversity

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

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

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

2.2.1.21 Southern Oregon/Northern California Coast Coho Salmon

Abundance and Productivity

To estimate the abundance of adult spawners, we took the geometric means of the last five years of adult returns—as estimated by dam counts, radio-tag studies, PIT-stag studies, redd counts, and other methods (SWFSC 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. Sandercock (1991) published fecundity estimates for several coho salmon stocks;

average fecundity ranged from 1,983 to 5,000 eggs per female. By applying a very conservative value of 2,000 eggs per female to an estimated 1,154 females returning (50 percent of the run) to this ESU, one may expect approximately 12.6 million eggs to be produced annually. Nickelson (1998) found survival of coho salmon from egg to parr in Oregon coastal streams to be around 7 percent. Thus, we can estimate that roughly the Southern Oregon/Northern California Coast ESU produces 884,870 natural-origin juvenile coho salmon annually. Combined hatchery releases for the Cole Rivers, Trinity River, and Iron Gate hatchery programs result in an estimate of 650 thousand hatchery-origin outmigrants per year (A. Cranford pers comm., ODFW 2020)

Table 23. Recent Five-Year Geometric Means for Estimated SONCC coho Juvenile Outmigrations and Adult Returns (SWFSC 2022[a]).

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

[a] Data are provisional and subject to change

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

Spatial Structure and Diversity

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

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

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

In summary, data availability for this ESU remains generally poor, new information available since Williams et al. (2016) suggests there has been little improvement over the five years since the last viability assessment (SWFSC 2022). For the seven independent populations with appropriate data to assess population viability, all are at or above a moderate risk based on population viability criteria (Williams et al. 2008). Five of the seven populations have negative trends in abundance including two (Shasta and Mattole rivers) that are at high-risk based on viability criteria (Williams et al. 2008). Of the two populations with positive abundance trends (Elk and Scott rivers), only one has a significant positive abundance trend (Elk River). The Scott River's 12-year average of 670 fish is well below the recovery target of 6,500 (NMFS 2014); both the Elk River and Scott River are at moderate-risk of extinction based on the spawner density criterion (Williams et al. 2008). Based on the available data, the extinction risk of the SONCC Coho Salmon ESU has increased since the last assessment.

2.2.1.22 Northern California Steelhead

Abundance and Productivity

Adult abundance and redd surveys are frequently conducted throughout many of the populations in this DPS. However, the record is inconsistent with either no fish observed or no surveys conducted in some years. Due to the inconsistency of the record we have used a 5-year average as an estimate for abundance (2014-2015 to 2018-2019 sampling seasons) for population data were available (CDFW 2020). While we currently lack data on naturally produced juvenile NC steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. Juvenile NC steelhead abundance estimates come from the escapement data displayed in the table below (Table 24). For this species, fecundity estimates range from 3,500 to 12,000 eggs per female, and the male to female ratio averages 1:1 (Pauley et al. 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (half of the escapement of spawners –4,178 females), 14.6 million eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce roughly 950,495 natural-origin outmigrants annually. No hatchery NC steelhead are listed as part of this DPS.

Table 24. Recent Five-Year Means for Estimated NC Steelhead Adult Returns and Estimated Juvenile Outmigrations (CDFW 2020, Pauley et al. 1986, Ward and Slaney 1993).

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

The SWFSC (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. Moreover, there appears to be a downward (but non-significant) trend in abundance for smaller populations.

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

Spatial Structure and Diversity

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

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

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

2.2.1.23 California Coastal Chinook Salmon

Abundance and Productivity

Adult Chinook salmon abundance estimates come from (1) sonar-based estimates on Redwood Creek and the Mad and Eel rivers, (2) weir counts at Freshwater Creek (one tributary of the Humboldt Bay population), (3) trap counts at Van Arsdale Station (representing a small portion of the upper Eel River population), (4) adult abundance estimates based on spawner surveys for six populations on the Mendocino Coast, and (5) video counts of adult Chinook salmon at Mirabel on the Russian River (SWFSC 2022). Previous status reviews have included maximum live/dead counts in three index reaches in the Eel River (Sproul and Tomki creeks) and Mad River (Cannon Creek); however, these efforts have been discontinued and replaced with the more rigorous efforts to monitor populations in the Eel and Mad rivers using sonar methods. Nonetheless, and despite the recent improvements, population-level abundance data are still limited. Abundance estimates for the ESU components are listed below (Table 25).

Table 25. Recent 5-Year Means for Estimated CC Chinook Adult Returns and Estimated Juvenile Outmigrations (SWFSC 2022).

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

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

Structure and Diversity

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

Data from populations in the more southerly diversity strata indicate that most populations (all except the Russian River) have exhibited mixed trends but remain far from recovery targets. In all Mendocino Coast populations (Ten Mile, Noyo, Big, Navarro, and Garcia rivers), surveys have failed to detect Chinook salmon in 3–10 of the 11 or 12 years of monitoring, suggesting only sporadic occurrence in these watersheds. Thus, concerns remain not only about the small population sizes, but the maintenance of connectivity across the ESU. Only the Russian River population has consistently numbered in the low thousands of fish in most years, making it the largest population south of the Eel River. The ESU therefore continues to be at risk of reduced spatial structure and diversity throughout its range (SWFSC 2022).

2.2.1.24 Sacramento River Winter-run Chinook Salmon

Abundance and Productivity

To estimate the abundance of adult spawners in this ESU we took the means of the last three years of adult returns—as estimated by mark-recaptures studies, redd counts, and carcass surveys (SWFSC 2022). The average of the estimated run size of in-river spawners from the most recent three years (2017-2019) was 3,702 adults. Over the most recent three years 68% of in-river spawners on average were hatchery-origin (SWFSC 2022), and therefore we estimate there would be 1,185 natural-origin and 2,517 hatchery-origin in-river spawners in a given year. When added to the average of 180 adults spawned per year at the Livingston Stone National Fish Hatchery (LSNFH) over the most recent three years, the total abundance of hatchery-origin adults is estimated to be 2,697 annually.

To estimate the abundance of juvenile Sacramento River winter-run Chinook salmon we utilize estimates developed pursuant to the biological opinion for the long-term operations of the Central Valley Project and State Water Project. Each year, a technical team from the Interagency Ecological Program uses adult escapement estimates from carcass surveys in the prior year, genetic data, the estimated number of fry-equivalents passing Red Bluff Diversion Dam, and survival rates of fry and smolts as they migrate downstream, to estimate the number of juvenile winter-run Chinook salmon to enter the Sacramento-San Joaquin Delta. We use these projections as our estimates of the number of hatchery-origin and naturally produced juveniles expected to be present in the system, as summarized in the table below (Table 26).

Table 26. Recent 5-Year Means for Estimated SacRWR Chinook Adult Returns and Estimated Juvenile Outmigrations (SWFSC 2022).

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

As with many Central Valley Chinook salmon populations, the abundance of Sacramento River winter-run Chinook salmon has declined during recent periods of unfavorable ocean conditions and droughts (SWFSC 2022). These conditions likely contributed to the low numbers of natural-origin adults observed in 2017 and 2018. However, recent improvements in adult returns in 2018 and 2019 have resulted in current population sizes that satisfy the low-risk criterion for abundance of this population. Still, the 10-year trend in run size, is not significantly different from zero (SWFSC 2022), and therefore does not indicate long-term improvements.

Structure and Diversity

The Sacramento River winter-run Chinook salmon population continues to be considered at high extinction risk because of the lack of population redundancy within the ESU, which has long consisted of a single spawning population spawning in the mainstem Sacramento River (SWFSC 2022). Reintroduction efforts in Battle Creek initiated in 2017 have begun the process of establishing a second winter-run Chinook salmon population, though it is not sufficient to mitigate the risk to the primary population in this ESU (SWFSC 2022).

In addition to limited spatial structure, this ESU is also highly dependent on the hatchery-origin fish produced by the LSNFH (SWFSC 2022). The primary role of this conservation hatchery is to prevent extinction of this ESU, so in response to drought conditions from 2013-2015 the number of hatchery adults spawned and juveniles released was greatly increased. This resulted in a significant increase in the proportion of hatchery-origin adult spawners in 2017 and 2018 (>80%), continuing a worsening trend of increasing hatchery influence that has reached levels placing this ESU at a high risk of extinction (SWFSC 2022).

2.2.1.25 Central Valley Spring-run Chinook Salmon

Abundance and Productivity

To estimate annual abundance of natural adult spawners (natural- and hatchery-origin), we calculate the average of the most recent three years of adult spawner counts (2017 through 2019) from surveys conducted by CDFW (SWFSC 2022). The Feather River Hatchery (FRH) is the only hatchery that produces Central Valley spring-run Chinook salmon (with the exception of the San Joaquin Salmon Conservation and Research Facility). The majority of spring-run Chinook salmon adults returning to spawn in the Feather River are therefore of hatchery origin; coded-wire tag data collected by CDFW from 2015-2019 spawning surveys indicates that on average 96% of adults spawning in the Feather River over the past five years have been of hatchery origin (Palmer-Zwahlen *et al.* 2019 and 2020, Letvin *et al.* 2020, 2021a, and 2021b). We therefore multiplied this fraction by the total population of spawners reported for the Feather River to estimate 2,083 hatchery-origin adults in this ESU, and the remainder of the Feather River adults in addition to all other populations estimated for this ESU resulted in the estimate of 6,756 natural-origin adults annually, based on the three-year averages (SWFSC 2022, Table 27).

While we currently lack data on naturally produced juvenile CVS Chinook salmon production, it is possible to make rough estimates of juvenile abundance from adult return data. The abundance of natural-origin CVS Chinook salmon juveniles was generated by applying estimates of the percentage of females in the population, fecundity, and survival rates to escapement data. Assuming half of the returning adults are females (4,420 females), and applying an average fecundity of 4,161 eggs per female and a 10% survival rate from egg to juvenile outmigrant (CDFG 1998), over 1.8 million natural-origin juvenile CVS Chinook salmon could be produced annually. The annual release target for hatchery juvenile spring-run Chinook salmon from the Feather River Hatchery is 2 million. Abundance estimates for the ESU components are listed below (Table 17).

Table 27. Recent Three-Year Means for Estimated CVS Chinook Adult Returns and Estimated Juvenile Outmigrations (SWFSC 2022).

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

All populations of CVS Chinook salmon continue to decline in abundance, with the exception of two dependent populations (SWFSC 2022). The total abundance (hatchery- and natural-origin spawners) of CVS Chinook in the Sacramento River basin in 2019 was approximately half of the population size in 2014 and close to the decadal lows that occurred as recently as the last two years (Azat 2020). The Butte Creek spring-run population has become the backbone of this ESU, in part due to extensive habitat restoration and the accessibility of floodplain habitat in the Butte Sink and the Sutter Bypass for juvenile rearing in the majority of years. Butte Creek remains at low risk, yet all viability metrics for the ESU have been trending in a negative direction in recent years (SWFSC 2022). Most dependent spring-run populations have been experiencing continued and, in some cases, drastic declines (SWFSC 2022).

Structure and Diversity

The Central Valley Technical Review Team estimated that historically there were 18 independent populations of CVS Chinook salmon, along with a number of dependent populations, in four distinct or diversity groups (Lindley *et al.* 2004). Of these 18 populations, only three remain (Mill, Deer, and Butte creeks, which are tributary to the upper Sacramento River) and they represent only the northern Sierra Nevada diversity group (SWFSC 2022). However, spatial diversity in the ESU is increasing and spring-run Chinook salmon are present (albeit at low numbers in some cases) in all diversity groups. The reestablishment of a population in Battle Creek and increasing abundance in Clear Creek observed in some years appears to be increasing the species' viability (SWFSC 2022). Similarly, the reappearance of early migrating Chinook salmon to the San Joaquin River tributaries may be the beginning of natural dispersal processes into rivers where they were once extirpated. Active reintroduction efforts on the Yuba River, above Shasta and Don Pedro dams, and below Friant Dam, if successful, would further improve the viability of this ESU.

Current introgression between fall- and spring-run Chinook salmon in the FRH breeding program and straying of FRH spring-run Chinook salmon to other spring-run populations where genetic introgression would be possible is having an adverse effect on the diversity of this ESU (SWFSC 2022). Off-site releases of FRH spring-run Chinook salmon have caused hatchery fish to increasingly stray into other spring-run populations and, if continued, could result in a moderate risk of extinction to other spring-run Chinook salmon populations. However, in 2014, the FRH started releasing spring-run production into the Feather River rather than the San Francisco Bay and it is hypothesized that this will reduce straying (Palmer-Zwahlen *et al.* 2019; Sturrock *et al.* 2019.

2.2.1.26 California Central Valley Steelhead

Abundance and Productivity

To estimate annual abundance for adult spawners (natural- and hatchery-origin) we use the average of the estimated run sizes for the most recent three years (2017-2019) from populations with available survey data (SWFSC 2022). It is important to note that these estimates do not include data from a number of watersheds where steelhead are known to be present, and therefore likely represent an underestimate of adult abundance for the DPS. In addition, while we know that the large average numbers of adults returning to the Mokelumne River, Feather River, and Coleman hatcheries (9,325 of the 11,494 returning adults) are predominantly of hatchery origin, we do not have sufficient population-level data to estimate the proportion of hatchery-origin spawners across the DPS. Abundance estimates for the DPS components are listed below (Table 28).

Table 28. Recent Three-Year Means for Estimated CCV Steelhead Adult Returns and Estimated Juvenile Outmigrations (SWFSC 2022).

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

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

Steelhead are present throughout most of the watersheds in the Central Valley, but often in low numbers, especially in the San Joaquin River tributaries, and population abundance data remain extremely limited for this DPS. While the total hatchery populations have continued to increase in abundance in recent years, the state of natural-origin fish remains poor and largely unknown (SWFSC 2022). Recent expansions in monitoring, such as in the Yuba, Stanislaus, and Tuolumne rivers and the San Joaquin River tributaries, have recently allowed several populations to be evaluated using viability criteria for the first time, and many show recent declines. Data collected through 2019 from the Chipps Island midwater trawl, which provides information on the trends in abundance for the DPS as a whole, indicate that the production of natural-origin steelhead remains very low relative to the abundance of hatchery-origin steelhead (SFWSC 2022).

Structure and Diversity

Recent modest improvements in the abundance of this DPS is driven by the increase in adult returns to hatcheries from previous lows, but improvements to the sizes of the largely hatchery populations does not warrant a downgrading of the DPS extinction risk. As described above, the lack of improved natural production as estimated by exit at Chipps Island, and low abundances coupled with large hatchery influence in the Southern Sierra Nevada diversity group, are cause for concern (SWFSC 2022). In addition to the major populations being reliant on hatchery supplementation, the influence of hatchery-origin steelhead that are not part of the DPS also threaten the genetic diversity of this species. Nimbus Hatchery steelhead were founded from coastal steelhead populations, and continued introgression of strays from this program with natural-origin American River steelhead poses a risk to the CV steelhead DPS (SWFSC 2022).

2.2.1.27 Central California Coast Coho Salmon

Abundance and Productivity

To estimate annual abundance of adult spawners (natural- and hatchery-origin), we calculate the geometric mean of the most recent years of adult spawner estimates, as reported in SWFSC (2022). Population estimates are based on redd counts from surveys of stream reaches selected according to a Generalized Randomized Tessellation Survey (GRTS) design. Redd counts are then expanded to adult estimates based on spawner:redd ratios estimated at a network of life cycle monitoring (LCM) stations (SFWSC 2022). Abundance estimates for the ESU components are listed below (Table 29).

Table 29. Geometric Means for Estimated CCC Coho Adult Returns, Estimated Juvenile Outmigrations, and Target Annual Hatchery Releases (SWFSC 2022, CDFW 2020).

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

While we currently lack data on how many natural juvenile coho salmon this ESU produces, it is possible to make rough estimates of juvenile abundance from adult return data. Sandercock (1991) published fecundity estimates for several coho salmon stocks; average fecundity ranged from 1,983 to 5,000 eggs per female. By applying a very conservative value of 2,000 eggs per female to an estimated 1,154 females returning (50 percent of the run, including the Russian River hatchery returns which are allowed to spawn in the wild) to this ESU, one may expect approximately 2.3 million eggs to be produced annually. Nickelson (1998) found survival of coho salmon from egg to parr in Oregon coastal streams to be around 7 percent. Thus, we can estimate that roughly the Central California Coast ESU produces 161,560 juvenile coho salmon annually (Table 29). The CCC coho salmon ESU includes three artificial propagation programs (79 FR 20802), and the combined minimum annual target for hatchery releases for CCC coho salmon is 140,000 LHIA juveniles.

Available data for CCC coho salmon populations indicate that all remain far below recovery targets for abundance (SWFSC 2022). In recent years there have been slight improvements in the abundance of populations in the Lost Coast—Navarro Point and Navarro Point—Gualala Point strata at the northern end of the species' range. However, in the Coastal diversity stratum there has been little change in abundance since the last 5-year status review, and is possibly declining in the Santa Cruz Mountain stratum, although assessment of both of these strata is difficult due to the scarcity of reliable data and how rarely CCC coho salmon are observed in these areas (SWFSC 2022).

Structure and Diversity

The current viability of populations is progressively worse moving north to south in the ESU (SWFSC 2022). While abundance trends appear to be increasing in the Lost Coast diversity stratum and remained stable in the Navarro Point diversity stratum, the already-small population sizes have not improved in the Coastal stratum since 2016. In the Santa Cruz Mountain stratum, natural production of coho salmon is extremely low. In this stratum observations of adult coho salmon are rare in the two historically independent populations, and all dependent populations are either extirpated or at critically low levels. Population persistence in this stratum is also highly dependent on the ongoing captive rearing program, and there has been a loss of genetic diversity in the hatchery broodstock, which necessitated the incorporation of out-of-stratum broodstock into the program. The loss of genetic diversity in this stratum and risk of very low abundance population in this stratum being lost to the ESU negatively affect the diversity and spatial structure of this ESU.

2.2.1.28 Central California Coast Steelhead

Abundance and Productivity

Data for both adult and juvenile abundance are limited for this DPS. Moreover, the record is inconsistent with either no fish being observed or no surveys being conducted in some years. Due to the inconsistency of the record, we have used a 5-year average as an estimate for abundance (2015-2019)(CDFW 2020, unpubl., SWFSC 2022). While we currently lack data on naturally produced juvenile CCC steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. For steelhead, fecundity estimates range from 3,500 to 12,000; and the male to female ratio averages 1:1 (Pauley *et al.* 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (half of the escapement of spawners – 953 females), roughly 3.3 million eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce over 216 thousand natural outmigrants annually. In addition, hatchery managers could produce 520,000 listed hatchery juvenile CCC steelhead each year given hatchery release targets. Abundance estimates for the DPS components are listed below (Table 30).

Table 30. Recent 5-Year Means for Estimated CCC Steelhead Adult Returns and Estimated Juvenile Outmigrations (SWFSC 2022).

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

The scarcity of information on steelhead abundance in the CCC Steelhead DPS continues to make it difficult to assess trends in abundance and productivity (SWFSC 2022). Population-level estimates of adult abundance are entirely lacking for the 25 independent populations in the North Coastal, Interior, Coastal San Francisco Bay, and Interior San Francisco Bay diversity strata identified as essential or supporting in the DPS. A few survey efforts that are targeting coho salmon do collect data on steelhead as well, but generally, surveys do not encompass the entire spawning space of season for steelhead. The implementation of the Coastal Monitoring Plan (CMP) in the Russian River basin has improved our understanding of the overall abundance of steelhead in the watershed, providing basin-wide estimates of abundance of steelhead (combined natural and hatchery-origin) that have ranged from about 800–2,000 over three years, but as population estimates are not produced for individual populations within the basin, direct comparison with recovery targets is not yet possible. Spawner surveys and rotary screw trapping in recent years in selected portions of the Napa River watershed confirm the continued occurrence of steelhead in this watershed, however, there is insufficient data to determine if the population has increased or decreased since the previous status review. Likewise, limited spawner surveys in selected tributaries of the Petaluma River confirmed steelhead presence very small numbers in the watershed, but do not allow conclusions to be drawn about current viability.

Implementation of the CMP in the Santa Cruz Mountain stratum has been intermittent, and difficulties in assigning redds to species (steelhead versus coho) confound interpretation of these data. Scott Creek remains the only population for which robust estimates are available for more than a few years, and while the population appeared to be declining, a sizable return in 2018-2019 indicates that the population is somewhat resilient (SWFSC 2022). Populations in the San Lorenzo River and Pescadero Creek appear to typically number in the low hundreds of fish, while other independent populations appear to number in the tens of fish. Two dependent populations (Gazos and San Vicente creeks) likewise appear to number in the tens of fish in most years, with considerable variation in numbers among years. Though uncertainty remains high for nearly all of these populations, it is clear that they are well below recovery targets.

Structure and Diversity

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

Hatchery programs can provide short-term demographic benefits, such as increases in abundance, during periods of low natural abundance. They also can help preserve genetic resources until limiting factors can be addressed. However, the long-term use of artificial propagation can pose a risk to natural productivity and diversity. The Russian River monitoring program has provided quantitative evidence that hatchery-origin steelhead constitute roughly 50% of all fish on natural spawning grounds and that these hatchery fish are being observed throughout the basin. Thus, concerns expressed in the recent status review update about potential genetic consequences of interbreeding between hatchery and wild fish appear well-founded (SWFSC 2022).

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

2.2.1.29 South-Central California Coast Steelhead

Abundance and Productivity

Data for both adult and juvenile abundance are limited for this DPS. In addition, the record is inconsistent with either no fish observed or no surveys conducted in some years. Due to the inconsistency of the record, we have used a 5-year average as an estimate for abundance (2015-2019)(CDFW 2020, unpublished). While we currently lack data on naturally produced juvenile SCCC steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. For steelhead, fecundity estimates range from 3,500 to 12,000; and the male to female ratio averages 1:1 (Pauley *et al.* 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (half of the escapement of natural-origin spawners – 98 females), roughly 340 thousand eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce roughly 22,295 natural outmigrants annually. There are no hatchery components of this DPS. Abundance estimates for the DPS components are listed below (Table 31).

Table 31. Recent 5-Year Geometric Means for Estimated SCCC Steelhead Juvenile Outmigrations and Adult Returns SWFSC 2022).

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

Data on abundance of adult steelhead and fish density indicate that the recent drought had very large negative impacts on this DPS, with generally negative trends observed in all indicators, most with statistical significance (SWFSC 2022). However, since the end of the drought in 2017 all indicators of abundance have improved, suggesting that *O. mykiss* populations have persisted in drought refugia (e.g., lower Pajaro River tributaries, the upper Carmel River, the Big Sur Coast) and are now recovering from the drought. Yet the size of steelhead runs is still extremely low, and the mean fish densities for the past four years are still below the provisional viability criterion of 0.3 fish/m2 (SWFSC 2022). While monitoring of status and trends continues to be insufficient in this DPS, a draft plan to update the monitoring strategy is in progress.

Spatial Structure and Diversity

The SCCC steelhead DPS consists of 12 discrete sub-populations representing localized groups of interbreeding individuals. Most of these sub-populations are characterized by low population abundance, variable or negative population growth rates, and reduced spatial structure and diversity. In 2002, NMFS surveyed 36 watersheds and found that between 86 and 94 percent of the historic watersheds were still occupied. Also, occupancy was determined for 18 watershed basins with no historical record of steelhead (NMFS 2013b).

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

2.2.1.30 Southern California Steelhead

Description, Geographic Range. On August 18, 1997, NMFS listed SC steelhead as an endangered species (62 FR 43937). NMFS concluded that the SC steelhead DPS was in danger of extinction throughout all or a significant portion of its range. There is no hatchery production in support of this DPS. The geographic range of the SC steelhead DPS extends from the Santa Maria River, near Santa Maria, to the California–Mexico border, which represents the known southern geographic extent of the anadromous form of *O. mykiss*.

Spatial Structure and Diversity. NMFS described historical and recent steelhead abundance and distribution for the southern California coast through a population characterization (Boughton et al. 2006). Surveys in Boughton et al. (2005) indicate between 58 percent and 65 percent of the historical steelhead basins currently harbor *O. mykiss* populations at sites with connectivity to the ocean. Most of the apparent losses of steelhead were noted in the south, including Orange and San Diego Counties (Boughton et al. 2005).

Abundance and Productivity. While 46 drainages support the SC steelhead DPS (Boughton et al. 2005), only 10 population units possess a high and biologically plausible likelihood of being viable and independent[2] (Boughton et al. 2006). Very little data regarding abundances of Southern

[2] Independent population: a collection of one or more local breeding units whose population dynamics or extinction

California Coast steelhead are available, but the picture emerging from available data suggest very small (<10 fish) but surprisingly consistent annual runs of anadromous fish across the diverse set of basins that are currently being monitored (Williams et al. 2011). The most significant population that has been recently monitored is in Topanga Creek, where mark-recapture studies were done in 2007-2008. According to the authors (Bell et al. 2011), that data indicated a population of resident fish whose abundance is on the order of 500 individuals, including all size and age classes in Topanga Creek. It is believed that population abundance trends can significantly vary based on yearly rainfall and storm events within the range of the Southern California Coast DPS (Williams et al. 2011). A relatively large number of adult steelhead were observed in 2008, two years after an extended wet spring that presumably gave smolts ample opportunity to migrate to the ocean. Some of the strength of the 2008 season may also be an artifact of conditions that year. Low rainfall appears to have caused many spawners to get trapped in freshwater, where they were observed during the summer; in addition, low rainfall probably improved conditions for viewing fish during snorkel surveys, and for trapping fish in weirs (Williams et al. 2011). Much of the data pertaining to the incidence of adult anadromous *O. mykiss* in the SC steelhead DPS is not appropriate to be used to generate abundance estimates. However, the annual presence and count of adult SC steelhead has been documented annually in a number of streams (Table 32).

Table 32. Mean and Total Observations of Adult Anadromous SC Steelhead from 2005 to 2014. (Santa Ynez River Adaptive Management Committee 2009, United States Bureau of Reclamation 2011, Hovey and O'Brien 2013, Dagit et al. 2015, Casitas Municipal Water District (2005 through 2014), United Water Conservation District (2005 through 2014), Mark Capelli unpublished data, George Sutherland unpublished data, Resource Conservation District of the Santa Monica Mountains unpublished data, Mauricio Gomez unpublished data, Dave Katjaniak unpublished data)

		Observations	
System	**Years**	**Total**	**Mean Annual**
Santa Ynez River	2005 - 2014	29	2.9
Ventura River	2006 - 2014	13	1.4
Santa Clara River	2005 - 2014	5	0.5
Goleta Slough	2005 - 2014	6	0.6
Mission Creek	2005 - 2014	18	1.8
Carpinteria Creek	2008	3	-

risk over a 100-year time period is not substantially altered by exchanges of individuals with other populations (Boughton et al. 2006).

Conejo Creek	2013	1	-
Malibu Creek	2006 - 2014	23	2.6
Topanga Creek	2005 - 2014	8	0.8
Ballona Creek	2008	2	-
San Juan Creek	2005 - 2014	5	0.5
Santa Margarita Creek	2009	1	-
San Luis Rey River	2007	2	-
Las Penasquito Creek	2012	1	-
	Total	**117**	**11.1**

There is little new evidence to suggest that the status of the Southern California DPS has changed appreciably in either direction since publication of the most recent collections of status reviews (Good et al. 2005; NMFS 2011d; Williams et al. 2011). The observations of adult SC steelhead for the last ten years of only average around 11 individuals annually (Table 32). However, the most recent SC steelhead recovery plan found no evidence that the annual return of anadromous adults has changed since the original 2005 status review, which estimated the number to be less than 500 individuals (NMFS 2012b). Given this range of expected annual returning spawners, the most conservative estimate of juvenile production based on those returns would be based on the assumption that the number of returning spawners for the DPS is just 11 fish. 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 – 5.5 females), 19,425 eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce a minimum of 1,262 natural outmigrants annually. This estimate of outmigrants is derived from the most conservative estimate within the range of the abundance estimate of adult anadromous returns, but further complicating this calculation, the SC steelhead DPS is also influenced by the presence of a significant unlisted resident population of *O. mykiss.* Due to the phenotypic plasticity between these two life history strategies that has been demonstrated in *O. mykiss* (Pearse 2009), it is possible that additional outmigrants may be derived from this unlisted resident population, or that some residual offspring of anadromous parents may express a resident life history. For that reason, differentiating anadromous and resident juveniles pre-smoltification is not possible, so for precautionary reasons, all juvenile *O. mykiss* that occur within the SC steelhead range are considered to be SC steelhead.

Threats and Limiting Factors. The majority of lost populations (68 percent) of SC steelhead have been associated with anthropogenic barriers to steelhead migration (e.g., dams, flood-control structures, culverts, etc.). Additionally, investigators have found that barrier exclusions are statistically associated with highly-developed watersheds. SC steelhead populations experience a high magnitude of threat to a small number of extant populations vulnerable to extirpation due to loss of accessibility to freshwater spawning and rearing habitat, low abundance, degraded estuarine habitats and watershed processes essential to maintain freshwater habitats (NMFS 2012b). The practice of fire suppression within the range of this DPS, and the associated potential for increased fire intensity and duration, has also been identified as a potential threat to the steelhead in this DPS (62 FR 43937). The recovery potential is low to moderate due to the lack of additional populations, lack of available/suitable freshwater habitat, steelhead passage barriers, and inadequate instream flow.

Status Summary. There is little new evidence to suggest that the status of the SC steelhead DPS has changed appreciably in either direction since publication of the most recent collections of status reviews (Good et al. 2005; NMFS 2012bd; Williams et al. 2011, Williams et al. 2016).

2.2.1.31 SDPS Eulachon

Abundance and Productivity

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

In recent years, abundance estimates of Southern eulachon in the Columbia River have fluctuated from a low of just over 4 million in 2018 to over 96 million in 2021. The geometric mean spawner abundance over the past five years is just over 23.5 million, though this is almost certainly an underestimate as surveys were cut short in 2020. These estimated abundance levels are an improvement over estimated abundance at the time of listing (Gustafson *et al.* 2010), but a decline from the average abundances at the time of the last status review (Gustafson *et al.* 2016). Since 2018 annual abundance has been increasing, although the mean abundance estimated in 2021 was only about half of the peak annual estimate from the past 20 years (i.e., 185,965,200 in 2014). The situation in the Klamath River is also more positive than it was at the time of the 2010 status review with adult eulachon presence being documented in the Klamath River in the spawning seasons of 2011–2014, although it has not been possible to calculate estimates of SSB in the Klamath River (Gustafson *et al.* 2016). The Fraser River population has been at low levels most years since 2004 although recent years have shown higher spawning numbers, which may signal a positive trend (DFO 2022). SSB estimations of eulachon in the Fraser River from the years 2018 through 2022 have ranged from a low of an estimated 248,496 fish in 2022 to a high of 15,352,621 fish in 2020 (DFO 2023, estimate based on report weight assuming 11.16 fish per pound and 2,204.62 pounds per metric tonne). Abundance estimates for the DPS components are listed below (Table 33).

Table 33. Southern DPS eulachon spawning stock biomass survey estimates (NMFS 2022f, DFO 2023).

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

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

Structure and Diversity

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

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

Threats and Limiting Factors

The greatest threat identified to the persistence of southern DPS eulachon was climate change impacts on ocean conditions (Gustafson *et al.* 2016, NMFS 2017b). Poor conditions in the Northeast Pacific Ocean in 2013-2015 are likely linked to the sharp declines in eulachon abundance in monitored rivers in 2016 and 2017 (NMFS 2017b). The likelihood that these poor ocean conditions will persist into the near future suggest that subpopulation declines may again be widespread in the upcoming return years (NMFS 2017b), although returns in 2021 do not appear to have been as dramatically impacted by the 2019 Northeast Pacific marine heatwave as prior years were by the 2013-2015 event (Table 33). Climate change impacts on freshwater habitat were also identified as a moderate threat to all subpopulations due to increasing water temperatures and changes in flow quantity and timing (Gustafson *et al.* 2016, NMFS 2017b).

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

2.2.1.32 SDPS Green Sturgeon

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

Abundance and Productivity

Since 2010, Dual Frequency Identification Sonar (DIDSON) surveys of aggregating sites in the upper Sacramento River for S green sturgeon have been conducted. Previous reports based on data from 2010 to 2015 estimated the total population size to be 17,548 individuals, and abundance estimates were derived for each age class by applying a conceptual demographic structure from prior modeling (Mora et al. 2018). The Southwest Fisheries Science Center (SWFSC) continued Mora et al. (2018)'s work and conducted DIDSON surveys at aggregation sites in the upper Sacramento River from 2016-2020. The total population estimate has recently been updated to 17,723 individuals based on data from 2016 to 2018 (Dudley 2021, as cited in Ford 2022). Applying the same demographic proportions as prior previous estimates (Beamesderfer et al. 2007 as cited in Mora et al. 2018) to this total, we calculated abundance estimates of adults, juveniles, and sub-adults that would be expected as portions of this updated total (Table 34).

Table 34. SDPS green sturgeon estimated total population size based on data from 2016 to 2018 (Dudley 2021), and life stage-specific abundance estimates derived from the total (Beamesderfer et al. 2007 as cited in Mora et al. 2018).

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

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

The DIDSON surveys and associated modeling will eventually provide population trend data, but we currently do not have enough data to provide information on long-term trends, and demographic features or trends needed to evaluate the recovery of 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 (Dudley 2020, as cited in Ford 2022). There are currently no studies that address juvenile and subadult abundance of S green sturgeon to evaluate whether the recovery criterion for increasing trends of these life stages is being met (NMFS 2021a).

Structure and Diversity

Telemetry data and genetic analyses suggest that 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 NMFS-Northwest Fisheries Science Center (NWFSC) have shown a great amount of seasonal movement between the coastal bays and estuaries and the nearshore marine environment (NMFS 2021a). Green sturgeon also move extensively within an individual estuary and between different estuaries during the same season (WDFW and ODFW 2014, as cited in NMFS 2021a). In California, Miller et al. (2020) recorded adult and subadult 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.

2.2.2 Status of the Species' Critical Habitat

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

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

A summary of the status of critical habitats, considered in this opinion, is provided in Table 35, below.

Table 35. Critical habitat, designation date, federal register citation, and status summary for critical habitat considered in this opinion.

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
Puget Sound Chinook salmon	09/02/2005 70 FR 52630	Critical habitat for Puget Sound Chinook salmon includes 1,683 miles of streams, 41 square mile of lakes, and 2,182 miles of nearshore marine habitat in Puget Sounds. The Puget Sound Chinook salmon ESU has 61 freshwater and 19 marine areas within its range. Of the freshwater watersheds, 41 are rated high conservation value, 12 low conservation value, and eight received a medium rating. Of the marine areas, all 19 are ranked with high conservation value. Primary constitute elements relevant for this consultation include: 1) Estuarine areas free of obstruction with water quality and aquatic vegetation to support juvenile transition and rearing; 2) Nearshore marine areas free of obstruction with water quality

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
		conditions, forage, submerged and overhanging large wood, and aquatic vegetation to support growth and maturation; 3) Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.
Puget Sound steelhead	02/24/2016 81 FR 9252	Critical habitat for Puget Sound steelhead includes 2,031 stream miles. Nearshore and offshore marine waters were not designated for this species. There are 66 watersheds within the range of this DPS. Nine watersheds received a low conservation value rating, 16 received a medium rating, and 41 received a high rating to the DPS.
Puget Sound/Georgia Basin DPS of bocaccio	11/13/2014 79 FR 68042	Critical habitat for bocaccio includes 590.4 square miles of nearshore habitat and 414.1 square miles of deepwater habitat. Critical habitat is not designated in areas outside of United States jurisdiction; therefore, although waters in Canada are part of the DPSs' ranges for all three species, critical habitat was not designated in that area. Based on the natural history of bocaccio and their habitat needs, NMFS identified two physical or biological features, essential for their conservation: 1) Deepwater sites (>30 meters) that support growth, survival, reproduction, and feeding opportunities; 2) Nearshore juvenile rearing sites with sand, rock and/or cobbles to support forage and refuge. Habitat threats include degradation of rocky habitat, loss of eelgrass and kelp, introduction of non-native species that modify habitat, and degradation of water quality as specific threats to rockfish habitat in the Georgia Basin.
Puget Sound/Georgia Basin DPS of yelloweye rockfish	11/13/2014 79 FR 68042	Critical habitat for yelloweye rockfish includes 414.1 square miles of deepwater marine habitat in Puget Sound, all of which overlaps with areas designated for canary rockfish and bocaccio. No nearshore component was included in the CH listing for juvenile yelloweye rockfish as they, different from bocaccio and canary rockfish, typically are not found in intertidal waters (Love et al. 1991). Yelloweye rockfish are most frequently observed in waters deeper than 30 meters (98 ft) near the upper depth range of adults (Yamanaka et al. 2006). Habitat threats include degradation of rocky habitat, loss of eelgrass and kelp, introduction of non-native species that modify habitat, and degradation of water quality as specific threats to rockfish habitat in the Georgia Basin.
Hood Canal summer-run chum salmon	09/02/2005 70 FR 52630	Critical habitat for Hood Canal summer-run chum salmon includes 79 miles and 377 miles of nearshore marine habitat in HC. Primary constituent elements relevant for this consultation include: 1) Estuarine areas free of obstruction with water quality and aquatic vegetation to support juvenile transition and rearing; 2) Nearshore marine areas free of obstruction with water quality conditions, forage, submerged and overhanging large wood, and aquatic vegetation to support growth and maturation; 3) Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.
Ozette Lake sockeye salmon	09/02/2005 70 FR 52630	Critical habitat is comprised of a single subbasin containing a single watershed, Ozette Lake Subbasin located in Clallam County, Washington. It encompasses approximately 101 mi^2 and approximately 317 miles of streams; Ozette Lake, the dominant feature of the watershed, is entirely located within the Olympic National Park. The known beach spawning areas, and three tributaries used by sockeye salmon for spawning, incubation, and migration, are encompassed as part of critical habitat for the listed species. Beach spawning is degraded by historical sediment loading, disrupted hydrology, and encroachment of riparian vegetation. Streams supporting spawning, rearing, and migration are impaired by lack of large wood, excessive fine sediment levels (Big River), and mammalian predation.
Upper Columbia River spring-run Chinook salmon	09/02/2005 70 FR 52630	Critical habitat encompasses four subbasins in Washington containing 15 occupied watersheds, as well as the Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition. However, most of these watersheds have some, or high, potential for improvement. We rated conservation value of HUC5 watersheds as high for 10 watersheds, and medium for five watersheds. Migratory habitat quality in this area

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
		has been severely affected by the development and operation of the dams and reservoirs of the Federal Columbia River Power System.
Upper Columbia River steelhead	09/02/2005 70 FR 52630	Critical habitat encompasses 10 subbasins in Washington containing 31 occupied watersheds, as well as the Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. We rated conservation value of HUC5 watersheds as high for 20 watersheds, medium for eight watersheds, and low for three watersheds.
Middle Columbia River steelhead	09/02/2005 70 FR 52630	Critical habitat encompasses 15 subbasins in Oregon and Washington containing 111 occupied watersheds, as well as the Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. We rated conservation value of occupied HUC5 watersheds as high for 80 watersheds, medium for 24 watersheds, and low for 9 watersheds.
Snake River spring/summer-run Chinook salmon	10/25/1999 64 FR 57399	Critical habitat consists of river reaches of the Columbia, Snake, and Salmon rivers, and all tributaries of the Snake and Salmon rivers (except the Clearwater River) presently or historically accessible to this ESU (except reaches above impassable natural falls and Hells Canyon Dam). Habitat quality in tributary streams varies from excellent in wilderness and roadless areas, to poor in areas subject to heavy agricultural and urban development (Wissmar et al. 1994). Reduced summer stream flows, impaired water quality, and reduced habitat complexity are common problems. Migratory habitat quality in this area has been severely affected by the development and operation of the dams and reservoirs of the Federal Columbia River Power System.
Snake River fall-run Chinook salmon	10/25/1999 64 FR 57399	Critical habitat consists of river reaches of the Columbia, Snake, and Salmon rivers, and all tributaries of the Snake and Salmon rivers presently or historically accessible to this ESU (except reaches above impassable natural falls, and Dworshak and Hells Canyon dams). Habitat quality in tributary streams varies from excellent in wilderness and roadless areas, to poor in areas subject to heavy agricultural and urban development (Wissmar et al. 1994). Reduced summer stream flows, impaired water quality, and reduced habitat complexity are common problems. Migratory habitat quality in this area has been severely affected by the development and operation of the dams and reservoirs of the Federal Columbia River Power System.
Snake River basin steelhead	09/02/2005 70 FR 52630	Critical habitat encompasses 25 subbasins in Oregon, Washington, and Idaho. Habitat quality in tributary streams varies from excellent in wilderness and roadless areas, to poor in areas subject to heavy agricultural and urban development (Wissmar et al. 1994). Reduced summer stream flows, impaired water quality, and reduced habitat complexity are common problems. Migratory habitat quality in this area has been severely affected by the development and operation of the dams and reservoirs of the Federal Columbia River Power System.
Snake River sockeye salmon	10/25/1999 64 FR 57399	Critical habitat consists of river reaches of the Columbia, Snake, and Salmon rivers; Alturas Lake Creek; Valley Creek; and Stanley, Redfish, Yellow Belly, Pettit and Alturas lakes (including their inlet and outlet creeks). Water quality in all five lakes generally is adequate for juvenile sockeye salmon, although zooplankton numbers vary considerably. Some reaches of the Salmon River and tributaries exhibit temporary elevated water temperatures and sediment loads that could restrict sockeye salmon production and survival (NMFS 2015). Migratory habitat quality in this area has been severely affected by the development and operation of the dams and reservoirs of the Federal Columbia River Power System.
Lower Columbia River Chinook salmon	09/02/2005 70 FR 52630	Critical habitat encompasses 10 subbasins in Oregon and Washington containing 47 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some, or

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
		high potential for improvement. We rated conservation value of HUC5 watersheds as high for 30 watersheds, medium for 13 watersheds, and low for four watersheds.
Lower Columbia River coho salmon	02/24/2016 81 FR 9252	Critical habitat encompasses 10 subbasins in Oregon and Washington containing 55 occupied watersheds, as well as the lower Columbia River and estuary rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. We rated conservation value of HUC5 watersheds as high for 34 watersheds, medium for 18 watersheds, and low for three watersheds.
Lower Columbia River steelhead	09/02/2005 70 FR 52630	Critical habitat encompasses nine subbasins in Oregon and Washington containing 41 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. We rated conservation value of HUC5 watersheds as high for 28 watersheds, medium for 11 watersheds, and low for two watersheds.
Columbia River chum salmon	09/02/2005 70 FR 52630	Critical habitat encompasses six subbasins in Oregon and Washington containing 19 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. We rated conservation value of HUC5 watersheds as high for 16 watersheds, and medium for three watersheds.
Upper Willamette River Chinook salmon	09/02/2005 70 FR 52630	Critical habitat encompasses 10 subbasins in Oregon containing 56 occupied watersheds, as well as the lower Willamette/Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition. However, most of these watersheds have some, or high, potential for improvement. Watersheds are in good to excellent condition with no potential for improvement only in the upper McKenzie River and its tributaries (NMFS 2005). We rated conservation value of HUC5 watersheds as high for 22 watersheds, medium for 16 watersheds, and low for 18 watersheds.
Upper Willamette River steelhead	09/02/2005 70 FR 52630	Critical habitat encompasses seven subbasins in Oregon containing 34 occupied watersheds, as well as the lower Willamette/Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. Watersheds are in good to excellent condition with no potential for improvement only in the upper McKenzie River and its tributaries (NMFS 2005). We rated conservation value of HUC5 watersheds as high for 25 watersheds, medium for 6 watersheds, and low for 3 watersheds.
Oregon Coast coho salmon	02/11/2008 73 FR 7816	Critical habitat encompasses 13 subbasins in Oregon. The long-term decline in Oregon Coast coho salmon productivity reflects deteriorating conditions in freshwater habitat as well as extensive loss of access to habitats in estuaries and tidal freshwater. Many of the habitat changes resulting from land use practices over the last 150 years that contributed to the ESA-listing of Oregon Coast coho salmon continue to hinder recovery of the populations; changes in the watersheds due to land use practices have weakened natural watershed processes and functions, including loss of connectivity to historical floodplains, wetlands and side channels; reduced riparian area functions (stream temperature regulation, wood recruitment, sediment and nutrient retention); and altered flow and sediment regimes (NMFS 2016b). Several historical and ongoing land uses have reduced stream capacity and complexity in Oregon coastal streams and lakes through disturbance, road building, splash damming, stream cleaning, and other activities. Beaver removal, combined with loss of large wood in streams, has also led to degraded stream habitat conditions for coho salmon (Stout et al. 2012)
Southern Oregon/Northern	05/05/1999 64 FR 24049	Critical habitat includes all areas accessible to any life-stage up to long-standing, natural barriers and adjacent riparian zones. SONCC coho salmon critical habitat

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

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

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

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
		are activities that affect prey resources. Prey resources are affected by: commercial shipping and activities generating point source pollution and non-point source pollution that discharge contaminants and result in bioaccumulation of contaminants in green sturgeon; disposal of dredged materials that bury prey resources; and bottom trawl fisheries that disturb the bottom (but result in beneficial or adverse effects on prey resources for green sturgeon).
Southern resident killer whale	11/29/2006 71 FR 69054 08/02/2021 86 FR 41688	Critical habitat consists of three specific marine areas of inland waters of Washington: 1) the Summer Core Area in Haro Strait and waters around the San Juan Islands; 2) Puget Sound; and 3) the Strait of Juan de Fuca. These areas comprise approximately 2,560 square miles of marine habitat. Based on the natural history of the Southern Residents and their habitat needs, NMFS identified three PBFs, or physical or biological features, essential for the conservation of Southern Residents: 1) Water quality to support growth and development; 2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction and development, as well as overall population growth; and 3) passage conditions to allow for migration, resting, and foraging Water quality in Puget Sound, in general, is degraded. On September 19, 2019 NMFS proposed to revise the critical habitat designation for the SRKW DPS under the ESA by designating six new areas along the U.S. West Coast (84 FR 49214). Specific new areas proposed along the U.S. West Coast include 15,626.6 square miles (mi\2\) (40,472.7 square kilometers (km\2\)) of marine waters between the 6.1-meter (m) (20 feet (ft)) depth contour and the 200-m (656.2 ft) depth contour from the U.S. international border with Canada south to Point Sur, California. The proposed rule to revise critical habitat designation was based on new information about the SRKW's habitat use along the coast. In 2021, NMFS published a final rule (86 FR 41668, August 2, 2021) to revise SRKW critical habitat to designate six additional coastal critical habitat areas (approximately 15,910 sq. miles), in addition to the 2,560 square miles previously designated in 2006 in inland waters of Washington (71 FR 69054; November 29, 2006). Each coastal area contains all three physical or biological essential features identified in the 2006 designation: (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality and availability to support individual growth, reproduction and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging.

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). For the purposes of this opinion, the action area includes all river reaches accessible to listed Chinook salmon, chum salmon, coho salmon, sockeye salmon, and steelhead in all sub-basins of the Pacific Northwest (Washington, Oregon, Idaho) and California. Additionally, the action area includes all marine waters off the West Coast of the contiguous United States (including nearshore waters, from California to the Canadian border and Puget Sound) accessible to listed Chinook salmon, chum salmon, coho salmon, sockeye salmon, steelhead, eulachon, green sturgeon, and rockfish.

Where it is possible to narrow the range of the research, the effects analysis would take that limited geographic scope into account when determining the proposed actions' impacts on the species and their critical habitat (see permit summaries below for the instances in which this would be applicable). Still, the action area is generally spread out over much of Idaho, Oregon, Washington and California. It is also discontinuous. That is, there are large areas in between the various actions' locations where listed salmonids, sturgeon, eulachon, rockfish, etc., do exist, but where they would not be affected to any degree by any of the proposed activities. 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).

In most cases, the proposed research activities would take place in individually very small sites. For example, the researchers might electrofish a few hundred feet of river, deploy a beach seine covering only a few hundred square feet of stream, or operate a screw trap in a few tens of square feet of habitat. Many of the proposed research activities would take place in designated critical habitat. More detailed habitat information (i.e., migration barriers, physical and biological habitat features, and special management considerations) for species considered in this opinion may be found in the Federal Register notices designating critical habitat (Table 35).

2.3.1. Action Areas for the Individual Permits

Permit 1134-8R—The proposed activities would take place in the mainstems of and dozens of tributaries to the Snake, Salmon, Selway, Grande Ronde, Tucannon, Lochsa, and Clearwater Rivers in Idaho, Oregon, and Washington. Not all sites would be sampled in all years, but over the proposed five-year course of the permit, many dozens of sites in all the listed watersheds would be sampled.

Permit 15573-4R—The proposed activities would all take place in an oxbow off the main Sacramento River (RM 206), approximately 350 feet downstream of the Glenn-Colusa Irrigation District fish screen.

Permit 15824-3R—The proposed activities would all take place throughout Santa Cruz county, CA including San Lorenzo River and its tributaries, Aptos Creek and its tributaries, Corralitos Creek and its tributaries, and Soquel Creek and its tributaries

Permit 16303-3R – The proposed activities would take place in the nearshore and offshore epi-pelagic marine waters of Puget Sound, Hood Canal, and the Strait of Juan de Fuca in Washington state.

Permit 21061-2R – The proposed activities would take place within the Lower Duwamish Waterway superfund site where the Duwamish River empties into Elliott Bay in King County, Washington.

Permit 22093-2R – The proposed activities would take place in small creeks and agricultural ditches throughout the Snoqualmie River subbasin in King and Snohomish Counties in the state of Washington.

Permit 22998-2R – The proposed activities would take place in small streams on Navy Base Kitsap properties in Kitsap County, Washington.

Permit 26368-2M – The proposed activities would take place in more than 20 different subbasins scattered across Idaho, Washington, and Oregon. Not all sites would be sampled in all years, but over the proposed four-year course of the permit, many dozens of sites in all three states would be sampled.

Permit 26714 – The proposed activities would all take place between River Miles 10.1 and 20.3 on the Wallowa River in Northeastern Oregon.

Permit 26766 – The proposed activities would take place in small (Type 4 or 5) streams that may be located on any private forest lands anywhere in the State of Washington, and the sites could vary widely from year to year in terms of both location and number.

Permit 26968 – The proposed activities would all take place in streams and rivers throughout California at pre-selected locations.

Permit 27069 – The proposed activities would all take place in a backwater area of the Sacramento River directly downstream of its confluence with Battle Creek.

Permit 27091 – The proposed activities would take place at the Port of Seattle's T-117 restoration site within the Lower Duwamish Waterway superfund site where the Duwamish River empties into Elliott Bay in King County, Washington.

Permit 27098 – The proposed activities would take place in the estuarine and marine intertidal and subtidal waters of the Lower Columbia River in Washington and Oregon, and in Puget Sound, including the sub-basins of Hood Canal and the Eastern Strait of Juan de Fuca, primarily focusing on DNR Natural Areas and DNR Aquatic Reserves in the state of Washington.

Permit 27129 – The proposed activities would take place at 10 randomly-chosen sites in the Bonneville pool (reservoir) on the Columbia River.

Permit 27162 – The proposed activities would take place in upstream and headwater reaches of streams on WDNR lands in Clallam, Jefferson, and Grays Harbor counties in Washington state.

Permit 27212 – The proposed activities would take place in more than 20 different subbasins scattered across Idaho, Washington, and Oregon. Not all sites would be sampled in all years, but over the proposed five-year course of the permit, dozens of sites in all three states would be sampled.

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).

The environmental baseline for this opinion is therefore the result of the impacts that many activities (summarized below and in the species' status sections) have had on the various listed species' survival and recovery. In many cases, the action area under consideration covers individual animals that could come from anywhere in the various listed species' entire ranges (see Sections 1.3 and 2.3). As a result, the effects of these past activities on the species themselves (that is, effects on abundance, productivity, etc.) cannot be tied to any particular population and are therefore displayed individually in the species status section summaries above (see Section 2.2).

Thus, for some of the work being contemplated here, the impacts that previous Federal, state, and private activities in the action area have had on the species are indistinguishable from those effects summarized below and in the previous section on the species' rangewide status. The same is true with respect to the species' habitat: for much of the contemplated work, the environmental baseline is the result of these activities' rangewide effects on the PBFs that are essential to the conservation of the species. However, as noted previously, some of the proposed work has a more limited geographic scope. If the work would not take place in marine or mainstem areas or would not be widely distributed across the majority of a given species' range, then the action area can be narrowed for a more specific analysis—and in those instances, the relevant local status information will be taken into account for both species and critical habitat.

Analysis at the ESU/DPS level will be performed for all permits listed in Table 1. The permits for which population-level analysis will be performed are:

- 21061-2R
- 22093-2R
- 26714
- 27091

2.4.1 Summary for all Listed Species

2.4.1.1 Factors Limiting Recovery

The best scientific information presently available demonstrates that a multitude of factors, past and present, have contributed to the decline of west coast salmonids, sturgeon, eulachon, and rockfish. NMFS' status reviews, Technical Recovery Team publications, and recovery plans for the listed species considered in this opinion identify several factors that have caused them to decline, as well as those that prevent them from recovering (many of which are the same). Very generally, these include harvest and hatchery practices and habitat degradation and curtailment caused by human development and resource extraction. NMFS' decisions to list the species identified a variety of factors that were limiting their recovery. None of these documents identifies scientific research as either a cause for decline or a factor preventing their recovery. See Tables 2 and 35 for summaries of the major factors limiting recovery of the listed species and how various factors have degraded PBFs and harmed listed species considered in this opinion. Also, please see section 2.2 for information regarding how climate change has affected and is affecting species and habitat in the action areas. Climate change was not generally considered a relevant factor when the species were listed and the critical habitat designated, but it is now.

As a general matter, all the species considered in this opinion have at least some biological requirements that are not being met in the action areas. The listed species are still experiencing the impact of a variety of past and ongoing Federal, state, and private activities in the action areas and that impact is expressed in the limiting factors described above and in the species status sections—all of which, in combination, are currently keeping the species from recovering and actively preventing them from having all their biological requirement met in the action area.

For detailed information on how various factors have degraded PBFs and harmed listed species, please see the references listed in the species and critical habitat status sections.

Research Effects

Although not identified as a factor for decline or a threat preventing recovery, scientific research and monitoring activities have the potential to affect the species' survival and recovery by killing listed salmonids—whether intentionally or not. For the year 2023, NMFS has issued numerous research section 10(a)(1)(A) scientific research permits allowing listed species to be taken and sometimes killed. NMFS has also issued numerous authorizations for state and tribal scientific research programs under ESA section 4(d). Table 36 displays the total take for the ongoing research authorized under ESA sections 4(d) and 10(a)(1)(A).

Table 36. Total Allowed Take of Listed Species for Scientific Research Approved at the end of 2022 *Not Including* the Take from Permits Being Renewed as Part of This Action.

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
PS Chinook salmon	Adult	Natural	619	34	2.649	0.145
		LHIA	521	14	5.368	0.314
		LHAC	726	59		
	Juvenile	Natural	767,554	13,594	20.588	0.365
		LHIA	273,989	4,991	3.157	0.057
		LHAC	215,389	8,649	0.841	0.034
PS steelhead	Adult	Natural	4,235	78	23.274	0.429
		LHIA	419	12	27.812	1.174
		LHAC	31	7		
	Juvenile	Natural	119,397	2,101	5.297	0.093
		LHIA	4,028	61	7.600	0.115
		LHAC	11,432	200	5.058	0.088
	Adult	Natural	26	15	2.280	0.955

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
PS/GB bocaccio	Subadult	Natural	2	1		
	Juvenile	Natural	77	28		
PS/GB yelloweye rockfish	Adult	Natural	32	20	0.079	0.046
	Subadult	Natural	2	1		
	Juvenile	Natural	57	32		
HCS chum salmon	Adult	Natural	2,137	36	7.600	0.128
	Juvenile	Natural	1,249,431	4,578	29.461	0.108
		LHIA	1,445	45	-	-
		LHAC	85	18		
OL sockeye salmon	Adult	Natural	10	4	0.170	0.068
		LHIA	1	0	2.265	0.000
		LHAC	6	0		
	Juvenile	Natural	42	5	0.003	<0.001
		LHIA	1	0	<0.001	0.000
		LHAC	42	4	0.092	0.009
UCR Chinook salmon	Adult	Natural	195	6	23.985	0.738
		LHIA	152	3	28.246	0.877
		LHAC	170	7		
	Juvenile	Natural	12,808	273	2.622	0.056
		LHIA	1,785	55	0.379	0.012
		LHAC	1,506	78	0.221	0.011
UCR steelhead	Adult	Natural	207	4	14.130	0.273
		LHIA	94	2	10.819	0.277
		LHAC	219	6		
	Juvenile	Natural	11,364	71	7.553	0.047

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
		LHIA	2,219	55	1.587	0.039
		LHAC	10,146	235	1.325	0.031
MCR steelhead	Adult	Natural	2,078	27	15.282	0.199
		LHIA	200	7	262.973	3.787
		LHAC	1,675	20		
	Juvenile	Natural	168,658	3,872	47.985	1.102
		LHIA	8,743	120	7.717	0.106
		LHAC	981	49	0.263	0.013
SnkR spr/sum Chinook salmon	Adult	Natural	1,703	15	38.538	0.339
		LHIA	220	3	49.858	0.461
		LHAC	1,187	10		
	Juvenile	Natural	480,101	6,415	70.334	0.940
		LHIA	27,158	426	3.905	0.061
		LHAC	28,819	763	0.607	0.016
SnkR fall-run Chinook salmon	Adult	Natural	85	9	1.170	0.124
		LHIA	34	1	0.786	0.101
		LHAC	83	14		
	Juvenile	Natural	4,438	259	0.555	0.032
		LHIA	2,013	144	0.068	0.005
		LHAC	2,624	282	0.101	0.011
SnkR steelhead	Adult	Natural	9,877	119	99.117	1.194
		LHIA	2,043	33	160.731	2.557
		LHAC	3,237	51		
	Juvenile	Natural	343,903	4,860	59.992	0.848
		LHIA	23,960	349	4.530	0.066

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
		LHAC	31,083	541	1.016	0.018
SnkR sockeye salmon	Adult	Natural	111	6	693.750	37.500
		LHIA	1	0	2.062	0.000
		LHAC	1	0		
	Juvenile	Natural	8,215	292	45.639	1.622
		LHIA	1	0	-	-
		LHAC	201	61	0.067	0.020
CR Chinook salmon	Adult	Natural	418	19	1.427	0.065
		LHIA	12	0	0.866	0.069
		LHAC	151	13		
	Juvenile	Natural	514,252	6,472	4.618	0.058
		LHIA	428	45	0.045	0.005
		LHAC	2,949	663	0.010	0.002
LCR coho salmon	Adult	Natural	1,119	19	5.979	0.102
		LHIA	31	0	4.433	0.263
		LHAC	676	42		
	Juvenile	Natural	241,379	2,913	29.187	0.352
		LHIA	875	116	0.270	0.036
		LHAC	19,770	1,100	0.249	0.014
LCR steelhead	Adult	Natural	3,699	41	45.375	0.503
		LHAC	86	4	1.348	0.063
	Juvenile	Natural	68,902	1,101	18.364	0.293
		LHIA	3	0	0.020	0.000
		LHAC	4,540	106	0.383	0.009
	Adult	Natural	64	9	0.370	0.052

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
CR chum salmon		LHIA	1	0	0.087	0.000
	Juvenile	Natural	57,399	717	0.738	0.009
		LHIA	697	19	0.126	0.003
		LHAC	10	0	-	-
UWR Chinook salmon	Adult	Natural	266	7	2.526	0.066
		LHAC	81	11	0.319	0.043
	Juvenile	Natural	61,487	1,219	5.304	0.105
		LHIA	40	7	-	-
		LHAC	15,618	419	0.358	0.010
UWR steelhead	Adult	Natural	379	6	14.422	0.228
	Juvenile	Natural	23,066	472	17.048	0.349
OC coho salmon	Adult	Natural	14,784	169	24.386	0.279
		LHAC	25	4	3.918	0.627
	Juvenile	Natural	816,808	18,620	19.047	0.434
		LHAC	365	23	0.608	0.038
SONCC coho salmon	Adult	Natural	3,985	37	65.454	0.633
		LHIA	3,221	25		
		LHAC	1,068	18		
	Juvenile	Natural	245,708	4,060	27.768	0.459
		LHIA	17,118	854	22.824	1.139
		LHAC	19,541	387	3.398	0.067
NC steelhead	Adult	Natural	1,710	25	20.464	0.299
	Juvenile	Natural	145,512	2,676	15.309	0.282
CC Chinook salmon	Adult	Natural	514	22	3.903	0.167
	Juvenile	Natural	102,248	1,792	4.273	0.075

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
SacR winter-run Chinook salmon	Adult	Natural	1,421	22	119.916	1.857
		LHAC	1,415	49	52.466	1.817
	Juvenile	Natural	420,657	11,281	336.423	9.022
		LHAC	201,219	7,196	126.668	4.530
CVS Chinook salmon	Adult	Natural	1,617	31	23.934	0.459
		LHAC	745	84	35.766	4.033
	Juvenile	Natural	1,286,463	22,137	69.956	1.204
		LHIA	2,000	0	-	-
		LHAC	58,237	4,628	2.912	0.231
CCV steelhead	Adult	Natural	4,477	139	57.734	3.184
		LHIA	50	1		
		LHAC	2,109	226		
	Juvenile	Natural	85,791	2,240	6.562	0.171
		LHAC	27,863	1,809	2.654	0.172
CCC coho salmon	Adult	Natural	4,418	62	263.128	4.203
		LHIA	1,655	35		
	Juvenile	Natural	204,381	3,471	126.505	2.148
		LHIA	106,516	1,603	76.083	1.145
CCC Coast steelhead	Adult	Natural	2,601	48	138.667	2.886
		LHAC	42	7		
	Juvenile	Natural	262,778	6,152	121.203	2.838
		LHAC	15,501	448	2.981	0.086
SCCC steelhead	Adult	Natural	2,549	38	1300.510	19.388
	Juvenile	Natural	71,843	1,152	322.238	5.167
SC steelhead	Adult	Natural	22	0	-[d]	-[d]

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
	Juvenile	Natural	1,298	36		
SDPS eulachon	Adult	Natural	39,227	31,074	0.156	0.125
	Subadult	Natural	1,030	1,030		
	Juvenile	Natural	1,450	1,368		
SDPS green sturgeon	Adult	Natural	522	12	24.542	0.564
	Subadult	Natural	346	11	3.099	0.099
	Juvenile	Natural	6,593	189	148.793	4.265
	Larvae	Natural	11,256	1,051	-	-
	Egg	Natural	4,370	4,370		

[a] LHAC=Listed Hatchery Adipose Clipped, LHIA = Listed Hatchery Intact Adipose.
[b] Abundances for adult hatchery salmonids are LHAC and LHIA combined.
[c] Abundances for all adult components are combined.
[d] Abundance data for SC steelhead are very limited, and for populations that are regularly monitored many have runs that are ephemeral and may see zero anadromous adults in a given year. Using 5-year geometric mean abundances of these was therefore not considered a meaningful representation of effects to the DPS, so these calculations were not reported.

Actual take levels associated with these activities are almost certain to be a substantially lower than the permitted levels. There are three reasons for this. First, most researchers do not handle the full number of juveniles or adults they are allowed. That is, for the vast majority of scientific research permits, history has shown that researchers generally take far fewer salmonids than the allotted number of salmonids every year (20.45% of requested take and 14.74% of requested mortalities were used in ID, OR, and WA Section 10a1A permits from 2008 to 2017). Over the past five years, (2014-2019) all section 10(a)(1)(A) permits active in California for ESA-listed steelhead and salmon resulted in only 8.8% of the requested handling (i.e., non-observation) take and 3.6% of the requested mortalities. (More recent figures on less-than-allotted take for individual permits are discussed in the individual analyses in Section 2.5.) Second, we purposefully inflate our take and mortality estimates for each proposed study to account for the effects of potential accidental deaths. Therefore it is very likely that far fewer fish—especially juveniles—would be killed under any given research project than the researchers are permitted. Third, for salmonids, many of the fish that may be affected would be in the smolt stage, but others would be yearlings, parr, or even fry. These are all simply be described as “juveniles,” and treated as if they were smolts even though a great many of them would be from life stages represented by multiple spawning years and containing more individuals than reach the smolt stage—perhaps as much as an order of magnitude more. Therefore, the estimates of percentages of ESUs/DPSs taken were derived by (a) conservatively estimating the actual number of juveniles, (b) overestimating the number of fish likely to be killed, and (c) treating each dead juvenile fish as part of the same year class. Thus, the actual numbers of juvenile salmonids the research is likely to kill are undoubtedly smaller than the stated figures—probably something on the order of one seventh of the values given in the tables.

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. All of these techniques 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. Some fish collection activities involve bottom trawls in marine or estuarine environments which may temporarily disturb substrate, displace benthic invertebrate prey, and increase turbidity just above the water surface. However, such trawl actions affect small spatial areas of habitat that are not designated as "critical" and are brief in duration, so these effects are expected to be ephemeral and attenuate rapidly. Therefore none of the activities analyzed in this Opinion will measurably affect any habitat PBF function or value described earlier (see section 2.2.2).

2.5.2 Effects on the Species

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

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

The following subsections describe the types of activities being proposed. Each is described in terms broad enough to apply to all the permits. 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 a permit unless the activities (e.g., electrofishing) incorporate NMFS' uniform, pre-established set of mitigation measures. These measures are described in Section 1.3 of this opinion. They are incorporated (where relevant) into every permit as part of the conditions to which a researcher must adhere.

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.

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' electrofishing guidelines (NMFS 2000). The guidelines require that field crews:

- Use electrofishing only when other survey methods are not feasible.
- Be trained by qualified personnel in equipment handling, settings, maintenance to ensure proper operating condition, and safety.
- Conduct visual searches prior to electrofishing on each date and avoid electrofishing near adults or redds. If an adult or a redd is detected, researchers must stop electrofishing at the research site and conduct careful reconnaissance surveys prior to electrofishing at additional sites.
- Test water conductivity and keep voltage, pulse width, and rate at minimal effective levels. Use only DC waveforms.
- Work in teams of two or more technicians to increase both the number of fish seen at one time and the ability to identify larger fish without having to net them. Working in teams allows netter(s) to remove fish quickly from the electrical field and to net fish farther from the anode, where the risk of injury is lower.
- Observe fish for signs of stress and adjust electrofishing equipment to minimize stress.
- Provide immediate and adequate care to any fish that does not revive immediately upon removal from the electrical current.

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

Gastric Lavage

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

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

Hook and Line/Angling

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

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

The referenced studies were conducted when water temperatures were relatively cool, and primarily involve winter-run steelhead. Catch and release mortality of steelhead is likely to be higher if the activity occurs during warm water conditions. In a study conducted on the catch and release mortality of steelhead in a California river, Taylor and Barnhart (1999) reported over 80% of the observed mortalities occurred at stream temperatures greater than 21 degrees C. Catch and release mortality during periods of elevated water temperature are likely to result in post-release mortality rates greater than reported by Nelson et al. (2005) or Hooton (1987) because of warmer water and that fact that summer fish have an extended freshwater residence that makes them more likely to be caught. 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 incidental to the recreational fishery for Chinook salmon in the Willamette River. A study of the recreational fishery estimates a per-capture hook-and-release mortality for wild spring Chinook salmon in Willamette River fisheries of 8.6% (Schroeder et al. 2000), which is similar to a mortality of 7.6% reported by Bendock and Alexandersdottir (1993) in the Kenai River, Alaska.

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

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

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

Based on the available data, the *U.S. v. Oregon* Technical Advisory Committee has adopted a 10% rate in order to make conservative estimates of incidental mortality in fisheries (TAC 2008). Nonetheless, given the fact that no ESA section 10 permit or 4(d) authorization may "operate to the disadvantage of the species," we 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.

Observation

For some parts of the proposed studies, listed fish would be observed but not captured (e.g., by snorkel surveys or from the banks). Observation without handling is the least disruptive method for determining a species' presence/absence and estimating their relative numbers. Its effects are also generally the shortest-lived and least harmful of the research activities discussed in this section because a cautious observer can effectively obtain data while only slightly disrupting the fishes' behavior. Fry and juveniles frightened by the turbulence and sound created by observers are likely to seek temporary refuge in deeper water or behind or under rocks or vegetation. In extreme cases, some individuals may leave a particular pool or habitat type and then return when observers leave the area. At times, the research involves observing adult fish—which are more sensitive to disturbance. During some of the research activities discussed below, redds may be visually inspected, but per NMFS' pre-established mitigation measures (included in state fisheries agency submittals), would not be walked on. Only in the rarest cases would any take be associated with these observation activities, and that would be in the form of harassment (see section 2.9). No injuries and no deaths would be expected to occur—particularly in cases where the researchers observe from the stream banks rather than in the water. Because these effects are so small, there is little a researcher can do to mitigate them except to avoid disturbing sediments, gravels, and, to the extent possible, the fish themselves, and allow any disturbed fish the time they need to reach cover.

Rockfish barotrauma

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

For rockfish caught in waters deeper than 60 feet (18.3 m), the primary cause of injury and death is often barotrauma (NMFS 2017d). During rapid decompression, swim bladder gases expand exponentially which is further exacerbated by temperature increases. This results in swim bladder expansion; reduction in body cavity space; and displacement, eversion, and/or injury to the heart, kidneys, stomach, liver, and other internal organs (Rogers et al. 2008, Pribyl et al. 2009, Pribyl et al.

2011). Further, expanding gas can rupture and escape from the swim bladder filling the orbital space behind the eyes, stretching the optic nerve, and causing exophthalmia (Rogers et al. 2008). Once on the surface, rockfish can become positively buoyant, meaning they are unable to return to their previous water depth become susceptible to predation (Starr et al. 2002, Hannah et al. 2008, Jarvis and Lowe 2008).

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

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.

Screw trapping

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

The 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.

Tangle Netting

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

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

Tagging/Marking

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

A PIT tag is an electronic device that relays signals to a radio receiver; it allows salmonids to be identified whenever they pass a location containing such a receiver (e.g., any of several dams) without researchers having to handle the fish again. The tag is inserted into the body cavity of the fish just in front of the pelvic girdle. The tagging procedure requires that the fish be captured and extensively handled; therefore, any researchers engaged in such activities will follow the conditions listed previously in this Opinion (as 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.

Tissue Sampling

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

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

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

Trawls

Trawls are cone-shaped, mesh nets that are towed, often, along benthic habitat (Hayes 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, Stickney 1983, Hayes et al. 1996).

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 Each Permit

In previous sections, we estimated the annual abundance of adult and juvenile listed salmonids, eulachon, green sturgeon, and rockfish. Since there are no measurable habitat effects, the analysis will consist primarily of examining directly measurable impacts of proposed activities on abundance. Abundance effects are themselves relevant to extinction risk, are directly related to productivity effects, and are somewhat but less directly to structure and diversity effects. Examining the magnitude of these effects at the individual and, where possible, population levels is the best way to determine effects at the species level. Table 37 displays the estimated annual abundance of the listed species.

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 our Science Centers for the species status reviews, which are updated every five years. Additional data sources include state agencies (i.e. CDFW, IDFW, ODFW, WDFW), 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. Table 37 displays the estimated annual abundance of hatchery-propagated and naturally produced listed fish.

In conducting the following analyses, we have tied the effects of each proposed action to its impacts on individual populations (or population groups) wherever it was possible to do so. In those instances, the status of the local population will be discussed and taken into account. In other instances, the nature of the project (i.e., it is broadly distributed or situated in mainstem habitat) is such that the take cannot reliably be assigned to any population or group of populations. In those cases, the effects of the action are measured in terms of how they are expected to affect each listed unit's total abundance by origin (Natural) and production [Listed Hatchery Adipose Clip (LHAC) and Listed Hatchery Intact Adipose (LHIA)]—rather than at the population scale. Table 37 displays the estimated annual abundance of the listed species.

Table 37. Estimated annual abundance of ESA listed fish (Ford 2022, SWFSC 2022, CDFW 2020) (LHAC= Listed Hatchery, Adipose-clipped, LHIA= Listed Hatchery, Intact Adipose).

<table>
<tr><th>Species</th><th>Life Stage</th><th>Origin</th><th>Abundance</th></tr>
<tr><td rowspan="5">PS Chinook salmon</td><td rowspan="2">Adult</td><td>Natural</td><td>23,371</td></tr>
<tr><td>Listed Hatchery</td><td>23,232</td></tr>
<tr><td rowspan="3">Juvenile</td><td>Natural</td><td>3,728,240</td></tr>
<tr><td>LHIA</td><td>8,680,000</td></tr>
<tr><td>LHAC</td><td>25,624,500</td></tr>
<tr><td rowspan="5">PS steelhead</td><td rowspan="2">Adult</td><td>Natural</td><td>18,196</td></tr>
<tr><td>Listed Hatchery</td><td>1,618</td></tr>
<tr><td rowspan="3">Juvenile</td><td>Natural</td><td>2,253,842</td></tr>
<tr><td>LHIA</td><td>53,000</td></tr>
<tr><td>LHAC</td><td>226,000</td></tr>
<tr><td>PS/GB DPS bocaccio</td><td rowspan="4">Adult</td><td>Natural</td><td>4,606</td></tr>
<tr><td>PS/GB DPS yelloweye rockfish</td><td>Natural</td><td>114,494</td></tr>
<tr><td rowspan="3">HCS chum salmon</td><td>Natural</td><td>28,117</td></tr>
<tr><td>Listed Hatchery</td><td>881</td></tr>
<tr><td>Juvenile</td><td>Natural</td><td>4,240,958</td></tr>
<tr><td rowspan="4">OL sockeye salmon</td><td rowspan="2">Adult</td><td>Natural</td><td>5,876</td></tr>
<tr><td>Listed Hatchery</td><td>309</td></tr>
<tr><td rowspan="2">Juvenile</td><td>Natural</td><td>1,273,337</td></tr>
<tr><td>LHIA</td><td>259,250</td></tr>
</table>

Species	**Life Stage**	**Origin**	**Abundance**
		LHAC	45,750
UCR Chinook salmon	Adult	Natural	813
		Listed Hatchery	1,140
	Juvenile	Natural	488,401
		LHIA	470,744
		LHAC	682,958
UCR steelhead	Adult	Natural	1,465
		Listed Hatchery	2,893
	Juvenile	Natural	150,459
		LHIA	139,810
		LHAC	765,850
MCR steelhead	Adult	Natural	13,598
		Listed Hatchery	713
	Juvenile	Natural	351,481
		LHIA	113,302
		LHAC	372,581
SnkR spr/sum Chinook salmon	Adult	Natural	4,419
		Listed Hatchery	2,822
	Juvenile	Natural	682,600
		LHIA	695,385
		LHAC	4,743,977
SnkR fall-run Chinook salmon	Adult	Natural	7,262
		Listed Hatchery	14,879
	Juvenile	Natural	799,765

Species	Life Stage	Origin	Abundance
		LHIA	2,966,190
		LHAC	2,608,733
SnkR steelhead	Adult	Natural	9,965
		Listed Hatchery	3,285
	Juvenile	Natural	573,245
		LHIA	528,903
		LHAC	3,058,720
SnkR sockeye salmon	Adult	Natural	16
		Listed Hatchery	97
	Juvenile	Natural	18,000
		LHAC	298,464
LCR Chinook salmon	Adult	Natural	29,298
		Listed Hatchery	18,814
	Juvenile	Natural	11,135,315
		LHIA	942,328
		LHAC	30,923,844
LCR coho salmon	Adult	Natural	18,714
		Listed Hatchery	15,949
	Juvenile	Natural	827,007
		LHIA	324,130
		LHAC	7,941,886
LCR steelhead	Adult	Natural	8,152
		Listed Hatchery	6,382
	Juvenile	Natural	375,208

Species	Life Stage	Origin	Abundance
		LHIA	14,801
		LHAC	1,183,963
CR chum salmon	Adult	Natural	17,305
		Listed Hatchery	1,145
	Juvenile	Natural	7,777,554
		LHIA	554,973
UWR Chinook salmon	Adult	Natural	10,531
		Listed Hatchery	25,380
	Juvenile	Natural	1,159,334
		LHIA	0
		LHAC	4,361,832
UWR steelhead	Adult	Natural	2,628
	Juvenile	Natural	135,303
OC coho salmon	Adult	Natural	60,624
		Listed Hatchery	638
	Juvenile	Natural	4,288,340
		LHAC	60,000
SONCC coho salmon	Adult	LHAC, LHIA & NOR	12,641
	Juvenile	Natural	884,870
		LHIA	75,000
		LHAC	575,000
NC steelhead	Adult	LHAC, LHIA & NOR	8,356
	Juvenile	Natural	950,493

Species	Life Stage	Origin	Abundance
CC Chinook salmon	Adult	Natural	13,169
	Juvenile	Natural	2,392,807
SacR winter-run Chinook salmon	Adult	Natural	1,185
		Listed Hatchery	2,697
	Juvenile	Natural	125,038
		LHAC	158,855
CVS Chinook salmon	Adult	Natural	6,756
		Listed Hatchery	2,083
	Juvenile	Natural	1,838,954
		LHAC	2,000,000
CCV steelhead	Adult	LHAC, LHIA & NOR	11,494
	Juvenile	Natural	1,307,443
		LHAC	1,050,000
CCC coho salmon	Adult	LHAC, LHIA & NOR	2,308
	Juvenile	Natural	161,560
		LHIA	140,000
CCC steelhead	Adult	LHAC, LHIA & NOR	1,906
	Juvenile	Natural	216,808
		LHAC	520,000
SCCC steelhead	Adult	LHAC, LHIA & NOR	196
	Juvenile	Natural	22,295

Species	Life Stage	Origin	Abundance
SC steelhead	Adult	LHAC, LHIA & NOR	See subsection*
	Juvenile	Natural	See subsection*
SDPS eulachon	Adult	Natural	26,746,391
SDPS green sturgeon		Natural	2,127
	Subadult	Natural	11,165
	Juvenile	Natural	4,431

* Abundance data for SC steelhead are very limited, and for populations that are regularly monitored many have runs that are ephemeral and may see zero anadromous adults in a given year. Using 5-year geometric mean abundances of these was therefore not considered a meaningful representation of effects to the DPS.

Please note that the juvenile abundance numbers presented above for each species should be viewed with caution because they only address one of several juvenile life stages. Moreover, deriving any juvenile abundance estimate for species with no dam/passage counts is complicated by a host of variables, including the facts that: (1) the available data do not include all populations; (2) spawner counts and associated sex ratios and fecundity estimates can vary widely between years; (3) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; (4) it is very difficult to distinguish between non-listed juvenile rainbow trout and listed juvenile steelhead; and (5) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, fishing, etc.). Thus, as stated previously, we purposefully under-estimate abundances—particularly for juvenile fish—in order to account for information gaps and ensure that we remain as conservative a possible when estimating the effects of the proposed actions. We kept these variables in mind (as well as the suit of other factors described in “Research Effects”) when conducting the following analyses.

Permit 1134-8R

As stated previously, Permit 1134 has been in existence for many years and currently allows CRITFC to annually take adult and juvenile threatened SnkR spring/summer Chinook salmon (natural and artificially propagated); and adult and juvenile threatened SnkR steelhead at many locations in the Snake River basin. If granted, the renewal would allow them to continue some of the same activities they have been pursuing for more than 20 years, but with significant reductions in the amount of take they are requesting

Under the renewed permit, CRITFC would continue three of the five projects in which they are currently engaged (see Proposed Action). The continuing projects are:

Project 1—Cryopreservation of spr/sum Chinook Salmon and Summer Steelhead Gametes

Under this project, CRITFC would annually collect spr/sum Chinook and steelhead gametes throughout the Snake River basin. The fish would be collected by various methods—dipnet, hand, seine, angling, and at already-established screw traps and hatchery weirs. Once captured, the fish would be tissue sampled (a fin punch and/or a scale taken), examined, and measured. At that point, no females would be handled further and all would be allowed to escape immediately back to the stream. The males would be anesthetized (anywhere from 30 seconds to two minutes), their abdomens wiped dry, and sperm samples would be taken. They would then be placed in a pool area of the stream and assisted until they recover. The sperm samples would be preserved in liquid nitrogen tanks and transported to the University of Idaho and Washington State University.

Project 2— Snorkel, Seine, Fyke net, Minnow Trap, and Electro-Fishing Surveys for the collection of Juvenile Chinook Salmon and Steelhead.

Under Project 2, CRITFC would annually collect and PIT-tags juvenile SnkR spr/sum Chinook and steelhead. The researchers would use the capture methods listed above. The captured fish would be anesthetized, measured and weighed, scale and/or other tissue samples would be taken in most instances, and many of the fish would be PIT-tagged. Once these operations are complete, the fish would be allowed to recover and move back into the stream. The amounts of requested take are displayed in the following table. (They also intend to observe a number of fish, but as stated previously, any negative effects associated with observation are unmeasurably small and some benefit would be derived.)

Project 3—Juvenile Anadromous Salmonid Emigration Studies Using Rotary Screw Traps.

Under Project 3, CRITFC researchers would annually trap, anesthetize, examine, measure, and PIT-tag SnkR spr/sum Chinook and steelhead at several rotary screw traps in the upper Snake River Basin. Some of the captured fish would be marked and returned upstream to check trap efficiency. Some adults may be captured during the operations, but they would immediately be released.

The researchers are not proposing to kill any of the listed fish being captured, but a small number of fish may be killed as an inadvertent result of these activities. The researchers are requesting the following amounts of take:

Table 38. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 1134-8R.

Species	Life Stage	Origin*	Take Action**	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
SnkR spr/sum Chinook Salmon	Adult	Natural	C/H/R	50	1	6.223	0.068
		Natural	C/M, T, ST/R	500	5		
		LHIA	C/M, T, ST/R	500	5	17.718	0.177

Species	Life Stage	Origin*	Take Action**	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
	Juvenile	Natural	C/H/R	10,000	50	4.849	0.048
		Natural	C/M, T, ST/R	56,200	610		
		LHIA	C/H/R	50,000	250	3.811	0.023
		LHIA	C/M, T, ST/R	3,000	70		
		LHAC	C/H/R	50,000	250	1.054	0.005
SnkR steelhead	Adult	Natural	C/H/R	50	1	2.760	0.030
		Natural	C/M, T, ST/R	500	5		
		LHIA	C/M, T, ST/R	500	5	15.221	0.152
	Juvenile	Natural	C/H/R	10,000	50	5.669	0.056
		Natural	C/M, T, ST/R	55,000	590		
		LHIA	C/H/R	25,000	125	2.647	0.017
		LHIA	C/M, T, ST/R	3,000	60		
		LHAC	C/H/R	25,000	125	0.817	0.004

***LHIA=Listed Hatchery, Intact Adipose fin. LHAC=Listed Hatchery, Adipose-fin-clipped**
****C/H/R = Capture/Handle/Release, T=Tag, M=Mark, ST=Sample Tissue.**

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. 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 population and species—these figures are presented in the last column of Table 38 above.

As Table 38 illustrates, for most species' components, the researchers would take a small percent of any listed unit—and kill an even smaller percent of those units. Because the research would take place over such a broad area, the potential losses cannot be ascribed to any population for any species and must therefore be viewed in the context of the listed units as individual wholes. As a result, though the research may in some instances have a very small impact on species abundance and productivity, it would in no measurable way impact structure or diversity for any species.

It is also likely that the impacts will be smaller than those laid out above. Over the most recent five years, the researchers have only taken 11.24% of their requested take, and killed 4.9% of their requested mortalities, so it is most likely that the actual effect will be approximately one-twentieth of that displayed in the table above. But even if the entirety of the effect were actually to occur, that impact would be offset to some degree by the fact that the research conducted for years under various iterations of Permit 1134 provides managers from several states and Federal agencies with critical information about the yearly outmigration and the status of the various species. River and dam operations, land use planning, restoration efforts, and other scientific research projects depend upon the information generated by the CRITFC researchers under this permit, and they have done so for many years. Also, and again, the amounts of take being requested are far lower than they have been historically—and for many years, those higher levels were found to not jeopardize either species.

Permit 15573-4R

Under permit 15573-4R the Glenn-Colusa Irrigation District (GCID) is seeking to renew a permit that would authorize them to take juvenile SacR winter-run Chinook salmon, CVS Chinook salmon, CCV steelhead, SDPS green sturgeon in order to monitor restoration actions and to detect annular and cyclic population changes. The GCID project provides the longest and most complete anadromous fish data set on the Sacramento River.

Juveniles would be collected via screw trap. A subsample of captured juveniles would be anesthetized, tissue sampled and PIT-tagged prior to release. Juvenile fish would be captured, handled, and released. The researchers are not proposing to kill any of the listed fish being captured, but a small number of fish may be killed as an inadvertent result of these activities. The amount of take the Glenn-Colusa Irrigation District is requesting is found in the Table 39 below.

Table 39. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 15573-4R

Species	Life Stage	Origin*	Take Action**	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
SacR winter-run Chinook salmon	Juvenile	Natural	C/M, T, ST/R	4,400	132	3.519	0.106
		LHAC	C/M, T, ST/R	1,500	45	0.944	0.028
CVS Chinook salmon		Natural	C/M, T, ST/R	3,950	119	0.215	0.006

Species	Life Stage	Origin*	Take Action**	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
CVS steelhead		Natural	C/H/R	500	15	0.038	0.001
		LHAC	C/H/R	2,000	60	0.190	0.006
SDPS green sturgeon		Natural	C/H/R	50	1	1.128	0.023

***LHIA=Listed Hatchery, Intact Adipose fin. LHAC=Listed Hatchery, Adipose-fin-clipped**
****C/H/R = Capture/Handle/Release, T=Tag, M=Mark, ST=Sample Tissue.**

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. 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 population and species—these figures are presented in the last column of Table 38 above.

As Table 38 illustrates, for most species the researchers would take a small percent of any listed unit—and kill an even smaller percent of those units. Because the research would take place downstream of the confluence of several rivers, the potential losses cannot be ascribed to any population for any species and must therefore be viewed in the context of the listed units as individual wholes. As a result, though the research may in some instances have a very small impact on species abundance and productivity, it would in no measurable way impact structure or diversity for any species.

It is also likely that the impacts will be smaller than those laid out above. Over the most recent 5 years, the researchers have only taken 27.97% of their requested take, and killed 6.21% of their requested mortalities, so it is most likely that the actual effect will be less than that displayed in the table above by a similar magnitude.

Permit 15824-3R

Under permit 15824-3R the County of Santa Cruz is seeking to renew a permit that would authorize them to take juvenile CCC coho salmon, CCC steelhead, SCCC steelhead in order to document habitat conditions and collect data on juvenile salmonid abundance in Santa Cruz County watersheds. Juveniles would be collected via backpack electrofishing, beach seine, and observed during snorkel surveys. Juvenile fish would be captured, handled, and released. A subsample of captured juveniles would be anesthetized, tissue sampled and PIT-tagged prior to release.

The researchers are not proposing to kill any of the listed fish being captured, but a small number of fish may be killed as an inadvertent result of these activities. The amount of take the County of Santa Cruz is requesting is found in Table 40 below.

Table 40. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 15824-3R

Species	Life Stage	Origin	Take Action*	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
CCC coho salmon	Juvenile	Natural	C/H/R	1,300	14	0.696	0.010
		Natural	C/M, T, ST/R	950	19		
CCC steelhead		Natural	C/H/R	4,955	49	1.381	0.019
		Natural	C/M, T, ST/R	3,825	77		
		Natural	O/H	200	0		
SCCC steelhead		Natural	C/H/R	2,290	23	6.257	0.074
		Natural	C/M, T, ST/R	500	10		

C/H/R = Capture/Handle/Release, T=Tag, M=Mark, ST=Sample Tissue, O/H=observe/harass.

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. 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 population and species—these figures are presented in the last column of Table 40 above.

As Table 40 illustrates, for most species the researchers would take a small percent of any listed unit—and kill an even smaller percent of those units. Because the research would take place over such a broad area, the potential losses cannot be ascribed to any population for any species and must therefore be viewed in the context of the listed units as individual wholes. As a result, though the research may in some instances have a very small impact on species abundance and productivity, it would in no measurable way impact structure or diversity for any species.

It is also likely that the impacts will be smaller than those laid out above. Over the most recent 5 years, the researchers have only taken 25.48% of their requested take, and killed 19.57% of their requested mortalities, so it is most likely that the actual effect will be less than that displayed in the Table 40 above by a similar magnitude.

Permit 16303-3R

The United States Geological Survey (USGS) is seeking to renew a research permit that allows them to take juvenile PS/GB DPS bocaccio, juvenile HCS chum salmon, juvenile PS steelhead, and juvenile, subadult, and adult PS Chinook salmon throughout the marine waters of Puget Sound, Hood Canal, and the Strait of Juan de Fuca (Washington State). The USGS research may also cause them to take adult SDPS eulachon and juvenile PS/GB DPS yelloweye rockfish—species for which there are currently no ESA take prohibitions.

The USGS proposes capturing fish by beach seine, purse seine, Lampara seine, and micro-trolling (*i.e.,* hook-and-line angling). All captured, viable subadult or adult salmon and any rockfish would be released as swiftly as possible. Listed rockfish would be released via rapid submergence to their capture depth to reduce the effects from barotrauma, and sub-adult/adult salmonids would be released at the surface. Under all capture methods, the juvenile salmonids would be anesthetized, identified to species, checked for coded wire tags (CWTs), measured to length, gastric-lavaged, tissue-sampled (fin clip and scales), and released. All juvenile, hatchery-origin, CWT fish (marked and unmarked) captured during the seining would be intentionally sacrificed to determine their origins. The researchers also propose to intentionally kill small numbers of hatchery- and natural-origin juvenile Chinook salmon for otolith collection and whole-body chemical analyses. Additionally, a small number of listed fish may die as an unintended result of the activities. The amount of take the USGS Western Fisheries Research Center is requesting is found in Table 41 below.

Table 41. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 16303-3R

Species	Life Stage	Origin*	Take Action**	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
PS Chinook salmon	Adult	Natural	C/H/R	30	1	0.492	0.006
			C/M, T, ST/R	200	2		
		LHIA	C/H/R	20	1	1.722	0.022
			C/M, T, ST/R	150	1		
		LHAC	C/H/R	30	1		
			C/M, T, ST/R	200	2		
	Juvenile	Natural	C/M, T, ST/R	2,000	20	0.029	0.002
			IM	140	140		
		LHIA	C/M, T, ST/R	500	5	0.006	0.003
			IM	600	600		
		LHAC	C/M, T, ST/R	6,500	10	0.014	0.002
			IM	900	900		
PS steelhead	Juvenile	Natural	C/M, T, ST/R	30	1	0.001	<0.001
		LHAC	C/M, T, ST/R	30	1	0.013	<0.001
PS/GB DPS bocaccio	Juvenile	Natural	C/H/R	1	1	0.022	0.022

Species	Life Stage	Origin*	Take Action**	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
PS/GB DPS yelloweye rockfish	Juvenile	Natural	C/H/R	1	1	<0.001	<0.001
HCS chum salmon	Juvenile	Natural	C/M, T, ST/R	20	1	<0.001	<0.001
SDPS eulachon	Adult	Natural	C/H/R	55	15	<0.001	<0.001

***LHAC = Listed Hatchery Adipose Clip; LHIA = Listed Hatchery Intact Adipose**
****C/H/R = Capture/Handle/Release, IM = Intentional (Directed) Mortality, C/M, T, ST/R = Capture/Mark, Tag, Sample Tissue/Release**

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. 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 population and species—these figures are presented in the last column of Table 41above.

As Table 41 illustrates, for most species the researchers would take a small percent of any listed unit—and kill an even smaller percent of those units. Because the research would take place over such a broad area, the potential losses cannot be ascribed to any population for any species and must therefore be viewed in the context of the listed units as individual wholes. As a result, though the research may in some instances have a very small impact on species abundance and productivity, it would in no measurable way impact structure or diversity for any species. It is also likely that the impacts will be smaller than those laid out above. Over the most recent 5 years, the researchers have only taken 13.72% of their requested take, and killed 7.59% of their requested mortalities, so it is most likely that the actual effect will be less than that displayed in Table 41 above by a similar magnitude.

An effect of the research that cannot be quantified is the benefit it would have with respect to species conservation. Information gained from this research is likely to improve the understanding of threats to marine survival for juvenile PS Chinook salmon and steelhead, clarifying causes of mortality for this critical juvenile life stage. This information will improve predictions of PS Chinook salmon and steelhead survival and productivity responses to changing environmental conditions, and may be used by managers to inform future conservation actions that protect or enhance the resiliency of these species to years with poor marine survival conditions.

Permit 21061-2R

Windward Environmental is seeking to renew a permit that would authorize them to take juvenile and adult PS steelhead and Chinook salmon and juvenile PS/GB DPS bocaccio in order to establish baseline Lower Duwamish Waterway-wide concentrations of contaminants in non-listed resident fish species and evaluate how well this superfund site is progressing toward meeting the cleanup target tissue concentrations set by the Environmental Protection Agency (EPA). The research may also cause unintentional take of juvenile PS/GB DPS yelloweye rockfish—a species for which there are currently no ESA take prohibitions.

The researchers may unintentionally capture juvenile and adult ESA-listed fish while conducting otter trawls that target sole and surfperch. All captured juvenile or adult ESA-listed fish captured would be identified, enumerated, and immediately released at the location of capture. The researchers would also deploy crab traps targeting Dungeness crab, although neither juvenile nor adult ESA-listed fish are expected to be unintentionally captured by this gear. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the proposed activities. The amount of take Windward Environmental is requesting is found Table 42 below.

Table 42. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 21061-2R

Species	Life Stage	Origin*	Take Action**	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
PS Chinook salmon	Adult	Natural	C/H/R	2	0	0.009	0.000
		LHAC	C/H/R	2	0		
	Juvenile	Natural	C/H/R	20	1	<0.001	<0.001
		LHAC	C/H/R	20	1	<0.001	<0.001
PS steelhead	Adult	Natural	C/H/R	2	0	0.011	0.000
		LHAC	C/H/R	2	0	0.124	0.000
	Juvenile	Natural	C/H/R	20	1	<0.001	<0.001
		LHAC	C/H/R	20	1	0.009	<0.001
PS/GB DPS bocaccio	Juvenile	Natural	C/H/R	1	0	0.022	0.000
PS/GB DPS yelloweye rockfish	Juvenile	Natural	C/H/R	1	0	<0.001	0.000

***LHAC = Listed Hatchery Adipose Clip**
****C/H/R = Capture/Handle/Release**

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. 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 population and species—these figures are presented in the last column of Table 42 above.

As Table 42 illustrates, for most species the researchers would take a small percent of any listed unit—and kill an even smaller percent of those units. At the population level, even when combined with the other permit under consideration for the Lower Duwamish Waterway (#27091) only a total of four natural-origin juvenile PS Chinook salmon and two natural-origin juvenile PS steelhead could be killed within the Green River populations of these species. Current adult abundances reported for the Green River populations (Ford 2022) allow us to estimate that more than 500,000 PS Chinook salmon juveniles and more than 145,000 PS steelhead juveniles are naturally produced in the Green River per year. Therefore, even within this one tributary the take authorized for both studies in the Lower Duwamish Waterway would amount to <0.002% of natural-origin juveniles in the Green River populations for both PS steelhead and PS Chinook salmon. As a result, though the research may in some instances have a very small impact on species abundance and productivity, it would in no measurable way impact structure or diversity for any species.

It is also likely that the impacts will be smaller than those laid out above. Over the most recent year of reporting, the researchers have taken none of their requested take, and caused no mortalities, so it is most likely that the actual effect will be less than that displayed in Table 42 above by a similar magnitude.

An effect of the research that cannot be quantified is the benefit it would have with respect to species conservation. The information would be used to determine progress towards cleanup goals for the Lower Duwamish Waterway and inform future sediment remediation efforts. This information would benefit listed PS Chinook salmon and steelhead by confirming where contaminated areas remain a threat and how concentrated contaminants continue to be within the Lower Duwamish. Identifying remaining contamination and informing design of further cleanup activities is expected to ensure the threat of legacy contaminants has been sufficiently reduced to protect the productivity and survival of salmon and steelhead that migrate through the Lower Duwamish Waterway, as well as protect and allow recovery of other critical habitat features these species depend on.

Permit 22093-2R

Under permit 22093-2R the Snoqualmie Valley Watershed Improvement District (SVWID) is seeking to renew a permit that would authorize them to take adult and juvenile PS Chinook salmon and PS steelhead in order to assess the presence or absence of fish in various streams and agricultural drainage ditches within the boundary of the SVWID.

Juveniles would be collected via backpack electrofishing, beach seining, and minnow traps. Adults would be collected via beach seine. Fish would be captured, handled (weighed, measured, and checked for marks or tags), and released. The researchers are not proposing to kill any of the listed fish being captured, but a small number of fish may be killed as an inadvertent result of these activities. The amount of take the SVWID is requesting is found in Table 43 below.

Table 43. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 22093-2R

Species	Life Stage	Origin*	Take Action**	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
	Adult	Natural	C/H/R	2	0	0.009	0.000

Species	Life Stage	Origin*	Take Action**	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
PS Chinook salmon		LHAC	C/H/R	2	0		
	Juvenile	Natural	C/H/R	100	1	0.003	<0.001
		LHAC	C/H/R	100	1	<0.001	<0.001
PS steelhead	Adult	Natural	C/H/R	2	0	0.011	0.000
	Juvenile	Natural	C/H/R	100	1	0.004	<0.001

***LHAC = Listed Hatchery Adipose Clip**
****C/H/R = Capture/Handle/Release**

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. 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 population and species—these figures are presented in the last column of Table 43 above.

As Table 43 illustrates, for most species the researchers would take a small percent of any listed unit—and kill an even smaller percent of those units. Even at the population level, over 91,000 natural-origin juvenile PS Chinook salmon and over 56,000 natural-origin PS steelhead are estimated to be outmigrating in the Snoqualmie River per year, and therefore the loss of a single individual would have a negligible impact on the abundance of either population. As a result, though the research may in some instances have a very small impact on species abundance and productivity, it would in no measurable way impact structure or diversity for any species.

It is also likely that the impacts will be smaller than those laid out above. Over the most recent 5 years, the researchers have only taken none of their requested take, and killed none of their requested mortalities, so it is most likely that the actual effect will be less than that displayed in Table 42 above by a similar magnitude.

An effect of the research that cannot be quantified is the benefit it would have with respect to species conservation. The information gathered as part of this work will benefit ESA-listed species by informing plans to improve drainage, minimize flooding, and restore salmon habitat within SVWID lands. Data and observations gathered through this research will also provide data about the presence and abundance of PS Chinook salmon and steelhead in agricultural drainage ditches and small streams that may not otherwise be studied.

Permit 22998-2R

The United States Fish and Wildlife Service (FWS) is seeking to renew a permit that would once again authorize them to annually take juvenile PS Chinook salmon and steelhead and adult HCS chum salmon in streams and waterbodies on the Kitsap Peninsula (Kitsap County, WA). The purpose of the study is to determine where in those waterbodies ESA-listed salmonids are present.

The FWS would use backpack electrofishing equipment, beach seines, and dip nets to capture the juvenile fish. For electrofishing, the captured fish would be anesthetized, identified by species, measured for length, weighed, allowed to recover, and released. For beach seines and dip netting, the captured fish would only be identified by species and swiftly released. The researchers would also conduct snorkel surveys for juvenile PS Chinook salmon and steelhead, and spawner surveys in which adult chum salmon may be observed. The FWS does not intend to kill any of the fish being captured, but a small number of juveniles may die as an unintended consequence of the proposed activities. The amount of take the FWS is requesting is found in Table 44 below.

Table 44. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 22998-2R

Species	Life Stage	Origin*	Take Action**	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
PS Chinook salmon	Juvenile	Natural	C/H/R	105	3	0.003	<0.001
			O/H	100	0	-	-
		LHAC	C/H/R	105	3	<0.001	<0.001
			O/H	100	0	-	-
PS steelhead	Juvenile	Natural	C/H/R	150	3	0.006	<0.001
			O/H	100	0	-	-
HCS chum salmon	Adult	Natural	O/H	2	0	-	-

***LHAC = Listed Hatchery Adipose Clip**
****C/H/R = Capture/Handle/Release; O/H = Observe/Harass**

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. 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 population and species—these figures are presented in the last column of Table 44above.

As Table 44 illustrates, for most species the researchers would take a small percent of any listed unit—and kill an even smaller percent of those units. At the population level, we don't have sufficient data available for the East Kitsap Peninsula tributaries DIP (PS steelhead) where Navy Base Kitsap is located to analyze the effects at that level, and there is not an independent population identified in that area that is part of the PS Chinook salmon ESU. However, even if we considered only the small populations for which we have data on the other side of Kitsap Peninsula in the South and East Hood Canal (PS steelhead) and mid-Hood Canal (PS Chinook salmon), the estimated abundance of natural-origin juveniles is still many thousands of individuals (>16,000 PS steelhead and >17,000 PS Chinook salmon). The lethal impacts would therefore still be <0.02% of any of the natural-origin juveniles in any of these populations. As a result, though the research may in some instances have a very small impact on species abundance and productivity, it would in no measurable way impact structure or diversity for any species.

It is also likely that the impacts will be smaller than those laid out above. Over the most recent 2 years of reporting (only sampling events that occurred), the researchers have taken none of their requested take, and reported no mortalities, so it is most likely that the actual effect will be near zero.

An effect of the research that cannot be quantified is the benefit it would have with respect to species conservation. Currently, there is little information about the distribution of ESA-listed salmonids on Navy Base Kitsap lands. Information collected as part of this work would provide baseline information on PS Chinook salmon and PS steelhead distribution in these areas, and be used to help guide future land use management and habitat restoration in streams and riparian areas on Navy Base Kitsap lands.

Permit 26368-2M

As noted previously, a newly-granted Permit 26368-2M would modify a permit that currently authorizes ISU researchers to annually take juvenile MCR steelhead, SnkR spr/sum and fall-run Chinook salmon, SnkR steelhead, UWR Chinook salmon, UWR steelhead, and OC coho salmon at more than a dozen locations from Idaho to western Oregon. The modification would entail authorizing the researchers to also take PS steelhead and Chinook, UCR steelhead and Chinook, SONCC coho salmon, SnkR sockeye salmon, and SDPS eulachon and green sturgeon at several new locations. No adult fish would be taken, and the juvenile fish would be collected via backpack electrofishing and hook-and-line angling. Only juvenile steelhead would be handled (anesthetized, weighed, measured, and checked for marks or tags), sampled, and released. All other listed fish that may be captured would be released as swiftly as possible—although in some cases they might first need to held for a short time in aerated water so they can recover before being released. Juveniles would be collected via backpack electrofishing, hook and line angling. The researchers are requesting to add the following amounts of take to their current permit:

Table 45. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 26368-2M.

Species	Life Stage	Origin*	Take Action**	Prior Total Take	Prior Lethal Take	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
PS Chinook salmon	Juvenile	Natural	C/H/R	0	0	50	1	0.001	<0.001
PS steelhead		Natural	C/M/T/ ST/R	0	0	90	1	0.004	
UCR Chinook salmon		Natural	C/H/R	0	0	50	1	0.010	

Species	Life Stage	Origin*	Take Action**	Prior Total Take	Prior Lethal Take	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
UCR steelhead		Natural	C/M/T/ST/R	0	0	90	1	0.060	
MCR steelhead		Natural	C/M/T/ST/R	250	5	0	0	0.000	0.000
SnkR spr/sum Chinook salmon		Natural	C/H/R	300	5	50	1	0.007	<0.001
SnkR fall-run Chinook salmon		Natural	C/H/R	0	0	50	1	0.006	
SnkR steelhead		Natural	C/M/T/ST/R	800	7	90	1	0.016	
SnkR sockeye salmon		Natural	C/H/R	0	0	50	1	0.278	0.006
UWR Chinook salmon		Natural	C/H/R	100	2	-50	-1	-	-
UWR steelhead		Natural	C/M/T/ST/R	120	1	0	0	0.000	0.000
OC coho salmon		Natural	C/H/R	300	3	0	0		
SONCC coho salmon		Natural	C/H/R	0	0	50	1	0.006	<0.001
SDPS eulachon		Natural	C/H/R	0	0	15	3	<0.001	
SDPS green sturgeon		Natural	C/H/R	0	0	10	2	0.226	0.045

***LHIA=Listed Hatchery, Intact Adipose fin. LHAC=Listed Hatchery, Adipose-fin-clipped**
**** C/H/R = Capture/Handle/Release, T=Tag, M=Mark, ST=Sample Tissue.**

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. 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 population and species—these figures are presented in the last column of Table 45 above.

As Table 45 illustrates, for all species' components, the researchers would take a small percent of any listed unit and kill almost no fish from any of those units. In addition, because the research would take place over such a broad area, the potential losses cannot be ascribed to any population for any species and must therefore be viewed in the context of the listed units as individual wholes. As a result, though the research may in some instances have a very small impact on species abundance and productivity, it would in no measurable way impact structure or diversity for any species.

It is also likely that the impacts will be smaller than those laid out above. The permit has only been in operation for a year, but in that time, the researchers have only taken 2.62% of their requested take, and killed none of their requested mortalities, so it is most likely that the actual effect will be very close to zero. But even if the work were to have the maximum effect displayed, that very small effect would be offset to some degree by the fact that the work would provide information about population structure and local biodiversity in a variety of settings and take some measure of how intra- and inter-species variability contribute to ecosystem maintenance. And that information, in turn, would be used to monitor and adjust for variances in species diversity and population structure and health across a broad section of the listed species' habitat.

Permit 26714

If granted, Permit 26714 would authorize the ODFW to take juvenile and adult SnkR spr/sum Chinook salmon and steelhead in the Wallowa River while studying the distribution, relative abundance, movement ecology, and angler exploitation rates of rainbow trout and mountain whitefish in the Wallowa River in Northeastern Oregon.

Juveniles would be collected via boat electrofishing and then handled and released. A subsample of captured juveniles would be anesthetized, tissue-sampled and PIT-tagged before being released back to the sites of their capture. Adults would be avoided at all times, and if any are encountered, the electrofishing equipment would immediately be turned off and the fish allowed to swim away. The surveyors would then relocate the equipment before beginning again.

The researchers are not proposing to kill any of the listed fish being captured, but a small number of fish may be killed as an inadvertent result of these activities. The researchers are requesting the following amounts and types of take:

Table 46. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 26714.

Species	Life Stage	Origin*	Take Action**	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
SnkR spr/sum Chinook salmon	Adult	Natural	C/H/R	5	0	0.113	0.000
		LHAC	C/H/R	5	0	0.177	
	Juvenile	Natural	C/H/R	150	4	0.022	<0.001
		LHAC	C/H/R	150	4	0.003	
SnkR steelhead	Adult	Natural	C/H/R	5	0	0.050	0.000
	Juvenile	Natural	C/H/R	500	15	0.052	0.002
		Natural	C/M/T/ ST/R	100	3		

*** LHAC=Listed Hatchery, Adipose-fin-clipped**
**** C/H/R = Capture/Handle/Release, T=Tag, M=Mark, ST=Sample Tissue.**

Because the majority of the fish that may be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. 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—these figures are presented in the last column of Table 46 above.

As Table 46 illustrates, the researchers would take only a small percent of any listed unit and kill an even smaller percent of those units. However, because the research would be limited to the Wallowa River, the effects would be magnified to a degree at the local level. No adults would be killed, so the effects on those components would be minimal regardless of how many animals are present.

Juvenile Steelhead: From 2015 through 2019, the 5-year geometric mean for natural steelhead spawner counts in the Wallowa River was 605 adults (Ford 2022). If half of those adults were female and each produced (conservatively) 3,500 eggs with a survival rate to smolthood of 5%, then the Wallowa river would produce approximately 53,000 outmigrants. This would signify that the research would kill, at most, 0.03% of the local population. This would constitute a very small effect on abundance (and therefore productivity), but no discernable effect on local diversity or structure.

Juvenile spr/sum Chinook: The effect on listed juvenile Chinook would be even smaller than that on steelhead. First, half of the mortalities (four) would come from listed hatchery fish that have had their adipose fins clipped. There are no take prohibitions on these fish because they are considered surplus to recovery needs; therefore, the activities' effects on that component would have essentially no effect on any VSP parameter for the species. Second, even though the four dead fish that may come from the natural spr/sum Chinook component would come not from the entire ESU, but from one river, they would represent an increase over the "<0.001%" figure displayed above, but not a large one. We do not know how many spr/sum Chinook the Wallowa river produces but, at a minimum, the major population group (MPG) to which it belongs, produced a (geometric) mean of 1,206 adults over the 2015-2019 period (Ford 2022). Given the assumption that half of those fish were females and each (conservatively) produced 4,000 eggs (of which 5% survived to smolthood) the proposed activities might kill, at most, about 0.003% of the fish that may come from the MPG. Again, this is a nearly negligible effect on abundance and productivity and it is so small that it would have no discernable effect on the species' structure or diversity at either the MPG or ESU level.

Moreover, it is most likely that the impacts would be even smaller than those laid out above. Over the past five years, an average of all researchers in the Section 10(a)(1)(A) program have reported taking approximately 24%, and killing approximately 10%, of the juveniles they were authorized. So it is most likely that the actual effect will be less than that displayed by at least an order of magnitude. But even if the full effect displayed above were to take place, it would be offset at least to some degree by the fact that the work would help managers understand (1) the distribution and general habitat use of listed salmonids in the Wallowa River, (2) the distribution and abundance of residualized hatchery steelhead, and (3) the rates at which recreational anglers capture and handle listed juvenile steelhead.

Permit 26766

If granted Permit 26766, the WDNR would be authorized to take juvenile PS Chinook salmon and steelhead; HCS chum salmon; OL sockeye salmon; UCR Chinook salmon and steelhead; MCR steelhead; SnkR spr/sum salmon, fall-run Chinook salmon, sockeye salmon and steelhead; LCR Chinook, coho and steelhead; and CR chum salmon during the course of work designed to determine where listed animals are present on privately-held forest land in Washington State.

The juvenile fish would be collected via backpack electrofishing. Some of the captured fish would be measured, but most would simply be identified and released as swiftly as possible back to the sites of their capture.

The researchers are not proposing to kill any of the listed fish being captured, but a small number of fish may be killed as an inadvertent result of these activities. The WDNR researchers are requesting the following amounts of take:

Table 47. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 26766.

Species	Life Stage	Origin	Take Action*	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
PS Chinook salmon	Juvenile	Natural	C/H/R	10	1	<0.001	<0.001
PS steelhead		Natural	C/H/R	10	1		

Species	Life Stage	Origin	Take Action*	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
HCS chum salmon		Natural	C/H/R	10	1		
OL sockeye salmon		Natural	C/H/R	5	1		
UCR Chinook salmon		Natural	C/H/R	10	1	0.002	
UCR steelhead		Natural	C/H/R	10	1	0.007	
MCR steelhead		Natural	C/H/R	10	1	0.003	
SnkR spr/sum Chinook salmon		Natural	C/H/R	10	1	0.001	
SnkR fall-run Chinook salmon		Natural	C/H/R	10	1		
SnkR steelhead		Natural	C/H/R	10	1	0.002	
SnkR sockeye salmon		Natural	C/H/R	5	1	0.028	0.006
LCR Chinook salmon		Natural	C/H/R	10	1	<0.001	<0.001
LCR coho salmon		Natural	C/H/R	10	1	0.001	
LCR steelhead		Natural	C/H/R	10	1	0.003	
CR chum salmon		Natural	C/H/R	10	1	<0.001	

*** C/H/R = Capture/Handle/Release**

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. 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 population and species—these figures are presented in the last column of Table 47above.

As Table 47 illustrates, the effect on listed species would be as nearly zero as possible. The only instance in which the researchers might kill more than one-thousandth of one percent of any ESU/DPS is that of SnkR sockeye salmon, and even in that case the likelihood is extremely small. The one mortality is included here out of an abundance of caution, not because there is any expectation that it would happen. In most years, no mortalities at all would be expected (especially for SnkR sockeye salmon). Therefore the research is anticipated in all cases to have only the smallest possible impact on abundance (and productivity) and no discernable effect at all on either structure of diversity.

Over the past five years, an average of all researchers in the Section 10(a)(1)(A) program have reported taking approximately 24%, and killing approximately 10%, of the juveniles they were authorized. So it is most likely that the actual effect will be essentially zero for all listed species. But even if the full effect were to occur, it would be offset to some extent by the fact that the information to be gained would be used to conduct forest harvest practices in a manner designed to avoid harming listed species.

Permit 26968

Under permit 26968 the CDFW is seeking a new permit that would authorize them to take juvenile SONCC coho salmon, NC steelhead, CC Chinook salmon, SacR winter-run Chinook salmon, CVS Chinook salmon, CCV steelhead, CCC coho salmon, CCC steelhead, SCCC steelhead, SC steelhead, and adult SDPS green sturgeon in streams and rivers throughout California at pre-selected locations. The study's purpose is to assess the condition of the rivers and streams in California and provide a baseline for future comparisons. CDFW is participating in the USEPA National Rivers and Streams Assessment (NRSA), a probability-based survey designed to assess the condition of the Nation's rivers and streams. NRSA is a keystone program in California that provides data for the National Water Quality Inventory Report to Congress (305(b) report) and fulfills the water quality monitoring requirements of the Clean Water Act.

Juveniles would be collected via kick nets, backpack and boat electrofishing. Juvenile fish would be captured, handled, and released. The researchers are not proposing to kill any of the listed fish being captured, but a small number of fish may be killed as an inadvertent result of these activities. The amount of take the CDFW is requesting is found in the Table 48 below.

Table 48. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 26968.

<table>
<tr><th>Species</th><th>Life Stage</th><th>Origin*</th><th>Take Action**</th><th>Requested Take</th><th>Lethal Take</th><th>Percent of ESU/DPS taken</th><th>Percent of ESU/DPS killed</th></tr>
<tr><td>SONCC coho salmon</td><td rowspan="14">Juvenile</td><td>Natural</td><td>C/H/R</td><td>384</td><td>10</td><td>0.043</td><td>0.001</td></tr>
<tr><td>NC steelhead</td><td>Natural</td><td>C/H/R</td><td>286</td><td>7</td><td>0.030</td><td rowspan="2"><0.001</td></tr>
<tr><td>CC Chinook salmon</td><td>Natural</td><td>C/H/R</td><td>65</td><td>6</td><td>0.003</td></tr>
<tr><td rowspan="2">SacR winter-run Chinook salmon</td><td>Natural</td><td>C/H/R</td><td>22</td><td>0</td><td>0.018</td><td rowspan="4">0.000</td></tr>
<tr><td>LHAC</td><td>C/H/R</td><td>7</td><td>0</td><td>0.004</td></tr>
<tr><td rowspan="2">CVS Chinook salmon</td><td>Natural</td><td>C/H/R</td><td>24</td><td>0</td><td>0.001</td></tr>
<tr><td>LHAC</td><td>C/H/R</td><td>8</td><td>0</td><td><0.001</td></tr>
<tr><td>CCV steelhead</td><td>Natural</td><td>C/H/R</td><td>240</td><td>7</td><td>0.018</td><td><0.001</td></tr>
<tr><td rowspan="2">CCC coho salmon</td><td>Natural</td><td>C/H/R</td><td>58</td><td>2</td><td>0.036</td><td>0.001</td></tr>
<tr><td>LHAC</td><td>C/H/R</td><td>1</td><td>0</td><td>-</td><td>-</td></tr>
<tr><td rowspan="2">CCC steelhead</td><td>Natural</td><td>C/H/R</td><td>62</td><td>2</td><td>0.029</td><td><0.001</td></tr>
<tr><td>LHAC</td><td>C/H/R</td><td>1</td><td>0</td><td><0.001</td><td rowspan="2">0.000</td></tr>
<tr><td>SCCC steelhead</td><td>Natural</td><td>C/H/R</td><td>2</td><td>0</td><td>0.009</td></tr>
<tr><td>SC steelhead</td><td>Natural</td><td>C/H/R</td><td>4</td><td>0</td><td>-</td><td>-</td></tr>
</table>

*** LHAC=Listed Hatchery, Adipose-fin-clipped**
**** C/H/R = Capture/Handle/Release**

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. 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 population and species—these figures are presented in the last column of Table 48above.

As Table 48 illustrates, for most species the researchers would take a small percent of any listed unit—and kill an even smaller percent of those units. Because the research would take place over such a broad area, the potential losses cannot be ascribed to any population for any species and must therefore be viewed in the context of the listed units as individual wholes. As a result, though the research may in some instances have a very small impact on species abundance and productivity, it would in no measurable way impact structure or diversity for any species.

It is also likely that the impacts will be smaller than those laid out above. Over the past five years other researchers in the Section 10(a)(1)(A) program have reported taking approximately 24% and killing approximately 10% of the juveniles that were authorized, and only taking roughly 15% and killing roughly 5% of the adults that were authorized across all species, so it is most likely that the actual effect will be less than that displayed in Table 48above by a similar magnitude.

Permit 27069

Under permit 27069 the Thomas Gast & Associates Environmental Consultants is seeking a new permit that would authorize them to take juvenile SacR winter-run Chinook salmon, CVS Chinook salmon, CCV steelhead, and SDPS green sturgeon in a backwater area of the Sacramento River directly downstream of its confluence with Battle Creek. The study's purpose is to characterize seasonal changes and variability within the fish community in the backwater area.

Juveniles would be collected via fyke net, beach seine, minnow trap and observed during snorkel surveys. The researchers are not proposing to kill any of the listed fish being captured, but a small number of fish may be killed as an inadvertent result of these activities. The amount of take the Thomas Gast & Associates Environmental Consultants is requesting is found in Table 49 below.

Table 49. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 27069.

Species	Life Stage	Origin*	Take Action**	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
SacR winter-run Chinook salmon	Juvenile	Natural	C/H/R	600	6	0.280	0.002
		Natural	O/H	100	0		
		LHAC	C/H/R	600	6	0.378	0.004
CVS Chinook salmon		Natural	C/H/R	600	6	0.019	<0.001
		Natural	O/H	100	0		
		LHIA	C/H/R	600	6	-	-
		LHAC	C/H/R	600	6	0.030	<0.001
CCV steelhead		Natural	C/H/R	600	6	0.027	
		Natural	O/H	100	0		
		LHAC	C/H/R	600	6	0.057	
SDPS green sturgeon		Natural	C/H/R	10	1	0.226	0.023

***LHAC=Listed Hatchery, Adipose-fin-clipped, LHIA-Listed Hatchery, Intact Adipose fin**
****C/H/R = Capture/Handle/Release**

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. 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 population and species—these figures are presented in the last column of Table 49above.

As Table 49 illustrates, for most species the researchers would take a small percent of any listed unit—and kill an even smaller percent of those units. Further, at the population or basin level, the researchers are requesting mortality for six natural-origin and six hatchery-origin juvenile for SacR winter-run Chinook, CVS Chinook and CCV steelhead, with no lethal take of adults. The researchers are requesting one lethal take for juvenile green sturgeon. Therefore, the take authorized through this permit would have an immeasurably small impact on the abundance or productivity of SacR winter-run Chinook, CVS Chinook salmon, CCV steelhead, and Southern DPS green sturgeon populations in the Sacramento River.

It is also likely that the impacts will be smaller than those laid out above. Over the past five years other researchers in the Section 10(a)(1)(A) program have reported taking approximately 24% and killing approximately 10% of the juveniles that were authorized, and only taking roughly 15% and killing roughly 5% of the adults that were authorized across all species, so it is most likely that the actual effect will be less than that displayed in Table 49above by a similar magnitude.

Permit 27091

The Port of Seattle is seeking a permit that would allow them to take juvenile PS steelhead and Chinook salmon while conducting survey work designed to examine ecological response to restoration actions that have been undertaken in the lower Duwamish River waterway in Washington state.

All captured salmonids would be anesthetized, identified by species, weighed and measured. Once measured and weighed, the fish would be placed into a recovery bucket and be transported to the bank of the Duwamish River and released downstream of the capture site. The process would be halted if the fish appear to be overly stressed, or recovery times are unusually long. Any fish with coded wire tags or that have had their adipose fins clipped would be noted in order to calculate the ratio of natural-origin to hatchery fish in the lower Duwamish River. The researchers do not intend to kill any of the fish being captured, but a small number may die as an unintended consequence of the proposed activities. The amount of take the Port of Seattle is requesting is found in Table 50 below.

Table 50. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 27091.

Species	Life Stage	Origin*	Take Action**	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
	Juvenile	Natural	C/H/R	250	3	0.007	<0.001

Species	Life Stage	Origin*	Take Action**	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
PS Chinook salmon		LHAC	C/H/R	250	3	0.001	<0.001
PS steelhead	Juvenile	Natural	C/H/R	50	1	0.002	<0.001
		LHAC	C/H/R	50	1	0.022	<0.001

***LHAC = Listed Hatchery Adipose Clip**
****C/H/R = Capture/Handle/Release**

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. 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 population and species—these figures are presented in the last column of Table 50above.

As Table 50 illustrates, for most species the researchers would take a small percent of any listed unit—and kill an even smaller percent of those units. At the population level, even when combined with the other permit under consideration for the Lower Duwamish Waterway (#21061-2R) only a total of four natural-origin juvenile PS Chinook salmon and two natural-origin juvenile PS steelhead could be killed within the Green River populations of these species. Current adult abundances reported for the Green River populations (Ford 2022) allow us to estimate that more than 500,000 PS Chinook salmon juveniles and more than 145,000 PS steelhead juveniles are naturally produced in the Green River per year. Therefore, even within this one tributary the take authorized for both studies in the Lower Duwamish Waterway would amount to <0.002% of natural-origin juveniles in the Green River populations for both PS steelhead and PS Chinook salmon. As a result, though the research may in some instances have a very small impact on species abundance and productivity, it would in no measurable way impact structure or diversity for any species.

It is also likely that the impacts will be smaller than those laid out above. Over the past five years other researchers in the Section 10(a)(1)(A) program have reported taking approximately 24% and killing approximately 10% of the juveniles that were authorized, and only taking roughly 15% and killing roughly 5% of the adults that were authorized across all species, so it is most likely that the actual effect will be less than that displayed in Table 50above by a similar magnitude.

An effect of the research that cannot be quantified is the benefit it would have with respect to species conservation. The purpose of the work is to ensure the habitat restored in the Lower Duwamish for the benefit of listed salmon and steelhead functions to promote their survival. Information gained from this work would also help the listed species by helping guide similar habitat restoration actions elsewhere in the Puget Sound and beyond.

Permit 27098

The WDNR is seeking a new permit that would authorize them to annually take juvenile UCR steelhead and spring-run Chinook salmon; MCR steelhead; SnkR steelhead, sockeye, and spr/sum and fall-run Chinook salmon; LCR Chinook salmon, coho salmon and steelhead; UWR Chinook salmon and steelhead; and CR chum salmon. The permit would also allow them to take adult and juvenile SDPS eulachon—a species for which there are currently no take prohibitions. Under the permit, the WDNR researchers would monitor, track, trap, and remove invasive European green crabs on WDNR aquatic lands in the Puget Sound and lower Columbia River.

The researchers would use modified shrimp and minnow traps placed in the estuarine and marine intertidal and subtidal waters in the Puget Sound and lower Columbia River. The researchers do not actually expect to catch any listed salmonids or eulachon; nonetheless, all traps will be checked very regularly and any listed animals that are captured will be swiftly released without further handling. Trap configurations and locations would also be adjusted to minimize the risk of encountering adult salmonids or hindering adult passage through main migration channels. The researchers do not intend to kill any of the fish being captured, but a small number may die as an unintended consequence of the proposed activities. The amount of take the WDNR is requesting is found in Table 51 below.

Table _51_. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 27098.

Species	Life Stage	Origin*	Take Action**	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
PS Chinook salmon	Juvenile	Natural	C/H/R	10	1	<0.001	<0.001
		LHAC	C/H/R	10	1	<0.001	<0.001
PS steelhead	Juvenile	Natural	C/H/R	10	1	<0.001	<0.001
		LHAC	C/H/R	10	1	0.004	<0.001
HCS chum salmon	Juvenile	Natural	C/H/R	10	1	<0.001	<0.001
		LHAC	C/H/R	10	1	-*	-*
UCR Chinook salmon	Juvenile	Natural	C/H/R	6	1	0.001	<0.001
		LHAC	C/H/R	6	1	<0.001	<0.001
UCR steelhead	Juvenile	Natural	C/H/R	6	1	0.004	<0.001
		LHAC	C/H/R	6	1	<0.001	<0.001
MCR steelhead	Juvenile	Natural	C/H/R	6	1	0.002	<0.001
		LHAC	C/H/R	6	1	0.002	<0.001
	Juvenile	Natural	C/H/R	6	1	<0.001	<0.001

Species	Life Stage	Origin*	Take Action**	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
SnkR spr/sum Chinook salmon		LHAC	C/H/R	6	1	<0.001	<0.001
SnkR fall-run Chinook salmon	Juvenile	Natural	C/H/R	6	1	<0.001	<0.001
		LHAC	C/H/R	6	1	<0.001	<0.001
SnkR steelhead	Juvenile	Natural	C/H/R	6	1	0.001	<0.001
		LHAC	C/H/R	6	1	<0.001	<0.001
SnkR sockeye salmon	Juvenile	Natural	C/H/R	6	1	0.033	0.006
		LHAC	C/H/R	6	1	0.002	<0.001
LCR Chinook salmon	Juvenile	Natural	C/H/R	6	1	<0.001	<0.001
		LHAC	C/H/R	6	1	<0.001	<0.001
LCR coho salmon	Juvenile	Natural	C/H/R	6	1	<0.001	<0.001
		LHAC	C/H/R	6	1	<0.001	<0.001
LCR steelhead	Juvenile	Natural	C/H/R	6	1	0.002	<0.001
		LHAC	C/H/R	6	1	<0.001	<0.001
CR chum salmon	Juvenile	Natural	C/H/R	6	1	<0.001	<0.001
		LHAC	C/H/R	6	1	-***	-
UWR Chinook salmon	Juvenile	Natural	C/H/R	6	1	<0.001	<0.001
		LHAC	C/H/R	6	1	<0.001	<0.001
UWR steelhead	Juvenile	Natural	C/H/R	6	1	0.004	<0.001
SDPS eulachon	Adult	Natural	C/H/R	10	1	<0.001	<0.001
	Juvenile	Natural	C/H/R	10	1		

***LHAC = Listed Hatchery Adipose Clip**
****C/H/R = Capture/Handle/Release**
**** Hatchery releases of HCS chum salmon that are considered part of the ESU have been discontinued as of 2022, although some juveniles from prior years of releases may continue to exist in the system.**

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. 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 population and species—these figures are presented in the last column of Table 51above.

As Table 51 illustrates, for most species the researchers would take a small percent of any listed unit—and kill an even smaller percent of those units. Because the research would take place over such a broad area, the potential losses cannot be ascribed to any population for any species and must therefore be viewed in the context of the listed units as individual wholes. As a result, though the research may in some instances have a very small impact on species abundance and productivity, it would in no measurable way impact structure or diversity for any species.

It is also likely that the impacts will be smaller than those laid out above. Over the past five years other researchers in the Section 10(a)(1)(A) program have reported taking approximately 24% and killing approximately 10% of the juveniles that were authorized, and only taking roughly 15% and killing roughly 5% of the adults that were authorized across all species, so it is most likely that the actual effect will be less than that displayed in Table 51above by a similar magnitude.

An effect of the research that cannot be quantified is the benefit it would have with respect to species conservation. The purpose of the research is to explore the best means of locating and eliminating European green crab incursions. The research would benefit listed species by monitoring, trapping, and removing individuals of an invasive species that is known to greatly damage eelgrass beds—an important habitat type upon which juvenile salmonids depend for rearing and food production.

Permit 27129

If granted Permit 27129, the USGS would be authorized to take juvenile and adult UCR Chinook and steelhead; MCR steelhead, SnkR spr/sum and fall-run Chinook salmon; SnkR steelhead and sockeye salmon; LCR Chinook and coho salmon; LCR steelhead and CR chum salmon, while seeking to measure contaminant levels in the tissues of fish residing in the reservoir behind Bonneville Dam on the Columbia River. The fish would be collected via net, hoop, and fyke nets. Juvenile fish would be captured, handled, and released. Adults would be captured, handled (anesthetized, weighed, measured, and checked for marks or tags), and released.

The researchers are not proposing to kill any of the listed fish being captured, but a small number of fish may be killed as an inadvertent result of these activities. The USGS researchers are requesting the following amounts of take:

Table 52. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 27129.

Species	Life Stage	Origin	Take Action*	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
UCR Chinook salmon	Adult	Natural	C/H/R	2	0	0.246	0.000
	Juvenile	Natural	C/H/R	20	1	0.004	<0.001

Species	Life Stage	Origin	Take Action*	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
UCR steelhead	Adult	Natural	C/H/R	2	0	0.137	0.000
	Juvenile	Natural	C/H/R	20	1	0.013	<0.001
MCR steelhead	Adult	Natural	C/H/R	2	0	0.015	0.000
	Juvenile	Natural	C/H/R	20	1	0.006	<0.001
SnkR spr/sum Chinook salmon	Adult	Natural	C/H/R	2	0	0.045	0.000
	Juvenile	Natural	C/H/R	20	1	0.003	<0.001
SnkR fall-run Chinook salmon	Adult	Natural	C/H/R	2	0	0.028	0.000
	Juvenile	Natural	C/H/R	20	1	0.003	<0.001
SnkR steelhead	Adult	Natural	C/H/R	2	0	0.020	0.000
	Juvenile	Natural	C/H/R	10	1	0.002	<0.001
SnkR Sockeye salmon	Adult	Natural	C/H/R	2	0	12.500	0.000
	Juvenile	Natural	C/H/R	10	1	0.056	0.006
LCR Chinook salmon	Adult	Natural	C/H/R	2	0	0.007	0.000
	Juvenile	Natural	C/H/R	10	1	<0.001	<0.001
LCR coho salmon	Adult	Natural	C/H/R	2	0	0.011	0.000
	Juvenile	Natural	C/H/R	10	1	0.001	<0.001
LCR steelhead	Adult	Natural	C/H/R	2	0	0.025	0.000
	Juvenile	Natural	C/H/R	20	1	0.005	<0.001
	Adult	Natural	C/H/R	2	0	0.012	0.000

Species	Life Stage	Origin	Take Action*	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
CR chum salmon	Juvenile	Natural	C/H/R	10	1	<0.001	<0.001

*** C/H/R = Capture/Handle/Release**

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. 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 population and species—these figures are presented in the last column of Table 52 above.

As Table 52 illustrates, the effect on listed species would be as nearly zero as possible. Because the research would take place in the mainstem of the Columbia River, even the small potential losses displayed above cannot be ascribed to any population for any species and must therefore be viewed in the context of the listed units as individual wholes. As a result, though the research may in some instances have as small as possible an effect abundance and productivity, it would in no measurable way impact structure or diversity for any species.

It is also likely that the impacts will be smaller than those laid out above. Over the past five years other researchers in the Section 10(a)(1)(A) program have reported taking approximately 24% and killing approximately 10% of the juveniles that were authorized, and only taking roughly 15% and killing roughly 5% of the adults that were authorized across all species, so it is most likely that the actual effect will be less than that displayed in Table 52 above by a similar magnitude. But even if the full effect were to be felt by all the species in the table above, that impact would still be offset to at least some degree by the information to be gained regarding contamination in the river and its inhabitants.

Permit 27162

Under permit 27162 the WDNR (Olympic Region) is seeking a new permit that would authorize them to take juvenile PS Chinook salmon, PS steelhead, HCS chum salmon, and OL sockeye salmon in streams on WDNR land on the Olympic Peninsula (Clallam, Jefferson, and Grays Harbor counties in Washington) in order to determine listed fish presence or absence in small streams. The information gathered would be used to determine salmonid presence and distribution and thereby inform land management decisions on WDNR holdings.

Juvenile salmonids would be collected via backpack electrofishing, handled (anesthetized, weighed, measured, identified, and checked for marks or tags), and released back to the waters from which they came. In some cases, the researchers may not actually capture any fish but would merely note their presence, however electrofishing where listed species are observed would still be reported as take. The researchers are not proposing to kill any of the listed fish being taken, but a small number may be killed as an inadvertent result of these activities. The amount of take the WDNR is requesting is found in Table 53 below.

Table 53. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 27162.

Species	Life Stage	Origin*	Take Action**	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
PS Chinook salmon	Juvenile	Natural	C/H/R	11	1	<0.001	<0.001
		LHAC	C/H/R	11	1	<0.001	<0.001
PS steelhead	Juvenile	Natural	C/H/R	11	1	<0.001	<0.001
		LHAC	C/H/R	11	1	0.005	<0.001
HCS chum salmon	Juvenile	Natural	C/H/R	11	1	<0.001	<0.001
OL sockeye salmon	Juvenile	Natural	C/H/R	11	1	<0.001	<0.001
		LHAC	C/H/R	11	1	0.024	0.002

***LHAC = Listed Hatchery Adipose Clip**
****C/H/R = Capture/Handle/Release**

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. 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 population and species—these figures are presented in the last column of Table 53above.

As Table 53 illustrates, for most species the researchers would take a small percent of any listed unit—and kill an even smaller percent of those units. Because the research would take place over such a broad area, the potential losses cannot be ascribed to any population for any species and must therefore be viewed in the context of the listed units as individual wholes. As a result, though the research may in some instances have a very small impact on species abundance and productivity, it would in no measurable way impact structure or diversity for any species.

It is also likely that the impacts will be smaller than those laid out above. Over the past five years other researchers in the Section 10(a)(1)(A) program have reported taking approximately 24% and killing approximately 10% of the juveniles that were authorized, and only taking roughly 15% and killing roughly 5% of the adults that were authorized across all species, so it is most likely that the actual effect will be less than that displayed in Table 53above by a similar magnitude.

An effect of the research that cannot be quantified is the benefit it would have with respect to species conservation. The purpose of this research is to inform land management decisions on WDNR holdings by determining the presence of fish species in potentially fish-bearing streams. This information would benefit listed salmon and steelhead by helping WDNR identify existing man-made fish barriers that should be removed or replaced with structures that fish can pass over or through, and support a region-wide program of road maintenance and other forest management activities in the vicinity of streams. Confirming which streams currently support ESA-listed fish species would help prioritize those locations for restoration actions.

Permit 27212

If granted, Permit 27212 would authorize OSU researchers to take juvenile UCR Chinook and steelhead; MCR steelhead, SnkR spr/sum and fall-run Chinook salmon; SnkR steelhead and sockeye salmon; LCR Chinook and coho salmon; LCR steelhead, CR chum salmon, UWR Chinook salmon; and SDDPS eulachon while seeking to understand the diversity and distribution of sculpins across the Pacific Northwest.

The juvenile fish would be collected via backpack electrofishing and beach seine. All listed animals would be immediately released back to the sites of their capture unless an individual is seriously injured or killed during capture, in which case it would be euthanized and preserved immediately. Accidental mortalities would be preserved as specimens in the OSU Ichthyology collection, rather than being discarded.

The researchers are not proposing to kill any of the listed fish being captured, but a small number of fish may be killed as an inadvertent result of these activities. The OSU researchers are requesting the following amounts of take:

Table 54. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 27212

Species	Life Stage	Origin	Take Action*	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
PS Chinook salmon	Juvenile	Natural	C/H/R	60	2	0.002	<0.001
PS steelhead		Natural	C/H/R	60	2	0.003	
HCS chum salmon		Natural	C/H/R	60	2	0.001	
UCR Chinook salmon		Natural	C/H/R	120	6	0.025	0.001
UCR steelhead		Natural	C/H/R	120	6	0.080	0.004
MCR steelhead		Natural	C/H/R	360	12	0.102	0.003
SnkR spr/sum		Natural	C/H/R	180	6	0.026	<0.001

Species	Life Stage	Origin	Take Action*	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Chinook salmon							
SnkR fall-run Chinook salmon		Natural	C/H/R	5	1	<0.001	
SnkR steelhead		Natural	C/H/R	360	12	0.063	0.002
SnkR sockeye salmon		Natural	C/H/R	40	1	0.222	0.006
LCR Chinook salmon		Natural	C/H/R	240	8	0.002	<0.001
LCR coho salmon		Natural	C/H/R	300	10	0.036	0.001
LCR steelhead		Natural	C/H/R	240	8	0.064	0.002
UWR Chinook salmon		Natural	C/H/R	240	6	0.021	<0.001
SDPS Eulachon	Adult	Natural	C/H/R	20	2	0.001	
	Subadult	Natural	C/H/R	180	6		
	Juvenile	Natural	C/H/R	60	2		

***C/H/R = Capture/Handle/Release**

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. 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 population and species—these figures are presented in the last column of Table 54 above.

As Table 54 illustrates, for most species the researchers would take a small percent of all the listed units and kill an even smaller percentage of those units. Because the research would take place over such a broad area, the potential losses cannot be ascribed to any population for any species and must therefore be viewed in the context of the listed units as individual wholes. As a result, though the research may in some instances have a very small impact on a species' abundance and productivity, it would in no measurable way impact structure or diversity for any species.

It is also likely that the impacts will be smaller than those laid out above. Over the past five years other researchers in the Section 10(a)(1)(A) program have reported taking approximately 24% and killing approximately 10% of the juveniles that were authorized, and only taking roughly 15% and killing roughly 5% of the adults that were authorized across all species, so it is most likely that the actual effect will be less than that displayed in Table 54above by a similar magnitude. But even if all the fish that could be killed were killed in fact, that small loss would be offset to some degree by the ecosystem health information to be gained.

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 the action area falls entirely within designated critical habitat and navigable marine waters, 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, rockfish, 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 biological opinion, we considered several efforts being made at the local, tribal, state, and national levels to conserve listed species—primarily final recovery plans and efforts laid out in the Status review updates for Pacific salmon and steelhead listed under the Endangered Species Act.[3] The recovery plans, status summaries, and limiting factors that are part of the analysis of this Opinion are discussed in detail in Table 2 (Section 2.2.1).

The result of that review was that salmon take—particularly take associated with monitoring and habitat restoration—is likely to continue to increase in the region for the foreseeable future.

[3] NOAA Fisheries – West Coast Region - 2016 Status Reviews of Listed Salmon & Steelhead

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 PS Chinook salmon and other listed salmonids, see any of the recent status reviews, listing Federal Register notices, and recovery planning documents, as well as recent consultations on issuance of section 10(a)(1)(A) research permits.

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 foreseeable" 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 foreseeable" in its analysis of cumulative effects. Thus, the most likely cumulative effect is that the habitat in the action area is likely to continue to be degraded with respect to its ability to support the listed salmonids.

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.[4] 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,[5] 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).[6] And, though Eastern Washington has also seen some population increase, it has largely been restricted to the population centers rather than the rural areas.[7] 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.

[4] Idaho State Journal June 2, 2013 "Idaho's rural population continues to shrink"
[5] Portland State University "Annual Oregon Population Report"
[6] State of Oregon Employment Department Dec 20, 2018 "A Quick Look at Population Trends in Eastern Oregon"
[7] Cashmere Valley Record March 9, 2011 "Population growth slowed during last decade, but state is more diversified"

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.
One final thing to take into account when considering cumulative effects is the time period over which the activity would operate. The permits considered here would be good for a maximum of five years and the effects on listed species abundance they generate could continue for up to four years after that, though they would decrease in each succeeding year. We are unaware of any major non-Federal activity that could affect listed salmonids and is certain to occur in the action area during that timeframe.

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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 add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species. Aside from the considerations listed above, these assessments are also 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 permits considered here with the take from previous (but ongoing) research authorizations 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 two tables therefore (a) combine the proposed take for all the permits considered in this opinion for all components of each species (Table 55), (b) add that take to the take that has already been authorized in the region and (c) compare those totals to the estimated annual abundance of each species under consideration (Table 56).

Table 55. Total requested take for the permits and percentages of the ESA listed species for permits covered in this Biological Opinion.

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
PS Chinook salmon	Adult	Natural	234	3	1.001	0.013
		LHIA	170	2	1.739[a]	0.022 [a]
		LHAC	234	3		
	Juvenile	Natural	2,756	174	0.074	0.005
		LHIA	1,100	605	0.013	0.007
		LHAC	7,896	920	0.031	0.004
PS steelhead	Adult	Natural	4	0	0.022	0.000
		LHAC	2	0	0.124	
	Juvenile	Natural	531	13	0.024	<0.001
		LHAC	121	5	0.054	0.002
PS/GB bocaccio		Natural	2	1	0.043	0.022
PS/GB yelloweye rockfish		Natural	2	1	0.002	<0.001
HCS chum salmon		Natural	111	6	0.003	
		LHAC	10	1	-	-
OL sockeye salmon		Natural	16	2	0.001	<0.001
		LHAC	11	1	0.024	0.002
UCR Chinook salmon	Adult	Natural	2	0	0.246	0.000
	Juvenile	Natural	206	10	0.042	0.002
		LHAC	6	1	<0.001	<0.001
UCR steelhead	Adult	Natural	2	0	0.137	0.000
	Juvenile	Natural	246	10	0.163	0.007
		LHAC	6	1	<0.001	<0.001
	Adult	Natural	2	0	0.015	0.000

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
MCR steelhead	Juvenile	Natural	396	15	0.113	0.004
		LHAC	6	1	0.002	<0.001
SnkR spr/sum Chinook salmon	Adult	Natural	557	6	12.605	0.136
		LHIA	500	5	17.895 [a]	0.177 [a]
		LHAC	5	0		
	Juvenile	Natural	66,616	674	9.759	0.099
		LHIA	53,000	320	7.622	0.046
		LHAC	50,156	255	1.057	0.005
SnkR fall-run Chinook salmon	Adult	Natural	2	0	0.028	0.000
	Juvenile	Natural	91	5	0.011	<0.001
		LHAC	6	1	<0.001	
SnkR steelhead	Adult	Natural	557	6	5.590	0.060
		LHIA	500	5	15.221	0.152
	Juvenile	Natural	66,076	674	11.527	0.118
		LHIA	28,000	185	5.294	0.035
		LHAC	25,006	126	0.818	0.004
SnkR sockeye salmon	Adult	Natural	2	0	12.500	0.000
	Juvenile	Natural	111	5	0.617	0.028
		LHAC	6	1	0.002	<0.001
LCR Chinook salmon	Adult	Natural	2	0	0.007	0.000
	Juvenile	Natural	266	11	0.002	<0.001
		LHAC	6	1	<0.001	
LCR coho salmon	Adult	Natural	2	0	0.011	0.000
	Juvenile	Natural	326	13	0.039	0.002
		LHAC	6	1	<0.001	<0.001

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
LCR steelhead	Adult	Natural	2	0	0.025	0.000
	Juvenile	Natural	276	11	0.074	0.003
		LHAC	6	1	<0.001	<0.001
CR chum salmon	Adult	Natural	2	0	0.012	0.000
	Juvenile	Natural	26	3	<0.001	<0.001
		LHAC	6	1	-	-
UWR Chinook salmon		Natural	196	6	0.017	<0.001
		LHAC	6	1	<0.001	
UWR steelhead		Natural	6	1	0.004	
OC coho salmon		Natural	0	0	0.000	0.000
SONCC coho salmon		Natural	434	11	0.049	0.001
NC steelhead		Natural	286	7	0.030	<0.001
CC Chinook salmon		Natural	65	6	0.003	
SacR winter-run Chinook salmon		Natural	5,022	138	4.016	0.110
		LHAC	2,107	51	1.326	0.032
CVS Chinook salmon		Natural	4,574	125	0.249	0.007
		LHIA	600	6	-	-
		LHAC	608	6	0.030	<0.001
CCV steelhead		Natural	1,340	28	0.102	0.002
		LHAC	2,600	66	0.248	0.006
CCC coho salmon		Natural	2,308	35	1.429	0.022
		LHAC	1	0	-	-
		Natural	8,842	128	4.078	0.059

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
CCC steelhead		LHAC	1	0	<0.001	0.000
SCCC steelhead		Natural	2,792	33	12.523	0.148
SC steelhead		Natural	4	0	-[b]	-[b]
SDPS eulachon	Adult	Natural	85	18	0.001[c]	<0.001[c]
	Subadult	Natural	180	6		
	Juvenile	Natural	85	6		
SDPS green sturgeon		Natural	70	4	1.580	0.090

[a] Abundances for adult hatchery salmonids are LHAC and LHIA combined.
[b] Abundance data for SC steelhead are very limited, and for populations that are regularly monitored many have runs that are ephemeral and may see zero anadromous adults in a given year. Using 5-year geometric mean abundances of these was therefore not considered a meaningful representation of effects to the DPS, so these calculations were not reported.
[c] Abundance for these species are only known for the adult life stage which is used to represent the entire DPS.

Thus, the activities contemplated in this opinion may kill—in combination and at most—as much as 0.152% of the fish from any component of any listed species; that component is hatchery-origin adult SnkR steelhead with intact adipose fins. It should be noted, however, that in nearly all other instances found in the table above, the effect is far smaller than that figure and, in many cases, the effect is orders of magnitude smaller. And these figures are probably much lower in actuality, but before engaging in that discussion, it is necessary to add all the take considered in this opinion to the rest of the research take that has been authorized on the West Coast.

Table 56. Total expected take of the ESA listed species for scientific research and monitoring already approved for 2023 plus the permits covered in this Biological Opinion.

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
PS Chinook salmon	Adult	Natural	853	37	3.650	0.158
		LHIA	691	16	7.107[a]	0.336[a]
		LHAC	960	62		
	Juvenile	Natural	770,310	13,768	20.661	0.369
		LHIA	275,089	5,596	3.169	0.064
		LHAC	223,285	9,569	0.871	0.037

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
PS steelhead	Adult	Natural	4,239	78	23.296	0.429
		LHIA	419	12	27.936	1.174
		LHAC	33	7		
	Juvenile	Natural	119,928	2,114	5.321	0.094
		LHIA	4,028	61	7.600	0.115
		LHAC	11,553	205	5.112	0.091
PS/GB bocaccio	Adult	Natural	26	15	2.323[b]	0.977[b]
	Subadult	Natural	2	1		
	Juvenile	Natural	79	29		
PS/GB yelloweye rockfish	Adult	Natural	32	20	0.081 [b]	0.047 [b]
	Subadult	Natural	2	1		
	Juvenile	Natural	59	33		
HCS chum salmon	Adult	Natural	2,137	36	7.600	0.128
	Juvenile	Natural	1,249,542	4,584	29.464	0.108
		LHIA	1,445	45	-	-
		LHAC	95	19		
OL sockeye salmon	Adult	Natural	10	4	0.170	0.068
		LHIA	1	0	2.265[a]	0.000[a]
		LHAC	6	0		
	Juvenile	Natural	58	7	0.005	<0.001
		LHIA	1	0	<0.001	0.000
		LHAC	53	5	0.116	0.011
UCR Chinook salmon	Adult	Natural	197	6	24.231	0.738
		LHIA	152	3	28.246[a]	0.877[a]
		LHAC	170	7		

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
	Juvenile	Natural	13,014	283	2.665	0.058
		LHIA	1,785	55	0.379	0.012
		LHAC	1,512	79	0.221	
UCR steelhead	Adult	Natural	209	4	14.266	0.273
		LHIA	94	2	10.819[a]	0.277[a]
		LHAC	219	6		
	Juvenile	Natural	11,610	81	7.716	0.054
		LHIA	2,219	55	1.587	0.039
		LHAC	10,152	236	1.326	0.031
MCR steelhead	Adult	Natural	2,080	27	15.296	0.199
		LHIA	200	7	262.973[a]	3.787[a]
		LHAC	1,675	20		
	Juvenile	Natural	169,054	3,887	48.098	1.106
		LHIA	8,743	120	7.717	0.106
		LHAC	987	50	0.265	0.013
SnkR spr/sum Chinook salmon	Adult	Natural	2,260	21	51.143	0.475
		LHIA	720	8	67.753[a]	0.638[a]
		LHAC	1,192	10		
	Juvenile	Natural	546,717	7,089	80.093	1.039
		LHIA	80,158	746	11.527	0.107
		LHAC	78,975	1,018	1.665	0.021
SnkR fall-run Chinook salmon	Adult	Natural	87	9	1.198	0.124
		LHIA	34	1	0.786[a]	0.101[a]
		LHAC	83	14		
	Juvenile	Natural	4,529	264	0.566	0.033

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
		LHIA	2,013	144	0.068	0.005
		LHAC	2,630	283	0.101	0.011
SnkR steelhead	Adult	Natural	10,434	125	104.706	1.254
		LHIA	2,543	38	175.951[a]	2.709[a]
		LHAC	3,237	51		
	Juvenile	Natural	409,979	5,534	71.519	0.965
		LHIA	51,960	534	9.824	0.101
		LHAC	56,089	667	1.834	0.022
SnkR sockeye salmon	Adult	Natural	113	6	706.250	37.500
		LHIA	1	0	2.062[a]	0.000[a]
		LHAC	1	0		
	Juvenile	Natural	8,326	297	46.256	1.650
		LHIA	1	0	-	-
		LHAC	207	62	0.069	0.021
LCR Chinook salmon	Adult	Natural	420	19	1.434	0.065
		LHIA	12	0	0.866[a]	0.069[a]
		LHAC	151	13		
	Juvenile	Natural	514,518	6,483	4.621	0.058
		LHIA	428	45	0.045	0.005
		LHAC	2,955	664	0.010	0.002
LCR coho salmon	Adult	Natural	1,121	19	5.990	0.102
		LHIA	31	0	4.433[a]	0.263[a]
		LHAC	676	42		
	Juvenile	Natural	241,705	2,926	29.226	0.354
		LHIA	875	116	0.270	0.036

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
		LHAC	19,776	1,101	0.249	0.014
LCR steelhead	Adult	Natural	3,701	41	45.400	0.503
		LHAC	86	4	1.348	0.063
	Juvenile	Natural	69,178	1,112	18.437	0.296
		LHIA	3	0	0.020	0.000
		LHAC	4,546	107	0.384	0.009
CR chum salmon	Adult	Natural	66	9	0.381	0.052
		LHIA	1	0	0.087	0.000
	Juvenile	Natural	57,425	720	0.738	0.009
		LHIA	697	19	0.126	0.003
		LHAC	16	1	-	-
UWR Chinook salmon	Adult	Natural	266	7	2.526	0.066
		LHAC	81	11	0.319	0.043
	Juvenile	Natural	61,683	1,225	5.321	0.106
		LHIA	40	7	-	-
		LHAC	15,624	420	0.358	0.010
UWR steelhead	Adult	Natural	379	6	14.422	0.228
	Juvenile	Natural	23,072	473	17.052	0.350
OC coho salmon	Adult	Natural	14,784	169	24.386	0.279
		LHAC	25	4	3.918	0.627
	Juvenile	Natural	816,808	18,620	19.047	0.434
		LHAC	365	23	0.608	0.038
SONCC coho salmon	Adult	Natural	3,985	37	65.454[c]	0.633[c]
		LHIA	3,221	25		
		LHAC	1,068	18		

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
	Juvenile	Natural	246,142	4,071	27.817	0.460
		LHIA	17,118	854	22.824	1.139
		LHAC	19,541	387	3.398	0.067
NC steelhead	Adult	Natural	1,710	25	20.464	0.299
	Juvenile	Natural	145,798	2,683	15.339	0.282
CC Chinook salmon	Adult	Natural	514	22	3.903	0.167
	Juvenile	Natural	102,313	1,798	4.276	0.075
SacR winter-run Chinook salmon	Adult	Natural	1,421	22	119.916	1.857
		LHAC	1,415	49	52.466	1.817
	Juvenile	Natural	425,679	11,419	340.440	9.132
		LHAC	203,326	7,247	127.995	4.562
CVS Chinook salmon	Adult	Natural	1,617	31	23.934	0.459
		LHAC	745	84	35.766	4.033
	Juvenile	Natural	1,291,037	22,262	70.205	1.211
		LHIA	2,600	6	-	-
		LHAC	58,845	4,634	2.942	0.232
CCV steelhead	Adult	Natural	4,477	139	57.734[c]	3.184[c]
		LHIA	50	1		
		LHAC	2,109	226		
	Juvenile	Natural	87,131	2,268	6.664	0.173
		LHAC	30,463	1,875	2.901	0.179
CCC coho salmon	Adult	Natural	4,418	62	263.128[c]	4.203[c]
		LHIA	1,655	35		
	Juvenile	Natural	206,689	3,506	127.933	2.170
		LHIA	106,516	1,603	76.083	1.145

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
CCC steelhead	Adult	Natural	2,601	48	138.667[c]	2.886[c]
		LHAC	42	7		
	Juvenile	Natural	271,620	6,280	125.281	2.897
		LHAC	15,502	448	2.981	0.086
SCCC steelhead	Adult	Natural	2,549	38	1300.510	19.388
	Juvenile	Natural	74,635	1,185	334.761	5.315
SC steelhead	Adult	Natural	22	0	-[d]	-[d]
	Juvenile	Natural	1,302	36		
SDPS eulachon	Adult	Natural	39,312	31,092	0.157[c]	0.125[c]
	Subadult	Natural	1,210	1,036		
	Juvenile	Natural	1,535	1,374		
SDPS green sturgeon	Adult	Natural	522	12	24.542	0.564
	Subadult	Natural	346	11	3.099	0.099
	Juvenile	Natural	6,663	193	150.372	4.356
	Larvae	Natural	11,256	1,051	-	-
	Egg	Natural	4,370	4,370		

[a] Abundances for adult hatchery salmonids are LHAC and LHIA combined.
[b] Abundance for these species are only known for the adult life stage which is used to represent the entire DPS
[c] Abundances for all adult components are combined.
[d] Abundance data for SC steelhead are very limited, and for populations that are regularly monitored many have runs that are ephemeral and may see zero anadromous adults in a given year. Using 5-year geometric mean abundances of these was therefore not considered a meaningful representation of effects to the DPS, so these calculations were not reported.

As the table above illustrates, in many cases the dead fish from all of the permits in this opinion and all the previously authorized research would amount to a less than half a percent of each component's total abundance. 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.

However, in 21cases involving 15 species, the total potential mortality could amount to a more substantial percentage of an ESU component (i.e., life stage and origin). As a result, we will review the potential mortality in these instances in more detail.

Salmonid Species

As Tables 55 and 56 illustrate, in most instances, the research—even in total—would have 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 newly proposed research, when considered in combination with research already authorized would potentially kill more than one half of one percent of the estimated abundance of an adult or juvenile component of the following listed species: UCR Chinook, PS/GB bocaccio, MCR steelhead, SnkR spr/sum Chinook, SnkR sockeye, SnkR steelhead, SONCC coho, OC coho, SacR winter-run Chinook salmon, CVS Chinook salmon, CCV steelhead, CCC coho salmon, CCC steelhead, SCCC steelhead, and SC steelhead, and SDPS green sturgeon. Detailed descriptions of these effects for juveniles and adults follow in the paragraphs below.

A few considerations apply generally to our analyses of the total mortalities that would be permitted for juveniles and adults of each of these species (Table 55). First, we do not expect the potential mortality of adipose-fin-clipped, 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 considered surplus to recovery needs. We therefore focus primarily on the naturally produced ESU or DPS components.

Second, the true numbers of fish that would actually be taken would most likely be smaller than the amounts authorized. We develop conservative estimates of abundance, as described in Section 2.2. As noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur. It is therefore very likely that researchers will take fewer fish than estimated, and that the actual effect is likely to be lower than the numbers stated in the tables above. The degree to which these values are likely overestimates, based on actual reported data from recent years of the research program, is discussed for each species and age class in the following subsections and in the effects section.

Another reason effects on natural-origin components of each listed unit may be smaller than the values in the tables above stems from how we ask researchers to report taken fish of unknown origin. In those instances where a non-clipped hatchery fish cannot be differentiated from a natural-origin fish, we ask that researchers err to the side of caution and treat all fish with intact adipose fins as if they were natural-origin fish. So for instance, given that 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 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. The overall percentages for the listed unit would, however, remain at the same low levels shown.

Lastly, the research being conducted in the region adds critical knowledge about the species' status—knowledge that we are required to have every five years to perform status reviews for all listed species. 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, because we found for each ESU and DPS that . . .

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

. . . we determined that the impact of the research program—even in its entirety—would be restricted to a small effect on abundance and productivity and that the activities analyzed here would add only a small increment to that impact. 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 recovery.

Juveniles

MCR Steelhead

Under the research program as a whole, 1.1% of the natural-origin juvenile MCR steelhead may be killed in a given year. The actions considered in this opinion would add 15 fish to the total being allotted. Thus, the 1.1% actually represents only a small increase in an amount of take that has previously and repeatedly been found to not jeopardize the species.

In addition, the mortality rate for this species is undoubtedly less than that displayed due to the overlap of MCR steelhead with resident trout species. The reason for this is that it is effectively certain that at least some of the fish that could be taken and counted as juvenile natural-origin MCR steelhead would in fact be native, resident redband trout or other *O. mykiss* subspecies. Because it is extremely difficult to tell the difference between the juvenile MCR steelhead and resident redband and other rainbow trout in the field, we ask that any captured fish that *could* come from a listed unit be counted as such. Thus, the actual lethal take rate would be less than 1.1%.

Moreover, and out of an abundance of caution, we analyze the effect of removing juveniles from an experimental population in the Deschutes River as if they were part of the listed unit, but in fact it will be two years until they are actually considered to be part of the MCR steelhead DPS. As a result, more than 100 juveniles that may be killed come from a population that actually has no take prohibitions and is currently considered excess to the species' survival needs. Still, if all the fish that are permitted to be taken were to be taken in fact, it would likely result in small but measurable abundance and productivity losses for the DPS.

However, it should also be noted that over the last five years, the amount of natural MCR steelhead juveniles taken was only 18.47% of what was permitted and the mortality rate was only 7.96% of that permitted. As a result, the effects of the program as a whole are very likely to be much smaller than those displayed above—probably less than a tenth of the figure displayed. And in any case, the losses would be spread out across the species' entire range, so there would be no measurable effect on structure or diversity, and no single population would bear the brunt of the effect. The impact of the program, even in its entirety, is thus a very small effect on abundance and productivity, the activities analyzed here would add little increment to that impact, and the information gained from the program as a whole would generate lasting benefits for the listed fish.

SnkR spr/sum Chinook Salmon

Under the research program as a whole, 1.04% of the natural-origin juvenile SnkR spr/sum Chinook salmon may be killed in a given year. The actions considered in this opinion would appear to add 674 fish to the total being allotted, but in fact very nearly all of those additional fish (660 of them) come from a permit that is being renewed (1134). Thus, though they are not currently considered part of the baseline, they have been such for a number of years and, as a result, take levels almost exactly the same as the 1.04% have previously been analyzed. This minor effect on abundance and (therefore) productivity has thus repeatedly been determined to not jeopardize the species.

Moreover, it should be noted that over the last five years, the amount of natural SnkR spr/sum Chinook salmon juvenile taken was only 13.56% of what was permitted and the mortality rate was only 4.78% of what had been approved. As a result, the effects of the program as a whole are very likely to be much smaller than those displayed above—probably around a twentieth of the figure displayed. Also, the losses would be spread out across the species' entire range, so there would be no measurable effect on structure or diversity, and no single population would be disproportionately affected. The impact of the program, even in its entirety, is thus a very small effect on abundance and productivity, the activities analyzed here would add little increment to impacts that have previously been examined, and the information gained from the program as a whole would generate lasting benefits for the listed fish.

SnkR Steelhead

Under the research program as a whole, 0.96% of the natural-origin juvenile SnkR steelhead may be killed in a given year. Just as with SnkR spr/sum Chinook, The actions considered in this opinion would appear to add 674 fish to the total being allotted, but in fact very nearly all of those additional fish (640 of them) come from a permit that is being renewed (1134). Thus, though they are not currently considered part of the baseline, they have been such for a number of years and, as a result, take levels almost exactly the same as the 0.96% have previously been analyzed. This minor effect on abundance and (therefore) productivity has thus repeatedly been determined to not jeopardize the species.

In addition, the mortality rate for this species is undoubtedly lower than that displayed due to the overlap of SnkR steelhead with resident trout species. The reason for this is that it is effectively certain that at least some of the fish that could be taken and counted as juvenile natural-origin SnkR steelhead would in fact be native, resident redband trout or other *O. mykiss* subspecies. Because it is extremely difficult to tell the difference between the juvenile SnkR steelhead and resident redband

and other rainbow trout in the field, we ask that any captured fish that could come from a listed unit be counted as such. Thus, the actual lethal take rate would be less than 0.96%.

Moreover, it should be noted that over the last five years, the amount of natural SnkR steelhead juveniles taken was only 16.37% of what was permitted and the mortality rate was only 5.3% of what has been permitted. As a result, the effects of the program as a whole are very likely to be much smaller than those displayed above—probably around a twentieth of the figure displayed. And, in any case, the losses would be spread out across the species' entire range, so there would be no measurable effect on structure or diversity, and no single population would bear the brunt of the effect. The impact of the program, even in its entirety, is thus a very small effect on abundance and productivity, the activities analyzed here would add little increment to that impact, and the information gained from the program as a whole would generate lasting benefits for the listed fish.

SnkR Sockeye Salmon

When combined with scientific research and monitoring permits already approved, 1.6% of the juvenile natural-origin SnkR sockeye salmon may be killed by permitted research activities in a given year. While this figure should be viewed with caution, there are two important caveats associated with the mortality numbers: very few of the juveniles that may be killed in the program are associated with new permits, and the numbers are expected to be much lower than authorized. The actions considered in this opinion would add four juvenile sockeye to the total being allotted—but in all cases, they are not actually expected to be taken and are included in their permits as worst-case scenarios. This means that mortality rates very nearly the same as the 1.6% have previously been analyzed a number of times and, as a result, this minor effect on abundance and (therefore) productivity has repeatedly been determined to not jeopardize the species. Still, the research program as a whole could have a small effect on the species' abundance and productivity—but not on structure or diversity given that there is only one population and it is largely upheld by hatchery supplementation.

In addition, these truly are worst-case numbers. Over the last five years, the amount of natural SnkR sockeye juveniles taken was only 13.9% of what was permitted and the mortality rate was only 11.77% of what has been permitted. As a result, the effects of the program as a whole are very likely to be much smaller than those displayed above—probably around a tenth of the figure displayed.

Lastly, the entire purpose of both of the two permits with the most juvenile SnkR sockeye salmon take (Permits 1124 and 1341) is to help the sockeye salmon survive and recover. Under Permit 1124 (held by IDFG) the researchers support the use of captive broodstock and other methods and technology to capture, preserve, and study the few remaining sockeye salmon. Under Permit 1341 (held by the Shoshone-Bannock Tribes) researchers seek to help SnkR sockeye salmon recover and expand their range. Though these permits could have some minor negative effect on SnkR sockeye salmon abundance, it is possible that without the research conducted under them this ESU might have gone extinct; and even if that is not the entirely the case, it is inarguable that the research has been critical to whatever recovery the sockeye salmon have experienced.

SacR winter-run Chinook salmon

When combined with scientific research and monitoring permits already approved, the potential mortality for juvenile SacR winter-run Chinook salmon would be 9.13% for naturally produced fish. This represents a notable portion of the species' total abundance, however there are a two caveats to this number. First, while the research contemplated in this opinion would appear to add 138 dead natural juvenile SacR winter-run Chinook to the total, 132 of those fish would actually come from a permit renewal. Thus, though they are not currently considered part of the baseline, nearly all the juveniles have been in the baseline for a number of years and, as a result, mortality rates similar to (and even higher than) the 9.13% have previously been analyzed and found not to jeopardize the species. But even if all 138 juvenile fish contained in this opinion were killed, the effect on species viability would still be a very small one.

Second, it is very likely that researchers will take fewer fish than estimated, and that the actual effects would be lower than the numbers stated in the tables above. Our research tracking system reveals that over the past five years (a time when the permits being renewed were in effect), researchers took 15.4% of the naturally produced SacR winter-run Chinook salmon juveniles they were authorized, and the actual lethal take rate of natural-origin juveniles was only 8.74% of the mortalities authorized. This would mean that the actual effect is likely to be less than one tenth of what is displayed in the table above. Thus, we expect the research activities' detrimental effects on the species' abundance and productivity to be small—even in combination with all the rest of the research authorized in the region. And because that slight impact would be distributed throughout the species' entire range, it would be so attenuated as to have no appreciable effect on spatial structure or diversity. So once again, the impact of the program—even in its entirety—is a small effect on abundance and productivity, the activities analyzed here would add almost no increment to that impact, and the information gained from the program as a whole would generate lasting benefits for the listed fish.

CVS Chinook

When combined with scientific research and monitoring permits already approved, the potential mortality for juvenile CVS Chinook salmon from the entire research program would be 1.21% for naturally produced fish. The actions considered in this opinion would appear to add 125 fish to the total being allotted, but in fact 119 of those additional fish come from permits that would be renewed. Thus, the new activities considered here would add only six juveniles and though the other 199 fish are not currently considered part of the baseline, they have been part of it for a number of years previously and, as a result, take levels nearly identical to the 1.21% rate have repeatedly been analyzed before and found not to jeopardize the species.

It is also very likely that researchers will take fewer fish than estimated, and that the actual effects would be lower than the numbers stated above. For naturally produced CVS Chinook salmon, our research tracking system reveals that for the past five years researchers ended up taking in total only 19.9% of the juveniles they were authorized, and the actual mortality rates also averaged only 13.4% of what was requested for juveniles. This would mean that the actual effect is likely to be on the order of one-tenth of the impact displayed in the table above. Thus, we expect the research activities' detrimental effects on the species' abundance and productivity to be small—even in combination with all the rest of the research authorized in the region. And because that slight impact would be distributed throughout the species' entire range, it would be so attenuated as to have no appreciable effect on spatial structure or diversity. We therefore find that the impact of the program—even in its entirety—is a small effect on abundance and productivity, the activities analyzed here would add only a small increment to that impact, and the information gained from the program as a whole would generate lasting benefits for the listed fish.

CCC coho

When combined with scientific research and monitoring permits already approved, the potential mortality for juvenile CCC coho salmon from the entire research program would be 2.17% for naturally produced fish. The actions considered in this opinion would appear to add 35 fish to the total being allotted, but in fact all of those additional fish come from a permit that would be renewed (15824-3R). Thus, the actual new activities considered here would add no juveniles at all and, though the 35 fish are not currently considered part of the baseline, they have been part of it for a number of years previously and, as a result, take levels nearly identical to the 2.17% rate have repeatedly been analyzed before and found not to jeopardize the species.

It is also very likely that researchers will take fewer fish than estimated, and that the actual effects would be lower than the numbers stated above. For naturally produced CCC coho salmon, our research tracking system reveals that for the past five years researchers ended up taking in total only 23.7% of the juveniles they were authorized, and the actual mortality rates also averaged only 3.7% of what was requested for juveniles. This would mean that the actual effect is likely to be a small fraction of the impact displayed in the table above. Thus, we expect the research activities' detrimental effects on the species' abundance and productivity to be small—even in combination with all the rest of the research authorized in the region. And because that slight impact would be distributed throughout the species' entire range, it would be so attenuated as to have no appreciable effect on spatial structure or diversity. We therefore find that the impact of the program—even in its entirety—is a small effect on abundance and productivity, the activities analyzed here would add (effectively) no increment to that impact, and the information gained from the program as a whole would generate lasting benefits for the listed fish.

CCC steelhead

When combined with scientific research and monitoring permits already approved, the potential mortality for juvenile CCC steelhead from the entire research program would be 2.9% for naturally produced fish. The actions considered in this opinion would appear to add 128 fish to the total being allotted, but in fact nearly all of those additional fish (116 of them) come from a permit that would be renewed (15824-3R). Thus, the new activities considered here would add only eight juveniles and, though the other 116 fish are not currently considered part of the baseline, they have been part of it for a number of years previously and, as a result, take levels nearly identical to the 2.9% rate have repeatedly been analyzed before and found not to jeopardize the species.

It is also very likely that researchers will take fewer fish than estimated, and that the actual effects would be lower than the numbers stated above. For naturally produced CCC steelhead, our research tracking system reveals that for the past five years researchers ended up taking in total only 11.08%

of the juveniles they were authorized, and the actual mortality rates averaged only 4.34% of what was requested for juveniles. This would mean that the actual effect is likely to be around one-twentieth of the impact displayed in the table above. Thus, we expect the research activities' detrimental effects on the species' abundance and productivity to be small—even in combination with all the rest of the research authorized in the region. And because that slight impact would be distributed throughout the species' entire range, it would be so attenuated as to have no appreciable effect on spatial structure or diversity. We therefore find that the impact of the program—even in its entirety—is a small effect on abundance and productivity, the activities analyzed here would add very little increment to that impact, and the information gained from the program as a whole would generate lasting benefits for the listed fish.

SCCC steelhead

When combined with scientific research and monitoring permits already approved, the potential mortality for juvenile SCCC steelhead from the entire research program would be 5.31% for naturally produced fish. The actions considered in this opinion would appear to add 33 fish to the total being allotted, but in fact all of those additional fish come from a permit that would be renewed (15824-3R). Thus, the actual new activities considered here would add no juveniles at all and, though the 33 fish are not currently considered part of the baseline, they have been part of it for a number of years previously and, as a result, take levels nearly identical to the 5.31% rate have repeatedly been analyzed before and found not to jeopardize the species.

It is also very likely that researchers will take fewer fish than estimated, and that the actual effects would be lower than the numbers stated above. For naturally produced SCCC steelhead, our research tracking system reveals that for the past five years researchers ended up taking in total only 0.28% of the juveniles they were authorized, and the actual mortality rates also averaged only .011% of what was requested for juveniles. This would mean that the actual effect is likely to be *a small fraction of one percent* of the impact displayed in the table above. Thus, we expect the research activities' detrimental effects on the species' abundance and productivity to be small—even in combination with all the rest of the research authorized in the region. And because that slight impact would be distributed throughout the species' entire range, it would be so attenuated as to have no appreciable effect on spatial structure or diversity. We therefore find that the impact of the program—even in its entirety—is a small effect on abundance and productivity, the activities analyzed here would add (effectively) no increment to that impact, and the information gained from the program as a whole would generate lasting benefits for the listed fish.

Adults

UCR Chinook Salmon

The research program as a whole would permit up to six natural adult the UCR Chinook to be killed in any given year; this would constitute 0.74% of that component of the ESU. However, the research contemplated in this opinion would add no fish at all to that total. This signifies that the entirety of the research take has been analyzed in the past on more than one occasion and been found not to jeopardize the species; it is therefore unnecessary to repeat the entirety of that analysis here.

Nonetheless, it is likely that researchers will take fewer fish than estimated and that the actual effect is likely to be lower than the numbers stated in the table above. Our research tracking system reveals that over the past five years, researchers ended up taking 1.64% of the adult naturally produced UCR Chinook they were authorized, and the actual mortality rate was zero—signifying that the actual effect arising from the research program is likely to be very close to “none” in any given year. Thus, we expect the research activities’ detrimental effects on the species’ abundance and productivity to be small—even in combination with all the rest of the research authorized in the basin. And because that slight impact would be distributed throughout the species’ entire range, it would be so attenuated as to have no appreciable effect on spatial structure or diversity. We therefore find the impact of the program—even in its entirety—is a small effect on abundance and productivity, the activities proposed here would add no increment to that impact, and the information gained from the program as a whole would generate lasting benefits for the listed fish.

SnkR Steelhead

Under the research program as a whole, 1.3% of the natural-origin adult SnkR steelhead may be killed in a given year. The actions considered in this opinion would appear to add six fish to the total being allotted, but in fact all of those additional fish come from a permit renewal (1134-8R). Thus, though they are not currently considered part of the baseline, they have been such for a number of years and, as a result, take levels nearly identical to the 1.3% rate have previously been repeatedly analyzed and found not to jeopardize the species.

In addition, it is likely that researchers will take fewer fish than estimated and that the actual effect is likely to be lower than the numbers stated in the table above. Our research tracking system reveals that over the past five years, researchers ended up taking 10.23% of the adult naturally produced SnkR steelhead they were authorized, and the actual mortality rate was only 1.64% of the mortalities authorized for juveniles. This would mean that the actual effect of mortalities is likely to be less than one-fiftieth of the effect displayed in the table above. Thus, we expect the research activities’ detrimental effects on the species’ abundance and productivity to be small—even in combination with all the rest of the research authorized in the basin. And because that slight impact would be distributed throughout the species’ entire range, it would be so attenuated as to have no appreciable effect on spatial structure or diversity. We therefore find the impact of the program—even in its entirety—is a small effect on abundance and productivity, the activities analyzed here would add only a small increment to that impact, and the information gained from the program as a whole would generate lasting benefits for the listed fish.

SnkR Sockeye Salmon

Under the research program as a whole, researcher could possibly kill as many as 6 adult natural fish—this translates to a yearly mortality rate of 37.5% for the natural-origin adult SnkR sockeye salmon. The actions considered in this opinion would add no fish to the total being allotted, so the six possible mortalities have been part of several previous analyses and found not to jeopardize the species. Nonetheless, the 37.5% mortality rate is very high and could genuinely operate to the species disadvantage should it ever actually occur; as such, it requires careful consideration.

To that end, there are a number of caveats associated with that figure. First, the six fish are listed as "natural" but most, if not all, would probably be hatchery fish instead (of which there are approximately six times as many). They are considered "natural" for the purposes of this analysis (and in permits) in order to lay out the worst-case scenario associated with the research. However, this is not to say that hatchery fish aren't critical to the species survival and recovery at this point. It is simply that, as a precaution, we are treating mortalities as if they were coming from a component with far fewer fish. Thus, without any further caveats, the *actual maximum* mortality rate would probably be on the order of 6% instead of 37%. But it is unlikely that the rate would ever reach even that high because, second, these truly are worst-case numbers. Over the last 10 years, no adult sockeye have been killed by any researcher. As a result, the actual effect in any given year is very likely to be zero.

Third, ongoing Permits 1124 and 1341—which together account for four out of the six possible dead adults—are specifically designed to monitor SnkR sockeye and help them survive and recover. Under Permit1124, the researchers support the use of captive broodstock and other methods and technologies to capture, preserve, study, and *propagate* the few remaining sockeye salmon. Under Permit 1341, researchers seek to help SnkR sockeye recover and expand their range. Therefore, though these permits could in very rare circumstances have some negative effect on sockeye abundance, it is possible that without the research conducted under them for more than 20 years, the sockeye salmon might already have gone extinct; and even if that is not the entirely the case, it is inarguable that the research has been critical to whatever recovery the sockeye salmon have experienced.

And finally, all permits that might allow one or more adult sockeye mortalities contain a special condition stating that if any adult sockeye (natural or hatchery) are killed, the researchers must stop all work and contact NMFS to determine the best way forward—which may involve stopping work altogether, depending on circumstances. We will very carefully monitor all work that could affect adult sockeye salmon to ensure that the actual mortality rates never reach the level contemplated in Table 55.

LCR Steelhead

Under the research program as a whole, O.5% of the natural-origin adult LCR steelhead may be killed in a given year. However, the research contemplated in this opinion would add no fish at all to that total. This signifies that the entirety of the research take has been analyzed in the past on more than one occasion and been found not to jeopardize the species; it is therefore unnecessary to repeat the entirety of that analysis here.

Nonetheless, it is likely that researchers will take fewer fish than estimated and that the actual effect is likely to be lower than the numbers stated in the table above. Our research tracking system reveals that over the past five years, researchers ended up taking 22.89% of the adult naturally produced LCR steelhead they were authorized, and the actual mortality rate was 4.41%—signifying that the actual effect arising from the research program is likely to be far smaller than the displayed effect in any given year. Thus, we expect the research activities' detrimental effects on the species' abundance and productivity to be small—even in combination with all the rest of the research authorized in the basin. And because that slight impact would be distributed throughout the species' entire range, it would be so attenuated as to have no appreciable effect on spatial structure or diversity. We therefore find the impact of the program—even in its entirety—is a small effect on abundance and productivity, the activities proposed here would add no increment to that impact, and the information gained from the program as a whole would generate lasting benefits for the listed fish.

SONCC Coho Salmon

As it stands, the research program as a whole could potentially kill 0.63% of estimated adult abundance for this ESU. The 0.63% potential mortality figure is combined for natural-origin and hatchery adult fish because we do not currently have sufficient information to provide reliable estimates of the proportion of hatchery-origin spawners in this DPS. Nearly half (18 out of 43) of the hatchery-origin fish are considered surplus to recovery needs; therefore, we do not expect the loss from that component to have any genuine effect on the species' survival and recovery in the wild. And when those fish are removed from consideration, the actual effect of the maximum mortalities would drop by about 25% (which would bring it under the 0.5% threshold referred to above).

Moreover, the research contemplated in this opinion would add no fish at all to that total. This signifies that the entirety of the research take has been analyzed in the past on more than one occasion and been found not to jeopardize the species; it is therefore unnecessary to repeat the entirety of that analysis here.

Nonetheless, it is likely that researchers will take fewer fish than estimated, and that the actual effect is likely to be lower than the numbers stated in the table above. Our research tracking system reveals that over the past five years, researchers ended up taking between 7.1% (LHAC) and 24.0% (natural) of the adult SONCC coho they were authorized, and killed none from any component. This would mean that the actual effect of take is likely to be very nearly zero in any given year, and the activities considered here would add no increment to that effect.

Thus, the losses are very small and have previously been analyzed, the effects are only seen in potential reductions in abundance and productivity, and the estimates of adult mortalities are almost certainly much greater than the actual numbers are likely to be. 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. Still, even in the worst-case scenarios the effects are small, 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.

SacR winter-run Chinook Salmon

The scientific research and monitoring permits already approved the potential mortality for adult SacR winter-run Chinook salmon would range from about 1.8% for hatchery-origin fish to about 1.9% for naturally produced fish in this ESU (Table 56). The projected total lethal take for all research and monitoring activities thus represents a notable portion of the species' total abundance, however, the research contemplated in this opinion would add no fish at all to that total. This signifies that the entirety of the research take has been analyzed in the past on more than one occasion and been found not to jeopardize the species; it is therefore unnecessary to repeat the entirety of that analysis here.

Nonetheless, it is likely that researchers will take fewer fish than estimated, and that the actual effect is likely to be lower than the numbers stated in the table above. Our research tracking system reveals that over the past five years, researchers ended up taking and average of 0.8% of the natural adult SacR winter-run Chinook salmon they were authorized, and the actual mortality rate was only 1.75% of the mortalities authorized for adults. The take for hatchery fish was similarly low and, because all those fish are considered excess to the species' survival and recovery needs, that low level of impact would actually and effectively be zero. As a result, the actual effect of take is likely to be about one-fiftieth of the effect displayed in the table above, and the activities considered here would add no increment to that effect.

Thus, the losses are very small and have previously been analyzed, the effects are only seen in reductions in abundance and productivity, and the estimates of adult mortalities are almost certainly much greater than the actual numbers are likely to be. 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. Still, even in the worst-case scenarios the effects are small, 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.

CCV Steelhead

As it stands, the research program as a whole could potentially kill 3.18% of estimated adult abundance for this DPS. The 3.18% potential mortality figure is combined for natural-origin and hatchery adult fish because we do not currently have sufficient information to provide reliable estimates of the proportion of hatchery-origin spawners in this DPS. Nearly all (226 out of 227) of the hatchery-origin fish are considered surplus to recovery needs; therefore, we do not expect the loss from that component to have any genuine effect on the species' survival and recovery in the wild. And when those fish are removed from consideration, the actual effect of the maximum mortalities would drop by more than 60%.

Moreover, the research contemplated in this opinion would add no fish at all to that total. This signifies that the entirety of the research take has been analyzed in the past on more than one occasion and been found not to jeopardize the species; it is therefore unnecessary to repeat the entirety of that analysis here.

Nonetheless, it is likely that researchers will take fewer fish than estimated, and that the actual effect is likely to be lower than the numbers stated in the table above. Our research tracking system reveals that over the past five years, researchers ended up taking and average of 8.9% of the adult CCV steelhead they were authorized, and the actual mortality rate was only 1.2% of the mortalities authorized for adults. This would mean that the actual effect of take is likely to be about one onehundredth of the effect displayed in the table above, and the activities considered here would add no increment to that effect.

Thus, the losses are very small and have previously been analyzed, the effects are only seen in reductions in abundance and productivity, and the estimates of adult mortalities are almost certainly much greater than the actual numbers are likely to be. 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. Still, even in the worst-case scenarios the effects are small, 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.

CCC Coho Salmon

As it stands, the research program as a whole could potentially kill 4.2% of estimated adult abundance for this ESU. The 4.2% potential mortality figure is combined for natural-origin and hatchery adult fish because we do not currently have sufficient information to provide reliable estimates of the proportion of hatchery-origin spawners in this ESU. However, the research contemplated in this opinion would add no fish at all to the total that has already been authorized. This signifies that the entirety of the research take has been analyzed in the past on more than one occasion and been found not to jeopardize the species; it is therefore unnecessary to repeat the entirety of that analysis here.

Nonetheless, it is likely that researchers will take fewer fish than estimated, and that the actual effect is likely to be lower than the numbers stated in the table above. Our research tracking system reveals that over the past five years, researchers ended up taking and average of 8.0% of the adult natural CCC coho they were authorized, and the actual mortality rate was only 3.95% of the mortalities authorized for natural adults. This would mean that the actual effect of take is likely to be about one one-twentieth of the effect displayed in the table above, and the activities considered here would add no increment to that effect.

Thus, the losses are very small and have previously been analyzed, the effects are only seen in reductions in abundance and productivity, and the estimates of adult mortalities are almost certainly much greater than the actual numbers are likely to be. 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. Still, even in the worst-case scenarios the effects are small, 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.

CCC Coast Steelhead

As it stands, the research program as a whole could potentially kill 2.89% of estimated adult abundance for this DPS. The 2.89% potential mortality figure is combined for natural-origin and hatchery adult fish because we do not currently have sufficient information to provide reliable estimates of the proportion of hatchery-origin spawners in this DPS. All of the hatchery-origin fish that may be killed in the program are considered surplus to recovery needs; therefore, we do not expect the loss from that component to have any genuine effect on the species' survival and recovery in the wild. And when those fish are removed from consideration, the actual effect of the maximum mortalities would drop by 15%.

Moreover, the research contemplated in this opinion would add no fish at all to that total. This signifies that the entirety of the research take has been analyzed in the past on more than one occasion and been found not to jeopardize the species; it is therefore unnecessary to repeat the entirety of that analysis here.

Nonetheless, it is likely that researchers will take fewer fish than estimated, and that the actual effect is likely to be lower than the numbers stated in the table above. Our research tracking system reveals that over the past five years, researchers ended up taking and average of 6.7% of the adult natural CCC steelhead they were authorized, and the actual mortality rate was only 3.77% of the mortalities authorized for natural adults. This would mean that the actual effect of take is likely to be about one one-twentieth of the effect displayed in the table above, and the activities considered here would add no increment to that effect.

Thus, the losses are very small and have previously been analyzed, the effects are only seen in reductions in abundance and productivity, and the estimates of adult mortalities are almost certainly much greater than the actual numbers are likely to be. 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. Still, even in the worst-case scenarios the effects are small, 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.

SCCC Steelhead

The potential mortality rate for adult, natural SCCC steelhead that has already been approved and authorized in scientific research permits already is 19.4% (Table 56). The projected total lethal take for all research and monitoring activities thus represents a notable portion of the species' total abundance, however, the research contemplated in this opinion would add no fish at all to that total. This signifies that the entirety of the research take has been analyzed in the past on more than one occasion and been found not to jeopardize the species; it is therefore unnecessary to repeat the entirety of that analysis here.

Nonetheless, it should be noted that is very likely that researchers will take fewer fish than estimated and that the actual effect is likely to be lower than the numbers stated in the table above. Our research tracking system reveals that over the past five years, researchers have neither nor killed a single adult fish from this DPS. As a result, the actual effect of take is likely to be very close to zero in any given year.

Thus, the have previously been analyzed, the effects are only seen in reductions in abundance and productivity, and the estimates of adult mortalities are almost certainly much greater than the actual numbers are likely to be. And because that impact would be distributed throughout the entire listing units' ranges, it would have no appreciable effect on spatial structure or diversity. Still, even in the worst-case scenario, the effects are well-understood, restricted to abundance and productivity reductions, and the negative effects (should they even occur) would to some degree be offset by the information to be gained—information that in all cases would be used to protect listed fish or promote their recovery.

Other species

Beyond the salmonid ESUs and DPSs discussed above, are two additional DPSs that merit additional discussion.

SDPS Green Sturgeon

For southern DPS green sturgeon, when combined with already authorized research the permits contemplated in this opinion could result in lethal take up to what would equal approximately 4.4% of the annual abundance of juveniles. However, a portion of this take has already been analyzed in previous opinions and been determined not to jeopardize this DPS. The potential mortality of southern DPS green sturgeon resulting from activities contemplated in this opinion would only be four individual juveniles, or 0.09% of the juvenile abundance, or just over 2% of the total authorized lethal juvenile take for the region (Table 56). The majority of this potential lethal take of juveniles (189 individuals) has been previously analyzed and found not to jeopardize the continued existence of this DPS.

In addition, while it appears that this take of juveniles may impact a particular age class of southern DPS green sturgeon, it is important to recognize that the abundance estimates for all age classes come from applying an age structure distribution from prior studies to an estimate of the entire DPS. We do not have abundance estimates generated specifically by tracking the number of maturing juveniles, so the actual demographic structure of southern green sturgeon DPS could be different from these estimates in any given year. Overall, the sum of juvenile, subadult, and adult lethal take authorized in combination with new proposed take (four individuals) would be equivalent to <0.001% of the total estimated abundance of southern DPS green sturgeon (17,723 individuals), and the fact that primarily juveniles would be taken reduces the risk of authorized take impacting productivity of the species relative to take of subadults or adults.

It is also highly likely that researchers will take fewer fish than estimated, and that the actual effects would be lower than the numbers stated in Tables 55 and 56 above. For southern DPS green sturgeon, our research tracking system reveals that, as described under the individual permits above, researchers ended up lethally taking far fewer individuals of all age classes than they were authorized. This is in part because for many studies requesting take of green sturgeon the probability of encounters at each study site is low, but in order to be properly permitted across all of the study locations some individuals are authorized to be taken in each area, which increases the total amount of take authorized for encounters that actually have a low probability of occurring in each instance.

Thus, we expect the research activities' detrimental effects on the species' abundance and productivity to be small—even in combination with all the rest of the research authorized in the basin. But even if in the worst-case scenario all the fish authorized as mortalities were to be killed in actuality, this would represent only a small reduction in overall abundance and productivity, and because that slight impact would be distributed throughout the species' range, it would be so attenuated as to have no appreciable effect on spatial structure or diversity. And finally, regardless of its relative magnitude, all the negative effect associated with the research program on this species would to some extent be offset by gaining information that would be used to help the species survive and recover.

PS/GB Bocaccio

For all life-stages combined for PS/GB bocaccio, the existing take authorized in combination with that contemplated in this opinion would be equivalent to lethal take of 0.977% of the abundance of this ESU. However, we know this to be an overestimate of the potential impacts of research. PS/GB bocaccio abundance is underestimated in two ways: (1) adult abundance is based on an ROV survey of only a small part of their range (i.e., the marine waters around the San Juan Islands), and (2) there is no estimate of juvenile abundance specifically. Since we do not have a juvenile estimate for the DPS (which would be expected to be greater than the adult estimate based on demographic structure), we analyze the requested take of PS/BG bocaccio juveniles as though they are adults in an overabundance of caution. This, combined with the only available adult abundance estimate reflecting only part of the DPS range, means that we knowingly overestimate the impacts of research to the DPS. It is therefore certain that the impact to the abundance of the population overall is less than the one percent estimated here, and because the majority of requested take is for juveniles any impact on productivity of the DPS would be much less than if all fish to be taken were truly adults. It is also highly likely that the actual impact of the proposed research will be much lower. None of the permits considered in this opinion primarily target ESA-listed rockfish, so while they contain lethal take requests as a precaution due to their capture methods and locations within the marine waters of Puget Sound, these research programs hope to avoid capturing ESA-listed species entirely. In addition, specific equipment is used to safely release listed rockfish should they be captured to minimize harm; every permit that could collect ESA-listed rockfish take in Puget Sound at depth via hook and line angling is required to have a descending device (e.g. SeaQualizer) that can quickly return the rockfish to their capture depth, reducing the effects of barotrauma. Further, bocaccio are in such low abundance that they are very rarely captured. Since 2012, PS/GB bocaccio take for the entire research program has been very low, with only five captures (all adults) and no mortalities of any life stage reported.

Thus, we expect the research activities' detrimental effects on the species' abundance and productivity to be small—even in combination with all the rest of the research authorized in the basin. But even if in the worst-case scenario all the fish authorized as mortalities were to be killed in actuality, this would represent only a small reduction in overall abundance and productivity, and because that slight impact would be distributed throughout the species' range, it would be so attenuated as to have no appreciable effect on spatial structure or diversity.

Critical Habitat

As previously discussed, we do not expect the individual actions to have any appreciable 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 overall lack of measurable effect signify that even when taken together they would have no discernible impact on critical habitat.

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 proposed actions exacerbate any of the negative cumulative effects discussed (habitat alterations, etc.) and in all cases the research may eventually help to limit adverse effects by increasing our knowledge about the species' requirements, habitat use, and abundance. The effects of climate change are also likely to continue to be negative. However, given the proposed actions' short time frames and limited areas, those negative effects, while somewhat unpredictable, are too small to be effectively gauged as an additional increment of harm over the time span considered in this analysis. Moreover, the actions would in no way contribute to climate change (even locally) and, in any case, many of the proposed actions 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 proposed actions would have any additive impact to the pathways by which those effects are realized (e.g., a slight reduction in salmonid abundance would have no effect on increasing stream temperatures or continuing land development).

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

For over two decades, research and monitoring activities conducted on anadromous salmonids 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 authorizations—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 authorization, the ESA (section 4(c)(2)) requires that we examine the status of each listed species every five years and report on our findings. At that point, we must determine whether each listed species should (a) be removed from the list (b) have its status changed from threatened to endangered, or (c) have its status changed from endangered to threatened. As a result, it is legally incumbent upon us to monitor the status of every species considered here, and 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 actions—even in combination—would have no appreciable effect on the species' diversity or structure. Moreover, we expect the actions to provide lasting benefits for the listed fish and that all habitat effects would be negligible. And finally, we expect the program as a whole and the permit actions considered here 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' biological opinion that the proposed actions are not likely to jeopardize the continued existences of PS, UCR, SnkR spr/sum, SnkR fall-run, LCR, UWR, SacR winter-run, CVS, CC Chinook salmon; LCR, OC, SONCC, CCC coho salmon, HCS and CR chum salmon; OL and SnkR sockeye salmon; PS, UCR, MCR, SnkR, LCR, NC, CCV, CCC, SCCC steelhead, SDPS green sturgeon, SDPS eulachon, PS/GB bocaccio, and PS/GB yelloweye rockfish; or destroy or adversely modify their designated critical habitats.

2.9 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). "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 at all. The reason for this is that all the take contemplated in this document would be carried out under permits that allow the permit holders to directly take the animals in question. Because the action would not cause any incidental take, we are not specifying an amount or extent of incidental take that would serve as a reinitiation trigger. Nonetheless, the amounts of direct take have been specified and analyzed in the effects section above (2.5). Those amounts—displayed in the various permits' effects analyses—constitute hard limits on both the amount and extent of take the permit holders would be allowed in a given year. Those amounts are also noted in the reinitiation clause just below because exceeding them would likely trigger the need to reinitiate consultation.

2.10 Reinitiation of Consultation

This concludes formal consultation for "Consultation on the Issuance of 17 ESA Section 10(a)(1)(A) Scientific Research Permits affecting Salmon, Steelhead, Eulachon, Green Sturgeon, and Rockfish in the West Coast Region."

As 50 CFR 402.16 states, 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 if: (1) The amount or extent of incidental taking specified in the ITS is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the 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 (4) a new species is listed or critical habitat designated that may be affected by the action.

In the context of this opinion, there is no incidental take anticipated and the reinitiation trigger set out in (1) is not applicable. If any of the direct take amounts specified in this opinion's effects analysis section (2.5) are exceeded, reinitiation of formal consultation will be required because the regulatory reinitiation triggers set out in (2) and/or (3) will have been met.

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.

In 2021, NMFS published a final rule (86 FR 41668, August 2, 2021) to revise SRKW critical habitat to designate six additional coastal critical habitat areas (approximately 15,910 sq. miles), in addition to the 2,560 square miles previously designated in 2006 in inland waters of Washington (71 FR 69054; November 29, 2006). Each coastal area contains all three physical or biological essential features identified in the 2006 designation: (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality and availability to support individual growth, reproduction and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging.

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

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 2008a; Hanson et al. 2013; Carretta et al. 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 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). 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 2021b).

SRKWs consume a variety of fish species (22 species) and one species of squid (Ford et al. 1998; Ford 2000; Ford and Ellis 2006; Hanson et al. 2010; Ford et al. 2016), but salmon are identified as their primary prey. The diet of SRKWs is the subject of ongoing research, including direct observation of feeding, scale and tissue sampling of prey remains, and fecal sampling. The diet data suggest that SRKWs are consuming mostly larger (i.e., generally age 3 and up) Chinook salmon (Ford and Ellis 2006). 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 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. Focusing on

Chinook salmon provides a conservative estimate of potential effects of the action on SRKWs because the total abundance of all salmon and other potential prey species is orders of magnitude larger than the total abundance of Chinook. To assess the indirect effects of the proposed action on the Southern Resident killer whale DPS, we considered the geographic area of overlap in the marine distribution of Chinook salmon affected by the action, and the range of SRKWs. We also considered the importance of the affected Chinook salmon ESUs compared to other Chinook salmon runs in the SRKW diet composition, and the influence of hatchery mitigation programs. As described in the effects analysis for salmonids, an absolute maximum of 3,310 juvenile and 19 adult Chinook salmon may be killed during the course of the research. 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 distribution for any Chinook salmon ESUs. The affected Chinook salmon ESUs are:

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

The fact that the research would kill Chinook salmon could affect prey availability to the whales in future years throughout their range. For the adult take, almost all of the 19 fish that could, at maximum, be killed from these ESUs would only be taken by research after they return to shallower bays, estuaries, and (mostly) their natal rivers, and are therefore very unlikely to be available as prey to the whales that typically feed in coastal offshore areas. This portion of the proposed work would therefore have minimal, if any, effect on prey availability for SRKWs.

Because SRKWs prey on adult salmon, to determine effect the juvenile losses might have on SRKWs, we must convert those fish to adult equivalents: 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 the 3,310 juvenile Chinook salmon that may be killed by the proposed research activities were otherwise to survive to adulthood, this would translate to the effective loss of about 33 adult Chinook salmon. 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 intercept and feed on many (if any) of these salmon.

Taken together, this would mean that the research, in total, could remove something on the order of 138 adult Chinook from the SRKW prey base in any given year. Given that the number of adult Chinook (listed and unlisted) in the ocean at any given time is orders of magnitude greater than that figure, it is unlikely that SRKW would intercept and feed on many (if any) of these 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 2019). 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). Williams et al. (2011) modeled annual SRKW prey requirements and found that the whole population requires approximately 211,000 to 364,100 Chinook salmon per year. Based on dietary/energy needs and 2015 SRKW abundances, Chasco et al. (2017) also modeled SRKW prey requirements and found that in Salish Sea and U.S. West Coast coastal waters (not including British Columbia), the population requires approximately 393,109, adult (age 1+) Chinook salmon annually on average across model simulations.

Using methods described in NMFS 2021b (and originally used in NMFS 2019), 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 2020 (72 whales) and using ages for the year 2021. Assuming again a Chinook caloric density of 16,386, a SRKW population of 72 whales, ≥1 year of age, need 755-906 fish/day. Using an energy density of 13,868 kcal/fish (O'Neill et al. 2014, Columbia river fall run energy content), 72 whales would need 892-1071 fish/day. But these numbers depend a lot on the ages of the killer whales, as well as the run, size, and calorie content of the salmon prey. But, using these values, this means that the research contemplated in this opinion could kill, in its entirety and at a maximum, about 5% 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 5% 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.

In addition, as described in Sections 2.4 and 2.5, the estimated Chinook salmon mortality is likely to be much smaller than stated. First, the mortality rate estimates for most of the proposed studies are purposefully inflated to account for potential accidental deaths and it is therefore very likely that fewer salmonids will be killed by the research than stated. In fact, as described in Section 2.4 according to our take tracking in the past, researchers have killed between 4% and 15% of the fish they have been permitted. Thus, the actual reduction in prey that could possibly become available to the whales is probably closer to 5 than 33 fish.

Given these circumstances, and the fact that we anticipate no direct interaction between any of the researchers and SRKWs, NMFS finds that potential adverse effects of the proposed research on SRKWs are insignificant and determines that the proposed action may affect, but is not likely to adversely affect, SRKWs or their critical habitat.

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. The MSA (section 3) defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH.

This analysis is based, in part, on the EFH assessment provided by the **NMFS** and descriptions of EFH for Pacific Coast salmon (PFMC 2022) 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 2022). 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, singly 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

Because no EFH recommendations are being made, there is no statutory response requirement.

3.5 Supplemental Consultation

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

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

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

4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion are the agencies listed on the first page of the preceding biological opinion. Other interested users could include the permittees and other local and tribal interests. The document will be available within two weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. The format and naming adheres to conventional standards for style.

This ESA section 7 consultation on the issuance of the ESA section 10(a)(1)(A) research permit 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 permit 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.

5. REFERENCES

5.1 Federal Register Notices

June 16, 1993 (58 FR 33212). Designated Critical Habitat; Sacramento River Winter-Run Chinook Salmon.

January 4, 1994 (59 FR 440). Endangered and Threatened Species; Status of Sacramento River Winter-run Chinook Salmon; Final Rule

October 31, 1996 (61 FR 56138). Endangered and Threatened Species; Threatened Status for Central California Coast Coho Salmon Evolutionarily Significant Unit (ESU).

March 23, 1999 (64 FR 14067). Endangered and Threatened Species; Regulations Consolidation.

May 5, 1999 (64 FR 24049). Final Rule: Designated Critical Habitat: Critical Habitat for 19 Evolutionarily Significant Units of Salmon and Steelhead in Washington, Oregon, Idaho, and California.

September 16, 1999 (64 FR 50394). Endangered and Threatened Species; Threatened Status for Two Chinook Salmon Evolutionarily Significant Units (ESUs) in California.

October 25, 1999 (64 FR 57399). Final Rule: Designated Critical Habitat: Revision of Critical Habitat for Snake River Spring/Summer Chinook Salmon.

June 28, 2005 (70 FR 37160). Endangered and Threatened Species: Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs.

September 2, 2005 (70 FR 52488). Final Rule: Endangered and Threatened Species: Designation of Critical Habitat for Seven Evolutionarily Significant Units of Pacific Salmon and Steelhead in California.

September 2, 2005 (70 FR 52630). Final Rule: Endangered and Threatened Species: Designated Critical Habitat: Designation of Critical Habitat for 12 Evolutionarily Significant Units of West Coast Salmon and Steelhead in Washington, Oregon, and Idaho.

November 18, 2005 (70 FR 69903). Final Rule: Endangered and Threatened Wildlife and Plants: Endangered Status for Southern Resident Killer Whales.

January 5, 2006 (71 FR 834). Final Rule: Endangered and Threatened Species: Final Listing Determinations for 10 Distinct Population Segments of West Coast Steelhead.

April 7, 2006 (71 FR 17757). Endangered and Threatened Wildlife and Plants: Threatened Status for Southern Distinct Population Segment of North American Green Sturgeon

November 29, 2006 (71 FR 69054). Final Rule: Endangered and Threatened Species; Designation of Critical Habitat for Southern Resident Killer Whale.

May 11, 2007 (72 FR 26722). Final Rule: Endangered and Threatened Species: Final Listing Determination for Puget Sound Steelhead.

February 11, 2008 (73 FR 7816). Final Rule: Endangered and Threatened Species: Final Threatened Determination, Final Protective Regulations, and Final Designation of Critical Habitat for Oregon Coast Evolutionarily Significant Unit of Coho Salmon.

October 9, 2009 (74 FR 52300). Final Rulemaking to Designate Critical Habitat for the Threatened Southern Distinct Population Segment of North American Green Sturgeon.

March 18, 2010 (75 FR 13012). Endangered and Threatened Wildlife and Plants: Threatened Status for Southern Distinct Population Segment of Eulachon.

June 20, 2011 (76 FR 35755). Listing Endangered and Threatened Species: Threatened Status for the Oregon Coast Coho Salmon Evolutionarily Significant Unit.

October 20, 2011 (76 FR 65324). Final Rule: Endangered and Threatened Species; Designation of Critical Habitat for the Southern Distinct Population Segment of Eulachon.

April 2, 2012 (77 FR 19552). Endangered and Threatened Species; Range Extension for Endangered Central California Coast Coho Salmon.

April 14, 2014 (79 FR 20802). Final Rule: Endangered and Threatened Wildlife; Final Rule to Revise the Code of Federal Regulations for Species Under the Jurisdiction of the National Marine Fisheries Service.

November 13, 2014 (79 FR 68042). Final Rule: Endangered and Threatened Species; Designation of Critical Habitat for the Puget Sound/Georgia Basin Distinct Population Segments of Yelloweye Rockfish, Canary Rockfish and Bocaccio.

February 11, 2016 (81 FR 7214). Final Rule: Interagency Cooperation—Endangered Species Act of 1973, as Amended; Definition of Destruction or Adverse Modification of Critical Habitat.

February 11, 2016 (81 FR 7414). Final Rule: Listing Endangered and Threatened Species and Designating Critical Habitat; Implementing Changes to the Regulations for Designating Critical Habitat.

February 24. 2016 (81 FR 9252). Final Rule: Endangered and Threatened Species; Designation of Critical Habitat for Lower Columbia River Coho Salmon and Puget Sound Steelhead.

February 19, 2019 (84 FR 4791). Endangered and Threatened Species; Take of Anadromous Fish.

March 8, 2019 (84 FR 8507). Endangered and Threatened Species; Take of Anadromous Fish.

August 27, 2019 (84 FR 44976). Endangered and Threatened Wildlife and Plants; Regulations for Interagency Cooperation.

August 2, 2021 (86 FR 41668). Endangered and Threatened Wildlife and Plants; Revision of Critical Habitat for the Southern Resident Killer Whale Distinct Population Segment.

5.2 Literature Cited

Abatzoglou, J. T., D. E. Rupp, and P. W. Mote. 2014. Seasonal climate variability and change in the Pacific Northwest of the United States. Journal of Climate. 27(5):2125-2142.

Abrams, A. E., A. M. Rous, J. L. Brooks, M. J. Lawrence, J. D. Midwood, S. E. Doka, and S. J. Cooke. 2018. Comparing immobilization, recovery, and stress indicators associated with electric fish handling gloves and a portable electrosedation system. Transactions of the American Fisheries Society, 147(2), 390-399.

Ainslie, B. J., J. R. Post, and A. J. Paul. 1998. Effects of pulsed and continuous DC electrofishing on juvenile rainbow trout. North American Journal of Fisheries Management: 18(4):905-918.

Alexander, R. M. 1966. Physical aspects of swimbladder function. Biological Reviews 41:141–176.

Alizedeh, M.R., J.T. Abatzoglou, C.H. Luce, J.F. Adamowski, A. Farid, and M. Sadegh. 2021. Warming enabled upslope advance in western US forest fires. PNAS 118(22) e2009717118. https://doi.org/10.1073/pnas.2009717118

Andrews, K. S, Nichols, K. M, Elz, A., Tolimieri, N., Harvey, C. J, Pacunski, R., Lowry, D., Yamanaka, K. Lynne, & Tonnes, D. M. 2018. Cooperative research sheds light on population structure and listing status of threatened and endangered rockfish species. Conservation genetics, 19, 865-878.

Araki, H., Cooper, B., Blouin, M. S. Araki2007. Genetic Effects of Captive Breeding Cause a Rapid, Cumulative Fitness Decline in the Wild. Science 318, 100 (2007); DOI: 10.1126/science.1145621

Ashbrook, C. E., K. W. Yi, J. Arterburn, and Colville Tribes. 2005. Tangle nets and gill nets as a live capture selective method to collect fall Chinook Salmon broodstock in the Okanogan River: 2004. Washington Department of Fish and Wildlife. Olympia, WA.

Azat, J. 2020. GrandTab California Central Valley Chinook Escapement Database Report. California Department of Fish and Wildlife. Available at: https://www.calfish.org/ProgramsData/Species/CDFWAnadromousResourceAssessment.aspx

Barnett, H. K., Quinn, T. P., Bhuthimethee, M., & Winton, J. R. 2020. Increased prespawning mortality threatens an integrated natural- and hatchery-origin sockeye salmon population in the Lake Washington Basin. Fisheries Research, 227, 105527. https://doi.org/10.1016/j.fishres.2020.105527

Bartholomew, A. and J. Bohnsack. 2005. A Review of Catch-and-Release Angling Mortality with Implications for No-take Reserves. Reviews in Fish Biology and Fisheries. 15:129-154.

Beamer, E. M., R. E. McClure, and B. A. Hayman. 2000. Fiscal Year 1999 Skagit River Chinook Restoration Research. Skagit System Cooperative.

Beacham, T.D., D.E. Hay, and K.D. Le. 2005. Population structure and stock identification of Eulachon (*Thaleichthys pacificus*), an anadromous smelt, in the Pacific Northwest. Marine Biotechnology 7(4): 363-372.

Beechie, T., H. Imaki, J. Greene, A. Wade, H. Wu, G. Pess, P. Roni, J. Kimball, J. Stanford, P. Kiffney, and N. Mantua. 2013. Restoring salmon habitat for a changing climate. River research and applications. 29(8):939-60.

Bendock, T. and M. Alexandersdottir. 1993. Hooking mortality of Chinook salmon released in the Kenai River, Alaska. North American Journal of Fisheries Management. 13:540-549.

Bergman, P. K., K. B. Jefferts, H. F. Fiscus, and R. C. Hager. 1968. A preliminary evaluation of an implanted, coded wire fish tag. Washington Department of Fisheries, Fisheries Research Papers. 3(1):63-84.

Bjorkstedt, E.P., B. C. Spence, J. C. Garza, D. G. Hankin, D. Fuller, W. E. Jones, J. J. Smith, and R Macedo. 2005. An analysis of historical population structure for evolutionary significant units of Chinook salmon, coho salmon, and steelhead in the North-Central California Coast Recovery Domain. NOAA Technical Memo NOAA-TM-NMFS-SWFSC-382. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Booth, D. B., D. Hartley, and R. Jackson. 2002. Forest cover, impervious-surface area, and the mitigation of stormwater impacts. J Amer Water Res Assoc. 38(3):835-845.

Bordner, C. E., S. I. Doroshov, D. E. Hinton, R. E. Pipkin, R. B. Fridley, and F. Haw. 1990. Evaluation of marking techniques for juvenile and adult white sturgeons reared in captivity *In* Parker, N.C., Giorgi, A.E., Heindinger, R.C., Jester, D.B., Prince, E.D., and Winans, G.A., eds. Fish Marking Techniques, Symposium 7: American Fisheries Society, Bethesda, MD, p. 293-303.

Boughton, D.A., Adams, P.B., Anderson, E.C., Fusaro, C., Keller, E.A., Kelley, E., Lentsch, L.D., Nielsen, J.L., Perry, K., Regan, H., Smith J., Swift, C., Thompson, L., and Watson, F. 2006. Steelhead of the south-central/southern California coast population characterization for recovery planning. NOAA Fisheries Technical Memo TM-NMFS-SWFSC-394.

BPA (Bonneville Power Administration). 2018. Comparative Survival Study of PIT-tagged Spring/Summer/Fall Chinook, Summer Steelhead, and Sockeye. 2018 Annual Report (12-1-2017 to 11-30-2018). BPA contract 70765, BPA Project 1996-020-00

Bruesewitz, S. L. 1995. Hook placement in steelhead. Technical Report No. AF95-01. Washington Department of Fish and Wildlife, Olympia.

Brynildson, O. M. and C. L. Brynildson. 1967. The effect of pectoral and ventral fin removal on survival and growth of wild brown trout in a Wisconsin stream. Transactions of the American Fisheries Society 96:353-355.

Carretta, J.V., Oleson, E.M., Forney, K.A., Muto, M.M., Weller, D.W., Lang, A.R., Baker, J., Hanson, B., Orr, A.J., Barlow, J. and Moore, J.E., 2021. Killer Whale (*Orcinus orca*): Eastern North Pacific Southern Resident Stock, US Pacific Marine Mammal Stock Assessments: 2020 (pp. 121-127). NOAA-TM-NMFS-SWFSC-629. US Department of Commerce. NOAA, NMFS, and SWFSC.

Carter, K. M., C. M. Woodley, and R. S. Brown. 2010. A review of tricaine methanesulfonate for anesthesia of fish. Reviews in Fish Biology and Fisheries, 21(1), 51–59. https://doi.org/10.1007/s11160-010-9188-0

CDFG (California Department of Fish and Game). 1998. A Status Review of the Spring-Run Chinook Salmon [*Oncorhynchus tshawytscha*] in the Sacramento River Drainage. Candidate Species Status Report 98-01. California Department of Fish and Game.

CDFW (California Department of Fish and Wildlife). 2018. Population Database Report - GrandTab 2018.04.09. Available at: GrandTab 2018.04.09

CDFW (California Department of Fish and Wildlife). 2020. Spreadsheet of abundance data sent to the SWFSC in response to 5-year review request for information (unpublished). Transmitted via email from CDFW to NOAA Fisheries Southwest Fisheries Science Center, May 2020.

CDFW (California Department of Fish and Wildlife). 2020. Coastal monitoring data spreadsheet from CDFW dated 18 May, 2020. Unpublished data received via email from T. Williams 22 December 2021.

Chasco, B. E., B. J. Burke, L. G. Crozier, and R. W. Zabel. 2021. Differential impacts of freshwater and marine covariates on wild and hatchery Chinook salmon marine survival. PLoS ONE 16:e0246659. https://doi.org/0246610.0241371/journal.pone.0246659.

Chiaramonte, L. V., K. A. Meyer, P. R. Branigan, and J. B. Reynolds. 2020. Effect of Pulsed DC Frequency on Capture Efficiency and Spinal Injury of Trout in Small Streams. North American Journal of Fisheries Management. 40(3): 691–699). https://doi.org/10.1002/nafm.10440

Chisholm, I. M. and W. A. Hubert. 1985. Expulsion of dummy transmitters by rainbow trout. Transactions of the American Fisheries Society. 114:766-767.

Cho, G. K., J. W. Heath, and D. D. Heath. 2002. Electroshocking Influences Chinook Salmon Egg Survival and Juvenile Physiology and Immunology. Transactions of the American Fisheries Society. 131(2): 224–233. https://doi.org/10.1577/15488659(2002)131<0224:EICSES>2.0.CO;2

Clancy, N. G., J. L. Dunnigan, and P. Budy. 2021. Relationship of Trout Growth to Frequent Electrofishing and Diet Collection in a Headwater Stream. North American Journal of

Fisheries Management. https://doi.org/10.1002/nafm.10728Coble, D. W. 1967. Effects of fin-clipping on mortality and growth of yellow perch with a review of similar investigations. Journal of Wildlife Management 31:173-180.

Coble, D. W. 1967. Effects of fin-clipping on mortality and growth of yellow perch with a review of similar investigations. Journal of Wildlife Management 31:173-180.

Conner, W. P., H. L. Burge, and R. Waitt. 2001. Snake River fall Chinook salmon early life history, condition, and growth as affected by dams. Unpublished report prepared by the U.S. Fish and Wildlife Service and University of Idaho, Moscow, ID. 4 p.

Cook, K. V., A. J. Reid, D. A. Patterson, K. A. Robinson, J. M. Chapman, S. G. Hinch, and S. J. Cooke. 2018. A synthesis to understand responses to capture stressors among fish discarded from commercial fisheries and options for mitigating their severity. Fish and Fisheries. 20(1), 25–43. https://doi.org/10.1111/faf.12322

Cowen, L. 2007. Effects of angling on chinook salmon for the Nicola River, British Columbia, 1996-2002. North Americana Journal of Fisheries Management 27:256-267.

Cox-Rogers, S., T. Gjernes, and E. Fast. 1999. Canadian Stock Assessment Secretariat Research Document 99/127. Fisheries and Oceans Canada. 16 p.

Crozier, L. G., A. P. Hendry, P. W. Lawson, T. P. Quinn, N. J. Mantua, J. Battin, R. G. Shaw, and R. B. Huey. 2008. Potential responses to climate change in organisms with complex life histories: evolution and plasticity in Pacific salmon. Evolutionary Applications. 1(2):252-270.

Crozier, L. G., M. D. Scheuerell, and E. W. Zabel. 2011. Using Time Series Analysis to Characterize Evolutionary and Plastic Responses to Environmental Change: A Case Study of a Shift Toward Earlier Migration Date in Sockeye Salmon. The American Naturalist. 178(6):755-773.

Crozier, E. G. R. 2016. Impacts of climate change on salmon of the Pacific Northwest: A review of the scientific literature published in 2015. Fish Ecology Division, Northwest Fisheries Science Center, National Marine Fisheries Service, NOAA.

Crozier, L. G., M. M. McClure, T. Beechie, S. J. Bograd, D. A. Boughton, M. Carr, T. D. Cooney, J. B. Dunham, C. M. Greene, M. A. Haltuch, E. L. Hazen, D. M. Holzer, D. D. Huff, R. C. Johnson, C. E. Jordan, I. C. Kaplan, S. T. Lindley, N. J. Mantua, P. B. Moyle, J. M. Myers, M. W. Nelson, B. C. Spence, L. A. Weitkamp, T. H. Williams, and E. Willis-Norton. 2019. Climate vulnerability assessment for Pacific salmon and steelhead in the California Current Large Marine Ecosystem. PLoS ONE 14(7):e0217711.

Crozier, L. G., J. E. Siegel, L. E. Wiesebron, E. M. Trujillo, B. J. Burke, B. P. Sandford, and D. L. Widener. 2020. Snake River sockeye and Chinook salmon in a changing climate: Implications for upstream migration survival during recent extreme and future climates. PLOS ONE 15(9): e0238886. https://doi.org/10.1371/journal.pone.0238886

Crozier, L.G., Burke, B.J., Chasco, B.E., Widener, D.L. and Zabel, R.W., 2021. Climate change threatens Chinook salmon throughout their life cycle. Communications biology, 4(1): 1-14.

Cuo, L., D. P. Lettenmaier, M. Alberti, and J. E. Richey. 2009. Effects of a century of land cover and climate change on the hydrology of the Puget Sound basin. Hydrol. Process. 23:907-933.

CWR (Center for Whale Research). 2021. Chinook Orca Survival – FACTS about Chinook Salmon. Center for Whale Research - Chinook Orca Survival webpage

Dalbey, S. R., T. E. McMahon, and W. Fredenberg. 1996. Effect of electrofishing pulse shape and electrofishing-induced spinal injury to long-term growth and survival of wild rainbow trout. North American Journal of Fisheries Management. 16:560-569.

Dalton, M.M., and E. Fleishman, editors. 2021. Fifth Oregon climate assessment. Oregon Climate Change Research Institute, Oregon State University, Corvallis, Oregon.

DFO (Department of Fisheries and Oceans Canada). 2022. 2020 Eulachon Integrated Fisheries Management Plan – Fraser River. Department of Fisheries and Oceans Canada-Pacific Region. 71pp.

DFO (Department of Fisheries and Oceans Canada. 2023. Pacific Region Integrated Fisheries Management Plan, Eulachon Fraser River, January 1, 2023 to December 31, 2023. DFO number: 22-2229.

Dominguez, F., E. Rivera, D. P. Lettenmaier, and C. L. Castro. 2012. Changes in Winter Precipitation Extremes for the Western United States under a Warmer Climate as Simulated by Regional Climate Models. Geophysical Research Letters. 39(5). DOI:10.1029/2011GL050762.

Doney, S. C., M. Ruckelshaus, J. E. Duffy, J. P. Barry, F. Chan, C. A. English, H. M. Galindo, J. M. Grebmeier, A. B. Hollowed, N. Knowlton, J. Polovina, N. N. Rabalais, W. J. Sydeman, and L. D. Talley. 2012. Climate Change Impacts on Marine Ecosystems. Annual Review of Marine Science. 4:11-37.

Drake J. S., E. A. Berntson, J. M. Cope, R. G. Gustafson, E. E. Holmes, P. S. Levin, N. Tolimieri, R. S. Waples, S. M. Sogard, and G. D. Williams. 2010. Status review of five rockfish species in Puget Sound, Washington: bocaccio (*Sebastes paucispinis*), canary rockfish (*S. pinniger*), yelloweye rockfish (*S. ruberrimus*), greenstriped rockfish (*S. elongatus*), and redstripe rockfish (*S. proriger*). U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-108, 234 pp.

Duda, J.J., Torgersen, C.E., Brenkman, S.J., Peters, R.J., Sutton, K.T., Connor, H.A., Kennedy, P., Corbett, S.C., Welty, E.Z., Geffre, A. and Geffre, J., 2021. Reconnecting the Elwha River: spatial patterns of fish response to dam removal. Frontiers in Ecology and Evolution, p.811.

Dwyer, W. P. and R. G. White. 1997. Effect of electroshock on juvenile Arctic grayling and Yellowstone cutthroat trout growth 100 days after treatment. North American Journal of Fisheries Management. 17:174-177.

Dwyer, W. P., B. B. Shepard, and R. G. White. 2001. Effect of Backpack Electroshock on Westslope Cutthroat Trout Injury and Growth 110 and 250 Days Posttreatment. North American Journal of Fisheries Management. 21(3): 646–650.

Emmons, C.K., Hanson, M.B. and Lammers, M.O., 2021. Passive acoustic monitoring reveals spatiotemporal segregation of two fish-eating killer whale Orcinus orca populations in proposed critical habitat. Endangered Species Research, 44, pp.253-261.

Essington T, Ward EJ, Francis TB, Greene C, Kuehne L, Lowry D 2021. Historical reconstruction of the Puget Sound (USA) groundfish community. Mar Ecol Prog Ser. 657:173-189.

Fletcher, D. H., F. Haw, and P. K. Bergman. 1987. Retention of coded-wire tags implanted into cheek musculature of largemouth bass. North American Journal of Fisheries Management 7:436-439.

Ford, J.K., Ellis, G.M., Barrett-Lennard, L.G., Morton, A.B., Palm, R.S. and Balcomb III, K.C., 1998. Dietary specialization in two sympatric populations of killer whales (*Orcinus orca*) in coastal British Columbia and adjacent waters. Canadian Journal of Zoology, 76(8), pp.1456-1471.

Ford, J. K. B., G. M. Ellis, and K. C. Balcomb. 2000. Killer Whales: The Natural History and Genealogy of Orcinus orca in British Columbia and Washington State. Vancouver, British Columbia, UBC Press, 2nd Edition.

Ford, J.K. and Ellis, G.M., 2006. Selective foraging by fish-eating killer whales Orcinus orca in British Columbia. *Marine Ecology Progress Series*, *316*, pp.185-199.

Ford, M. J. (ed.). 2011. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. U.S. Depart. of Commer., NOAA Tech. Memo. NOAA-TM-NWFSC-113, 281 pp.

Ford, M. J. 2013. Status review update of Southern Resident killer whales. U.S. Dept. of Commerce, Northwest Fisheries Science Center.41p. Available at (Accessed July 2015): Status review update of Southern Resident killer whales weblink

Ford, M. 2015. Results of NOAA BRT review of new genetics information, memo from the NWFSC to PRD, December 9, 2015.

Ford, M. J., Hempelmann, J., Hanson, M. B., Ayres, K. L., Baird, R. W., Emmons, C. K., Lundin, J. I., Schorr, G. S., Wasser, S. K. and Park, L. K., 2016. Estimation of a killer whale (*Orcinus orca*) population's diet using sequencing analysis of DNA from feces. Plos one, 11(1): e0144956.

Ford, M. J., editor. 2022. Biological Viability Assessment Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Pacific Northwest. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-171.

Fredenberg, W. A. 1992. Evaluation of electrofishing-induced spinal injuries resulting from field electrofishing surveys in Montana. Montana Department of Fish, Wildlife and Parks, Helena.

French, B. F., D. H. Baldwin, J. Cameron, J. Prat, K. King, J. W. Davis, J. K. McIntyre, and N. L. Scholz. 2022. Urban Roadway Runoff Is Lethal to Juvenile Coho, Steelhead, and Chinook Salmonids, But Not Congeneric Sockeye. Environmental Science & Technology Letters. 9(9):733-738. DOI: 10.1021/acs.estlett.2c00467

Good, T. P., R. S. Waples, and P. Adams (eds.). 2005. Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead. National Marine Fisheries Service, Northwest and Southwest Fisheries Science Centers. NOAA Technical Memorandum NMFS-NWFSC TM-66.

Goode, J. R., J. M. Buffington, D. Tonina D. J. Isaak, R. F. Thurow, S. Wenger, D. Nagel, C. Luce, D. Tetzlaff, and C. Soulsby. 2013. Potential effects of climate change on streambed scour and risks to salmonid survival in snow-dominated mountain basins. Hydrological Processes 27(5):750-765.

Griffith, J., M. Alexandersdottir, R. Rogers, J. Drotts, and P. Stevenson. 2004. 2003 annual Stillaguamish smolt report. Stillaguamish Tribe of Indians.

Gustafson, R. G., M. J. Ford, D. Teel, and J. S. Drake. 2010. Status review of eulachon (*Thaleichthys pacificus*) in Washington, Oregon, and California. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC-105, 360 p.

Gustafson, R., Y. W. Lee, E. Ward, K. Somers, V. Tuttle, and J. Jannot. 2016. Status review update of eulachon (*Thaleichthys pacificus*) listed under the Endangered Species Act: southern distinct population segment. 25 March 2016 Report to National Marine Fisheries Service – West Coast Region from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112.

Gutiérrez, J.M., R.G. Jones, G.T. Narisma, L.M. Alves, M. Amjad, I.V. Gorodetskaya, M. Grose, N.A.B. Klutse, S. Krakovska, J. Li, D. Martínez-Castro, L.O. Mearns, S.H. Mernild, T. Ngo-Duc, B. van den Hurk, and J.-H. Yoon, 2021: Atlas. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1927–2058, doi:10.1017/9781009157896.021.

Hallacher, L. E. 1974. The comparative morphology of extrinsic gas bladder musculature in the scorpionfish genus, *Sebastes* (Pisces: *Scorpaenidae*). Proceedings of the California Academy of Sciences. 40(3):59–86.

Hannah, R. W. and K. M. Matteson. 2007. Behavior of nine species of Pacific rockfish after hook-and-line capture, recompression, and release. Transactions of the American Fisheries Society 136:24–33.

Hannah, R. W., S. J. Parker, and K. M. Matteson. 2008. Escaping the surface: the effects of capture depth on submergence success of surface-released Pacific rockfish. North American Journal of Fisheries Management 28:694–700.

Hanson, M. B., and C. K. Emmons. 2010. Annual Residency Patterns of Southern Resident Killer Whales in the Inland Waters of Washington and British Columbia. Revised Draft - 30 October 10. 11p.

Hanson, M. B., K. L. Ayres, R. W. Baird, K. C. Balcomb, K. Balcomb-Bartok, J. R. Candy, C. K. Emmons, J. K. B. Ford, M. J. Ford, B. Gisborne, J. Hempelmann-Halos, G. S. Schorr, J. G. Sneva, D. M. Van Doornik, and S. K. Wasser. 2010. Species and stock identification of prey consumed by endangered southern resident killer whales in their summer range. Endangered Species Research. 11:69–82.

Hanson, M. B., C. K. Emmons, E. J. Ward, J. A. Nystuen, and M. O. Lammers. 2013. Assessing the coastal occurrence of endangered killer whales using autonomous passive acoustic recorders. The Journal of the Acoustical Society of America. 134(5): 3486–3495.

Hanson, M.B., Ward, E.J., Emmons, C.K., Holt, M.M. and Holzer, D.M., 2017. Assessing the movements and occurrence of southern resident killer whales relative to the US Navy's Northwest Training Range Complex in the Pacific Northwest. Prepared for: US Navy, US Pacific Fleet, Pearl Harbor, HI. Prepared by: National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center under MIPR, (00070).

Hanson, M. B., C. K. Emmons, M. J. Ford, M. Everett, K. Parsons, L. Park, J. Hempelmann, D. M. V. Doonik, G. S. Schorr, J. Jacobsen, M. F. Sears, M. S. Sears, J. G. Sneva, R. W. Baird, and L. Barre. 2021. Endangered predators and endangered prey: seasonal diet of Southern Resident killer whales. PloS ONE. 16(3): e0247031. https://doi.org/10.1371/journal.pone.0247031

Hard, J. J., J. M. Myers, M. J. Ford, R. G. Cope, G. R. Pess, R. S. Waples, G. A. Winans, B. A. Berejikian, F. W. Waknitz, P. B. Adams. P. A. Bisson, D. E. Campton, and R. R. Reisenbichler. 2007. Status review of Puget Sound steelhead (*Oncorhynchus mykiss*). NOAA Tech. Memo. NMFS-NWFSC-81. Department of Commerce, National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

Hard, J. J., J. M. Myers, E. J. Connor, R. A. Hayman, R. G. Kope, G. Lucchetti, A. R. Marshall, G. R. Pess, and B. E. Thomson. 2015. Viability criteria for steelhead within the Puget Sound distinct population segment. NOAA technical memorandum NMFS-NWFSC-129. Department of Commerce, National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. doi: http://doi.org/10.7289/V5/TM-NWFSC-129

Hauser, D.D., Logsdon, M.G., Holmes, E.E., VanBlaricom, G.R. and Osborne, R.W., 2007. Summer distribution patterns of southern resident killer whales *Orcinus orca*: core areas and spatial segregation of social groups. Marine Ecology Progress Series, 351, pp.301-310.

Hayes, M.L. Active fish capture methods in Fisheries Techniques. 1983. Nielson, L.A. and D.L. Johnson, editors. American Fisheries Society, Bethesda, Maryland.

Hayes, D.B., Ferreri, C.P. and Taylor, W.W., 1996. Active fish capture methods. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland, pp.193-220.

HCCC (Hood Canal Coordinating Council). 2005. Hood Canal & Eastern Strait of Juan de Fuca summer chum salmon recovery plan. Hood Canal Coordinating Council. Poulsbo, Washington.

Healey, M. C., and W. Ra Heard. 1984. Inter- and intra-population variation in the fecundity of chinook salmon (*Oncorhynchus tshawytscha*) and its relevance to life history theory. Can. J. Fish. Aquat. Sci. 4l:474-483.

Healey, M. C. 1991. The life history of Chinook salmon (*Oncorhynchus tshawytscha*). *In* C. Groot and L. Margolis (eds), Life history of Pacific salmon, p. 311-393. Univ. BC Press.

Hollender, B. A. and R. F. Carline. 1994. Injury to wild brook trout by backpack electrofishing. North American Journal of Fisheries Management. 14:643-649.

Hilborn, R., Cox, S.P., Gulland, F.M.D., Hankin, D.G., Hobbs, N.T., Schindler, D.E. and Trites, A.W., 2012. The Effects of Salmon Fisheries on Southern Resident Killer Whales: Final Report of the Independent Science Panel. November 30, 2012. Prepared with the assistance of DR Marmorek and AW Hall, ESSA Technologies Ltd., Vancouver, BC for NMFS, Seattle, Washington and Fisheries and Oceans Canada (Vancouver. BC). 87p.

Hochhalter S. J. and D. J. Reed. 2011. The effectiveness of deepwater release at improving the survival of discarded yelloweye rockfish. North American Journal of Fisheries Management 31:852-860.

Hockersmith, E. E., W. D. Muir, S. G. Smith, B. P Sanford, N. S. Adams, J. M. Plumb, R. W. Perry, and D. W. Rondorf. 2000. Comparative performance of sham radiotagged and PIT-tagged juvenile salmon. Report to U.S. Army Corps of Engineers, Contract W66Qkz91521282, 25 p.

Holliman, F. M., J. B. Reynolds, and J. A. S. Holmes. 2010. Effects of Healing Time and Pulsed-DC Waveform on Injury Detection and Incidence in Electroshocked Juvenile Chinook Salmon. North American Journal of Fisheries Management (Vol. 30, Issue 6, pp. 1413–1419). https://doi.org/10.1577/m10-049.1

Hooton, R. S. 1987. Catch and release as a management strategy for steelhead in British Columbia. *In* R. Barnhart and T. Roelofs, editors. Proceedings of Catch and Release Fishing: a Decade of Experience, a National Sport Fishing Symposium. Humboldt State University, Arcata, California.

Howe, N. R. and P. R. Hoyt. 1982. Mortality of juvenile brown shrimp *Penaeus aztecus* associated with streamer tags. Transactions of the American Fisheries Society. 111:317-325.

Huhn, D. and R. Arlinghaus. 2011. Determinants of hooking mortality in freshwater recreational fisheries: a quantitative meta-analysis. *In* The angler in the environment: social, economic, biological, and ethical dimensions: proceedings of the 5th World Recreational Fishing Conference, number 75 in American Fisheries Society symposium. American Fisheries Society, Bethesda, Md.

Hutchings, J. A. and J. D. Reynolds. 2004. Marine Fish Population Collapses: Consequences for Recovery and Extinction Risk. BioScience, Vol. 54(4): 297-309.

Huysman, N., J. M. Voorhees, H. Meyer, E. Krebs, and M. E. Barnes. 2018. Electrofishing of Landlocked Fall Chinook Salmon Broodstock Negatively Impacts Egg Survival. In North American Journal of Aquaculture (Vol. 80, Issue 4, pp. 411–417). https://doi.org/10.1002/naaq.10058

ICTRT 2007 (Interior Columbia Basin Technical Recovery Team): Viability criteria for application to Interior Columbia Basin Salmonid ESUs. ISAB 2007-4. July 18, 2007.

IPCC (Intergovernmental Panel on Climate Change) Working Group I (WGI). 2021. Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. V. Masson-Delmotte, P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou editor. Cambridge University Press (https://www.ipcc.ch/report/ar6/wg1/#FullReport).

ISAB (Independent Scientific Advisory Board). 2007. Climate change impacts on Columbia River Basin fish and wildlife. ISAB Climate Change Report, ISAB 2007-2, Northwest Power and Conservation Council, Portland, Oregon.

Isaak, D. J., S. Wollrab, D. Horan, and G. Chandler. 2012. Climate change effects on stream and river temperatures across the northwest US from 1980–2009 and implications for salmonid fishes. Climatic Change. 113(2):499-524.

Jarvis, E. T., and C. G. Lowe. 2008. The effects of barotrauma on the catch-and-release survival of southern California nearshore and shelf rockfish (*Scorpaenidae*, *Sebastes* spp.). Canadian Journal of Fisheries and Aquatic Sciences 65:1286–1296.

Javahery, S., H. Nekoubin, and A. H. Moradlu. 2012. Effect of anaesthesia with clove oil in fish (review). Fish Physiology and Biochemistry, 38(6), 1545–1552. https://doi.org/10.1007/s10695-012-9682-5

Jenkins, W. E. and T. I. J. Smith. 1990. Use of PIT tags to individually identify striped bass and red drum brood stocks. American Fisheries Society Symposium 7:341-345.

Johnson, M. A., T. A. Friesen, D. M. Van Doornik, D. J. Teel, and J. M. Myers. 2018. Genetic influence from hatchery stocks on upper Willamette River steelhead *Oncorhynchus mykiss*. Oregon Department of Fish and Wildlife Information Report Series Number 2018-03. June 2018.

Johnson, M.A., Friesen, T.A., VanDoornik, D.M., Teel, D.J. and Myers, J.M., 2021. Genetic interactions among native and introduced stocks of Oncorhynchus mykiss in the upper Willamette River, Oregon. Conservation Genetics, 22(1), pp.111-124.

Kamler, J. F. and K. L. Pope. 2001. Nonlethal Methods of Examining Fish Stomach Contents. Reviews in Fisheries Science. 9(1):1-11.

Keefer, M. L., T. S. Clabough, M. A. Jepson, E. L. Johnson, and C.A. Peery et al. 2018. Thermal exposure of adult Chinook salmon and steelhead: Diverse behavioral strategies in a large and warming river system. PLOS ONE 13(9): e0204274. https://doi.org/10.1371/journal.pone.0204274

Kohlhorst, D. W. 1979. Effect of first pectoral fin ray removal on survival and estimated harvest rate of white sturgeon in the Sacramento-San Joaquin estuary. California Department of Fish and Game. 65: 173-177.

Koontz, E.D., E.A. Steel, and J.D. Olden. 2018. Stream thermal responses to wildfire in the Pacific Northwest. Freshwater Science. 37: 731-746.

Krahn, M. M., P. R. Wade, S. T. Kalinowski, M. E. Dahlheim, B. L. Taylor, M. B. Hanson, G. M. Ylitalo, R. P. Angliss, J. E. Stein, and R. S. Waples. 2002. Status review of southern resident killer whales (*Orcinus orca*) under the Endangered Species Act. NOAA Technical Memorandum NMFS-NWFSC54, U.S. Department of Commerce, Seattle, Washington.

Krahn, M. M., M. J. Ford, W. F. Perrin, P. R. Wade, R. P. Angliss, M. B. Hanson, B. L. Taylor, G. M. Ylitalo, M. E. Dahlheim, J. E. Stein, and R. S. Waples. 2004. 2004 Status Review of Southern Resident Killer Whales (Orcinus orca) under the Endangered Species Act. December 2004. U.S. Dept. Commer., NOAA Tech. Memo., NMFS-NWFSC-62. NMFS, Seattle, Washington. 95p.

Krahn, M. M., M. B. Hanson, R. W. Baird, R. H. Boyer, D. G. Burrows, C. E. Emmons, J. K. B. Ford, L. L. Jones, D. P. Noren, P. S. Ross, G. S. Schorr, and T.K. Collier. 2007. Persistent organic pollutants and stable isotopes in biopsy samples (2004/2006) from Southern Resident killer whales. Marine Pollution Bulletin. 54:1903-1911.

Lacy, R.C., Williams, R., Ashe, E., Balcomb III, K.C., Brent, L.J., Clark, C.W., Croft, D.P., Giles, D.A., MacDuffee, M. and Paquet, P.C., 2017. Evaluating anthropogenic threats to endangered killer whales to inform effective recovery plans. Scientific reports, 7(1), pp.1-12.

Lawson, P. W., E. A. Logerwell, N. J. Mantua, R. C. Francis, and V. N. Agostini. 2004. Environmental factors influencing freshwater survival and smolt production in Pacific Northwest coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences. 61(3):360-373.

Lawson, P.W., Bjorkstedt, E.P., Chilcote, M.W., Huntington, C.W., Mills, J.S., Moore, K.S., Nickelson, T.E., Reeves, G.H., Stout, H.A., Wainwright, T.C. and Weitkamp, L.A., 2007. Identification of historical populations of coho salmon (*Oncorhynchus kisutch*) in the Oregon Coast Evolutionarily Significant Unit. US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Region.

LCFRB (Lower Columbia Fish Recovery Board). 2020. Summary of actions addressing threats criteria. Lower Columbia Fish Recovery Board comments on the 5-years status review for Pacific salmon and steelhead.

LeClair, L., Pacunski, R., Hillier, L., Blain, J., & Lowry, D. 2018. Summary of Findings from Periodic Scuba Surveys of Bottomfish Conducted Over a Sixteen-Year Period at Six Nearshore Sites in Central Puget Sound. https://wdfw.wa.gov/publications/02026.

Letvin, A., M. Palmer-Zwahlen, and B. Kormos. 2021a. Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement, Inland Harvest, and Ocean Harvest in 2019. Report to the U.S. Bureau of Reclamation East Bay Municipal Utilities District by the California Department of Fish and Wildlife and Pacific States Marine Fisheries Commission.

Letvin, A., M. Palmer-Zwahlen, and B. Kormos. 2021b. Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement, Inland Harvest, and Ocean Harvest in 2018. Report to the U.S. Bureau of Reclamation East Bay Municipal Utilities District by the California Department of Fish and Wildlife and Pacific States Marine Fisheries Commission.

Letvin, A., M. Palmer-Zwahlen, and B. Kormos. 2020. Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement, Inland Harvest, and Ocean Harvest in 2017. Report to the U.S. Bureau of Reclamation East Bay Municipal Utilities District by the California Department of Fish and Wildlife and Pacific States Marine Fisheries Commission.

Light, R. W., P. H. Adler, and D. E. Arnold. 1983. Evaluation of Gastric Lavage for Stomach Analyses. North American Journal of Fisheries Management. 3:81-85.

Lindley, S.T. 2004. Population structure of threatened and endangered Chinook salmon ESUs in California's Central Valley basin. NOAA technical memorandum NMFS-NOAA-TM-NMFS-SWFSC-360. U.S. Department of Commerce, National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, California.

Lindsay, R. B., R. K. Schroeder, and K. R. Kenaston. 2004. Hooking mortality by anatomical location and its use in estimating mortality of spring Chinook salmon caught and released in a river sport fishery. North American Journal of Fisheries Management 24:367-378.

Love, M. S., M. Carr, and L. Haldorson. 1991. The ecology of substrate-associated juveniles of the genus Sebastes. Environmental Biology of Fishes. 30:225-243.

Love, M. S., M. M. Yoklavich, and L. Thorsteinson. 2002. The rockfishes of the Northeast Pacific. University of California Press, Berkeley, California. 404 p.

Luers, A.L. and Moser, S.C., 2006. Preparing for the impacts of climate change in California: Opportunities and constraints for adaptation.

Mantua, N., I. Tohver, and A. Hamlet. 2009. Impacts of Climate Change on Key Aspects of Freshwater Salmon Habitat in Washington State. *in* The Washington Climate Change Impacts Assessment: Evaluating Washington's Future in a Changing Climate, M. M. Elsner, J. Littell, and L. Whitely Binder, Eds. The Climate Impacts Group, University of Washington, Seattle, Washington, pp. 217-253.

Mantua, N., I. Tohver, and A. Hamlet. 2010. Climate change impacts on streamflow extremes and summertime stream temperature and their possible consequences for freshwater salmon habitat in Washington State. Climatic Change. 102(1):187-223.

Martins, E.G., Hinch, S.G., Cooke, S.J. and Patterson, D.A., 2012. Climate effects on growth, phenology, and survival of sockeye salmon (*Oncorhynchus nerka*): a synthesis of the current state of knowledge and future research directions. Reviews in Fish Biology and Fisheries, 22(4), pp.887-914.

Martins, T., A. Valentim, N. Pereira, and L. M. Antunes. 2018. Anaesthetics and analgesics used in adult fish for research: A review. Laboratory Animals, 53(4), 325–341. https://doi.org/10.1177/0023677218815199

Matthews, K. R. and R. H. Reavis. 1990. Underwater tagging and visual recapture as a technique for studying movement patterns of rockfish. American Fisheries Society Symposium. 7:168-172.

May, C., C. Luce, J. Casola, M. Chang, J. Cuhaciyan, M. Dalton, S. Lowe, G. Morishima, P. Mote, A. Petersen, G. Roesch-McNally, and E. York, 2018: Northwest. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 1036–1100. doi: 10.7930/NCA4.2018.CH24

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Dept. Commer., NOAA Tech. Memo NMFS-NWFSC-42. 156pp.

McKenzie, D., and J. S. Littell, 2017. Climate change and the eco-hydrology of fire: Will area burned increase in a warming western USA? Ecological Applications, 27 (1), 26–36.

McMahon, T. E. and G. F. Hartman. 1989. Influence of cover complexity and current velocity on winter habitat use by juvenile coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences. 46:1551-1557.

McMichael, G. A. 1993. Examination of electrofishing injury and short-term mortality in hatchery rainbow trout. North American Journal of Fisheries Management 13:229-233.

McMichael, G. A., L. Fritts, and T. N. Pearsons. 1998. Electrofishing injury to stream salmonids; injury assessment at the sample, reach, and stream scales. North American Journal of Fisheries Management. 18:894-904.

McNeil, F. I. and E. J. Crossman. 1979. Fin clips in the evaluation of stocking programs for muskellunge (*Esox masquinongy*). Transactions of the American Fisheries Society. 108:335-343.

Mears, H. C. and R. W. Hatch. 1976. Overwinter survival of fingerling brook trout with single and multiple fin clips. Transactions of the American Fisheries Society 105: 669-674.

Meehan, W.R. and R.A. Miller. 1978. Stomach flushing: effectiveness and influence on survival and condition of juvenile salmonids. J. Fish. Res. Board Can. 35:1359-1363.

Mellas, E. J. and J. M. Haynes. 1985. Swimming performance and behavior of rainbow trout (*Salmo gairdneri*) and white perch (*Morone americana*): effects of attaching telemetry transmitters. Canadian Journal of Fisheries and Aquatic Sciences 42:488-493.

Meyer, J. L., M. J. Sale, P. J. Mulholland, and N. L. Poff. 1999. Impacts of climate change on aquatic ecosystem functioning and health. JAWRA Journal of the American Water Resources Association. 35(6):1373-1386.

Miller, E.A., Singer, G.P., Peterson, M.L., Chapman, E.D., Johnston, M.E., Thomas, M.J., Battleson, R.D., Gingras, M. and Klimley, A.P., 2020. Spatio-temporal distribution of green sturgeon (*Acipenser medirostris*) and white sturgeon (*A. transmontanus*) in the San Francisco estuary and Sacramento River, California. Environmental Biology of Fishes, 103(5), pp.577-603.

Monaco, M.E., R.L. Emmett, D.M. Nelson, and S.A. Hinton. 1990. Distribution and abundance of fishes and invertebrates in west coast estuaries, Volume I: Data summaries. ELMR Rep. No. 4. NOAA/NOS Strategic Environmental Asessments Division, Silver Spring, MD, 232 p.

Mongillo, P. E. 1984. A summary of salmonid hooking mortality. Washington Department of Game, Olympia.

Moody, M. F. 2008. Eulachon past and present. M.S. Thesis. University of British Columbia Resource Management and Environmental Studies Program. Vancouver, British Columbia. doi: 10.14288/1.0070785

Mora, E. A., R. D. Battleson, S. T. Lindley, M. J. Thomas, R. Bullmer, L. J. Zarri, and A. P. Klimley. 2018. Estimating the Annual Spawning Run Size and Population Size of the Southern Distinct Population Segment of Green Sturgeon. Transactions of the American Fisheries Society. 147:195-203.

Moring, J. R. 1990. Marking and tagging intertidal fishes: review of techniques. American Fisheries Society Symposium. 7:109-116.

Morrison, J. and D. Zajac. 1987. Histologic effect of coded wire tagging in chum salmon. North American Journal of Fisheries Management 7:439-441.

Mote, P. W., J. Abatzoglou, and K. Kunkel. 2013. Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities. Island Press, 224 pp.

Mote, P. W, A. K. Snover, S. Capalbo, S. D. Eigenbrode, P. Glick, J. Littell, R. R. Raymondi, and W. S. Reeder. 2014. Ch. 21: Northwest. *in* Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, T.C. Richmond, and G.W. Yohe, Eds., U.S. Global Change Research Program, pp. 487-513.

Mote, P. W., D. E. Rupp, S. Li, D. J. Sharp, F. Otto, P. F. Uhe, M. Xiao, D. P. Lettenmaier, H. Cullen, and M. R. Allen. 2016. Perspectives on the cause of exceptionally low 2015 snowpack in the western United States. Geophysical Research Letters. 43:10980-10988. doi:10.1002/2016GLO69665

Mote, P.W., J. Abatzoglou, K.D. Dello, K. Hegewisch, and D.E. Rupp, editors. 2019. Fourth Oregon climate assessment report. Oregon Climate Change Research Institute, Oregon State University, Corvallis, Oregon.

Muoneke, M. and W. M. Childress. 1994. Hooking Mortality: A Review for Recreational Fisheries. Reviews in Fisheries Science. 2:123-156.

Musick, J.A. 1999. Criteria to define extinction risk in marine fishes: The American Fisheries Society Initiative. Fisheries. Volume 24, pages 6-14.

Myers, J., C. Busack, D. Rawding, A. Marshall, D. Teel, D.M. Van Doornik, and M.T. Maher. 2006. Historical population structure of Pacific salmonids in the Willamette River and lower Columbia River basins. NOAA Tech. Memo. NMFS-NWFSC-73. U.S. Department of Commerce, National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

Myers, J. M., Hard J. J., Connor E. J., Hayman R. A., Kope R. G., Lucchetti G., Marshall A. R., Pess G. R., and B.E. Thompson. 2015. Identifying historical populations of steelhead within the Puget Sound distinct population segment. NOAA Technical Memorandum NMFS-NWFSC-128. U.S. Department of Commerce, National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

Neiffer, D. L., and M. A. Stamper. 2009. Fish Sedation, Anesthesia, Analgesia, and Euthanasia: Considerations, Methods, and Types of Drugs. ILAR Journal, 50(4), 343–360. https://doi.org/10.1093/ilar.50.4.343

Nelson, T., M. Rosenau, and N. T. Johnston. 2005. Behavior and Survival of Wild and Hatchery-Origin Winter Steelhead Spawners Caught and Released in a Recreational Fishery. North American Journal of Fisheries Management. 25(3):931-943.

Nickelson, T.E. 1998. A Habit-Based Assessment of Coho Salmon Production Potential and Spawner Escapement Needs for Oregon Coastal Streams. INFORMATION REPORTS NUMBER 98-4. Oregon Department of Fish and Wildlife. April, 1998.

Nicola, S. J. and A. J. Cordone. 1973. Effects of fin removal on survival and growth of rainbow trout (*Salmo gairdneri*) in a natural environment. Transactions of the American Fisheries Society. 102(4):753-759.

Nielsen, L. A. 1992. Methods of marking fish and shellfish. American Fisheries Society Special Publication 23. Bethesda, Maryland.

NMFS (National Marine Fisheries Service). 2000. Guidelines for electrofishing waters containing salmonids listed under the Endangered Species Act, June 2000. Available at: NOAA Fisheries Guidelines for Electrofishing Waters webpage

NMFS (National Marine Fisheries Service). 2005. Assessment of NOAA Fisheries' critical habitat analytical review teams for 12 evolutionarily significant units of West Coast salmon and steelhead. NMFS, Protected Resources Division, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2006. Final supplement to the Puget Sound Salmon Recovery Plan. Available at: Final supplement to PS Salmon Recovery Plan weblink

NMFS (National Marine Fisheries Service). 2007. Final Supplement to the recovery plan for the Hood Canal and eastern Strait of Juan de Fuca summer chum salmon (*Oncorhynchus keta*). National Marine Fisheries Service, Northwest Region. Portland, Oregon

NMFS (National Marine Fisheries Service). 2008a. Recovery plan for Southern Resident Killer Whales (*Orcinus orca*). National Marine Fisheries Service, Northwest Region, Seattle, Washington.

NMFS (National Marine Fisheries Service). 2008b. Endangered Species Act Section 7(a)(2) Consultation Biological Opinion & Magnuson-Stevens Fishery Conservation & Management Act Essential Fish Habitat Consultation on the Willamette River Basin Flood Control Project. 11 July 2008. National Marine Fisheries Service, West Coast Region, Portland, OR.

NMFS (National Marine Fisheries Service). 2009a. Recovery Plan For Lake Ozette Sockeye Salmon (*Oncorhynchus nerka*). National Marine Fisheries Service, West Coast Region, Portland, OR. 394 pp.

NMFS (National Marine Fisheries Service). 2009b. Middle Columbia Steelhead ESA Recovery Plan. National Marine Fisheries Service, West Coast Region, Portland, OR. 260 pp.

NMFS (National Marine Fisheries Service). 2012a. Final Recovery Plan for Central California Coast coho salmon Evolutionarily Significant Unit. National Marine Fisheries Service, Southwest Region, Santa Rosa, California.

NMFS (National Marine Fisheries Service). 2012b. Southern California Steelhead Recovery Plan. Southwest Region, Protected Resources Division, Long Beach, California.

NMFS (National Marine Fisheries Service). 2013a. ESA Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and

Lower Columbia River Steelhead. National Marine Fisheries Service, West Coast Region, Portland, OR. 503 pp.

NMFS (National Marine Fisheries Service). 2013b. South-Central California Steelhead Recovery Plan. National Marine Fisheries Service, West Coast Region, Long Beach, California.

NMFS (National Marine Fisheries Service). 2014a. Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon (*Oncorhynchus kisutch*). National Marine Fisheries Service. Arcata, CA. 406 pp.

NMFS (National Marine Fisheries Service). 2014b. Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead. California Central Valley Area Office. July 2014.

NMFS (National Marine Fisheries Service). 2015. ESA Recovery Plan for Snake River Sockeye Salmon (*Oncorhynchus nerka*). National Marine Fisheries Service, West Coast Region, Portland, OR. 431 pp.

NMFS (National Marine Fisheries Service). 2016a. Yelloweye rockfish (*Sebastes ruberrimus*), canary rockfish (*Sebastes pinniger*) and bocaccio (*Sebastes paucispinis*) of the Puget Sound/Georgia Basin – 5-Year Review: Summary and Evaluation. National Marine Fisheries Service. Seattle, WA. 131 pp.

NMFS (National Marine Fisheries Service). 2016b. Final ESA Recovery Plan for Oregon Coast Coho Salmon (*Oncorhynchus kisutch*). National Marine Fisheries Service, West Coast Region, Portland, OR. 230 pp.

NMFS (National Marine Fisheries Service). 2016c. Coastal Multispecies Recovery Plan. National Marine Fisheries Service, West Coast Region, Santa Rosa, California.

NMFS (National Marine Fisheries Service). 2016d. 2016 5-Year Review: Summary & Evaluation of California Coastal Chinook Salmon and Northern California Steelhead. National Marine Fisheries Service, West Coast Region, Portland, OR.

NMFS (National Marine Fisheries Service). 2016e. 2016 5-Year Review: Summary & Evaluation of Sacramento River Winter-Run Chinook Salmon ESU. National Marine Fisheries Service, West Coast Region, Portland, OR.

NMFS (National Marine Fisheries Service). 2016f. 2016 5-Year Review: Summary & Evaluation of Central Valley Spring-run Chinook Salmon Evolutionarily Significant Unit. National Marine Fisheries Service, West Coast Region, Portland, OR.

NMFS (National Marine Fisheries Service). 2016g. 2016 5-Year Review: Summary & Evaluation of California Central Valley Steelhead Distinct Population Segment. National Marine Fisheries Service, West Coast Region, Portland, OR.

NMFS (National Marine Fisheries Service). 2016h. 2016 5-Year Review: Summary & Evaluation of Central California Coast Coho Salmon. National Marine Fisheries Service, West Coast Region, Portland, OR.

NMFS (National Marine Fisheries Service). 2016i. 2016 5-Year Review: Summary & Evaluation of Central California Coast Steelhead. National Marine Fisheries Service, West Coast Region, Portland, OR.

NMFS (National Marine Fisheries Service). 2016j. 2016 5-Year Review: Summary & Evaluation of South-Central California Coast Steelhead. National Marine Fisheries Service, West Coast Region, Portland, OR.

NMFS (National Marine Fisheries Service). 2016k. 5-Year Review: Summary and Evaluation of Southern California Coast Steelhead Distinct Population Segment. National Marine Fisheries Service. West Coast Region. California Coastal Office. Long Beach, California

NMFS (National Marine Fisheries Service). 2017a. Rockfish Recovery Plan: Puget Sound / Georgia Basin yelloweye rockfish (*Sebastes ruberrimus*) and bocaccio (*Sebastes paucispinis*). National Marine Fisheries Service. Seattle, WA. 167 pp.

NMFS (National Marine Fisheries Service). 2017b. ESA Recovery Plan for Snake River Spring/Summer Chinook Salmon (*Oncorhynchus tshawytscha*) & Snake River Basin Steelhead (*Oncorhynchus mykiss*). National Marine Fisheries Service, West Coast Region, Portland, OR. 284 pp.

NMFS (National Marine Fisheries Service). 2017c. ESA Recovery Plan for Snake River Fall Chinook Salmon (*Oncorhynchus tshawytscha*). National Marine Fisheries Service, West Coast Region, Portland, OR. 366 pp.

NMFS (National Marine Fisheries Service). 2017d. Endangered Species Act Recovery Plan for the Southern Distinct Population Segment of Eulachon (*Thaleichthys pacificus*). National Marine Fisheries Service, West Coast Region, Portland, OR. 132 pp.

NMFS (National Marine Fisheries Service). 2018. Recovery Plan for the Southern Distinct Population Segment of North American Green Sturgeon (*Acipenser medirostris*). National Marine Fisheries Service, Sacramento, CA. 95 pp.

NMFS (National Marine Fisheries Service). 2019. ESA Recovery Plan for the Puget Sound Steelhead Distinct Population Segment (*Oncorhynchus mykiss*). National Marine Fisheries Service. Seattle, WA.

NMFS (National Marine Fisheries Service). 2021a. Southern Distinct Population Segment of North American Green Sturgeon (*Acipenser medirostris*) 5-Year Review: Summary and Evaluation. National Marine Fisheries Service California Central Valley Office, Sacramento, CA. October 28, 2021.

NMFS (National Marine Fisheries Service). 2021b. 2021 Southern Resident Killer Whales (Orcinus orca) 5-Year Review: Summary and Evaluation.

NMFS (National Marine Fisheries Service). 2021c. Revision of the Critical Habitat Designation for Southern Resident killer whales: Final Biological Report (to accompany the Final Rule). https://repository.library.noaa.gov/view/noaa/31587.

NMFS (National Marine Fisheries Service). 2022a. 2022 5-Year Review: Summary & Evaluation of Ozette Lake Sockeye Salmon. National Marine Fisheries Service, West Coast Region, Portland, OR.

NMFS (National Marine Fisheries Service). 2022b. 2022 5-Year Review: Summary & Evaluation of Upper Columbia River spring-run Chinook Salmon and Upper Columbia River Steelhead. National Marine Fisheries Service, West Coast Region, Portland, OR.

NMFS (National Marine Fisheries Service). 2022c. 2022 5-Year Review: Summary & Evaluation of Middle Columbia River Steelhead. National Marine Fisheries Service, West Coast Region, Portland, OR.

NMFS (National Marine Fisheries Service). 2022d. 2022 5-Year Review: Summary & Evaluation of Snake River spring/summer-run Chinook Salmon. National Marine Fisheries Service, West Coast Region, Portland, OR.

NMFS (National Marine Fisheries Service). 2022e. 2022 5-Year Review: Summary & Evaluation of Snake River fall-run Chinook Salmon. National Marine Fisheries Service, West Coast Region, Portland, OR.

NMFS (National Marine Fisheries Service). 2022f. 2022 5-Year Review: Summary & Evaluation of Snake River Basin Steelhead. National Marine Fisheries Service, West Coast Region, Portland, OR.

NMFS (National Marine Fisheries Service). 2022g. 2022 5-Year Review: Summary & Evaluation of Snake River Sockeye Salmon. National Marine Fisheries Service, West Coast Region, Portland, OR.

NMFS (National Marine Fisheries Service). 2002h. 2022 5-Year Review: Summary & Evaluation of Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, Lower Columbia River Coho Salmon, Lower Columbia River Steelhead. National Marine Fisheries Service, West Coast Region, Portland, OR.

NMFS (National Marine Fisheries Service). 2022i. 2022 5-Year Review: Summary & Evaluation of Oregon Coast Coho Salmon. National Marine Fisheries Service, West Coast Region, Protected Resources Division, Portland Branch.

NMFS (National Marine Fisheries Service). 2022j. 2022 5-Year Review: Summary & Evaluation of Eulachon, Southern DPS. National Marine Fisheries Service, West Coast Region, Protected Resources Division, Portland Branch. 29 July 2022.

NOAA National Centers for Environmental Information (NCEI), State of the Climate: Global Climate Report for Annual 2021, published online January 2022, retrieved on February 28, 2022 from https://www.ncdc.noaa.gov/sotc/global/202113.

Noren, Dawn P., "Estimated field metabolic rates and prey requirements of resident killer whales" (2011). Publications, Agencies and Staff of the U.S. Department of Commerce. 296. https://digitalcommons.unl.edu/usdeptcommercepub/296.

NWFSC (Northwest Fisheries Science Center). 2015. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. December 21, 2015. 357 pp.

ODFW (Oregon Department of Fish and Wildlife). 2017. Umpqua River Basin Coho Salmon Program - South Umpqua River/Cow Creek Coho Salmon Hatchery and Genetic Management Plan (HGMP). 64 pp.

ODFW (Oregon Department of Fish and Wildlife) and NMFS (National Marine Fisheries Service). 2011. Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead. 462 pp.

O'Neill, Sandra M. Gina M. Ylitalo1, and James E. West. Energy content of Pacific salmon as prey of northern and southern resident killer whales. Endangered Species Research. Vol. 25: 265–281, 2014 doi: 10.3354/esr00631.

Osterback, A.M.K., C.H. Kern, E.A. Kanawi, J.M. Perez, and J.D. Kiernan. 2018. The effects of early sandbar formation on the abundance and ecology of coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Oncorhynchus mykiss*) in a central California coastal lagoon. Canadian Journal of Fisheries and Aquatic Sciences. 75 (12): 2184–2197.

Ou, M., T. J. Hamilton, J. Eom, E. M. Lyall, J. Gallup, A. Jiang, J. Lee, D. A. Close, S. S. Yun, and C. J. Brauner. 2015. Responses of pink salmon to CO2-induced aquatic acidification. Nature Climate Change. 5:950-955.

Pacunski, R. E., W. A. Palsson, and H. G. Greene. 2013. Estimating Fish Abundance and Community Composition on Rocky Habitats in the San Juan Islands Using a Small Remotely Operated Vehicle. FPT 13-02. Retrieved from https://wdfw.wa.gov/publications/01453/

Pacunski, R., Lowry, D., Selleck, J., Beam, J., Hennings, A., Wright, E., Hilier, L., Palsson, W., Tsou, T.-S. 2020. Quantficiation of bottomfish populations, and species-specific habitat associations, in the San Juan Islands, WA employing a remotely operated vehicle and a systematic survey design. https://wdfw.wa.gov/sites/default/files/publications/02179/wdfw02179.pdf

Palmer-Zwahlen, M. V. Gusman, and B. Kormos. 2020. Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement, Inland Harvest, and Ocean Harvest in 2016. Report to the U.S. Bureau of Reclamation East Bay Municipal Utilities District by the California Department of Fish and Wildlife and Pacific States Marine Fisheries Commission.

Palmer-Zwahlen, M. V. Gusman, and B. Kormos. 2019. Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement, Inland Harvest, and Ocean Harvest in 2015. Report to the U.S. Bureau of Reclamation East Bay Municipal Utilities

District by the California Department of Fish and Wildlife and Pacific States Marine Fisheries Commission.

Panek, F. M., and C. L. Densmore. 2011. Electrofishing and the effects of depletion sampling on fish health: a review and recommendations for additional study. Khaled bin Sultan Living Oceans Foundation.

Panek, F. M., and C. L. Densmore. 2013. Frequency and Severity of Trauma in Fishes Subjected to Multiple-Pass Depletion Electrofishing. North American Journal of Fisheries Management (Vol. 33, Issue 1, pp. 178–185). https://doi.org/10.1080/02755947.2012.754803

Parker, S. J., H. I. McElderry, P. S. Rankin, and R.W. Hannah. 2006. Buoyancy regulation and barotrauma in two species of nearshore rockfish. Transactions of the American Fisheries Society 135:1213–1223.

Patterson, D.A., Robinson, K.A., Lennox, R.J., Nettles, T.L., Donaldson, L.A., Eliason, E.J., Raby, G.D., Chapman, J.M., Cook, K.V., Donaldson, M.R., Bass, A.L., Drenner, S.M., Reid, A.J., Cooke, S.J., and Hinch, S.G. 2017. Review and Evaluation of Fishing-Related Incidental Mortality for Pacific Salmon. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/010. ix + 155 p.

Pauley, G. B., B. M. Bortz, and M. F. Shepard. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest) -- steelhead trout. U.S. Fish Wildl. Serv. Biol. Rep. 82(11.62). U.S. Army Corps of Engineers, TR EL-82-4. 24 pp.

Peltz, L. and J. Miller. 1990. Performance of half-length coded wire tags in a pink salmon hatchery marking program. American Fisheries Society Symposium 7:244-252.

Pettit, S. W. 1977. Comparative reproductive success of caught-and-released and unplayed hatchery female steelhead trout (*Salmo gairdneri*) from the Clearwater River, Idaho. Transactions of American Fisheries Society. 106(5):431-435.

PFMC (Pacific Fishery Management Council). 2022. Pacific Coast Salmon Fishery Management Plan for Commercial and Recreational Salmon Fisheries off the Coasts of Washington, Oregon, and California as Revised through Amendment 22. PFMC, Portland, OR. 84 p. August 2022.

Pottier, G., M. Nevoux, and F. Marchand. 2020. Electrofishing eel, salmon and trout: impact of waveform and frequency on capture-per-unit-effort and spinal damage. Knowledge & Management of Aquatic Ecosystems. 421: 42. EDP Sciences. https://doi.org/10.1051/kmae/2020034

Prentice, E. F. and D. L. Park. 1984. A study to determine the biological feasibility of a new fish tagging system. Annual Report of Research, 1983-1984. Project 83-19, Contract DEA179-83BP11982.

Prentice, E. F., T. A. Flagg, and C. S. McCutcheon. 1987. A study to determine the biological feasibility of a new fish tagging system, 1986-1987. Bonneville Power Administration, Portland, Oregon.

Prentice, E. F., T. A. Flagg, and C. S. McCutcheon. 1990. Feasibility of using implantable passive integrated transponder (PIT) tags in salmonids. American Fisheries Society Symposium 7: 317-322.

Priborsky, J., and J. Velisek. 2018. A Review of Three Commonly Used Fish Anesthetics. Reviews in Fisheries Science & Aquaculture. 26(4): 417–442. https://doi.org/10.1080/23308249.2018.1442812

Pribyl, A. L., C. B. Schrek, M. L. Kent, and S. J. Parker. 2009. The differential response to decompression of three species of nearshore Pacific rockfish. North American Journal of Fisheries Management 29:1479–1486.

Pribyl A. L., M. L. Kent, S. J. Parker, and C. B. Schreck. 2011. The response to forced decompression in six species of pacific rockfish. Transactions of the American Fisheries Society 140:374–383.

PSTRT (Puget Sound Technical Recovery Team). 2002. Planning Ranges and Preliminary Guidelines for the Delisting and Recovery of the Puget Sound Chinook Salmon Evolutionarily Significant Unit. 30 April 2002.

Raymondi, R. R., J. E. Cuhaciyan, P. Glick, S. M. Capalbo, L. L. Houston, S. L. Shafer, and O. Grah. 2013. Water Resources: Implications of Changes in Temperature and Precipitation *in* Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities, M. M. Dalton, P. W. Mote, and A. K. Snover, Eds., Island Press, Washington, DC, pp. 41-58.

Reeder, W. S., P. R. Ruggiero, S. L. Shafer, A. K. Snover, L. L Houston, P. Glick, J. A. Newton, and S. M. Capalbo. 2013. Coasts: Complex Changes Affecting the Northwest’s Diverse Shorelines. *in* Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities, M. M. Dalton, P. W. Mote, and A. K. Snover, Eds. Island Press, Washington, DC, pp 41-58.

Reingold, M. 1975. Effects of displacing, hooking, and releasing on migrating adult steelhead trout. Transactions of the American Fisheries Society. 104(3):458-460.

Rogers, B. L., C. G. Lowe, E. Fernandez-Juricic, and L. R. Frank. 2008. Utilizing magnetic resonance imaging (MRI) to assess the effects of angling-induced barotrauma on rockfish (*Sebastes*). Canadian Journal of Fisheries and Aquatic Sciences 65:1245-1249.

Rondorf, D. W. and W. H. Miller. 1994. Identification of the spawning, rearing and migratory requirements of fall Chinook salmon in the Columbia River Basin. Prepared for the U.S. Dept. of Energy, Portland, OR. 219 p.

Rupp, D. E., J. T. Abatzoglou, and P. W. Mote. 2017. Projections of 21st century climate of the Columbia River Basin. Climate Dynamics. 49(5), 1783–1799. doi:10.1007/s00382-016-3418-7

Sandercock, F.K. 1991. Life history of coho salmon (*Oncorhynchus kisutch*). In Pacific salmon life histories. Edited by C. Root and L. Marolis. UBC Press, Vancouver, BC. pp. 296 – 445.

Schill, D. J., and R. L. Scarpella. 1995. Wild trout regulation studies. Annual performance report. Idaho Department of Fish and Game, Boise.

Schisler, G. J. and E. P. Bergersen. 1996. Post release hooking mortality of rainbow trout caught on scented artificial baits. North American Journal of Fisheries Management. 16(3):570-578.

Schweigert, J., B. McCarter, T. Therriault, L. Flostrand, C. Hrabok, P. Winchell, and D. Johannessen. 2007. Ecosystem overview: Pacific North Coast Integrated Management Area (PNCIMA), Appendix H: Pelagic fishes. Canadian Technical Report of Fisheries and Aquatic Sciences. 2667.

Schroeder, R. K., K. R. Kenaston, and R. B. Lindsay. 2000. Spring Chinook salmon in the Willamette and Sandy Rivers. October 1998 through September 1999. Annual progress report, Fish Research Project Oregon. Oregon Department of Fish and Wildlife, Portland.

Schroeder, R.K., L.D. Whitman, B. Cannon, and P. Olmsted. 2016. Juvenile life-history diversity and population stability of spring Chinook salmon in the Willamette River basin, Oregon. Canadian Journal of Fisheries and Aquatic Sciences. 73(6), pp.921-934.

Seiler, D., G. Volkhardt, P. Topping, and L. Kishimoto. 2002. 2000 Green River juvenile salmonid production evaluation. Washington Department of Fish and Wildlife.

Seiler, D., G. Volkhardt, P. Topping, L. Fleischer, T. Miller, S. Schonning, D. Rawding, M. Groesbeck, R. Woodard, and S. Hawkins. 2004. 2003 juvenile salmonid production evaluation report. Green River, Wenatchee River, and Cedar Creek. Washington Department of Fish and Wildlife.

Seiler, D., G. Volkhardt, and L. Fleischer. 2005. Evaluation of downstream migrant salmon production in 2004 from the Cedar River and Bear Creek. Washington Department of Fish and Wildlife.

Sharma, R. D. G. Graves, A. Farrell, and N. Mantua. 2016. Investigating Freshwater and Ocean Effects on Pacific Lamprey and Pacific Eulachon of the Columbia River Basin: Projections within the Context of Climate Change. Columbia River Inter-Tribal Fish Commission (CRITFC) Technical Report 16-05. October 2016.

Sharber, N. G. and S. W. Carothers. 1988. Influence of electrofishing pulse shape on spinal injuries in adult rainbow trout. North American Journal of Fisheries Management. 8:117-122.

Sharber, N. G., S. W. Carothers, J. P. Sharber, J. C. DeVos, Jr., and D. A. House. 1994. Reducing electrofishing-induced injury of rainbow trout. North American Journal of Fisheries Management. 14:340-346.

Siegel, J., and L. Crozier. 2020. Impacts of Climate Change on Salmon of the Pacific Northwest: A review of the scientific literature published in 2019. National Marine Fisheries Service, Northwest Fisheries Science Center, Fish Ecology Division. DOI : https://doi.org/10.25923/jke5-c307

Siegle M.R., E.B. Taylor, K.M. Miller, R.E. Withler, and K.L. Yamanaka. 2013. Subtle population genetic structure in yelloweye rockfish (Sebastes ruberrimus) is consistent with a major oceanographic division in British Columbia, Canada. PLoS ONE, 8.

Simpson, W. G., D. P. Peterson, and K. Steinke. 2016. Effect of Waveform and Voltage Gradient on the Survival of Electroshocked Steelhead Embryos and Larvae. North American Journal of Fisheries Management. 36(5): 1149–1155. https://doi.org/10.1080/02755947.2016.1185059

Snyder, D. E. 1995. Impacts of electrofishing on fish. Fisheries. 20(1):26-27

Snyder, D. E. 2003. Invited overview: conclusions from a review of electrofishing and its harmful effects on fish. Reviews in Fish Biology and Fisheries, 13(4), 445–453. https://doi.org/10.1007/s11160-004-1095-9

Souza, C. D. F., M. D. Baldissera, B. Baldisserotto, B. M. Heinzmann, J. A. Martos-Sitcha, and J. M. Mancera. 2019. Essential Oils as Stress-Reducing Agents for Fish Aquaculture: A Review. Frontiers in Physiology, 10. https://doi.org/10.3389/fphys.2019.00785

Spence, B.C., Bjorkstedt, E.P., Garza, J.C., Smith, J.J., Hankin, D.G., Fuller, D.W., Jones, W.E., Macedo, R., Williams, T.H. and Mora, E., 2008. A framework for assessing the viability of threatened and endangered salmon and steelhead in the North-Central California Coast Recovery Domain.

Sridhar, V., Billah, M.M. and Hildreth, J.W. (2018), Coupled Surface and Groundwater Hydrological Modeling in a Changing Climate. Groundwater, 56: 618-635. https://doi.org/10.1111/gwat.12610

SSDC (Shared Strategy Development Committee). 2007. Puget Sound Salmon Recovery Plan. Adopted by the National Marine Fisheries Service January 19, 2007. Available on-line at PS Salmon Recovery Plan weblink

Stachura, M.M., Mantua, N.J. and Scheuerell, M.D., 2014. Oceanographic influences on patterns in North Pacific salmon abundance. Canadian Journal of Fisheries and Aquatic Sciences, 71(2), pp.226-235.

Starr, R. M., J. N. Heine, J. M. Felton, and G. M. Cailliet. 2002. Movements of bocaccio (*Sebastes paucispinis*) and greenspotted (*S. chlorostictus*) rockfishes in a Monterey submarine canyon:

implications for the design of marine reserves. U.S. National Marine Fisheries Service Fishery Bulletin 100:324–337.

Stickney, R.R., 1983. Care and handling of live fish. Fisheries techniques. American Fisheries Society, Bethesda, Maryland, pp.85-94.

Stolte, L. W. 1973. Differences in survival and growth of marked and unmarked coho salmon. Progressive Fish-Culturist 35: 229-230.

Stout, H.A., P.W. Lawson, D. Bottom, T. Cooney, M. Ford, C. Jordan, R. Kope, L. Kruzic, G.Pess, G. Reeves, M. Scheuerell, T. Wainwright, R. Waples, L. Weitkamp, J. Williams and T. Williams. 2012. Scientific conclusions of the status review for Oregon Coast coho salmon (*Oncorhynchus kisutch*). Draft revised report of the Oregon Coast Coho Salmon Biological Review Team. NOAA/NMFS/NWFSC, Seattle, WA.

Strange, C. D. and G. J. Kennedy. 1981. Stomach flushing of salmonids: a simple and effective technique for the removal of the stomach contents. Fish. Manage. 12:9-15.

Sturrock, A.M., Satterthwaite, W.H., Cervantes-Yoshida, K.M., Huber, E.R., Sturrock, H.J., Nusslé, S. and Carlson, S.M., 2019. Eight decades of hatchery salmon releases in the California Central Valley: Factors influencing straying and resilience. Fisheries, 44(9), pp.433-444.

Swain, D.L., Langenbrunner, B., Neelin, J.D. and Hall, A., 2018. Increasing precipitation volatility in twenty-first-century California. Nature Climate Change, 8(5), pp.427-433.

SWFSC (Southwest Fisheries Science Center). 2022. Viability assessment for Pacific salmon and steelhead listed under the Endangered Species Act: Southwest. 11 July 2022 Report to National Marine Fisheries Service – West Coast Region from Southwest Fisheries Science Center, Fisheries Ecology Division 110 McAllister Way, Santa Cruz, California 95060.

TAC [TAC (U.S. v. Oregon Technical Advisory Committee)]. 2008. Biological assessment of incidental impacts on salmon species listed under the Endangered Species Act in the 2008-2017 non-Indian and treaty Indian fisheries in the Columbia River Basin.

Taylor, G. and R. A. Barnhart. 1999. Mortality of angler caught and released steelhead. California Cooperative Fish and Wildlife Research Unit, Arcata.

Taylor, M. J. and K. R. White. 1992. A meta-analysis of hooking mortality of non-anadromous trout. North American Journal of Fisheries Management. 12:760-767.

Teles, M., Oliveira, M., Jerez-Cepa, I., Franco-Martínez, L., Tvarijonaviciute, A., Tort, L., & Mancera, J. M. 2019. Transport and Recovery of Gilthead Sea Bream (*Sparus aurata L.*) Sedated With Clove Oil and MS222: Effects on Oxidative Stress Status. Frontiers in Physiology, 10. https://doi.org/10.3389/fphys.2019.00523

Thompson, K. G., E. P. Bergersen, R. B. Nehring, and D. C. Bowden. 1997. Long-term effects of electrofishing on growth and body condition of brown and rainbow trout. North American Journal of Fisheries Management. 17:154-159.

Tillmann, P., and D. Siemann. 2011. Climate Change Effects and Adaptation Approaches in Marine and Coastal Ecosystems of the North Pacific Landscape Conservation Cooperative Region. National Wildlife Federation.

Tolimieri, N. and P. S. Levin. 2005. The roles of fishing and climate in the population dynamics of bocaccio rockfish. Ecological Applications 15:458-468.

Tonina, D., McKean, J. A., Isaak, D., Benjankar, R. M., Tang, C., & Chen, Q. 2022. Climate change shrinks and fragments salmon habitats in a snow-dependent region. Geophysical Research Letters, 49, e2022GL098552. https://doi. org/10.1029/2022GL098552

Tonnes, D.M., M. Bhuthimethee, J. Sawchuk, N. Tolimieri, K. Andrews, and K. Nichols. 2016. Yelloweye rockfish (Sebastes ruberrimus), canary rockfish (Sebastes pinniger), and bocaccio (Sebastes paucispinis) of the Puget Sound/Georgia Basin. 5-Year Review. National Marine Fisheries Service. Seattle, WA.

UCSRB (Upper Columbia Salmon Recovery Board). 2007. Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan. 352 pp.

USDC (United States Department of Commerce). 2009. Endangered and threatened wildlife and plants: final rulemaking to designate critical habitat for the threatened southern distinct population segment of North American green sturgeon. U.S. Department of Commerce, National Marine Fisheries Service. Federal Register 74(195):52300-52351.

USFWS (United States Fish and Wildlife Service) and NMFS (National Marine Fisheries Service). 1998. Endangered Species Consultation Handbook Procedures for Conducting Consultation and Conference Activities Under Section 7 of the Endangered Species Act. U.S. Fish &Wildlife Service and National Marine Fisheries Service.

Van Doornik, D.M., Hess, M.A., Johnson, M.A., Teel, D.J., Friesen, T.A. and Myers, J.M., 2015. Genetic population structure of Willamette River steelhead and the influence of introduced stocks. Transactions of the American Fisheries Society, 144(1), pp.150-162.

Vander Haegen, G.E., Ashbrook, C.E., Yi, K.W., and Dixon, J.F. 2004. Survival of spring Chinook salmon captured and released in a selective commercial fishery using gill nets and tangle nets. Fisheries Research. 68(1-3): 123-133.

Vander Haegen, G.E., Blankenship, H.L., Hoffmann, A. and Thompson, D.A., 2005. The effects of adipose fin clipping and coded wire tagging on the survival and growth of spring Chinook salmon. North American Journal of Fisheries Management. 25(3): 1161-1170.

Volkhardt, G., P. Topping, L. Fleischer, T. Miller, S. Schonning, D. Rawding, M. Groesbeck. 2005. 2004 Juvenile salmonid production evaluation report. Green River, Wenatchee River, and Cedar Creek. Washington Department of Fish and Wildlife.

Vose, R. S., D. R. Easterling, K. E. Kunkel, A. N. LeGrande, and M. F. Wehner. 2017. Temperature Changes in the United States. Climate Science Special Report: Fourth National Climate Assessment, Volume I. Wuebbles, D. J., D. W. Fahey, K. A. Hibbard, D. J. Dokken, B. C.

Stewart, and T. K. Maycock, Eds., U.S. Global Change Research Program, Washington, DC, USA, 185–206. doi:10.7930/J0N29V45

Wagner, G. N., T. D. Singer, and R. Scott McKinley. 2003. The ability of clove oil and MS-222 to minimize handling stress in rainbow trout (*Oncorhynchus mykiss Walbaum*). Aquaculture Research. 34(13): 1139–1146. https://doi.org/10.1046/j.1365-2109.2003.00916.x

Wainwright, T. C. and L. A. Weitkamp. 2013. Effects of Climate Change on Oregon Coast Coho Salmon: Habitat and Life-Cycle Interactions. Northwest Science. 87:219-242.

Waples, R. S. 1991. Definition of "Species" under the Endangered Species Act: Application to Pacific Salmon. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS, F/NWC-194. 29 pp.

Ward, B. R. and P. A. Slaney. 1993. Egg-to-smolt survival and fry-to-smolt density dependence in Keogh River steelhead trout, p. 209-217. *In* R. J. Gibson and R. E. Cutting [ed.] Production of juvenile Atlantic salmon, *Salmon salar*, in natural waters. Can. Spec. Publ. Fish. Aquat. Sci. 118.

Ward, E.J., M.J. Ford, R.G. Kope, J.K.B. Ford, L.A. Velez-Espino, C.K. Parken, L.W. LaVoy, M.B. Hanson, and K.C. Balcomb. 2013. Estimating the impacts of Chinook salmon abundance and prey removal by ocean fishing on Southern Resident killer whale population dynamics. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-123.

Ward, T. D., Brownscombe, J. W., Gutowsky, L. F. G., Ballagh, R., Sakich, N., McLean, D., Quesnel, G., Gambhir, S., O'Connor, C. M., & Cooke, S. J. 2017. Electric fish handling gloves provide effective immobilization and do not impede reflex recovery of adult Largemouth bass. North American Journal of Fisheries Management, 37(3), 652–659. https://doi.org/10.1080/02755947.2017.1303558

Warner, M. D., C. F. Mass, and E. P. Salathe. 2015. Changes in Winter Atmospheric Rivers along the North American West Coast in CMIP5 Climate Models. Journal of Hydrometeorology 16(1):118–128.

WDFW (Washington Department of Fish and Wildlife). 2022. Final 2022 Future Brood Document. July 2022. Available at: https://wdfw.wa.gov/fishing/management/hatcheries/future-brood

Weitkamp, L.A., Wainwright, T.C., Bryant, G.J., Milner, G.B., Teel, D.J., Kope, R.G. and Waples, R.S., 1995. Status review of coho salmon from Washington, Oregon, and California. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

Welch, H.E. and K. H. Mills. 1981. Marking fish by scarring soft fin rays. Canadian Journal of Fisheries and Aquatic Sciences 38:1168-1170.

Westerling, A. L. 2018. Wildfire Simulations for California's Fourth Climate Change Assessment: Projecting Changes in Extreme Wildfire Events with a Warming Climate: a Report for California's Fourth Climate Change Assessment. Sacramento, CA: California Energy Commission.

Whitney, J.E., R. Al-Chokhachy, D.B. Bunnell, C. A. Caldwell, S. J. Cooke, E. J. Eliason, M. Rogers, A. J. Lynch, and C. P. Paukert. 2016. Physiological Basis of Climate Change Impacts on North American Inland Fishes, Fisheries, 41:7, 332-345, DOI: 10.1080/03632415.2016.1186656

Wiles, G. J. 2004. Washington State Status Report for the Killer Whale. March 2004. WDFW, Olympia, Washington. 120p.

Williams, T. H., E. P. Bjorkstedt, W. G. Duffy, D. Hillemeier, G. Kautsky, T. E. Lisle, M. McCain, M. Rode, R. G. Szerlong, R. S. Schick, M. N. Goslin, and A. Agrawal. 2006. Historical population structure of coho salmon in the southern Oregon/northern California coasts evolutionarily significant unit. Southwest Fisheries Science Center (SWFSC). Available at: https://kbifrm.psmfc.org/wp-content/uploads/2017/01/Williams-et-al_2006_0194_Historical-population-structure.pdf

Williams, T. H., B. C. Spence, W. Duffy, D. Hillemeier, G. Kautsky, T. E. Lisle, M. McCain, T. E. Nickelson, E. Mora, and T. Pearson. 2008. Framework for assessing viability of threatened coho salmon in the southern Oregon/northern California coast evolutionarily significant unit. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-TM-SWFSC-432.

Williams, R., M. Krkos, E. Ashe, T. A. Branch, S. Clark, P. S. Hammond, E. Hoyt, D. P. Noren, D. Rosen, and A. Winship. 2011. Competing Conservation Objectives for Predators and Prey: Estimating Killer Whale Prey Requirements for Chinook Salmon. PLoS ONE. 6(11): e26738.

Williams, T.H., B.C. Spence, D.A. Boughton, R.C. Johnson, L.G. Crozier, N.J. Mantua, M.R. O'Farrell, and S.T. Lindley. 2016. Viability assessment for Pacific salmon and steelhead listed under the Endangered Species Act: Southwest. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-564.

Williams, C. R., A. H. Dittman, P. McElhany, D. S. Busch, M. T. Maher, T. K. Bammler, J. W. MacDonald, and E. P. Gallagher. 2019. Elevated CO2 impairs olfactory-mediated neural and behavioral responses and gene expression in ocean-phase coho salmon (Oncorhynchus kisutch). 25:963-977.

Williams, T.H., B.C. Spence, D.A. Boughton, F. Cordoleani, L. Crozier, R.C. Johnson, N. Mantua, M. O'Farrell, K. Pipal, L. Weitkamp, and S.T. Lindley. 2021. DRAFT Viability assessment for Pacific salmon and steelhead listed under the Endangered Species Act: Southwest. 20 February 2021 Report to National Marine Fisheries Service – West Coast Region from Southwest Fisheries Science Center, Fisheries Ecology Division 110 Shaffer Road, Santa Cruz, California 95060.

Winder, M. and D. E. Schindler. 2004. Climate change uncouples trophic interactions in an aquatic ecosystem. Ecology. 85:2100–2106.

Wissmar, R. C., J. E. Smith, B. A. McIntosh, H. W. Li, G. H. Reeves, and J. R. Sedell. 1994. Ecological Health of River Basins in Forested Regions of Eastern Washington and Oregon. Gen. Tech. Rep. PNW-GTR-326. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. Portland, OR. 65 p.

Wydoski, R. S. 1977. Relation of hooking mortality and sublethal hooking stress to quality fishery management. Pages 43-87 in R.A. Barnhart and T.D. Roelofs, editors. Proceedings of a national symposium on catch-and-release fishing as a management tool. Humboldt State University, Arcata, California.

Yamanaka, K. L., L. C. Lacko, R. Witheler, C. Grandin, J. K. Lochead, J.-C. Martin, N. Olsen, and S. S. Wallace. 2006. A review of yelloweye rockfish *Sebastes ruberimus* along the Pacific coast of Canada: biology, distribution, and abundance trends. Research Document 2006/076. Fisheries and Oceans Canada. 54pp.

Yan, H., N. Sun, A. Fullerton, and M. Baerwalde. 2021. Greater vulnerability of snowmelt-fed river thermal regimes to a warming climate. Environmental Research Letters 16(5). https://doi.org/10.1088/1748-9326/abf393

Young, T., Walker, S. P., Alfaro, A. C., Fletcher, L. M., Murray, J. S., Lulijwa, R., & Symonds, J. 2019. Impact of acute handling stress, anaesthesia, and euthanasia on fish plasma biochemistry: implications for veterinary screening and metabolomic sampling. Fish Physiology and Biochemistry, 45(4), 1485–1494. https://doi.org/10.1007/s10695-019-00669-8

Zabel, R. W., M. D. Scheuerell, M. M. McClure, and J. G. Williams. 2006. The interplay between climate variability and density dependence in the population viability of Chinook salmon. Conservation Biology. 20(1):190-200.

Zabel, R. W. 2017a. Memorandum for Christopher E. Yates: Update, Corrected Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin in 2016. Northwest Fisheries Science Center. January 25, 2017.

Zabel, R. W. 2017b. Memorandum for Chris Yates: Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin in 2017. Northwest Fisheries Science Center. November 3, 2017.

Zabel, R. W. 2018. Memorandum for Chris Yates: Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin in 2018. Northwest Fisheries Science Center. December 18, 2018.

Zabel, R. W. 2020. Memorandum for Chris Yates: Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin in 2019. Northwest Fisheries Science Center. February 13, 2020.

Zabel, R. W. 2021. Memorandum for Chris Yates: Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin in 2020. Northwest Fisheries Science Center. March 10, 2021.

Zamon, J. E., T. J. Guy, K. Balcomb, and D. Ellifrit. 2007. Winter observations of Southern Resident Killer Whales (Orcinus orca) near the Columbia River plume during the 2005 spring Chinook salmon (Oncorhynchus tshawytscha) spawning migration. Northwestern Naturalist 88:193-198