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

NMFS Consultation Number: WCRO-2022-02398
ARN 151422WCR2022PR00183

Action Agencies: The National Marine Fisheries Service (NMFS)
The United States Geological Survey (USGS)
The Bureau of Indian Affairs (BIA)
The United States Fish and Wildlife Service (USFWS)
The National Park Service (NPS)

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 (*Oncorhynchus tshawytscha*)	Threatened	Yes	No	No	No
PS steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Hood Canal summer-run (HCS) chum salmon (*O. keta*)	Threatened	Yes	No	No	No
Upper Columbia River (UCR) spring-run Chinook salmon (*O. tshawytscha*)	Endangered	Yes	No	No	No
Upper Columbia River (UCR) steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Middle Columbia River (MCR) steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Snake River (SnkR) spring/summer-run (spr/sum) Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No

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?
Snake River (SnkR) steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Snake River (SnkR) sockeye salmon (*O. nerka*)	Endangered	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
California Coastal (CC) Chinook salmon (*O. 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
sDPS green sturgeon (*Acipenser medirostris*)	Threatened	Yes	No	No	No
Southern Resident (SR) killer whale (*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:

For Scott M. Rumsey, Ph.D.
Acting Regional Administrator

Date: September 30, 2022

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List of Acronyms

ARN – Administrative Record Number
BIA – Bureau of Indian Affairs
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
CDFW – California Department of Fish and Wildlife
CFR – Code of Federal Regulation
CH – Critical Habitat
CHART – Critical Habitat Analytical Review Teams
CVS – Central Valley spring-run
CWT – Coded Wire Tag
DC – Direct Current
DFO – Department of Fisheries and Oceans
DIDSON – Dual Frequency Identification Sonar
DPS – Distinct Population Segment
DQA – Data Quality Act
EFH – Essential Fish Habitat
ESA – Endangered Species Act
ESU – Evolutionarily Significant Unit
FR – Federal Register
HCS – Hood Canal summer-run
HUC5 – Hydrologic Unit Code (fifth-field)
ICTRT – Interior Columbia Technical Recovery Team
IDFG – Idaho Department of Fish and Game
IM – Intentional (Directed) Mortality
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
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
PBF – Physical or Biological Features
PCE – Primary Constituent Element
PSFMC – Pacific States Marine Fisheries Commission
PIT – Passive Integrated Transponder
PS – Puget Sound

RPM – Reasonable and Prudent Measure
SacR – Sacramento River
SBT – Shoshone-Bannock Tribes
sDPS – Southern Distinct Population Segment
SnkR – Snake River
spr/sum – spring/summer run
SRKW – Southern Resident Killer Whale
TRT – Technical Recovery Team
UCR – Upper Columbia River
USFWS – United States Fish and Wildlife Service
USGS –United States Geological Survey
UWR – Upper Willamette River
VSP – Viable Salmonid Population
WCR – West Coast Region
WDFW – Washington Department of Fish and Wildlife
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 U.S.C. 1531 et seq.), as amended, and implementing regulations at 50 CFR part 402. It constitutes a review of seventeen 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 seventeen applications for permits to conduct scientific research in Washington, Oregon, Idaho and California (see Table 1 and the text following it):

- fourteen applications were to renew existing permits; and
- three 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) spring/summer run
  - Upper Willamette River (UWR)

  - Central Valley spring-run (CVSR)
  - Sacramento River winter-run (SacRWR)
  - California Coastal (CC)
  - Central Valley spring-run (CVS)
- Coho salmon
  - Oregon Coast (OC)
  - Central California Coast (CCC)
- Chum salmon
  - Hood Canal summer-run (HCS)
- Sockeye salmon
  - Snake River (SnkR)
- Steelhead
  - Puget Sound (PS)
  - Upper Columbia River (UCR)
  - Middle Columbia River (MCR)
  - Snake River Basin (SnkR)
  - California Central Valley (CCV)
  - Central California Coast (CCC)
  - South-Central California Coast (SCCC)
- Southern DPS Eulachon
- Southern DPS (SDPS) Green sturgeon

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

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

Permit	Applicant	State
1124-7R	Idaho Department of Fish and Game	ID
1585-5R	Washington Department of Natural Resources	WA
14283-4R	Environmental Assessment Services	WA
15730-3R	Salmon Protection and Watershed Network	CA
16110-3R	Marin Municipal Water District	CA
16417-4R	Santa Clara Valley Water District	CA
16446-3R	Confederated Tribes of the Umatilla Indian Reservation	OR/WA
16979-3R	Washington Department of Fish and Wildlife	WA
17428-4R	U.S. Fish and Wildlife Service	CA
17851-4R	Coastal Watershed Institute	WA
18001-4R	Pierce County Washington Department of Public Works and Utilities	WA
20792-2R	FISHBIO Inc.	CA
21571-3R	U.S. Geological Survey	WA
22127-2R	U.S. Fish and Wildlife Service	WA
26368	Idaho State University	ID
26412	FISHBIO Inc.	CA
26626	National Park Service	WA

Permit 1124-7R – We received a permit renewal request from the Idaho Department of Fish and Game (IDFG) on March 28, 2022. Edits and clarifications were requested and discussed and the application was completed on August 4, 2022.

Permit 1585-5R – We received a permit renewal request from the Washington Department of Natural Resources (WDNR) on January 10, 2022. The application was reviewed and determined to be complete on August 1, 2022.

Permit 14283-4R – We received a permit renewal request from Environmental Assessment Services (EAS) on March 30, 2022. Edits and clarifications were requested and discussed and the application was completed on August 11, 2022.

Permit 15730-3R – We received a permit renewal request from Salmon Protection and Watershed Network (SPAWN) on April 1, 2022. The application was reviewed and determined to be complete on August 29, 2022.

Permit 16110-3R – We received a permit renewal request from the Marin Municipal Water District (Marin Water) on July 20, 2022. The application was reviewed and determined to be complete on August 29, 2022.

Permit 16417-4R – We received a permit renewal request from the Santa Clara Valley Water District (SCVWD) on March 25, 2022. The application was reviewed and determined to be complete on August 29, 2022.

Permit 16446-3R – We received a permit renewal request from the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) on March 2, 2022. Edits and clarifications were requested and discussed and the application was completed on August 1, 2022.

Permit 16979-3R – We received a permit renewal request from the Washington Department of Fish and Wildlife (WDFW) on March 30, 2022. Edits and clarifications were requested and discussed and the application was completed on August 17, 2022.

Permit 17428-4R – We received a permit renewal request from the U.S. Fish and Wildlife Service (USFWS) on April 8, 2022. Edits and clarifications were requested and discussed, and the application was completed on August 29, 2022.

Permit 17851-4R – We received a permit renewal request from the Coastal Watershed Institute (CWI) on March 15, 2022. After review edits and clarifications were requested and discussed, and the application was completed on August 1, 2022.

Permit 18001-4R – We received a permit renewal request from the Pierce County, Washington, Department of Public Works and Utilities (Pierce County) on March 28, 2022. The application was reviewed and determined to be complete on August 1, 2022.

Permit 20792-2R – We received a permit renewal request from FISHBIO, Inc. (FISHBIO) on March 7, 2022. Edits and clarifications were requested and discussed, and the application was completed on August 29, 2022.

Permit 21571-3R – We received a permit renewal request from the United States Geological Survey (USGS) on March 30, 2022. Edits and clarifications were requested and discussed and the application was completed on August 1, 2022.

Permit 22127-2R – We received a permit renewal request from the U.S. Fish and Wildlife Service (USFWS) on March 23, 2022. The application was reviewed and determined to be complete on August 1, 2022.

Permit 26368 – We received an application for a new permit from Idaho State University on December 31, 2021. Edits and clarifications were requested and discussed and the application was completed on August 1, 2022.

Permit 26412 – We received an application for a new permit from FISHBIO on May 10, 2022. The application was reviewed and determined to be complete on August 29, 2022.

Permit 26626 – We received a request for assistance with an application for a new permit from the National Park Service (NPS) on April 11, 2022. Edits and clarifications were requested and discussed and the application was submitted on June 13, 2022. The application was reviewed and determined to be complete on August 1, 2022.

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 August 29, 2022 asking for public comment on them (87 FR 52745). The public was given 30 days to comment on the permit applications and, once those periods closed on September 28, 2022, the consultation was formally initiated on September 29, 2022). 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.

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

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 action here is NMFS' issuance of seventeen 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 or not the proposed action would cause any other activities and determined that it would not.

Some of the activities identified in the sections below would be funded or carried out in part by Federal agencies including USGS, USFWS, BIA, and NPS, and NMFS would authorize them. These agencies are responsible for complying with Section 7 of the ESA. Because this consultation examines the actions they propose to fund, it also fulfills their section 7 consultation obligations with respect to the funding, since the funding of the action would not raise any potential for effects on ESA-listed salmonids, sturgeon, and eulachon beyond those already raised in consideration of the underlying actions themselves.

Permit 1124-7R

Under permit 1124-7R, the IDFG is seeking to renew for 5 years a permit that would authorize them to continue five research projects they have been conducting in the Snake River basin for over 20 years. The permit would continue to cover the following actions: one general fish population inventory; one project designed to monitor SnkR spr/sum Chinook salmon natural production; one project researching kokanee and SnkR sockeye salmon populations in three lakes in the upper Salmon River subbasin; one project monitoring salmon and steelhead fish health; and one project monitoring natural steelhead production. Under the permit, the IDFG would continue to take adult and juvenile SnkR spr/sum Chinook salmon, SnkR steelhead, and SnkR sockeye salmon in mainstem and tributary habitat throughout the Snake, Clearwater, and Salmon River subbasins.

Juveniles would be collected via screw trap, hook-and-line angling, backpack electrofishing and, in the Stanley Basin lakes, midwater trawls. Juvenile fish would be captured, handled (anesthetized, weighed, measured, and checked for marks or tags), and released. A subsample of captured juveniles would be anesthetized, tissue sampled and implanted with passive integrated transponder (PIT) tags before being released. A further subsample of captured sockeye juveniles would be intentionally sacrificed for genetic analysis. Adults captured at traps and weirs would be handled (anesthetized, weighed, measured, and checked for marks or tags), and released. In addition, tissues may be collected from carcasses encountered during spawning surveys. Other than the juveniles that would be sacrificed for genetic analysis, the researchers are not planning to kill any additional listed fish, however a further small number may be killed as an inadvertent result of the proposed activities.

Permit 1585-5R

Under permit 1585-5R the WDNR is seeking to renew for 5 years a permit that would authorize them to continue to take juvenile PS Chinook salmon, PS steelhead, HCS chum salmon, and southern DPS eulachon in streams on WDNR land in the central Puget Sound Basin (Mason, Kitsap, King, Pierce, Thurston, Snohomish and Lewis counties in Washington). The purpose of the work is to determine whether listed fish are present in the small streams of those watersheds. Juvenile salmonids would be collected via backpack electrofishing, handled (anesthetized, weighed, measured, and checked for marks or tags), and released. The permit would also allow WDNR to take adult Southern DPS eulachon—a species for which there are currently no take prohibitions—where they may be encountered in the Lower Chehalis River. Eulachon are not being targeted but may unintentionally be captured.

The captured fish would be identified 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 information gathered would be used to 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.

Permit 14283-4R

Under permit 14283-4R, EAS is seeking to renew for 5 years a permit that would authorize them to continue to take juvenile and adult UCR spring-run Chinook salmon, UCR steelhead, and MCR steelhead to support the U.S. Department of Energy's Hanford Site Cleanup Mission and regulatory drivers under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The research would take place various locations in the Columbia River, extending from a point upstream of Wanapum Dam to an area a few kilometers above the confluence of the Columbia and Yakima Rivers. Juveniles would be collected via backpack electrofishing, boat electrofishing, hook-and-line angling, longline, and beach seine. Juvenile fish would be captured, handled (anesthetized, weighed, measured, and checked for marks or tags), and released. Adults would be collected via hook and line angling, longline, and beach seine. No adults would be captured during electrofishing activities, and if any were to be encountered, the equipment would immediately be turned off and the fish allowed to swim away. Captured adults would be handled (anesthetized, weighed, measured, and checked for marks or tags), and released. The research would benefit listed fish by helping monitor and reduce contamination from the Hanford Nuclear Reservation. The researchers do not propose to kill any listed fish but a small number may inadvertently be killed by the activities.

Permit 15730-3R

Under permit 15730-3R the SPAWN is seeking to renew for 5 years a permit that would authorize them to continue to take juvenile CC Chinook salmon, CCC coho salmon, and CCC steelhead in Lagunitas Creek and its tributaries in Marin County, California, in order to provide baseline, habitat, and monitoring data for juvenile and adult ESA-listed salmonids throughout the CCC coho range. Juveniles would be collected via fyke net and would be captured, handled (enumerated, measured, and checked for marks or tags), and released. A subsample of captured juveniles would be anesthetized, tissue sampled, and marked before being released. Spawned adults or post-spawn carcasses would be enumerated during spawning surveys, and tissue samples may be collected. The researchers are not proposing to kill any of the listed fish being captured, but a small number may be killed as an inadvertent result of these activities. The research is expected to benefit listed species by providing data to inform future research, restoration, and conservation efforts involving *Oncorhynchus* species.

Permit 16110-3R

Under permit 16110-3R Marin Water is seeking to renew for 5 years a permit that would authorize them to continue to take adult and juvenile CC Chinook salmon, CCC coho salmon, and CCC steelhead in order to document trends in coho salmon abundance, determine freshwater and marine survival rates for coho salmon, assess the relationship between population trends and management efforts, and determine which coho life stage has the lowest survival rates. Juveniles would be collected via screw trap and backpack electrofishing and observed during snorkel surveys. Juvenile fish would be captured, handled (enumerated, measured, and checked for marks or tags), and released. A subsample of captured juveniles would be anesthetized, tissue sampled and PIT-tagged prior to release.

Adults would be observed during snorkel surveys and spawning surveys and, although screw traps do not target adult fish, some adult CCC steelhead moving downstream may be collected at a screw trap in Lagunitas Creek. Any adults collected in this way would be handled (enumerated, checked for marks or tags), and released. Spawned adults or post-spawn carcasses would be enumerated during spawning surveys, and tissues may be collected from any carcasses at that time. The researchers are not proposing to kill any of the listed fish being captured, but a small number may be killed as an inadvertent result of these activities. This research is expected to benefit the listed species by providing information on population trends in watersheds impacted by Marin Water's water supply operations and thereby help managers tailor those operations in ways designed to help achieve recovery goals.

Permit 16417-4R

Under permit 16417-4R the SCVWD is seeking to renew for 5 years a permit that would authorize them to continue to take juvenile and adult CCC steelhead and juvenile S-CCC steelhead in the Coyote Creek, Guadalupe River, Pajaro Creek, and Stevens Creek watersheds and Lake Almaden.

The work would continue to help fill data gaps with regard to *O. mykiss* distribution and habitat usage in Santa Clara County, California. The data to be gathered would also be used to improve understanding of fish migrations in the context of SCVWD water operations and monitor efforts to remediate total maximum daily mercury loads in the county.

Juveniles would be collected via beach seining and backpack electrofishing, and observations would be conducted at weirs, fish ladders, and dams where no trapping occurs. Captured juvenile fish would be handled (anesthetized, weighed, measured, and checked for marks or tags), enumerated, and released. A subsample of captured juveniles would be anesthetized, tissue sampled and PIT-tagged prior to release. Spawning surveys would be conducted without disturbing redds, and adults would be observed (live and by video) at weirs, fish ladders, dams. The researchers are not proposing to kill any of the listed fish being captured, but a small number may be killed as an inadvertent result of these activities. The research is expected to benefit listed species by improving alignment of water supply management and fisheries needs to help steelhead survive and recover.

Permit 16446-3R

Under permit 16446-3R, the CTUIR is seeking to renew for 5 years a permit that would authorize them to continue to take juvenile MCR steelhead during the course of research designed to monitor listed fish population status in the Walla Walla River watershed, Washington. The data gathered on fish abundance, trends, genetics, diversity, productivity, and population structure would be used to inform management decisions regarding land use activities and recovery planning in the Walla Walla subbasin. The researchers would use rotary screw traps and backpack electrofishing units to capture the fish. At the screw traps, the fish would then be identified, measured, weighed, tissue sampled, and implanted with PIT-Tags (if they do not already have tags). Fish captured via electrofishing would be handled, measured, allowed to recover, and released in a safe area. Some adult carcasses would also be sampled. If fish are found in areas experiencing low flows, those fish could be relocated to safer areas. The CTUIR researchers are not proposing to kill any of the listed fish being captured, but a small number may be killed as an inadvertent result of these activities.

Permit 16979-3R

Under permit 16979-3R, the WDFW is seeking to renew for 5 years a permit that would authorize them to continue to take adult and juvenile UCR spring-run Chinook salmon and UCR steelhead while collecting data on their abundance, status, distribution, diversity, species/ecological interactions, and behavior in the Columbia River—from its confluence with the Yakima River upstream to Chief Joseph Dam in Washington. The research would benefit fish by helping managers (a) understand the distribution and proportion of hatchery and natural origin steelhead, and Chinook in UCR tributaries, (b) understand the influences of other biotic and abiotic factors with respect to recovering listed species, (c) understand the potential effects of proposed land use practices, (d) determine appropriate regulatory and habitat protection measures in the areas where land use actions are planned, (e) project the impacts of potential hydraulic projects, and (f) evaluate the effectiveness of local forest practices and instream habitat improvement projects in terms of their ability to protect and enhance listed salmonid populations.

The WDFW researchers would capture fish via a wide variety of means (snorkeling, dip netting, seining, using electrofishing equipment, traps and weirs, and barbless hook-and-line sampling). The captured fish would be variously tissue sampled, measured, tagged, allowed to recover, and released. The researchers do not intend to kill any of the fish being captured, but a small percentage of them may inadvertently be killed as a result of the proposed activities.

Permit 17428-4R

Under permit 17428-4R, the USFWS, in collaboration with researchers from the Pacific States Marine Fisheries Commission (PSMFC) is seeking to renew for 5 years a permit that would authorize them to continue to take adult SacR winter-run Chinook salmon and CVS Chinook salmon, and juvenile and adult CCV steelhead in the lower American River and lower Stanislaus River, California, in order to monitor the abundance of juvenile salmon, infer biological responses to ongoing habitat restoration activities, and generate data for salmon life-cycle models. Juveniles would be collected via screw trap and would be handled (anesthetized, enumerated, measured, and checked for marks or tags), and released. A subsample of captured juveniles would be anesthetized, tissue sampled, and PIT-tagged prior to release. Although screw traps do not target adult fish, some adult steelhead moving downstream may be collected at screw traps. Any adults collected in this way would be handled (enumerated, checked for marks or tags), and released. Spawned adults or post-spawn carcasses that drift into the screw traps would also be enumerated and tissues may be collected from any carcasses encountered.

The researchers are not proposing to kill any of the listed fish being captured, but a small number may be killed as an inadvertent result of these activities. This work would benefit listed species by providing information on whether management activities should be modified to enhance the abundance, production, condition, and survival of juvenile CVS Chinook Salmon and CCV Steelhead in the American and Stanislaus Rivers. Improving life-cycle models would also provide insight on factors affecting abundance and help managers develop actions to address and mitigate those factors.

Permit 17851-4R

Under permit 17851-4R, the CWI is seeking to renew for 5 years a permit that would authorize them to continue to take juvenile PS Chinook salmon, PS steelhead, HCS chum salmon, and southern DPS eulachon at the estuary of the Elwha River, Washington. The purpose of the work is to define the nearshore restoration response to Elwha dam removals—with an emphasis on ecological function of nearshore habitats for juvenile salmon and forage fish. Juvenile salmonids would be collected via beach seine, handled (identified, weighed, measured, and checked for marks or tags), and released. The permit would also allow CWI to take adult Southern DPS eulachon—a species for which there are currently no take prohibitions—via beach seine. Eulachon are not being targeted but may unintentionally be captured, and would be handled and released. The researchers are not proposing to kill any of the listed fish being captured, but a small number may be killed as an inadvertent result of these activities.

This research would provide information beneficial to ESA-listed and unlisted native fish by defining nearshore habitat use by key species before, during, and after dam removal. This information will allow managers to identify if adaptive management, sediment management, or additional restoration considerations are warranted in the Elwha River estuary following dam removal. This work will also provide information on nearshore habitat response to dam removal that is relevant to co-managers of other ESA-listed salmon and steelhead on the West Coast.

Permit 18001-4R

Under permit 18001-4R, Pierce County is seeking to renew for 5 years a permit that would authorize them to continue to take adult PS Chinook salmon and PS steelhead in the waterways of Pierce County, Washington, in order to determine the distribution and diversity of anadromous fish species in the waterbodies adjacent to and within the County's jurisdiction. Juvenile salmonids would primarily be collected via beach seine and backpack electrofishing, although fish capture methods could also include dip nets or minnow traps. Juvenile fish would be captured, handled (weighed, measured, and checked for marks or tags), and released. Adults could also potentially be encountered during beach seining and, if they are, adult PS Chinook salmon and PS steelhead would be handled (weighed, measured, and checked for marks or tags), and released. All captured fish would be released into the same stream reach from which they were collected. 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.

These surveys would help establish listed salmonid presence in waterbodies about which this is currently little or inconclusive data. This information would be used to assess the impacts proposed projects might have on listed species and to guide decisions on where future projects should be implemented. The research would benefit PS Chinook salmon and PS steelhead by helping Pierce County develop a best management practices program, codify in-water work timing windows that would minimize harm to listed fish, and plan future habitat enhancement projects.

Permit 20792-2R

Under permit 20792-2R, FISHBIO is seeking to renew a permit that would authorize them to continue to take adult CVS Chinook salmon, CCV steelhead, and southern DPS green sturgeon in the San Joaquin River and South Delta in California in order to detail the relative abundance and distribution of predatory fishes (*i.e.,* striped, largemouth, spotted, and smallmouth bass, and catfishes) and characterize the diets of predators to determine how habitat and environmental conditions affect the composition of the non-native fish community. Data collected on non-native resident fishes will help identify areas of elevated predator abundance and improve understanding of predation impacts on juvenile salmonids migrating through this region. Listed species are not being targeted by this work, although some may be unintentionally encountered or captured. Juveniles and adults would be collected via boat electrofishing, and those captured would be handled (enumerated, measured, checked for marks or tags), their health assessed, and released. No listed species would be tagged during the course of this study; any captured listed species would be measured and released. The researchers are not proposing to kill any of the listed fish being captured, but a small number of juveniles may be killed as an inadvertent result of these activities. This project is likely to benefit listed species by better delineating the abundance and distribution of non-native fish species that prey upon them.

Permit 21571-3R

Under permit 21571-3R, the USGS is seeking to renew for 5 years a permit to conduct research on migration survival among MCR steelhead in the Yakima River system in Washington State. The research would look at how well the listed fish are surviving passage through various reaches of the Yakima River. The USGS researchers would capture juvenile MCR steelhead and tag them with acoustic and PIT tags. They would then use PIT tag detectors and acoustic receivers to follow the fish as they move downstream. The researchers would also use boat electrofishing equipment to count predators in several reaches, but they would not use that equipment to capture any listed animals for handling and adult steelhead would be avoided in all cases.

The research would benefit the listed fish by helping managers understand what survival risks the young salmonids face when migrating downriver in the Yakima system. River co-managers would then be able to use that information to take actions designed to increase fish survival. The USGS researchers do not intend to kill any listed animals, but a small number may die as an inadvertent result of the planned activities.

Permit 22127-2R

Under permit 22127-2R, the USFWS is seeking to renew for 5 years a permit that would authorize them to continue to take juvenile and adult PS Chinook salmon and PS steelhead in the Puyallup River basin (Pierce and King Counties, Washington), in order to gather information about bull trout (*Salvelinus confluentus*) movement and life history strategies in the basin. Bull trout are listed under the ESA and managed by USFWS. This research is not targeting ESA-listed fish under NMFS' jurisdiction (PS Chinook salmon and PS steelhead), but a small number may be unintentionally captured because their ranges overlap the target species. Juveniles may be collected via backpack electrofishing, gill net, and beach seine, and adults may be collected via gill net. Any adult or juvenile PS Chinook salmon or PS steelhead captured would be immediately released. The researchers are not proposing to kill any of the listed fish being captured, but a small number may be killed as an inadvertent result of these activities. While this work is intended to benefit listed bull trout by providing fine-scale information about their movement timing and upstream residency, any management and recovery actions informed by this work would likely also benefit PS Chinook salmon and PS steelhead due to their overlapping ranges and habitats.

Permit 26368

Under permit 26368, Idaho State University is seeking a new 5-year permit that would authorize 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 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 (primarily steelhead) 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 captured listed fish would be allowed to recover in aerated water and then released immediately. 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 26412

Under permit 26412, FISHBIO is seeking a new 5-year permit that would authorize them to annually take juvenile and adult SacR winter-run Chinook salmon, CVS Chinook salmon, and CCV steelhead, and adult southern DPS green sturgeon in the upper Sacramento River, in Glenn, Butte, and Tehama Counties, California. The purpose of this study is to provide new information or bolster limited existing information on the residency, movement patterns, and spatiotemporal distributions of juvenile non-native Striped bass (*Morone saxatilis*) in the upper reaches of the Sacramento River. ESA-listed fish are not being targeted by this sampling effort, although some of them may be unintentionally captured as their range overlaps with Striped bass in the study area.

ESA-listed salmon, steelhead, and sturgeon may be collected via hook-and-line angling or observed by camera or sonar. All listed fish captured would be handled (enumerated, measured, and checked for marks or tags), and released. Sampling would be limited to 6 to 10 days per month, and the permit would authorize no mortalities for listed fish. The information to be gathered is expected to benefit listed species by providing resource managers data to help them assess predation risks to outmigrating salmonids and juvenile southern DPS green sturgeon in the Sacramento River.

Permit 26626

Under permit 26626, the NPS is seeking a new 5-year permit that would authorize them to annually take adult and juvenile PS Chinook salmon and PS steelhead, as well as subadult PS steelhead and spawned carcasses of both species, in the Elwha River Basin in Clallam County, Washington. The purpose of the study is to continue monitoring the recolonization of Pacific salmonids and lamprey after dam removal in the Elwha River. The majority of fish encountered during this study would be observed during snorkel surveys but not handled. Small numbers of juveniles of both species would be collected via backpack electrofishing, and captured juveniles would be anesthetized, tissue-sampled and marked prior to release. Adult PS Chinook salmon and PS steelhead would be collected via tangle net and hook-and-line angling in addition to observations during snorkel surveys. Captured adults would be anesthetized, tissue sampled, and tagged with a Floy, internal radio, or external radio tag prior to release. Spawned adults and post-spawn carcasses would be counted during spawning surveys. Subadult PS steelhead would also be observed during snorkel surveys and captured via tangle nets and hook-and-line angling; these fish would also be anesthetized, tissue sampled, and tagged with a Floy, internal radio, or external radio tag prior to release. The researchers are not proposing to kill any of the listed fish being captured, but a small number may be killed as an inadvertent result of these activities.

The information gathered from this work would help scientists and managers assess spatial extent, relative abundance, migration patterns, and life history attributes of Pacific salmonids and map how those factors relate to four stages of restoration in the Elwha River: protection, recolonization, local adaptation, and recovered. This project is designed to generate data for assessing the life history responses of migratory salmonids to dam removal, and the work would help resource managers involved with the Elwha Ecosystem Restoration Project better carry out PS steelhead and Chinook recovery actions.

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 (ºF) 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 64ºF.

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 to adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, Federal action agencies consult with NMFS, and section 7(b)(3) requires that, at the conclusion of consultation, NMFS provide an opinion stating how the agency's actions would affect listed species and their critical habitats. If incidental take is reasonably certain to occur, section 7(b)(4) requires NMFS to provide an ITS that specifies the impact of any incidental taking and includes reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

This opinion constitutes formal consultation and an analysis of effects solely for the evolutionarily significant units (ESUs) and distinct population segments (DPSs) that are the subject of this opinion.[1] Herein, the NMFS determined that the proposed action of issuing seventeen scientific research permits, individually or in aggregate:

- May adversely affect PS, UCR spring-run, SnkR spr/sum-run, UWR, CC, SacR winter-run, and CVS Chinook salmon; HCS chum salmon; OC and CCC coho salmon; SnkR sockeye salmon; PS, UCR, MCR, SnkR basin, UWR, CCV, CCC and SCCC steelhead, sDPS eulachon, sDPS green sturgeon; but would not jeopardize their continued existence.
- Is not likely to adversely affect Southern Resident 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 CFR 402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

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

The critical habitat designations for many of the species considered here use the term primary constituent element (PCE) or essential features. The 2016 final rule (81 FR 7414; February 11,

[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.

2016) that revised the critical habitat regulations (50 CFR 424.12) replaced this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

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

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

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

2.2 Rangewide Status of the Species and Critical Habitat

This opinion examines the status of each species that is likely to be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' "reproduction, numbers, or distribution" for the jeopardy analysis. The opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses 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 foodwebs (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," "hatchery-origin," and "hatchery" are used interchangeably, as are the terms "naturally propagated," "natural-origin," 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 viability assessment, and limiting factors identified for each species considered in this opinion.

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent 5-Year Review	Limiting Factors (as identified in the most recent 5-Year Review)
Puget Sound Chinook salmon	Threatened 06/28/2005 (70 FR 37160)	SSDC 2007 NMFS 2006	NMFS 2016a	• 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 2018a (draft)	NMFS 2016a	• 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
Hood Canal summer-run chum salmon	Threatened 06/28/2005 (70 FR 37160)	HCCC 2005 NMFS 2007	NMFS 2016a	• Reduced floodplain connectivity and function • Poor riparian condition • Loss of channel complexity Sediment accumulation • Altered flows and water quality
Upper Columbia River spring-run Chinook salmon	Endangered 06/28/2005 (70 FR 37160)	UCSRB 2007	NMFS 2022a	• 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 2022a	• Adverse effects related to the mainstem Columbia River hydropower system • Impaired tributary fish passage • Degraded floodplain connectivity and function, channel structure and complexity, riparian areas, large woody debris recruitment, stream flow, and water quality • Hatchery-related effects • Predation and competition • Harvest-related effects
Middle Columbia River steelhead	Threatened 01/05/2006	NMFS 2009	NMFS 2022b	• Degraded freshwater habitat • Mainstem Columbia River hydropower-related impacts

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent 5-Year Review	Limiting Factors (as identified in the most recent 5-Year Review)
	(71 FR 834)			• 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 2017a	NMFS 2022c	• Degraded freshwater habitat • Effects related to the hydropower system in the mainstem Columbia River, • Altered flows and degraded water quality • Harvest-related effects • Predation
Snake River basin steelhead	Threatened 01/05/2006 (71 FR 834)	NMFS 2017a	NMFS 2022d	• 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
Snake River sockeye salmon	Endangered 06/28/2005 (70 FR 37160)	NMFS 2015	NMFS 2022e	• Effects related to the hydropower system in the mainstem Columbia River • Reduced water quality and elevated temperatures in the Salmon River • Water quantity • Predation
Upper Willamette River Chinook salmon	Threatened 06/28/2005 (70 FR 37160)	ODFW and NMFS 2011	NMFS 2016b	• Degraded freshwater habitat • Degraded water quality • Increased disease incidence • Altered stream flows • Reduced access to spawning and rearing habitats due to migration barriers, impaired fish passage, and increased pre-spawn mortality associated with conditions below dams • Altered food web due to reduced inputs of microdetritus • Predation by native and non-native species, including hatchery fish • Competition related to introduced races of salmon and steelhead • Altered population traits due to fisheries, bycatch, and natural origin fish interbreeding with hatchery origin fish
Upper Willamette River steelhead	Threatened 01/05/2006 (71 FR 834)	ODFW and NMFS 2011	NMFS 2016b	• 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

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent 5-Year Review	Limiting Factors (as identified in the most recent 5-Year Review)
				• Competition related to introduced salmon and steelhead • Altered population traits due to interbreeding with hatchery origin fish
Oregon Coast coho salmon	Threatened 06/20/2011 (76 FR 35755)	NMFS 2016c	NMFS 2016d	• 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
California Coastal Chinook salmon	Threatened 09/16/1999 (64 FR 50394)	NMFS 2016e	NMFS 2016f	• 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 2014	NMFS 2016g	• 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)
Central Valley spring-run Chinook salmon	Threatened 09/16/1999 (64 FR 50394)	NMFS 2014	NMFS 2016h	• Dams block access to 90 percent of historic spawning and summer holding areas along with altering river flow regimes and temperatures. • Diversions • Urbanization and rural development • Logging • Grazing

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent 5-Year Review	Limiting Factors (as identified in the most recent 5-Year Review)
				• 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 2014	NMFS 2016i	• Major dams • Water diversions • Barriers • Levees and bank protection • Dredging and sediment disposal • Mining • Contaminants • Alien species • Fishery-related effects • Hatchery-related effects
Central California Coast coho salmon	Endangered 04/02/2012 (77 FR 19552) 06/28/2005 (70 FR 37160) Threatened 10/31/1996 (61 FR 56138)	NMFS 2012	NMFS 2016j	• 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 2016e	NMFS 2016k	• Dams and other barriers to migration • Stream habitat degradation • Estuarine habitat degradation • Hatchery-related effects
South-Central California Coast steelhead	Threatened 8/18/1997 (62 FR 43937)	NMFS 2013	NMFS 2016l	• 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

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent 5-Year Review	Limiting Factors (as identified in the most recent 5-Year Review)
				• Natural environmental variability • Pesticide contaminants
Southern DPS of green sturgeon	Threatened 04/07/2006 (71 FR 17757)	NMFS 2018b	NMFS 2021a	• Reduction of its spawning area to a single known population • Impassible barriers and flood bypass systems • Altered flow and temperature regimes in the Sacramento River • Lack of water quantity • Poor water quality • Poaching
Southern DPS of eulachon	Threatened 03/18/2010 (75 FR 13012)	NMFS 2017b	NMFS 2022f	• 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

Summaries of the status of each ESU and DPS considered in this opinion, including estimates of abundance, are presented below. Please note that the juvenile abundance numbers presented below 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, 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 when conducting the effects analyses later in this Opinion.

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 used the geometric means of the last five years of adult returns as reported by the NWFSC (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. Abundance estimates for the ESU components are listed below (Table 3).

Table 3. Recent 5-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*	8,280,000
Juvenile	LHAC**	26,192,500

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 reported by the NWFSC (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 2021). The combined hatchery production goal for listed PS steelhead is roughly 274 thousand juveniles annually. Abundance estimates for the DPS components are listed below (Table 4).

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

Life Stage	Origin	Outmigration/Return
Adult	Natural	19,079
Adult	Hatchery	735
Juvenile	Natural	2,253,842
Juvenile	LHIA	87,500
Juvenile	LHAC	186,000

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 2018a) 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 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 5).

Table 5. 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
Juvenile	LHIA*	150,000

*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.

2.2.1.4 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 (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). Abundance estimates for the ESU components are listed below (Table 6).

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

Life Stage	Origin	Outmigration/Return
Adult	Natural	813
Adult	Hatchery	1,140
Juvenile	Natural	518,360
Juvenile	LHIA	443,774
Juvenile	LHAC	591,769

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.

2.2.1.5 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 (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). Abundance estimates for the DPS components are listed below (Table 7).

Table 7. Recent 5-Year Geometric Means for Estimated UCR Steelhead Juvenile Outmigrations and Adult Returns (Ford 2022; Zabel 2017a, 2017b, 2018, 2020, 2021).

Life Stage	Origin	Outmigration/Return
Adult	Natural	1,465
Adult	Hatchery	2,893
Juvenile	Natural	161,936
Juvenile	LHIA	132,453
Juvenile	LHAC	743,457

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.

2.2.1.6 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 (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). Abundance estimates for the DPS components are listed below (Table 8).

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

Life Stage	Origin	Outmigration/Return
Adult	Natural	13,598
Adult	Hatchery	713
Juvenile	Natural	375,923
Juvenile	LHIA	115,610
Juvenile	LHAC	432,003

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.

2.2.1.7 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 (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). Abundance estimates for the ESU components are listed below (Table 9).

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

Life Stage	Origin	Outmigration/Return
Adult	Natural	4,557
Adult	Hatchery	2,822
Juvenile	Natural	822,632
Juvenile	LHIA	728,543
Juvenile	LHAC	4,747,112

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.

2.2.1.8 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 (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). Abundance estimates for the DPS components are listed below (Table 10).

Table 10. Recent 5-Year Geometric Means for Estimated SnkR Steelhead Juvenile Outmigrations and Adult Returns (Ford 2022; Zabel 2017a, 2017b, 2018, 2020, 2021).

Life Stage	Origin	Outmigration/Return
Adult	Natural	10,796
Adult	Hatchery	3,292
Juvenile	Natural	790,184
Juvenile	LHIA	496,078
Juvenile	LHAC	3,135,597

The 5-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.

2.2.1.9 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 11).

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

Life Stage	Origin	Outmigration/Return
Adult	Natural	16
Adult	Hatchery	97
Juvenile	Natural	19,047
Juvenile	LHAC*	271,029

*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.

2.2.1.10 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 (2016-2020) by using annual abundance estimates provided by the NWFSC (Zabel 2017a, 2017b, 2018, 2020, 2021). 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 12).

Table 12. Recent 5-Year Geometric Means for Estimated UWR Chinook Salmon Juvenile Outmigrations and Adult Returns (Ford 2022; Zabel 2017a, 2017b, 2018, 2020, 2021).

Life Stage	Origin	Outmigration/Return
Adult	Natural	6,914
Adult	Hatchery	25,275
Juvenile	Natural	1,164,252
Juvenile	LHIA	0
Juvenile	LHAC	4,547,100

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.

2.2.1.11 Upper Willamette River Steelhead

Abundance and Productivity

To estimate current abundance of juvenile natural and hatchery UWR steelhead, we calculate the geometric means for outmigrating smolts over the past five years (2016-2020) by using annual abundance estimates provided by the NWFSC (Zabel 2017a, 2017b, 2018, 2020, 2021). 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 DPS components are listed below (Table 13).

Table 13. Recent 5-Year Geometric Means for Estimated UWR Steelhead Juvenile Outmigrations and Adult Returns (Ford 2022; Zabel 2017a, 2017b, 2018, 2020, 2021).

Life Stage	Origin	Outmigration/Return
Adult	Natural	2,628
Juvenile	Natural	136,980

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 2008a), 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).

2.2.1.12 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 14).

Table 14. 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.

2.2.1.13 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 15).

Table 15. 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).

2.2.1.14 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 16).

Table 16. 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).

2.2.1.15 Central Valley Spring-run Chinook Salmon

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 17).

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 17. 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).

2.2.1.16 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 18).

Table 18. 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	1,307,442
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, unpubl.).

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).

2.2.1.17 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 19).

Table 19. 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 19). 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.

2.2.1.18 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 20).

Table 20. 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 comprised of 37 independent populations and perhaps 30 or more smaller dependent populations of winter-run steelhead. These populations were placed in five geographically based diversity strata (Bjorkstedt *et al.* 2005; modified in Spence *et al.* 2008). Most of the coastal populations are assumed to be extant, however many of the Coastal San Francisco Bay and Interior San Francisco Bay populations are likely at high risk of extirpation due to the loss of historical spawning habitat and the heavily urbanized nature of these watersheds (Williams *et al.* 2011).

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

2.2.1.19 South-Central California Coast Steelhead

Abundance and Productivity

Data for both adult and juvenile abundance are limited for this DPS. In addition, the record is inconsistent with either no fish observed or no surveys conducted in some years. Due to the inconsistency of the record, we have used a 5-year average as an estimate for abundance (2015-2019)(CDFW 2020, unpubl.). While we currently lack data on naturally produced juvenile SCCC steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. For steelhead, fecundity estimates range from 3,500 to 12,000; and the male to female ratio averages 1:1 (Pauley *et al.* 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (half of the escapement of natural-origin spawners – 98 females), roughly 340 thousand eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce roughly 22,295 natural outmigrants annually. There are no hatchery components of this DPS. Abundance estimates for the DPS components are listed below (Table 21).

Table 21. 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 2012b).

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

2.2.1.20 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 2016 through 2020 have ranged from a low of an estimated 861,125 fish in 2017 to a high of 15,352,621 fish in 2020 (DFO 2022, estimate based on report weight assuming 11.16 fish per pound). Abundance estimates for the DPS components are listed below (Table 22).

Table 22. Southern DPS eulachon spawning stock biomass survey estimates (NMFS 2022f).

Year	Columbia River Spawning Stock Estimate (mean)	Fraser River Spawning Stock Estimate (mean)
2017	18,307,100	763,902
2018	4,100,000	8,904,912
2019	46,684,765	2,357,180
2020[a,b]	21,280,000	13,619,277
2021[b]	96,395,712	3,077,433
2017-2021[c]	**23,513,733**	**3,676,889**

[a] Abbreviated estimate; sampling stopped mid-March of 2020
[b] Data are provisional and subject to change
[c] 5-year geometric mean of mean eulachon biomass estimates (2017-2021)

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 22). 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).

2.2.1.21 SDPS Green Sturgeon

Green sturgeon are composed of 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 NMFS 2021a). 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 23).

Table 23. 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 NMFS 2021a). There are currently no studies that address juvenile and subadult abundance of S green sturgeon to evaluate whether the recovery criterion for increasing trends of these life stages is being met (NMFS 2021a).

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 24, below.

Table 24. 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 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.
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.
Upper Columbia River spring-run Chinook salmon	09/02/2005 70 FR 52630	Critical habitat encompasses four subbasins in Washington containing 15 occupied watersheds, as well as the Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition. However, most of these watersheds have some, or high, potential for improvement. We rated conservation value of HUC5 watersheds as high for 10 watersheds, and medium for five watersheds. Migratory habitat quality in this area has been severely affected by the development and operation of the dams and reservoirs of the Federal Columbia River Power System.
Upper Columbia River steelhead	09/02/2005 70 FR 52630	Critical habitat encompasses 10 subbasins in Washington containing 31 occupied watersheds, as well as the Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. We rated conservation value of HUC5 watersheds as high for 20 watersheds, medium for eight watersheds, and low for three watersheds.
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

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
		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.
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. 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)
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

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
		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.
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

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
		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 S-CCC steelhead. NMFS determined that marine areas did not warrant consideration as critical habitat for this DPS. S-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 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. S-CCC steelhead inhabit coastal river basins from the Pajaro River south to, but not including, the Santa Maria River. Major watersheds include Pajaro River, Salinas River, Carmel River, and numerous smaller rivers and streams along the Big Sur coast and southward. Only winter-run steelhead are found in this DPS. The climate is drier and warmer than in the north that is reflected in vegetation changes from coniferous forests to chaparral and coastal scrub. The mouths of many rivers and streams in this DPS are seasonally closed by sand berms that form during the low stream flows of summer. 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 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

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
		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 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	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.

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 the listed Chinook salmon, chum salmon, coho salmon, sockeye salmon, and steelhead listed in Section 2.2.1 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, and green sturgeon.

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, 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 24).

2.3.1. Action Areas for the Individual Permits

Permit 1124-7R – Most of the proposed activities would take place in the Snake, Clearwater, and Salmon Rivers and many of their tributaries in Idaho, Oregon, and Washington. Part of the research would take place in Redfish, Pettit, and Alturas Lakes in Idaho.

Permit 1585-5R - The proposed activities would take place in streams and rivers within WDNR lands in the central Puget Sound Basin (Mason, Kitsap, King, Pierce, Thurston, Snohomish and Lewis counties in Washington). This includes the Deschutes, Nisqually, Puyallup, Duwamish, Snoqualmie, Chehalis, Kitsap, and Skokomish subbasins, as well as Hood Canal and Lake Washington.

Permit 14283-4R - The proposed activities would take place in various locations in the Columbia River—extending from a point upstream of Wanapum Dam to an area a few kilometers above the confluence of the Columbia and Yakima Rivers.

Permit 15730-3R - The proposed activities would take place in the Lagunitas Creek and tributaries in Marin County, California. Studies will take place in San Geronimo Creek, Woodacre Creek, Willis Evans Canyon Creek, Larsen Creek, Arroyo Creek, Barranca Creek, El Cerrito Creek, and Montezuma Creek.

Permit 16110-3R - The proposed activities would take place in Lagunitas Creek upstream of the Highway 1 Bridge in Pt. Reyes Station, Walker Creek, and their tributaries in Marin County, California.

Permit 16417-4R - The proposed activities would take place in the Coyote Creek, Guadalupe River, Pajaro Creek, and Stevens Creek watersheds, and Lake Almaden in Santa Clara County, California. This also includes specific reaches within the Alamitos, Arroyo Aguague, Calero, Coyote, Guadalupe, Los Gatos, Stevens, Bodfish, Cedar, Hagerman Canyon, Little Arthur, Llagas, Middle Fork Pacheco, North Fork Pacheco, Pacheco, Solis, Tar, Uvas, and Upper Penitencia Creeks within these watersheds.

Permit 16446-3R - The proposed activities would take place in the Walla Walla River and its tributaries (primarily the Touchet River and Mill Creek) in Northeast Oregon and Southeast Washington.

Permit 16979-3R - The proposed activities would change locations from year to year, but in any given year, the work could be carried out in the Columbia River or any of its tributaries above its confluence with the Yakima River, Washington.

Permit 17428-4R - The proposed activities would take place in the American River west of the Watt Avenue Bridge, and the Stanislaus River at the northeastern most reach of Caswell Memorial State Park in Sacramento County, California.

Permit 17851-4R - The proposed activities would take place in the estuary of the Elwha River in Clallam County, Washington.

Permit 18001-4R - The proposed activities would take place in the Puyallup River, Puyallup River Basin tributaries, and the Nisqually River and its northern tributaries in Pierce County, Washington.

Permit 20792-2R - The proposed activities would take place in the San Joaquin River and South Delta in California.

Permit 21571-3R - The proposed activities would take place in the Yakima River anywhere from Wapato Dam downstream to the Yakima's confluence with the Columbia Rivers (all in Washington State).

Permit 22127-2R - The proposed activities would take place in the mainstem White, West Fork White, Carbon, and Puyallup Rivers and their tributaries in the Puyallup River Basin in Washington.

Permit 26368 - The proposed activities would take place in tributary habitat stretching from the Snake and Salmon River basins in Idaho, across Central Oregon and the Willamette River Valley, and extending all the way to coastal streams in Oregon. The work could take place in dozens of locations across that geography in any given year. Subbasins that may be sampled include: Big Sheep Creek, the upper Grande Ronde River, Joseph Creek, the middle Fork Salmon River, the south Fork Salmon River, the Lochsa River, the Potlatch River, the Deschutes River, the Little Deschutes River, the Crooked River, McKay Creek, the upper Willamette River, the McKenzie River, and the Wilson, Trask, Nestucca, and Umpqua Rivers.

Permit 26412 - The proposed activities would take place in the Sacramento River within Glenn, Butte, and Tehama Counties in California.

Permit 26626 - The proposed activities would take place in the Elwha River and its tributaries in Clallam County, Washington.

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 some 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:

- 15730-3R
- 16110-3R
- 16446-3R
- 17428-4R
- 17851-4R
- 18001-4R
- 20792-2R
- 21571-3R
- 22127-2R
- 26626

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, eulachon, and sturgeon. 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 24 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 2022, 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 25 displays the total take for the ongoing research authorized under ESA sections 4(d) and 10(a)(1)(A).

Table 25. Total authorized annual take of ESA listed species for scientific research and monitoring already approved for 2022, not including take from permits being renewed as part of this action.

Species	Life Stage	Origin[a]	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Puget Sound Chinook salmon	Adult	Natural	821	41	3.513	0.175
		LHIA	435	13	6.246[b]	0.379[b]
		LHAC	1,016	75		

Species	Life Stage	Origin[a]	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
	Juvenile	Natural	493,839	11,151	13.246	0.299
		LHIA	233,098	5,056	2.815	0.061
		LHAC	164,577	12,906	0.628	0.049
Puget Sound steelhead	Adult	Natural	1,867	38	9.786	0.199
		LHIA	22	1	7.755[b]	1.088[b]
		LHAC	35	7		
	Juvenile	Natural	91,606	1,521	4.064	0.067
		LHIA	3,272	49	3.739	0.056
		LHAC	8,445	163	4.540	0.088
Hood Canal summer-run chum salmon	Adult	Natural	1,088	22	3.870	0.078
	Juvenile	Natural	733,112	2,585	17.286	0.061
		LHIA	1,395	44	0.930	0.029
		LHAC	85	18	-	-
Upper Columbia River spring-run Chinook salmon	Adult	Natural	195	6	23.985	0.738
		LHIA	152	3	28.246[b]	0.877[b]
		LHAC	170	7		
	Juvenile	Natural	10,808	233	2.085	0.045
		LHIA	1,035	33	0.233	0.007
		LHAC	1,506	78	0.254	0.013
Upper Columbia River steelhead	Adult	Natural	207	4	14.130	0.273
		LHIA	94	2	10.819[b]	0.277[b]
		LHAC	219	6		
	Juvenile	Natural	31,364	651	19.368	0.402
		LHIA	2,419	69	1.826	0.052
		LHAC	10,346	249	1.392	0.033
Middle Columbia River steelhead	Adult	Natural	1,126	17	8.281	0.125
		LHIA	165	6	142.356[b]	2.384[b]
		LHAC	850	11		
	Juvenile	Natural	106,054	2,401	28.212	0.639
		LHIA	8,553	114	7.398	0.099
		LHAC	791	43	0.183	0.010
Snake River spring/summer-run Chinook salmon	Adult	Natural	2,307	16	52.206	0.362
		LHIA	388	4	54.890[b]	0.496[b]
		LHAC	1,161	10		
	Juvenile	Natural	579,575	6,060	70.454	0.737
		LHIA	51,568	544	7.078	0.075
		LHAC	81,491	1,221	1.717	0.026
Snake River Basin steelhead	Adult	Natural	9,281	109	93.136	1.094
		LHIA	1,983	28	146.819[b]	2.070[b]
		LHAC	2,840	40		
	Juvenile	Natural	280,043	4,008	35.440	0.507
		LHIA	35,415	467	7.139	0.094
		LHAC	78,143	984	2.492	0.031
Snake River sockeye salmon	Adult	Natural	111	6	693.750	37.500
		LHIA	1	0	2.062[b]	0.000[b]
		LHAC	1	0		
	Juvenile	Natural	11,090	473	58.224	2.483
		LHIA	1	0	-	-
		LHAC	401	261	0.148	0.096
	Adult	Natural	168	6	1.595	0.057
		LHAC	88	11	0.347	0.043

Species	Life Stage	Origin[a]	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Upper Willamette River Chinook salmon	Juvenile	Natural	36,902	769	3.170	0.066
		LHIA	40	7	-	-
		LHAC	9,876	330	0.217	0.007
Upper Willamette River steelhead	Adult	Natural	203	4	7.725	0.152
	Juvenile	Natural	13,776	287	10.057	0.210
Oregon Coast coho salmon	Adult	Natural	8,022	101	13.232	0.167
		LHAC	20	4	3.135	0.627
	Juvenile	Natural	463,840	10,813	10.816	0.252
		LHAC	275	20	0.458	0.033
California Coastal Chinook salmon	Adult	Natural	374	20	2.840	0.152
	Juvenile	Natural	60,018	1,188	2.508	0.050
Sacramento River winter-run Chinook salmon	Adult	Natural	1,520	24	128.270	2.025
		LHAC	1,515	51	56.174	1.891
	Juvenile	Natural	429,116	11,534	343.188	9.224
		LHAC	205,109	7,740	129.117	4.872
Central Valley spring-run Chinook salmon	Adult	Natural	1,614	28	23.890	0.414
		LHAC	729	87	34.998	4.177
	Juvenile	Natural	845,796	17,487	45.993	0.951
		LHAC	32,064	3,959	1.603	0.198
California Central Valley steelhead	Adult	Natural	3,390	115	51.705[c]	2.775[c]
		LHIA	50	1		
		LHAC	2,503	203		
	Juvenile	Natural	65,091	1,898	4.979	0.145
		LHAC	27,660	1,807	2.634	0.172
Central California Coast coho salmon	Adult	Natural	4,418	62	263.128[c]	4.203[c]
		LHIA	1,655	35		
	Juvenile	Natural	180,531	2,745	111.742	1.699
		LHIA	106,516	1,603	76.083	1.145
Central California Coast steelhead	Adult	Natural	2,506	48	133.683[c]	2.886[c]
		LHAC	42	7		
	Juvenile	Natural	230,318	5,180	106.231	2.389
		LHAC	15,501	448	2.981	0.086
South-Central California Coast steelhead	Adult	Natural	1,344	22	685.714	11.224
	Juvenile	Natural	35,233	783	158.031	3.512
Southern DPS eulachon[d]	Adult	Natural	37,739	31,066	0.148	0.123
	Subadult	Natural	1,030	1,030		
	Juvenile	Natural	940	862		
Southern DPS green sturgeon	Adult	Natural	344	9	16.173	0.423
	Subadult	Natural	231	9	2.069	0.081
	Juvenile	Natural	6,549	190	147.800	4.288
	Larvae	Natural	11,130	1,030	-	-
	Egg	Natural	2,810	2,810		

[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 for these species are only known for the adult life stage which is used to represent the entire DPS.

Actual take levels associated with these activities are almost certain to be a substantially lower than the permitted levels for three reasons. 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; only 24% of authorized total take and 8.6% of authorized mortalities were actually used in total across WCR research permits from 2017-2021. Proportions of used versus 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. It is therefore very likely that far fewer fish 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.

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 (see 50 CFR 402.02). 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 the factors set forth in 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 seines or 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.

Collection Methods

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. Harassment is the primary form of take associated with these observation activities, and few if any injuries (and no deaths) are expected to occur—particularly in cases where the researchers observe from the stream banks rather than in the water. Because these effects are so small, there is little a researcher can do to mitigate them except to avoid disturbing sediments, gravels, and, to the extent possible, the fish themselves, and allow any disturbed fish the time they need to reach cover.

Electrofishing

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

Adult salmonids are particularly susceptible to spinal injuries, as longer fish (> 300mm) are subjected to strong voltage gradients by the electrofishing anode (Pottier & Marchand 2020). Spinal injuries to salmonids become increasingly detectable over time and are often not immediately apparent (Holliman *et al.* 2010). To avoid causing such injuries, we do not allow electrofishing to be used as a method for capturing adult salmonids. Though electrofishing crews do sometimes inadvertently encounter adults during their work, they must immediately turn off their equipment and allow the fish to swim away. Smaller, juvenile fish are subjected to lesser voltage gradients, but there is conflicting evidence about whether this results in lower rates of injury (Snyder 2003). Spawning female salmonids are also vulnerable, since electrofishing can reduce survival rates for eggs spawned from previously electroshocked females (Cho *et al.* 2002, Huysman *et al.* 2018). Salmon in early developmental stages, including embryos and alevin, are another vulnerable group for whom electrofishing should be avoided (Simpson *et al.* 2016). Electrofishing can also inflict harm on non-target species, particularly during multiple pass depletion surveys, during which non-target fish can be exposed to multiple electroshocks (Panek & Densmore 2011). Incidence of injuries for target fish and non-target bycatch alike increases with multiple exposures (Panek & Densmore 2013).

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

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

- Use electrofishing only when other survey methods are not feasible.
- Be trained by qualified personnel in equipment handling, settings, maintenance to ensure proper operating condition, and safety.
- Conduct visual searches prior to electrofishing on each date and avoid electrofishing near adults or redds. If an adult or a redd is detected, researchers must stop electrofishing at the research site and conduct careful reconnaissance surveys prior to electrofishing at additional sites.

- Test water conductivity and keep voltage, pulse width, and rate at minimal effective levels. Use only DC waveforms.
- Work in teams of two or more technicians to increase both the number of fish seen at one time and the ability to identify larger fish without having to net them. Working in teams allows netter(s) to remove fish quickly from the electrical field and to net fish farther from the anode, where the risk of injury is lower.
- Observe fish for signs of stress and adjust electrofishing equipment to minimize stress.
- Provide immediate and adequate care to any fish that does not revive immediately upon removal from the electrical current.

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

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 non-landed 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.

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 (NMFS 2003b). Based on years of sampling at hundreds of locations under hundreds of scientific research authorizations, we would expect the mortality rates for fish captured at rotary screw type traps to be one percent or less.

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

Seines, Traps, and Hand/Dip Nets

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

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.

Trawls

Trawls are cone-shaped, mesh nets that are towed, often, along benthic habitat (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 (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.

Handling and Sedation

Handling

The primary factors that contribute to stress and mortality from post-capture handling and processing of fish 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. 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. Handling of fish may cause stress, injury, or death, which typically are due to overdoses of anesthetic, differences in water temperatures between the river and holding buckets, depleted dissolved oxygen in holding buckets, holding fish out of the water, and physical trauma. Excessive air exposure causes gill lamellae to collapse, ceasing aerobic respiration and causing hypoxia. High water temperature can contribute to high mortality following air exposure (Patterson *et al.* 2017).

Loss of protective mucus is a common injury during capture and handling which increases susceptibility to disease (Cook *et al.* 2018). Mucus contains antibacterial proteins, and its loss makes fish vulnerable to pathogens that may cause infections and latent mortality. Fish held at higher water temperature have a higher risk of infection post-sampling (Patterson *et al.* 2017). Stress on salmonids increases rapidly from handling if the water temperature exceeds 18ºC or dissolved oxygen is below saturation. Additionally, stress can occur if there are more than a few degrees difference in water temperature between the stream/river and the holding tank.

Exhaustion from excess physical activity can also result in death through acidosis or latent mortality due to the inability to recover from exhaustion. Fish that survive physiological imbalances caused during handling can lose equilibrium and have impaired swimming abilities, increasing their susceptibility to predation (Cook *et al.* 2018). Fish transferred to holding buckets can experience trauma if care is not taken in the transfer process, and fish can experience stress and injury from overcrowding in traps, nets, and buckets. Capture and handling stressors can combine to cause cumulative effects that greatly increase the likelihood of fish mortality. The permit conditions identified in Section 1.3 contain measures that mitigate factors that commonly lead to stress and trauma from handling, and thus minimize the harmful effects of capturing and handling fish. When these measures are followed, fish typically recover rapidly from handling.

Sedation

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

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

Clove oil is a common alternative to MS-222, although the FDA has not approved its use. Clove oil is an essential oil whose primary constituent is eugenol. Essential oils are natural plant extracts, which typically have fewer side effects and are generally less aversive to fish than synthetic anesthetics (Martins *et al.* 2018, Souza *et al.* 2019). Many essential oils exhibit antioxidant capacity and help activate a fish's antioxidant defense system (Souza *et al.* 2019). Clove oil requires mixing with ethanol when dispersed in cold water since it is insoluble on its own (Jahavery *et al.* 2012). Induction time for clove oil is shorter than for MS-222, but recovery times are longer (Wagner et al 2003). Clove oil exposure causes decreased respiratory rates and has a greater impact on the respiratory and cardiac systems than MS-222 (Priborski & Velisek 2018). A clove oil overdose can cause hypoxia and respiratory acidosis (Jahavery *et al.* 2012).

Electric fish handling gloves (FHGs) and portable electrosedation systems (PES) are an alternative to using fish anesthetics during handling and short surgical procedures. FHGs use a worn battery unit connected to gloves to sedate fish when both gloves are in contract with the animal. A PES uses a tank through which electric current is passed. FHGs and PES cause rapid immobilization and have short recovery times with minimal physiological or behavioral impairment when applied to largemouth bass (Ward *et al.* 2017, Abrams *et al.* 2018).

Tagging

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 tagging processes and its associated risks. The potential impacts associated with fin-clip marking are assumed to be equivalent to those discussed later in the discussion of tissue sampling.

PIT Tagging

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

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).

Acoustic/Radio Tags and Loggers

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.

Sample Collection

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.

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.

Sacrifice (Intentionally Killing)

In some instances, it is necessary to kill a captured fish in order to gather whatever data a study is designed to produce. In such cases, determining effect is a very straightforward process: the sacrificed fish, if they are juveniles, are forever removed from the gene pool and the effect of their deaths is weighed in the context that the effect on their listed unit and, where possible, their local population. If the fish are adults, the effect depends upon whether they are killed before or after they have a chance to spawn. If they are killed after they spawn, there is very little overall effect. Essentially, it amounts to removing the nutrients their bodies would have provided to the spawning grounds. If they are killed before they spawn, not only are they removed from the population, but so are all their potential progeny. Thus, killing pre-spawned adults has the greatest potential to affect the listed species. Because of this, NMFS only very rarely allows pre-spawned adults to be sacrificed. And, in almost every instance where it is allowed, the adults are stripped of sperm and eggs so their progeny can be raised in a controlled environment such as a hatchery—thereby greatly decreasing the potential harm posed by sacrificing the adults. As a general rule, adults are not sacrificed for scientific purposes and no such activity is considered in this opinion.

2.5.3 Species-specific Effects of Each Permit

In previous sections, we estimated the annual abundance of adult and juvenile listed salmonids, eulachon, and green sturgeon. 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. The tables in Section 2.2.1 (Status of the Species) display the estimated annual abundance of each 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. The tables in Section 2.2.1 (Status of the Species) display 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, or we do not have abundance data to support population-level analyses. 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 life stage and origin rather than at the population scale. The estimated annual abundances for each species considered in this analysis, and their derivations, are presented in the individual Status of the Species summaries in Section 2.2.1.

Permit 1124-7R

As stated previously, Permit 1124 has been in existence for over 20 years. It covers a suite of projects (described above) that have the potential to take all listed salmonid species in the Snake River basin except SnkR fall Chinook salmon. The programs would largely involve collecting, handling, marking/tagging, and tissue sampling juvenile salmon. The most commonly used collection procedures would be screw traps, hook-and-line angling, electrofishing and (in the Stanley Basin lakes) mid-water trawl. Most juveniles caught would be anesthetized, counted, sampled for length and released. In addition, a smaller number of juvenile fish would be PIT-tagged. Adult salmon may be trapped at weirs. Some sockeye would be killed during mid-water trawl operations in the Stanley Basin lakes—this portion of the research is considered critical for estimating sockeye abundance (population recovery monitoring) and gathering genetic information.

In all cases, the welfare of each fish is a primary concern for staff, and all necessary precautions are taken to ensure their health and survival. Individuals participating in research activities receive the proper training before being allowed to participate in Department research programs, and all researchers would follow well-established protocols for electrofishing, handling, tagging and, in general, interacting with listed salmonids. The researchers are requesting the following amounts of take:

Table 26. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 1124-7R

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Snake River spring/summer-run Chinook salmon	Adult	Natural	O/ST D	15	0	0.339	0.000
	Juvenile	Natural	C/H/R	6,000	60	1.033	0.010
		Natural	C/M, T, ST/R	11,000	110		
		LHIA	C/H/R	450	4	0.062	<0.001
		LHAC	C/H/R	50	1	0.001	<0.001
Snake River Basin steelhead	Adult	Natural	C/H/R	5	0	0.050	0.000
	Juvenile	Natural	C/H/R	1,100	11	0.215	0.002
		Natural	C/M, T, ST/R	2,300	23		
Snake River sockeye salmon	Adult	Natural	C/H/R	2	0	12.500	0.000
	Juvenile	Natural	C/H/R	300	6	1.116	0.344
		Natural	IM	125	125		
		LHAC	IM	50	50	0.018	0.018

O/ST D = Observe/Sample Tissue Dead Animal
C/H/R = Capture/Handle/Release
C/M, T, ST/R = Capture/Mark, Tag, Sample Tissue/Release
IM = Intentional (Directed) Mortality

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 those 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 the table above.

As the table above illustrates, the researchers are proposing to take small percentages of the listed SnkR steelhead and spr/sum Chinook and kill even smaller portions of those listed units. Because the research would take place over such a broad area, the potential losses cannot be ascribed to any population for either 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 Chinook or steelhead abundance (and therefore productivity), it would in no measurable way impact structure or diversity for either species.

There is currently only one population of SnkR sockeye salmon, thus the number of fish that may be killed would have no essentially effect on spatial structure or diversity. However, the possible juvenile losses do have the potential to affect both abundance and productivity. Both of these effects are small and research has never been identified as a limiting factor for any salmonid. Nonetheless, while the losses should be viewed with some caution, they must also be considered in the context of the work's purpose—and that purpose is largely to augment and monitor the effectiveness of a program that is specifically designed to help the sockeye survive and recover. The research proposed here supports sockeye management actions that have been underway in the in the Stanley basin for more than 25 years. In fact, while it is not certain, it is possible that without this research and the actions it supports, the sockeye might already have gone extinct.

In addition, it is very likely that the impacts will be smaller than those laid out above. Over the most recent 5 years, the researchers have only taken 9.2% of their requested take, and killed 5.3% of their requested mortalities, so it is most likely that the actual effect will be on the order of 20 times smaller than that displayed in the table above. But again, even if the losses were to be as large as those displayed in the table, they must still be placed in the context of the information to be gained: in all cases, the work is designed to benefit the listed fish by monitoring population status and the effectiveness of various recovery and mitigation actions. The end goal is to better inform management decisions and thereby protect both the listed fish and the habitats upon which they depend.

Permit 1585-5R

Under permit 1585-5R the WDNR is seeking to renew for five years a permit that would authorize them to continue to take juvenile PS Chinook salmon, PS steelhead, HCS chum salmon, and southern DPS eulachon in streams on WDNR land in the central Puget Sound Basin. The purpose of the work is to determine whether listed fish are present in the small streams of those watersheds. Juvenile salmonids would be collected via backpack electrofishing, handled (anesthetized, weighed, measured, and checked for marks or tags), and released. The permit would also allow WDNR to take adult Southern DPS eulachon—a species for which there are currently no take prohibitions—where they may be encountered in the Lower Chehalis River. Eulachon are not being targeted but may unintentionally be captured.

The captured fish would be identified 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 WADNR is requesting per year is found in the table below.

Table 27. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 1585-5R

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Puget Sound Chinook salmon	Juvenile	Natural	C/H/R	22	2	<0.001	<0.001
		LHAC	C/H/R	22	2	<0.001	<0.001
Puget Sound steelhead	Juvenile	Natural	C/H/R	22	2	0.0010	<0.001
		LHAC	C/H/R	22	2	0.012	0.001
Hood Canal summer-run chum salmon	Juvenile	Natural	C/H/R	11	1	<0.001	<0.001
Southern DPS eulachon	Adult	Natural	C/H/R	1	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 the table above.

As the table illustrates, for most species the researchers would take a small percent of any listed unit—and kill an even smaller percent of those units. 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. 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.

It is also likely that the impacts will be smaller than those laid out above. Over the most recent 5 years, the researchers have actually taken none (0%) of their requested take or mortalities, so it is most likely that the actual effect will be less than that displayed in the table above by a similar magnitude. The information gathered would be used to 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.

Permit 14283-4R

As noted earlier, Permit 14283-4R would allow the EAS to continue taking juvenile and adult UCR spring-run Chinook salmon, UCR steelhead, and MCR steelhead for the purpose of supporting the U.S. Department of Energy's Hanford Site Cleanup Mission under CERCLA. The researchers would seek to avoid listed species entirely, but some listed individuals may accidentally be encountered during the activities. Juvenile fish would be collected via backpack electrofishing, boat electrofishing, hook-and-line angling, longline, and beach seine. They would then be anesthetized, weighed, measured, and checked for marks or tags, and released. Adults would be collected via hook-and-line angling, longline, and beach seine. No adults would be captured during electrofishing activities, and if any were to be encountered during that activity, the equipment would immediately be turned off and the fish allowed to swim away. Captured adults would be anesthetized, weighed, measured, and checked for marks or tags, and released.

The researchers do not propose to kill any listed fish but a small number may inadvertently be killed by the activities. The EAS researchers are requesting the following amounts of take.

Table 28. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 14283-4R

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Upper Columbia River spring-run Chinook salmon	Adult	Natural	C/H/R	6	0	0.738	0.000
	Juvenile	Natural	C/H/R	5	1	0.0010	<0.001
Upper Columbia River steelhead	Adult	Natural	C/H/R	6	0	0.410	0.000
	Juvenile	Natural	C/H/R	5	1	0.003	<0.001
Middle Columbia River steelhead	Adult	Natural	C/H/R	6	0	0.044	0.000
	Juvenile	Natural	C/H/R	5	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 those 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 the table above.

As the table illustrates, the researchers would kill no adult fish, and their impact on juvenile fish is as close to zero as it is possible to get. Moreover, because the work would take place in the mainstem Columbia River, it is impossible to assign even those very low mortality rates to any individual population for any of the species involved. As a result, the work would have essentially zero effect on any species' structure or diversity and only the smallest possible effect on abundance and productivity.

It is also likely that the impacts will be even smaller than those laid out above. Over the most recent 4 years, the researchers have actually taken none (0%) of their requested take or mortalities, so it is most likely that the actual effect will be even less than the very small impact displayed. But even if all three juvenile fish were to be killed, that effect would be offset to some degree by the fact that the research is designed to help salmon and steelhead by guiding monitoring and, eventually, helping to ameliorate the negative effects that continue to emanate from the Hanford Nuclear Reservation.

Permit 15730-3R

Under permit 15730-3R the SPAWN is seeking to renew for five years a permit that would authorize them to continue to take juvenile CC Chinook salmon, CCC coho salmon, and CCC steelhead in order to provide baseline, habitat, and monitoring data for juvenile and adult ESA-listed salmonids throughout the CCC coho range. Juveniles would be collected via fyke net and would be captured, handled (enumerated, measured, and checked for marks or tags), and released. A subsample of captured juveniles would be anesthetized, tissue sampled, and marked before being released. Spawned adults or post-spawn carcasses would be enumerated during spawning surveys, and tissue samples may be collected.

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

Table 29. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 15730-3R

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
California Coastal Chinook salmon	Juvenile	Natural	C/H/R	100	3	0.004	<0.001
Central California Coast coho salmon	Juvenile	Natural	C/H/R	7,000	170	2.754	0.070
		Natural	C/M, T, ST/R	1,900	57		
Central California Coast steelhead	Juvenile	Natural	C/H/R	10,000	200	2.744	0.059
		Natural	C/M, T, ST/R	1,900	57		

C/H/R = Capture/Handle/Release
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 the table above.

As the table illustrates, for most species the researchers would take a small percent of any listed unit—and kill an even smaller percent of those units. 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.

Further, at the population level, the lethal take that would be authorized through this permit would still only have a very small impact on the abundance or productivity of the CCC coho salmon population in Lagunitas Creek. Recent population-level abundance data indicate there are at least 202 natural-origin CCC coho salmon adults within the Lagunitas Creek population (SWFSC 2022). Applying the same fecundity and survival estimates described in the Status of Species section to adult population estimates results in an estimate of 14,140 natural-origin juvenile CCC coho salmon within the watershed in a given year. Therefore, even at the population level the authorized take associated with this permit would result in, at most, less than (227/14140) 1.6% of juvenile CCC coho salmon in the watershed being killed. This project would therefore have very small impacts to abundance or productivity of CCC coho salmon at the population level, and those impacts are not likely to measurably affect the spatial structure or diversity of the species because any disproportionate impacts to these populations are so small.

In addition, the combined effects of this permit and permit 16110-3R would result in, at most, 760 natural-origin juvenile CCC coho salmon in Lagunitas Creek being killed. This figure would represent 5.4% of juveniles in the population if all authorized mortalities were to actually occur in a given year; a substantial figure when considering this is an endangered ESU, and Lagunitas Creek is one of three independent or potentially independent populations within the Coastal Diversity Stratum. However, such a loss of juveniles would not be expected to increase the extinction risk of the population because so few juveniles survive to adulthood under normal circumstances. Also, per the recovery plan only two of three such populations within a stratum must be at low risk of extinction for the stratum to be viable, as long as the populations combined are meeting abundance goals in aggregate (NMFS 2012). Therefore, even if these worst-case scenario mortality rates were to occur the effects to abundance and productivity of this one population would not be likely to significantly affect the viability of the stratum or the spatial structure or diversity of the ESU, and would not limit the recovery of this species. Most critically, we do not expect these authorization numbers to actually be realized mortality rates at the population or ESU-level, as described below. Population-level data for CC Chinook salmon and CCC steelhead are not available in the Lagunitas Creek watershed, so impacts can't be analyzed for these species at the population level.

It is also likely that the impacts will be smaller than those laid out above. Over the most recent 4 years, the researchers have only taken 8.31% of their requested take, and killed 2.21% 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. Furthermore, the research is expected to benefit listed species by providing data to inform future research, restoration, and conservation efforts involving *Oncorhynchus* species.

Permit 16110-3R

Under permit 16110-3R Marin Water is seeking to renew for five years a permit that would authorize them to continue to take adult and juvenile CC Chinook salmon, CCC coho salmon, and CCC steelhead in order to document trends in coho salmon abundance, determine freshwater and marine survival rates for coho salmon, assess the relationship between population trends and management efforts, and determine which coho life stage has the lowest survival rates. Juveniles would be collected via screw trap and backpack electrofishing and observed during snorkel surveys. Juvenile fish would be captured, handled (enumerated, measured, and checked for marks or tags), and released. A subsample of captured juveniles would be anesthetized, tissue sampled and PIT-tagged prior to release. Adults would be observed during snorkel surveys and spawning surveys and, although screw traps do not target adult fish, some adult CCC steelhead moving downstream may be collected at a screw trap in Lagunitas Creek. Any adults collected in this way would be handled (enumerated, checked for marks or tags), and released. Spawned adults or post-spawn carcasses would be enumerated during spawning surveys, and tissues may be collected from any carcasses at that time.

The researchers are not proposing to kill any of the listed fish being captured, but a small number may be killed as an inadvertent result of these activities. The amount of take Marin Water is requesting per year is found in the table below.

Table 30. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 16110-3R

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
California Coastal Chinook salmon	Adult	Natural	O/H	700	0	5.316	0.000
	Juvenile	Natural	C/H/R	6,500	195	0.178	0.005
		Natural	C/M, T, ST/R	2,000	60		
Central California Coast coho salmon	Adult	Natural	O/H	2,200	0	97.487	0.000
		Natural	O/ST D	50	0		
	Juvenile	Natural	C/H/R	14,500	435	4.384	0.110
		Natural	C/M, T, ST/R	3,250	98		
		Natural	O/H	3,500	0		
Central California Coast steelhead	Adult	Natural	C/H/R	50	0	41.973	0.000
		Natural	O/H	700	0		
		Natural	O/ST D	50	0		
	Juvenile	Natural	C/H/R	16,000	480	4.197	0.089
		Natural	C/M, T, ST/R	3,300	99		
		Natural	O/H	8,000	0		

O/ST D = Observe/Sample Tissue Dead Animal
O/H = Observe/Harass
C/H/R = Capture/Handle/Release
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 the table above.

As the table illustrates, for most species the researchers would take a small percent of any listed unit—and kill an even smaller percent of those units. 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.

Further, at the population level, the lethal take that would be authorized through this permit would still only have a very small impact on the abundance or productivity of the CCC coho salmon population in Lagunitas Creek. Recent population-level abundance data indicate there are at least 202 natural-origin CCC coho salmon adults within the Lagunitas Creek population (SWFSC 2022). Applying the same fecundity and survival estimates described in the Status of Species section to adult population estimates results in an estimate of 14,140 natural-origin juvenile CCC coho salmon within the watershed in a given year. Therefore, even at the population level the authorized take associated with this permit would result in, at most, less than 3.8% of juvenile CCC coho salmon in the watershed being killed.

In addition, the combined effects of this permit and permit 15730-3R would result in, at most, 760 natural-origin juvenile CCC coho salmon in Lagunitas Creek being killed. This figure would represent 5.4% of juveniles in the population if all authorized mortalities were to actually occur in a given year; a substantial figure when considering this is an endangered ESU, and Lagunitas Creek is one of three independent or potentially independent populations within the Coastal Diversity Stratum. However, such a loss of juveniles would not be expected to increase the extinction risk of the population because so few juveniles survive to adulthood under normal circumstances. Also, per the recovery plan only two of three such populations within a stratum must be at low risk of extinction for the stratum to be viable, as long as the populations combined are meeting abundance goals in aggregate (NMFS 2012). Therefore, even if these worst-case scenario mortality rates were to occur the effects to abundance and productivity of this one population would not be likely to significantly affect the viability of the stratum or the spatial structure or diversity of the ESU, and would not limit the recovery of this species. Most critically, we do not expect these authorization numbers to actually be realized mortality rates at the population or ESU-level, as described below. Population-level data for CC Chinook salmon and CCC steelhead are not available in the Lagunitas Creek watershed, so impacts can’t be analyzed for these species at the population level.

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 14.05% of their requested take, and killed 4.26% 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. Furthermore, this research is expected to benefit the listed species by providing information on population trends in watersheds impacted by Marin Water's water supply operations and thereby help managers tailor those operations in ways designed to help achieve recovery goals.

Permit 16417-4R

Under permit 16417-4R the SCVWD is seeking to renew for five years a permit that would authorize them to continue to take juvenile and adult CCC steelhead and juvenile S-CCC steelhead to continue to help fill data gaps with regard to *O. mykiss* distribution and habitat usage in Santa Clara County, California. The data to be gathered would also be used to improve understanding of fish migrations in the context of SCVWD water operations and monitor efforts to remediate total maximum daily mercury loads in the county.

Juveniles would be collected via beach seining and backpack electrofishing, and observations would be conducted at weirs, fish ladders, and dams where no trapping occurs. Captured juvenile fish would be handled (anesthetized, weighed, measured, and checked for marks or tags), enumerated, and released. A subsample of captured juveniles would be anesthetized, tissue sampled and PIT-tagged prior to release. Spawning surveys would be conducted without disturbing redds, and adults would be observed (live and by video) at weirs, fish ladders, dams. The researchers are not proposing to kill any of the listed fish being captured, but a small number may be killed as an inadvertent result of these activities. The amount of take the SCVWD is requesting per year is found in the table below.

Table 31. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 16417-4R

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Central California Coast steelhead	Adult	Natural	C/H/R	5	0	35.939	0.000
		Natural	O/H	680	0		
	Juvenile	Natural	C/H/R	955	34	0.670	0.014
		Natural	C/M, T, ST/R	1,900	58		
		Natural	O/H	1,500	0		
South-Central California Coast steelhead	Juvenile	Natural	C/M, T, ST/R	3,200	86	14.353	0.386

C/H/R = Capture/Handle/Release
C/M, T, ST/R = Capture/Mark, Tag, Sample Tissue/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 the table above.

As the table illustrates, for most species the researchers would take a small percent of any listed unit—and kill an even smaller percent of those units. 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. 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.

It is also likely that the impacts will be smaller than those laid out above. Over the most recent 4 years, the researchers have only taken 4.06% of their requested take, and killed 0.23% 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. Furthermore, the research is expected to benefit listed species by improving alignment of water supply management and fisheries needs to help steelhead survive and recover.

Permit 16446-3R

Under Permit 16446-3R, the CTUIR would continue and slightly expand upon work they have been performing in the Walla Walla River subbasin for nearly two decades under two previous permits (1365 and 16446). As noted in the proposed action, the researchers would use rotary screw traps and backpack electrofishing units to capture juvenile fish. At the screw traps, the fish would be identified, measured, weighed, tissue sampled, and implanted with PIT-Tags (if they do not already have tags). Fish captured via electrofishing would be handled, measured, allowed to recover, and released in a safe area. Some adult carcasses would also be sampled The CTUIR researchers are not proposing to kill any of the listed fish being captured, but a small number may be killed as an inadvertent result of these activities. The CTUIR is requesting the flowing amounts of take:

Table 32. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 16446-3R

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Middle Columbia River steelhead	Juvenile	Natural	C/H/R	1,000	20	0.931	0.019
		Natural	C/M, T, ST/R	6,000	120		

C/H/R = Capture/Handle/Release
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 the table above.

Thus, the research may kill, at most, 0.019% of the DPS's outmigration in a given year. However, that effect would not be spread uniformly throughout the species' range; it would be concentrated in that portion of the species inhabiting the Walla Walla River subbasin. From 2014-2019, an average of approximately 500 natural MCR steelhead returned to the Walla Walla River (Ford 2022). If half of those fish were females, each produced (conservatively) 2,500 eggs, and 5% of those eggs survived to reach the smolt stage, that would mean that the Walla Walla system has recently produced and average of 31,250 smolts and, consequently, the research could kill, at most, 0.45% of the local outmigration.

As a result, the research would have a very small effect on the local population's abundance (and therefore productivity), likely no measurable effect on structure or diversity, and a nearly negligible effect on the DPS as a whole. This is especially true when one considers that over the life of their previous permits, the researchers have killed far fewer fish than they have requested. Over the most recent 4 years, the researchers have only taken 27.07% of their requested take, and killed 36.91% of their requested mortalities, so it is most likely that the actual effect will be mortality rates on the order of 0.15% of the local population and 0.08% of the DPS as a whole. But even if all the fish permitted to be killed were killed in fact, that small effect would still be offset to some degree by the information to be gathered. The data on fish abundance, trends, genetics, diversity, productivity, and population structure would all be used to inform management decisions regarding land use activities and recovery planning in the Walla Walla River subbasin, and collecting those data is considered a priority in a number of regional salmon recovery forums.

Permit 16979-3R

Under Permit 16979, the WDFW would continue work that has been conducted sporadically under other authorities and previous permits for a number of years in Washington. The researchers may capture fish via dip netting, seining, snerding (using snorkelers to herd fish into a seine), electrofishing equipment, traps and weirs, and barbless hook-and-line sampling techniques. The captured fish may be tissue sampled (DNA and scales), measured, and tagged (PIT and radio-telemetry), allowed to recover, and released. No fish would intentionally be killed and, with the exception of radio-telemetry studies, all adult fish encountered will be allowed to escape without being captured (i.e., there would be no electrofishing nor targeted angling for adults). The researchers are requesting the following levels of take.

Table 33. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 16979-3R

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Upper Columbia River spring-run Chinook salmon	Adult	Natural	C/M, T, ST/R	100	2	12.300	0.246
		LHIA	C/M, T, ST/R	150	3	26.316	0.526
		LHAC	C/M, T, ST/R	150	3		
	Juvenile	Natural	C/M, T, ST/R	12,000	240	2.315	0.046
		LHIA	C/M, T, ST/R	1,750	52	0.394	0.012
		LHAC	C/M, T, ST/R	1,000	30	0.169	0.005
Upper Columbia River steelhead	Adult	Natural	C/M, T, ST/R	100	2	6.826	0.137
		LHIA	C/M, T, ST/R	90	2	10.024	0.207
		LHAC	C/M, T, ST/R	200	4		
	Juvenile	Natural	C/M, T, ST/R	10,000	20	6.175	0.012
		LHIA	C/M, T, ST/R	800	16	0.604	
		LHAC	C/M, T, ST/R	800	16	0.108	0.002

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 those 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 the table above.

Thus, if we exclude the LHAC hatchery fish that are by definition excess to recovery needs, the maximum effect stemming from the research is that the equivalent of two adult UCR Chinook and one adult UCR steelhead out of one thousand may annually be killed under Permit 16979-3R. All other effects would be smaller than that, and some would be orders of magnitude smaller. Moreover, because the research would be spread out across both the species' entire ranges upstream from the Yakima River, no individual population would be likely to experience a disproportionately large percentage of the negative impacts. Given these factors, it is likely that the research would have a small effect on the species' abundance and productivity, but no appreciable effect on structure or diversity. And, it should be noted, that the amounts of take being requested for UCR steelhead are more than 60% smaller than have been requested in the past.

It is also likely that the impacts will be a great deal smaller than those laid out above. Over the most recent 4 years, the researchers have only taken 17.71% of their requested take, and killed 7.83% of their requested mortalities, so it is most likely that the actual effect will be more than ten times smaller than that displayed in the table above. But even if all the fish permitted to be killed were killed in fact, that impact would still be offset to some degree by the data to be gained—data that would be used to inform entire suites of land management decisions and recovery actions throughout the upper Columbia River basin.

Permit 17428-4R

Under permit 17428-4R the USFWS, in collaboration with researchers from the PSMFC, is seeking to renew for five years a permit that would authorize them to continue to take adult SacR winter-run Chinook salmon and CVS Chinook salmon, and juvenile and adult CCV steelhead in the lower American River and lower Stanislaus River, California, in order to monitor the abundance of juvenile salmon, infer biological responses to ongoing habitat restoration activities, and generate data for salmon life-cycle models. Juveniles would be collected via screw trap and would be handled (anesthetized, enumerated, measured, and checked for marks or tags), and released. A subsample of captured juveniles would be anesthetized, tissue sampled, and PIT-tagged prior to release. Although screw traps do not target adult fish, some adult steelhead moving downstream may be collected at screw traps. Any adults collected in this way would be handled (enumerated, checked for marks or tags), and released. Spawned adults or post-spawn carcasses that drift into the screw traps would also be enumerated and tissues may be collected from any carcasses encountered.

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

Table 34. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 17428-4R

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Sacramento River winter-run Chinook salmon	Juvenile	Natural	C/M, T, ST/R	50	1	0.040	<0.001
		LHAC	C/M, T, ST/R	50	1	0.031	<0.001
Central Valley spring-run Chinook salmon	Juvenile	Natural	C/M, T, ST/R	140	6	0.008	<0.001
		LHAC	C/M, T, ST/R	140	6	0.007	<0.001
California Central Valley steelhead	Adult	Natural	C/H/R	13	2	0.113	0.017
	Juvenile	Natural	C/H/R	3,820	89	0.292	0.007

C/H/R = Capture/Handle/Release
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 the table above.

As the table illustrates, for most species the researchers would take a small percent of any listed unit—and kill an even smaller percent of those units. 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.

Further, at the population and basin levels, we anticipate the authorized lethal take would not have disproportionate effects on any population of SacRWR Chinook salmon, CVS Chinook salmon, or CCV steelhead. We do not have population-level data for SacRWR or CVS Chinook salmon in the American or Stanislaus Rivers because, although fish from these listed ESUs may occasionally migrate through (American River) or stray into (Stanislaus River) those areas, there are not currently spawning populations of either ESU in either basin. For that same reason, the loss of a few juveniles from these basins is not expected to disproportionately impact any component population of these ESUs, and so would also not impact the spatial structure or diversity of the ESUs.

For CCV steelhead, current population-level data for the American and Stanislaus Rivers indicate there are at least 134 adult steelhead in the two basins. Applying the fecundity and survival-rate calculations outlined in the Status of Species section above to the given adult populations produces estimates of 15,243 natural-origin juvenile CCV steelhead. Consequently, the authorized take would result in less than (2/134) 1.5% mortality of adult steelhead and less than (89/15,243) 0.5% for juveniles within this population. Further, while spawning populations of CCV steelhead do occur in the Stanislaus and American Rivers, neither is considered an independent population per the Recovery Plan for this species (NMFS 2014). While the recovery criteria for CCV steelhead include all dependent populations such as these continuing to exist, they also state only four populations from the Northern Sierra Nevada diversity group and two from the Southern Sierra Nevada group must be viable for these diversity groups to meet de-listing criteria. Each population sampled in this study represents only one of many populations within its' respective diversity group (NMFS 2014). Therefore, the potential loss of a single adult and fewer than 100 juvenile CCV steelhead from each population is expected to have small impacts on the abundance and productivity of those populations that would not impact the abundance, productivity, spatial structure, or diversity of CCV overall, and would not appreciably reduce the likelihood of survival and recovery of the DPS.

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 7.8% of their requested take, and killed 11.26% 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. Furthermore, this work would benefit listed species by providing information on whether management activities should be modified to enhance the abundance, production, condition, and survival of juvenile CVS Chinook Salmon and CCV Steelhead in the American and Stanislaus Rivers. Improving life-cycle models would also provide insight on factors affecting abundance and help managers develop actions to address and mitigate those factors.

Permit 17851-4R

Under permit 17851-4R the CWI is seeking to renew for five years a permit that would authorize them to continue to take juvenile PS Chinook salmon, PS steelhead, HCS chum salmon, and southern DPS eulachon at the estuary of the Elwha River, Washington. The purpose of the work is to define the nearshore restoration response to Elwha dam removals—with an emphasis on ecological function of nearshore habitats for juvenile salmon and forage fish. Juvenile salmonids would be collected via beach seine, handled (identified, weighed, measured, and checked for marks or tags), and released. The permit would also allow CWI to take adult Southern DPS eulachon—a species for which there are currently no take prohibitions—via beach seine. Eulachon are not being targeted but may unintentionally be captured, and would be handled and released.

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

Table 35. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 17851-4R

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Puget Sound Chinook salmon	Juvenile	Natural	C/H/R	2,500	25	0.067	<0.001
		LHAC	C/H/R	300	3	0.001	<0.001
Puget Sound steelhead	Juvenile	Natural	C/H/R	200	2	0.009	<0.001
		LHAC	C/H/R	120	2	0.065	0.001
Hood Canal summer-run chum salmon	Juvenile	Natural	C/H/R	900	9	0.021	<0.001
Southern DPS eulachon	Adult	Natural	C/H/R	300	8	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 the table above.

As the table illustrates, for most species the researchers would take a small percent of any listed unit—and kill an even smaller percent of those units. As a result, though the research may in some instances have a very small impact on species abundance and productivity, as described below it would in no measurable way impact structure or diversity for any species.

At the population level, the lethal take that would be authorized through this permit would still only have a very small impact on the abundance or productivity of PS Chinook salmon or steelhead populations in the Elwha River. Recent population-level abundance data indicate there are at least 134 natural-origin PS Chinook salmon adults and 1,241 natural-origin PS steelhead adults in the Elwha River where this work will take place (Ford 2022). Applying the same fecundity and survival estimates described in the Status of Species section to adult population estimates results in estimates of 224,800 natural-origin juvenile PS Chinook salmon and 141,164 natural-origin juvenile PS steelhead within the basin. Therefore, even at the population level the authorized take associated with this permit would result in, at most, 0.01% of natural-origin juvenile PS Chinook salmon in the basin being killed and less than 0.001% of natural-origin juvenile PS steelhead being killed. This project would therefore have very small impacts to abundance or productivity of PS Chinook salmon and steelhead at the population level, and those impacts are not likely to measurably affect the spatial structure or diversity of either species because any disproportionate impacts to these populations are so small. For HCS chum salmon and sDPS eulachon we do not have sufficient abundance data to conduct similar analyses at the population level, however, the very small number of individuals that could be killed are so small relative to the abundance of the ESU and DPS that it is very unlikely this impact on a single population could cause a measurable effect on spatial structure or diversity.

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 15.01% of their requested take, and killed none (0%) 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. Furthermore, this research would provide information beneficial to ESA-listed and unlisted native fish by defining nearshore habitat use by key species before, during, and after dam removal. This information will allow managers to identify if adaptive management, sediment management, or additional restoration considerations are warranted in the Elwha River estuary following dam removal. This work will also provide information on nearshore habitat response to dam removal that is relevant to co-managers of other ESA-listed salmon and steelhead on the West Coast.

Permit 18001-4R

Under permit 18001-4R Pierce County is seeking to renew for five years a permit that would authorize them to continue to take adult and juvenile PS Chinook salmon and PS steelhead in the waterways of Pierce County, Washington, in order to determine the distribution and diversity of anadromous fish species in the waterbodies adjacent to and within the County's jurisdiction. Juvenile salmonids would primarily be collected via beach seine and backpack electrofishing, although fish capture methods could also include dip nets or minnow traps. Juvenile fish would be captured, handled (weighed, measured, and checked for marks or tags), and released. Adults could also potentially be encountered during beach seining and, if they are, adult PS Chinook salmon and PS steelhead would be handled (weighed, measured, and checked for marks or tags), and released. All captured fish would be released into the same stream reach from which they were collected.

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

Table 36. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 18001-4R

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Puget Sound Chinook salmon	Adult	Natural	C/H/R	7	0	0.030	0.000
		LHAC	C/H/R	8	0	0.034	0.000
	Juvenile	Natural	C/H/R	60	1	0.002	<0.001
		LHAC	C/H/R	60	2	<0.001	<0.001
Puget Sound steelhead	Adult	Natural	C/H/R	10	0	0.052	0.000
	Juvenile	Natural	C/H/R	120	3	0.005	<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 the table above.

As the table illustrates, for most species the researchers would take a small percent of any listed unit—and kill an even smaller percent of those units. As a result, though the research may in some instances have a very small impact on species abundance and productivity, as described below it would in no measurable way impact structure or diversity for any species.

Further, at the population or basin level, the lethal take that would be authorized through this permit would still only have a very small impact on the abundance or productivity of PS Chinook salmon or steelhead populations in the Puyallup River Basin or Nisqually River. Recent population-level abundance data for Puyallup River Basin populations indicate there are at least 1,472 natural-origin PS Chinook salmon adults and 652 natural-origin PS steelhead in the populations within the White, Carbon, and Puyallup Rivers where this work will take place (Ford 2022). Applying the same fecundity and survival estimates described in the Status of Species section to adult population estimates results in estimates of 654,880 natural-origin juvenile PS Chinook salmon and 157,771 natural-origin juvenile PS steelhead within the basin. In the Nisqually River, applying the same fecundity and survival rates to the most recent adult population estimates results in estimates of 147,280 natural-origin juvenile PS Chinook salmon and 155,610 natural-origin juvenile PS steelhead in the Nisqually River.

The applicants are requesting to lethally take just one natural-origin juvenile PS steelhead and no natural-origin juvenile Chinook salmon in the Nisqually River and tributaries. In the Puyallup Basin they are requesting to lethally take only two natural-origin juvenile PS steelhead and one natural-origin juvenile Chinook salmon. Given the populations of juveniles in each of these locations, even at the population level the authorized take associated with this permit would result in, at most, less than 0.00l% of natural-origin juveniles of either species being killed. This project would therefore have almost no impacts to abundance or productivity of PS Chinook salmon or steelhead at the population level, and those impacts are not likely to measurably affect the spatial structure or diversity of either species because any disproportionate impacts to these populations are so small.

It is also likely that the impacts will be smaller than those laid out above. Over the most recent 5 years, the researchers have taken none (0%) of their requested take and mortalities, so it is most likely that the actual effect will be less than that displayed in the table above by a similar magnitude. Furthermore, these surveys would help establish listed salmonid presence in waterbodies about which this is currently little or inconclusive data. This information would be used to assess the impacts proposed projects might have on listed species and to guide decisions on where future projects should be implemented. The research would benefit PS Chinook salmon and PS steelhead by helping Pierce County develop a best management practices program, codify in-water work timing windows that would minimize harm to listed fish, and plan future habitat enhancement projects.

Permit 20792-2R

Under permit 20792-2R FISHBIO is seeking to renew a permit that would authorize them to continue to take adult CVS Chinook salmon, CCV steelhead, and southern DPS green sturgeon in the San Joaquin River and South Delta in California in order to detail the relative abundance and distribution of predatory fishes (i.e., striped, largemouth, spotted, and smallmouth bass, and catfishes) and characterize the diets of predators to determine how habitat and environmental conditions affect the composition of the non-native fish community. Data collected on non-native resident fishes will help identify areas of elevated predator abundance and improve understanding of predation impacts on juvenile salmonids migrating through this region. Listed species are not being targeted by this work, although some may be unintentionally encountered or captured. Juveniles and adults would be collected via boat electrofishing, and those captured would be handled (enumerated, measured, checked for marks or tags), their health assessed, and released. No listed species would be tagged during the course of this study; any captured listed species would be measured and released.

The researchers are not proposing to kill any of the listed fish being captured, but a small number of juveniles may be killed as an inadvertent result of these activities. The amount of take FISHBIO is requesting per year is found in the table below.

Table 37. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 20792-2R

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Central Valley spring-run Chinook salmon	Adult	Natural	C/H/R	5	0	0.111	0.000
		Natural	O/H	10	0		
		LHAC	C/H/R	5	0	0.240	0.000
	Juvenile	Natural	C/H/R	25	1	0.005	<0.001
		Natural	O/H	150	0		
		LHAC	C/H/R	30	1	0.002	<0.001
California Central Valley steelhead	Adult	Natural	C/H/R	3	0	0.131	0.000
		Natural	O/H	7	0		
		LHAC	C/H/R	5	0		
	Juvenile	Natural	C/H/R	15	1	0.004	<0.001
		Natural	O/H	100	0		
		LHAC	C/H/R	20	1	0.002	<0.001
Southern DPS green sturgeon	Adult	Natural	C/H/R	1	0	0.094	0.000
		Natural	O/H	3	0		

O/H = Observe/Harass
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 the table above.

As the table illustrates, for most species the researchers would take a small percent of any listed unit—and kill none of those units. 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.

Further, at the population or basin level, the researchers are requesting mortality for one natural-origin and one hatchery-origin juvenile for both CVS Chinook and CCV steelhead, with no lethal take of adults. The researchers are also requesting no lethal take for green sturgeon. Therefore, the take authorized through this permit would have an immeasurably small impact on the abundance or productivity of CVS Chinook salmon, CCV steelhead, and Southern DPS green sturgeon populations in the San Joaquin River and South Delta.

It is also likely that the impacts will be smaller than those laid out above. Over the most recent 4 years, the researchers have taken none (0%) of their requested take or mortalities, so it is most likely that the actual effect will be less than that displayed in the table above by a similar magnitude. Furthermore, this project is likely to benefit listed species by better delineating the abundance and distribution of non-native fish species that prey upon them.

Permit 21571-3R

Under Permit 21571, the USGS would continue conducting a series of studies designed to estimate smolt survival in relation to a number of factors in the Yakima River, Washington. In general, those factors are reach-specific survival, migration route choice, predator effects, and other biotic and abiotic variables. This work would be compared to similar work being conducted on non-listed Chinook salmon in the Yakima River with the goal of determining whether the Chinook studies can serve as surrogates for steelhead studies in the future. As noted previously, the researchers would use a variety of tags and capture methods to monitor the fishes' survival. The researchers would handle all listed fish with care, allow them to recover before returning them to the river, and follow well-established guidelines and protocols for all capture, handling and tagging procedures (e.g., NMFS's electrofishing guidelines). Adult fish will be avoided if at all possible.

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 21571-3R

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Middle Columbia River steelhead	Adult	Natural	C/H/R	3	0	0.022	0.000
	Juvenile	Natural	C/H/R	400	9	0.106	0.003
		Natural	C/M, T, ST/R	400	12		

C/H/R = Capture/Handle/Release
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 those 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 the table above.

As the table above shows, the effect of the proposed permit actions would be a very small one by any measure. There would be a slight reduction in abundance (and therefore productivity), but because so few fish would be killed, the effects on spatial structure and diversity would be negligible. However, because the fish would all come from the Yakima River major population group (MPG), the effect of the losses would be magnified somewhat at the local level. The Yakima River produces approximately 18% of the natural MCR steelhead in the DPS (Ford 2022), so at the local level, the effect may slightly more than five times as high as that displayed above—or about 0.015% of the Yakima River MPG. This equates to a little more than about one juvenile fish out of every ten thousand, which is still a very small effect and unlikely to have any impact in the species' structure or diversity.

It is also likely that the impacts will be smaller than those laid out above. Over the most recent 4 years, the researchers have only taken 52.89% of their requested take, and killed 28.4% 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. But even if the all the permitted mortalities were to happen, that loss must be placed in the context of the information the research is designed to generate regarding outmigrant survival in the Yakima River. For many years, there has been a data gap regarding sources of juvenile MCR steelhead mortality in the Yakima River, and this work is designed to fill that gap and thereby inform future management decisions for the benefit of the MCR steelhead in the basin.

Permit 22127-2R

Under permit 22127-2R the USFWS is seeking to renew for five years a permit that would authorize them to continue to take juvenile and adult PS Chinook salmon and PS steelhead in the Puyallup River basin (Pierce and King Counties, Washington), in order to gather information about bull trout (*Salvelinus confluentus*) movement and life history strategies in the basin. Bull trout are listed under the ESA and managed by USFWS. This research is not targeting ESA-listed fish under NMFS' jurisdiction (PS Chinook salmon and PS steelhead), but a small number may be unintentionally captured because their ranges overlap the target species. Juveniles may be collected via backpack electrofishing, gill net, and beach seine, and adults may be collected via gill net. Any adult or juvenile PS Chinook salmon or PS steelhead captured would be immediately released.

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

Table 39. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 22127-2R

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Puget Sound Chinook salmon	Adult	Natural	C/H/R	10	1	0.043	0.004
		LHAC	C/H/R	10	1		
	Juvenile	Natural	C/H/R	200	4	0.005	<0.001
		LHAC	C/H/R	200	4	<0.001	
Puget Sound steelhead	Adult	Natural	C/H/R	10	1	0.052	0.005
	Juvenile	Natural	C/H/R	600	16	0.027	<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 the table above.

As the table illustrates, for most species the researchers would take a small percent of any listed unit—and kill an even smaller percent of those units. As a result, though the research may in some instances have a very small impact on species abundance and productivity, as described below it would in no measurable way impact structure or diversity for any species.

At the population or basin level, the lethal take that would be authorized through this permit would still only have a very small impact on the abundance or productivity of PS Chinook salmon or steelhead populations in the Puyallup River Basin. Recent population-level abundance data available indicate there are at least 1,472 natural-origin PS Chinook salmon adults and 652 natural-origin PS steelhead in the populations within the Puyallup River Basin (including the White, Carbon, and Puyallup Rivers) where this work will take place (Ford 2022). Applying the same fecundity and survival estimates described in the Status of Species section to adult population estimates results in estimates of 654,880 natural-origin juvenile PS Chinook salmon and 157,771 natural-origin juvenile PS steelhead within the basin. Therefore, even at the population level the authorized take associated with this permit would result in, at most, 0.15% (1/652) of adult PS steelhead in the basin being killed and less than 0.1% of adult PS Chinook salmon or juveniles of either species in the Puyallup Basin being killed. This project would therefore have very small impacts to abundance or productivity of PS Chinook salmon and steelhead at the population level, and those impacts are not likely to measurably affect the spatial structure or diversity of either species because any disproportionate impacts to these populations are so small.

It is also likely that the impacts will be smaller than those laid out above. Over the most recent 4 years, the researchers have only taken 11.72% of their requested take, and killed 4.63% 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. Furthermore, while this work is intended to benefit listed bull trout by providing fine-scale information about their movement timing and upstream residency, any management and recovery actions informed by this work would likely also benefit PS Chinook salmon and PS steelhead due to their overlapping ranges and habitats.

Permit 26368

As noted previously, Permit 26368 would authorize Idaho State University researchers 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. 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 listed fish would be released as swiftly as possible—although in some cases they might need to recover in aerated water first.

The researchers are requesting the following amounts of take:

Table 40. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 26368

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Middle Columbia River steelhead	Juvenile	Natural	C/M, T, ST/R	250	5	0.067	0.001
Snake River spring/summer-run Chinook salmon	Juvenile	Natural	C/H/R	300	5	0.036	<0.001
Snake River Basin steelhead	Juvenile	Natural	C/M, T, ST/R	800	7	0.101	<0.001
Upper Willamette River Chinook salmon	Juvenile	Natural	C/H/R	100	2	0.009	<0.001
Upper Willamette River steelhead	Juvenile	Natural	C/M, T, ST/R	120	1	0.088	<0.001
Oregon Coast coho salmon	Juvenile	Natural	C/H/R	350	4	0.008	<0.001

C/H/R = Capture/Handle/Release
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 those 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 the table above.

As the table illustrates, the researchers would only take a very small percentage of any listed unit—and kill an even smaller percent of those units. 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. Moreover, 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, no ESA or DPS would experience a (juvenile fish) mortality rate of more than 0.001%, and in most instances, the rates would be far lower.

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 23% and killing approximately 11% of the juveniles authorized across all species, so it is most likely that the actual effect will be a good deal smaller than that displayed in the table above. This is especially true given the fact that the researchers would actively seek to avoid taking listed fish wherever possible. But even if the all the juvenile fish that are permitted to be killed are killed in fact, 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 26412

Under permit 26412 FISHBIO is seeking a new 5-year permit that would authorize them to annually take juvenile and adult SacR winter-run Chinook salmon, CVS Chinook salmon, and CCV steelhead, and adult southern DPS green sturgeon in the upper Sacramento River. The purpose of this study is to provide new information or bolster limited existing information on the residency, movement patterns, and spatiotemporal distributions of juvenile non-native Striped bass (*Morone saxatilis*) in the upper reaches of the Sacramento River. ESA-listed fish are not being targeted by this sampling effort, although some of them may be unintentionally captured as their range overlaps with Striped bass in the study area. ESA-listed salmon, steelhead, and sturgeon may be collected via hook-and-line angling or observed by camera or sonar.

All listed fish captured would be handled (enumerated, measured, and checked for marks or tags), and released. Sampling would be limited to six to ten days per month, and the permit would authorize no mortalities for listed fish. The amount of take the FISHBIO is requesting per year is found in the table below.

Table 41. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 26412

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Sacramento River winter-run Chinook salmon	Adult	Natural	C/H/R	1	0	0.675	0.000
		Natural	O/H	15	0		
	Juvenile	Natural	C/H/R	1	0	0.006	0.000
		Natural	O/H	15	0		
Central Valley spring-run Chinook salmon	Adult	Natural	C/H/R	5	0	0.185	0.000
		Natural	O/H	20	0		
		LHAC	C/H/R	5	0	0.240	0.000
California Central Valley steelhead	Adult	Natural	C/H/R	5	0	0.261	0.000
		Natural	O/H	20	0		
		LHAC	C/H/R	5	0		
	Juvenile	Natural	C/H/R	10	0	<0.001	0.000
		LHAC	C/H/R	15	0	0.001	0.000
Southern DPS green sturgeon	Adult	Natural	C/H/R	1	0	0.141	0.000
		Natural	O/H	5	0		

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 the table above. The researchers are requesting no lethal take. As a result, the research is not expected to have any measurable impacts on species abundance, productivity, structure, or diversity for any of the listed species above. Given that the research would not result in lethal take of any listed species we do not anticipate any discernable population-level impacts on these viability metrics and those impacts are not likely to measurably affect the spatial structure or diversity of either species because any disproportionate impacts to these populations are null.

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 only approximately 23% of the juveniles that were authorized, and only taking roughly 16% 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 the table above by a similar magnitude. Furthermore, the information to be gathered is expected to benefit listed species by providing resource managers data to help them assess predation risks to out-migrating salmonids and juvenile southern DPS green sturgeon in the Sacramento River.

Permit 26626

Under permit 26626 the NPS is seeking a new 5-year permit that would authorize them to annually take adult and juvenile PS Chinook salmon and PS steelhead, as well as subadult PS steelhead and spawned carcasses of both species, in the Elwha River Basin. The purpose of the study is to continue monitoring the recolonization of Pacific salmonids and lamprey after dam removal in the Elwha River. The majority of fish encountered during this study would be observed during snorkel surveys but not handled. Small numbers of juveniles of both species would be collected via backpack electrofishing, and captured juveniles would be anesthetized, tissue-sampled and marked prior to release. Adult PS Chinook salmon and PS steelhead would be collected via tangle net and hook-and-line angling in addition to observations during snorkel surveys. Captured adults would be anesthetized, tissue sampled, and tagged with a Floy, internal radio, or external radio tag prior to release. Spawned adults and post-spawn carcasses would be counted during spawning surveys. Subadult PS steelhead would also be observed during snorkel surveys and captured via tangle nets and hook-and-line angling; these fish would also be anesthetized, tissue sampled, and tagged with a Floy, internal radio, or external radio tag prior to release.

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

Table 42. Proposed Take and Comparison of Possible Lethal Take to Annual Abundance at the ESU/DPS Scale Under Permit 26626

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Puget Sound Chinook salmon	Adult	Natural	C/M, T, ST/R	10	2	0.128	0.004
		Natural	O/H	50	0		
		LHIA	C/M, T, ST/R	200	4	5.165	0.017
		LHIA	O/H	1,000	0		
	Juvenile	Natural	C/M, T, ST/R	200	4	0.004	<0.001
		Natural	O/H	100	0		
		LHIA	C/M, T, ST/R	200	4	0.013	<0.001
		LHIA	O/H	2,000	0		
Puget Sound steelhead	Adult	Natural	C/M, T, ST/R	380	10	4.927	0.026
		Natural	O/H	1,500	0		
		LHIA	C/M, T, ST/R	380	10	255.782	1.361
		LHIA	O/H	1,500	0		
	Juvenile	Natural	C/M, T, ST/R	200	4	0.049	<0.001
		Natural	O/H	2,000	0		
		LHIA	C/M, T, ST/R	200	4	1.257	0.002
		LHIA	O/H	2,000	0		

C/M, T, ST/R = Capture/Mark, Tag, Sample Tissue/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 the table above.

As the table illustrates, for most species the researchers would take a small percent of any listed unit—and kill an even smaller percent of those units. 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.

At the population level, the lethal take that would be authorized through this permit would still only have a very small impact on the abundance or productivity of PS Chinook salmon or steelhead populations in the Elwha River. Recent population-level abundance data indicate there are at least 134 natural-origin PS Chinook salmon adults and 358 natural-origin PS steelhead adults in the Elwha River where this work will take place (Ford 2022). Applying the same fecundity and survival estimates described in the Status of Species section to adult population estimates results in estimates of 224,800 natural-origin juvenile PS Chinook salmon and 141,164 natural-origin juvenile PS steelhead within the basin. Therefore, even at the population level the authorized take associated with this permit would result in, at most, 1.5% (2/134) of natural-origin adult and less than 0.002% of the natural-origin juvenile PS Chinook salmon in the population being killed, and less than 2.8% (10/358) of natural-origin adult and less than 0.003% of natural-origin juvenile PS steelhead being killed. This project would therefore have very small impacts to abundance or productivity of PS Chinook salmon or steelhead at the population level due to juvenile mortalities, and those impacts are not likely to measurably affect the spatial structure or diversity of either species because any disproportionate impacts to these populations are so small. For natural-origin adults of both species, the potential mortality rates of 1.5% (PS Chinook salmon) and 2.8% (PS steelhead) of the Elwha populations would, if they occurred, represent meaningful losses to the abundance and productivity of this population.

For PS Chinook salmon in the Elwha River, as one of only two historic populations in the Strait of Juan de Fuca, this population needs to attain a low-risk status and show improvement since 2007 for the ESU as a whole to reach viability, according to the Recovery Plan (NMFS 2006). However, our absolute estimate of the number of adult spawners in the Elwha population is so low that while the potential loss of only one or two individuals constitutes a substantial percentage of the adult population, it is within the range of interannual fluctuations in spawner abundance that would be expected without the research impacts. Therefore, potential reduction in Elwha population abundance associated with this project would not be expected to have long-term impacts on productivity, limit the continued recovery of this population, or preclude the major population group from being viable. Further, research and planning to support the recovery of Chinook salmon in the Elwha River wouldn't be possible without allowing the potential for lethal losses inherent in capturing and tagging adults. This information is critical to recovery planning for this population, and therefore the risks of potential impact to the population abundance and productivity would be outweighed by the benefits of the information gained from this research.

For PS steelhead, the Elwha represents only one of 8 demographically independent populations within the Strait of Juan de Fuca and Hood Canal major population group. The Recovery Plan for PS steelhead (NMFS 2019) specifies that at least 40% of winter-run and summer-run populations must be viable within each major population group for delisting, and that each independent population should have a minimum mean run size of 50. The loss of up to 0.8% of the Elwha population of adult spawners would not reduce the population to anywhere near that abundance threshold, nor would reducing the Elwha population abundance preclude viability of the major population group. Therefore, the impacts of this research, even if they occurred at the levels authorized above, are not likely to affect the spatial structure or diversity of the PS steelhead DPS relative to recovery goals.

Lastly, we know that our current abundance estimates for both PS steelhead and PS Chinook salmon Elwha River populations are likely underestimates because these populations have been growing since 2014 when the Elwha and Glines Canyon dam removals were completed. Our current estimates are based on geometric means of data collected from 2015-2019, however, surveys conducted in 2018 and 2019 reported observing more than 1,600 adult PS Chinook salmon each year and more than 220 adults for summer-run PS steelhead alone (not counting winter-run) each year (Duda *et al.* 2021). Therefore, the absolute numbers of adults being authorized to be lethally taken very likely represent a much smaller percent of the population abundance that will be present from 2022 onward. 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 23% and killing approximately 11% of the juveniles that were authorized, and only taking roughly 16% and killing roughly 4% 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 the table above by a similar magnitude. Furthermore, the information gathered from this work would help scientists and managers assess spatial extent, relative abundance, migration patterns, and life history attributes of Pacific salmonids and map how those factors relate to four stages of restoration in the Elwha River:

protection, recolonization, local adaptation, and recovered. This project is designed to generate data for assessing the life history responses of migratory salmonids to dam removal, and the work would help resource managers involved with the Elwha Ecosystem Restoration Project better carry out PS steelhead and Chinook recovery actions.

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, 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 5-year review updates for Pacific salmon and steelhead listed under the Endangered Species Act.[2] 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. 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,

[2] NOAA Fisheries – West Coast Region - 2022 5-Year Reviews of Listed Salmon & Steelhead

and national levels to conserve PS Chinook salmon and other listed salmonids, see any of the recent 5-year reviews, listing Federal Register notices, and recovery planning documents, as well as recent consultations on issuance of section 10(a)(1)(A) research permits.

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 2020, the population in Puget Sound and Western Washington counties has increased from 2.03 to 6.02 million people[3]. 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). Water quality is also a major concern for salmonids in urban watersheds—French *et al.* (2022) have documented significant mortality for coho salmon (92-100%), Chinook salmon (0-13%), and steelhead (4-42%) exposed to untreated urban runoff from central Puget Sound streams due to the presence of 6PPD-quinone, a breakdown product from the chemicals found in tire particles. In addition, factors degrading marine water quality conditions, such as climate change and pollution, are likely to continue to be caused 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

[3] Washington State Office of Financial Management Population and Demographics webpage

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, Eastern Oregon, and Washington

According to the U.S. Census bureau, Idaho was the second-fastest growing state in the country from 2010-2020, with the population increasing from 1.57 to 1.84 million, although that increase has largely been confined to the State's urban areas. In rural areas—the areas where the proposed actions would take place—communities had only modest increases or even decreases in population size.[4] This signifies that in the action areas, if this trend continues, there is likely to be little change in competing demands for resources such as water due to population growth, although such changes can be driven more broadly by water that is redirected for use in urban areas. Also, it is likely that streamside development will decrease in rural areas. However, given the overall increase in population, recreation demand for resources such as the fish themselves may increase, as well as overall demands for stored water and groundwater statewide.

The situation is similar for Eastern Oregon and Washington. According to the Census bureau both states have seen population increases overall, from 3.83 to 4.24 million in Oregon and from 6.72 to 7.71 in Washington, between 2010 and 2020. There was also a 2.7% population increase in rural, eastern Oregon in recent years (2013-2018).[5] And, though Eastern Washington has also seen some population increase, it has largely been restricted to the population centers rather than the rural areas.[3] This signifies that, as with Idaho, there is low likelihood that population increases will drive steep increases in competing demands for primary resources like water, but other factors such as climate change may increase competition over diminishing surface water and groundwater resources. As with Idaho, overall population growth of both Washington and Oregon may also increase recreational demand for the species themselves, as well as stored instream and groundwater resources that are essential for listed salmonids.

Western Oregon

The situation in Western Oregon is likely to be similar to that of the Puget Sound and Western Washington region as the area shows similar human population growth patterns. Cumulative effects are likely to continue increasing both in the Willamette Valley and along the coast, with Census bureau data showing the populations in all western counties grew from 2010 to 2020, increasing in total from 3.32 million to 3.67 million inhabitants. The result of this growth is that there will be more development, and therefore more habitat impacts such as stream channel simplification, changes to stream flows and temperatures, and greater levels of pollution (particularly from urban runoff, but also from agricultural uses). These effects would be somewhat lessened in the coastal communities, but resource extraction (particularly timber harvest) would likely 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

[4] Idaho Capital Sun August 20, 2021 "Census 2020 data illustrates Idaho's urban, rural divide"
[5] State of Oregon Employment Department Dec 20, 2018 "A Quick Look at Population Trends in Eastern Oregon"

habitat or affect listed species. So, it is difficult to characterize the effects that would not be consulted upon beyond saying they are likely to increase both in severity and geographic scope.

California

According to the U.S. Census Bureau, the State of California's population increased from 37.25 to 39.54 from 2010 to 2020.[6] 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.

While the impacts related to climate change and human development are likely to continue, the impacts of scientific research are not likely to exacerbate the effects of either on listed salmon and steelhead or their habitat. Many research projects authorized by the Section 10(a)(1)(A) program, including some considered as part of this action, would provide information that would help guide restoration efforts intended to reverse habitat degradation caused by past and ongoing land use practices, and minimize the negative impacts of climate change on salmon and steelhead habitat. 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 and productivity 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.

2.7 Integration and Synthesis

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

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 table therefore (a) combines the proposed take for all

[6] Census Bureau California Quick Facts from www.census.gov

the permits considered in this opinion for all components of each species (Table 43), (b) adds that take to the take that has already been authorized in the region and (c) compares those totals to the estimated annual abundance of each species under consideration (Table 44).

Table 43. Total requested take for the permits and percentages of the ESA listed species for permits covered in this Biological Opinion.

Species	Life Stage	Origin[a]	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Puget Sound Chinook salmon	Adult	Natural	27	3	0.116	0.013
		LHIA	200	4	0.938[b]	0.022[b]
		LHAC	18	1		
	Juvenile	Natural	2,982	36	0.080	0.001
		LHIA	200	4	0.002	<0.001
		LHAC	582	11	0.002	<0.001
Puget Sound steelhead	Adult	Natural	400	11	2.097	0.058
		LHIA	380	10	51.701	1.361
	Juvenile	Natural	1,142	27	0.051	0.001
		LHIA	200	4	0.229	0.005
		LHAC	142	4	0.076	0.002
Hood Canal summer-run chum salmon	Juvenile	Natural	911	10	0.021	<0.001
Upper Columbia River spring-run Chinook salmon	Adult	Natural	106	2	13.038	0.246
		LHIA	150	3	26.316[b]	0.526[b]
		LHAC	150	3		
	Juvenile	Natural	12,005	241	2.316	0.046
		LHIA	1,750	52	0.394	0.012
		LHAC	1,000	30	0.169	0.005
Upper Columbia River steelhead	Adult	Natural	106	2	7.235	0.137
		LHIA	90	2	10.024[b]	0.207[b]
		LHAC	200	4		
	Juvenile	Natural	10,005	21	6.178	0.013
		LHIA	800	16	0.604	0.012
		LHAC	800	16	0.108	0.002
Middle Columbia River steelhead	Adult	Natural	9	0	0.066	0.000
	Juvenile	Natural	8,055	167	2.143	0.044
Snake River spring/summer-run Chinook salmon	Juvenile	Natural	17,300	175	2.103	0.021
		LHIA	450	4	0.062	<0.001
		LHAC	50	1	0.001	<0.001
Snake River Basin steelhead	Adult	Natural	5	0	0.050	0.000
	Juvenile	Natural	4,200	41	0.532	0.005
Snake River sockeye salmon	Adult	Natural	2	0	12.500	0.000
	Juvenile	Natural	425	131	2.231	0.688
		LHAC	50	50	0.018	0.018
Upper Willamette River Chinook salmon	Juvenile	Natural	100	2	0.009	<0.001
Upper Willamette River steelhead	Juvenile	Natural	120	1	0.088	<0.001
Oregon Coast coho salmon	Juvenile	Natural	350	4	0.008	<0.001
California Coastal Chinook salmon	Juvenile	Natural	8,600	258	0.359	0.011

Species	Life Stage	Origin[a]	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Sacramento River winter-run Chinook salmon	Adult	Natural	1	0	0.084	0.000
	Juvenile	Natural	51	1	0.041	<0.001
		LHAC	50	1	0.031	<0.001
Central Valley spring-run Chinook salmon	Adult	Natural	10	0	0.148	0.000
		LHAC	10	0	0.480	0.000
	Juvenile	Natural	165	7	0.009	<0.001
		LHAC	170	7	0.008	<0.001
California Central Valley steelhead	Adult	Natural	21	2	0.270[c]	0.017[c]
		LHAC	10	0		
	Juvenile	Natural	3,845	90	0.294	0.007
		LHAC	35	1	0.003	<0.001
Central California Coast coho salmon	Juvenile	Natural	26,650	760	16.495	0.470
Central California Coast steelhead	Adult	Natural	55	0	2.886	0.000
	Juvenile	Natural	34,055	928	15.707	0.428
South-Central California Coast steelhead	Juvenile	Natural	3,200	86	14.353	0.386
Southern DPS eulachon	Adult	Natural	301	9	0.001	<0.001
Southern DPS green sturgeon	Adult	Natural	2	0	0.094	0.000

[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.

Thus, the activities contemplated in this opinion may kill—in combination and at most—as much as 1.36% of the fish from any component of any listed species; that component is hatchery Puget Sound steelhead adults. It should be noted, however, that hatchery-origin fish are considered excess to recovery needs, and the maximum proportion of any natural-origin listed species component that may be killed is, at most, 0.69% (SnkR sockeye salmon juveniles). In all other instances found in the table above, the effect is (at most) half a percent or less 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 44. Total expected take of the ESA listed species for scientific research and monitoring already approved for 2022 plus the permits covered in this Biological Opinion.

Species	Life Stage	Origin[a]	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Puget Sound Chinook salmon	Adult	Natural	848	44	3.628	0.188
		LHIA	635	17	7.184[b]	0.400[b]
		LHAC	1,034	76		
	Juvenile	Natural	496,821	11,187	13.326	0.300
		LHIA	233,298	5,060	2.818	0.061
		LHAC	165,159	12,917	0.631	0.049

Species	Life Stage	Origin[a]	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Puget Sound steelhead	Adult	Natural	2,267	49	11.882	0.257
		LHIA	402	11	59.456 [b]	2.449 [b]
		LHAC	35	7		
	Juvenile	Natural	92,748	1,548	4.115	0.069
		LHIA	3,472	53	3.968	0.061
		LHAC	8,587	167	4.617	0.090
Hood Canal summer-run chum salmon	Adult	Natural	1,088	22	3.870	0.078
	Juvenile	Natural	734,023	2,595	17.308	0.061
		LHIA	1,395	44	0.930	0.029
		LHAC	85	18	-	-
Upper Columbia River spring-run Chinook salmon	Adult	Natural	301	8	37.023	0.984
		LHIA	302	6	54.561[b]	1.404[b]
		LHAC	320	10		
	Juvenile	Natural	22,813	474	4.401	0.091
		LHIA	2,785	85	0.628	0.019
		LHAC	2,506	108	0.423	0.018
Upper Columbia River steelhead	Adult	Natural	313	6	21.365	0.410
		LHIA	184	4	20.843[b]	0.484[b]
		LHAC	419	10		
	Juvenile	Natural	41,369	672	25.547	0.415
		LHIA	3,219	85	2.430	0.064
		LHAC	11,146	265	1.499	0.036
Middle Columbia River steelhead	Adult	Natural	1,135	17	8.347	0.125
		LHIA	165	6	142.356[b]	2.384[b]
		LHAC	850	11		
	Juvenile	Natural	114,109	2,568	30.354	0.683
		LHIA	8,553	114	7.398	0.099
		LHAC	791	43	0.183	0.010
Snake River spring/summer-run Chinook salmon	Adult	Natural	2,307	16	52.206	0.362
		LHIA	388	4	54.890[b]	0.496[b]
		LHAC	1,161	10		
	Juvenile	Natural	596,875	6,235	72.557	0.758
		LHIA	52,018	548	7.140	0.075
		LHAC	81,541	1,222	1.718	0.026
Snake River Basin steelhead	Adult	Natural	9,286	109	93.186	1.094
		LHIA	1,983	28	146.819[b]	2.070[b]
		LHAC	2,840	40		
	Juvenile	Natural	284,243	4,049	35.972	0.512
		LHIA	35,415	467	7.139	0.094
		LHAC	78,143	984	2.492	0.031
Snake River sockeye salmon	Adult	Natural	113	6	706.250	37.500
		LHIA	1	0	2.062[b]	0.000[b]
		LHAC	1	0		
	Juvenile	Natural	11,515	604	60.456	3.171
		LHIA	1	0	-	-
		LHAC	451	311	0.166	0.115
Upper Willamette River Chinook salmon	Adult	Natural	168	6	1.595	0.057
		LHAC	88	11	0.347	0.043
	Juvenile	Natural	37,002	771	3.178	0.066
		LHIA	40	7	-	-
		LHAC	9,876	330	0.217	0.007

Species	Life Stage	Origin[a]	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Upper Willamette River steelhead	Adult	Natural	203	4	7.725	0.152
	Juvenile	Natural	13,896	288	10.145	0.210
Oregon Coast coho salmon	Adult	Natural	8,022	101	13.232	0.167
		LHAC	20	4	3.135	0.627
	Juvenile	Natural	464,190	10,817	10.824	0.252
		LHAC	275	20	0.458	0.033
California Coastal Chinook salmon	Adult	Natural	374	20	2.840	0.152
	Juvenile	Natural	68,618	1,446	2.868	0.060
Sacramento River winter-run Chinook salmon	Adult	Natural	1,521	24	128.354	2.025
		LHAC	1,515	51	56.174	1.891
	Juvenile	Natural	429,167	11,535	343.229	9.225
		LHAC	205,159	7,741	129.149	4.873
Central Valley spring-run Chinook salmon	Adult	Natural	1,624	28	24.038	0.414
		LHAC	739	87	35.478	4.177
	Juvenile	Natural	845,961	17,494	46.002	0.951
		LHAC	32,234	3,966	1.612	0.198
California Central Valley steelhead	Adult	Natural	3,411	117	51.975[c]	2.793[c]
		LHIA	50	1		
		LHAC	2,513	203		
	Juvenile	Natural	68,936	1,988	5.273	0.152
		LHAC	27,695	1,808	2.638	0.172
Central California Coast coho salmon	Adult	Natural	4,418	62	263.128[c]	4.203[c]
		LHIA	1,655	35		
	Juvenile	Natural	207,181	3,505	128.238	2.169
		LHIA	106,516	1,603	76.083	1.145
Central California Coast steelhead	Adult	Natural	2,561	48	136.569[c]	2.886[c]
		LHAC	42	7		
	Juvenile	Natural	264,373	6,108	121.939	2.817
		LHAC	15,501	448	2.981	0.086
South-Central California Coast steelhead	Adult	Natural	1,344	22	685.714	11.224
	Juvenile	Natural	38,433	869	172.384	3.898
Southern DPS eulachon	Adult	Natural	38,040	31,075	0.149[d]	0.123[d]
	Subadult	Natural	1,030	1,030		
	Juvenile	Natural	940	862		
Southern DPS green sturgeon	Adult	Natural	346	9	16.267	0.423
	Subadult	Natural	231	9	2.069	0.081
	Juvenile	Natural	6,549	190	147.800	4.288
	Larvae	Natural	11,130	1,030	-	-
	Egg	Natural	2,810	2,810		

[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 for these species are only known for the adult life stage which is used to represent the entire DPS.

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 species' 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 17 cases involving 11 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 43 and 44 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 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: MCR steelhead, SnkR spr/sum Chinook salmon, SnkR sockeye, SnkR steelhead, OC coho, SacR WR Chinook salmon, CVS Chinook salmon, CCV steelhead, CCC coho salmon, CCC steelhead, SCCC steelhead, and SC steelhead. 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 43). 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 sub sections 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 is 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 expected detrimental effects of the research activities 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 recover.

Adults

Upper Columbia River Spring-run Chinook Salmon

Under the research program as a whole, 0.984% of the natural-origin adult UCR spring-run Chinook salmon may be killed by permitted research activities in a given year. The actions considered in this opinion would appear to add two fish to the total being allotted, but in fact all additional fish come from permit renewals. 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 0.984% rate have previously been analyzed multiple times 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 killing only 3.4% of the adult, naturally- produced UCR spring-run Chinook salmon they were authorized. This would mean that the actual effect of mortalities is likely to be less than one-twentieth 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.

Snake River Basin Steelhead

Under the research program as a whole, up to 109 of the natural-origin adult SnkR steelhead may be killed by permitted research activities in a given year; this would constitute 1.094% of that component of the DPS. However, the research contemplated in this opinion would add no fish at all to that total; in fact, the current program would actually see a small reduction in the number of natural adult SnkR steelhead that may be killed. This signifies that more than the entirety of the natural-origin adult 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 that analysis here.

Snake River Sockeye Salmon

Under the research program as a whole, researchers 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 appear to add two fish to the total being allotted, but in fact both of those additional fish come from a permit that is being renewed (1124-7R). Thus, though the fish are not currently considered part of the baseline, they have been such for a number of years and have therefore been part of several previous analyses. Nonetheless, the 37.5% mortality rate is very high and could genuinely operate to the species' disadvantage should it ever occur; as such, it requires careful consideration.

To that end, there are a number of caveats associated with that figure. First, the 6 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, Permit 1124-7R (analyzed above) and Permit 1341-6R—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 Permit 1124, 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, henceforth all permits that might allow one or more adult sockeye mortalities will 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 43.

Sacramento River Winter-Run Chinook Salmon

When combined with scientific research and monitoring permits already approved the potential mortality for adult SacRWR Chinook salmon would range 1.9% for hatchery-origin fish to 2.0% for naturally produced fish in this ESU. However, the research contemplated in this opinion would add no fish at all to that total. This signifies that the entirety of the adult 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 that analysis here.

California Central Valley Steelhead

When combined with scientific research and monitoring permits already approved, the potential mortality for adult CCV steelhead could be equivalent to roughly 2.8% of estimated adult abundance for this DPS. The 2.8% potential mortality figure is combined for natural-origin and hatchery adult fish, as available data are not currently sufficient to provide reliable estimates of the proportion of hatchery-origin spawners in this DPS overall. 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. The

The actions considered in this opinion would appear to add 2 natural-origin fish to the total being allotted, but in fact both of those fish come from permit renewals. 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 2.8% rate have previously been 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 5.98% of the adult naturally produced CCV steelhead they were authorized, and the actual mortality rate was only 2.91% of the mortalities authorized for adults. This would mean that the actual effect of take is likely to be much less than the effect displayed in the table above, and is unlikely to cause additional natural-origin adult mortalities compared to the baseline.

Thus, the losses are very small, 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.

Central California Coast Coho Salmon

When combined with scientific research and monitoring permits already approved, the potential mortality for CCC coho salmon could be equivalent to up to 4.2% of estimated adult abundance for this ESU. However, the research contemplated in this opinion would add no adult fish to that total. This signifies that the entirety of the adult 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 that analysis here.

Central California Coast Steelhead

When combined with scientific research and monitoring permits already approved, the potential mortality for natural and hatchery-origin adult CCC steelhead would be 2.9% of estimated adult abundance for this DPS. However, the research contemplated in this opinion would add no adult fish 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 that analysis here.

South-Central California Coast Steelhead

When combined with scientific research and monitoring permits already approved, the potential mortality for natural adult SCCC steelhead would be 11.2% of the adult abundance in this DPS. However, the research contemplated in this opinion would add no adult fish to that total. This signifies that the entirety of the adult 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 that analysis here.

Juveniles

Middle Columbia River Steelhead

A figure requiring a closer view is the 0.683% of the natural-origin MCR steelhead juveniles killed by research activities in the Deschutes River basin. The actions considered in this opinion would appear to add 167 fish to the total being allotted, but in fact all but 5 of those additional juvenile fish come from permit renewals so, though they are not currently considered part of the baseline, they have been such for a number of years and their take has previously been analyzed and found not to jeopardize the species. Thus, the 0.683% actually represents little increase over 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 undoubtedly be less than that listed above. 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.

In addition, it should also be noted that over the last five years (a time when all the permits being renewed were in effect), the amount of natural MCR steelhead juvenile taken was only 23.6% of what was permitted—and the mortality rate was only 12.7% 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 around 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, 0.758% of the natural-origin juvenile SnkR spr/sum Chinook salmon may be killed by permitted research activities in a given year. The actions considered in this opinion would appear to add 175 fish to the total being allotted, but in fact all but 5 of those additional fish come from permit renewals. 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 0.758% 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 (a time when all the permits being renewed were in effect), the amount of natural SnkR spr/sum Chinook salmon juveniles taken was only 13.6% of what was permitted and the mortality rate was only 4.8% 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.

Snake River Basin Steelhead

Under the research program as a whole, 0.512% of the natural-origin juvenile SnkR steelhead may be killed by permitted research activities in a given year. The actions considered in this opinion would appear to add 41 fish to the total being allotted, but in fact only 7 of those additional fish are from new permits while the remaining 34 come from permit renewals. Thus, though they are not currently considered part of the baseline, they have been such for a number of years and, as a result, mortality rates very nearly the same as the 0.512% have previously been analyzed. As a result, 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 less 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 undoubtedly be less than 0.512%.

Moreover, it should be noted that over the last five years (a time when all the permits being renewed were in effect), the amount of natural SnkR steelhead juvenile taken was only 18.0% of what was permitted and the mortality rate was only 5.5% 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.

Snake River Sockeye Salmon

When combined with scientific research and monitoring permits already approved, 3.17% 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: all of these are associated with renewing existing permits, and the numbers are expected to be much lower than authorized. The actions considered in this opinion would appear to add 131 juvenile sockeye to the total being allotted, but in fact none of those fish are from new permits – all come from permit renewals. Thus, though they are not currently considered part of the baseline, they have been such for a number of years and, as a result, mortality rates very nearly the same as the 3.17% have previously been analyzed. As a result, this minor effect on abundance and (therefore) productivity has thus 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 actions.

In addition, these truly are worst-case numbers. Over the last five years, the IDFG researchers under Permit 1124 (the permit under which most juvenile SnkR sockeye salmon are taken, renewed in this opinion) have killed only 5.3% of the permitted mortalities. That is also true for the other main permit under which this species is taken –Permit 1341—which is held by the Shoshone-Bannock tribes and over the most recent five years, the researchers have taken only 0.1% of their requested take, and killed none of their requested mortalities. Thus, it is most likely that the actual effect will continue to be effectively negligible—on the order of 0.0% to 0.5% rather than the 3.17% displayed in the table.

Lastly, the entire purpose of both of these permits with the most juvenile SnkR sockeye salmon take (Permit 1124 and 1341) is to help the sockeye salmon survive and recover. Under Permit 1124 (as noted previously) 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 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.

Sacramento River Winter Run Chinook salmon

When combined with scientific research and monitoring permits already approved, 9.2% of the natural-origin juvenile SacRWR Chinook salmon may be killed by permitted research activities in a given year. This represents a notable portion of the species' total abundance, however, there are two caveats to this number. First, the research contemplated in this opinion would add only one dead natural juvenile SacRWR Chinook to the total, and that fish would come from a permit renewal (17428-4R). Thus, though renewals are not currently considered part of the baseline, this take has been such for a number of years and, as a result, mortality rates similar to the 9.2% have previously been analyzed. As a result, this minor effect on abundance and (therefore) productivity has thus repeatedly been determined to not jeopardize the species.

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 only 20.2% of the naturally produced SacRWR Chinook salmon juveniles they were authorized, and the actual lethal take rate of natural-origin juveniles was only 11.0% of the mortalities authorized. This would mean that the actual effect is likely to be roughly 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 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. Therefore, the impacts of the program—even in its entirety—have 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.

Central Valley Spring Run Chinook salmon

When combined with scientific research and monitoring permits already approved, 0.95% of natural-origin juvenile CVS Chinook salmon may be killed by permitted research activities in a given year. The activities contemplated in this opinion represent only a very small fraction (7 of 17,494, or less than 0.04%) of the total authorized across research programs. Therefore, the majority of this take has therefore previously been analyzed and found not to jeopardize the CVS Chinook salmon ESU. The potential additional mortality of CVS Chinook salmon resulting from activities contemplated in this opinion would equate to <0.001% of the abundance of natural-origin juveniles, and would therefore be unlikely to have a measurable impact on the abundance and productivity of this ESU even if take occurred at the maximum authorized amount. Furthermore, while actions considered in this opinion would appear to add 7 juvenile CVS Chinook salmon to the total being allotted, in fact none of those fish are from new permits – all come from permit renewals. Thus, though they are not currently considered part of the baseline, they have been such for a number of years and, as a result, mortality rates very nearly the same as those contemplated in this opinion have previously been analyzed. As a result, this minor effect on abundance and (therefore) productivity has thus repeatedly been determined to not 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 17.8% of the juveniles they were authorized, and the actual mortality rates also averaged only 11.5% 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 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 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.

Central California Coast Coho salmon

When combined with scientific research and monitoring permits already approved, 2.2% of natural-origin juvenile CCC coho salmon may be killed by permitted research activities in a given year. The actions considered in this opinion would appear to add 760 fish to the total being allotted, but in fact none of those additional fish are from new permits – all come from permit renewals. Thus, though they are not currently considered part of the baseline, they have been such for a number of years and, as a result, mortality rates very nearly the same as the 2.2% have previously been analyzed. As a result, this scale of effect on abundance and (therefore) productivity has thus 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 given the scale of the potential impact, but not on structure or diversity given the distribution of these impacts across the range of the ESU.

Moreover, it should be noted that over the last five years (a time when all the permits being renewed were in effect), the amount of CCC coho salmon juveniles taken was only 17.6% of what was permitted and the mortality rate was only 3.4% of what has been permitted. Specifically, the majority of these fish (533) would be taken through Permit 16110 (renewed in this biological opinion), and over the past five years researchers associated with that project have taken only 14.1% of their authorized take, and killed 4.3% of their authorized mortalities. 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 effect displayed in the table above (or 0.1% as compared to 2.2% of the ESU). Any 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—would thus have a 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.

Central California Coast Steelhead

When combined with scientific research and monitoring permits already approved, 2.8% of natural-origin juvenile CCC steelhead may be killed by permitted research activities in a given year. The potential mortality for natural-origin CCC steelhead resulting from activities contemplated here would only account for a small portion (15%) of the permitted lethal take for scientific research in the region. And while actions considered in this opinion would appear to add 928 juvenile CCC steelhead to the total being allotted, in fact none of those fish are from new permits – all come from permit renewals. Thus, though they are not currently considered part of the baseline, they have been such for a number of years and, as a result, mortality rates very nearly the same as those contemplated in this opinion have previously been analyzed. As a result, this small 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 less than that displayed due to the overlap of CCC 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 CCC steelhead would in fact be native, resident *O. mykiss* subspecies. Because it is extremely difficult to tell the difference between the juvenile CCC steelhead and resident 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 2.8%.

Moreover, the true numbers of fish that would actually be taken would almost certainly be smaller than the amounts authorized in the table above. Our research tracking system reveals that for the past five years, researchers ended up taking in total only 12% of the juvenile CCC steelhead they requested and the actual mortality was only 4.3% of the juveniles authorized to be killed. This would mean that the actual effect of mortalities is likely to be on the order of one twentieth of the effect displayed in the table above (or 0.1% as compared to 2.8% of the ESU). 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 small 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.

South-Central California Coast Steelhead

When combined with scientific research and monitoring permits already approved, under the research program as a whole 3.9% of the natural-origin juvenile SCCC steelhead may be killed by permitted research activities in a given year. The actions considered in this opinion would appear to add 86 fish to the total being allotted, but in fact all of those additional fish come from permit renewals. Thus, though they are not currently considered part of the baseline, they have been such for a number of years and, as a result, mortality rates very nearly the same as the 3.9% have previously been analyzed. As a result, this 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 less than that displayed due to the overlap of SCCC 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 SCCC steelhead would in fact be native, resident *O. mykiss* subspecies. Because it is extremely difficult to tell the difference between the juvenile SCCC steelhead and resident 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 3.9%.

Moreover, the true numbers of fish that would actually be taken would almost certainly be smaller than the amounts authorized in the table above. Our research tracking system reveals that for the past five years, researchers ended up taking 13.4% of the juvenile naturally-produced SCCC steelhead they were authorized, and the actual mortality rate was only 5.7% of the mortalities authorized for juveniles. This would mean that the actual effect of mortalities is likely to be on the order of one twentieth of the effect displayed in the table above (or 0.2% as compared to 3.9% of the ESU). 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 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 believe the impacts of the program—even in its entirety—would have small effects 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.

Other species

Beyond the salmonid ESUs and DPSs discussed above, are four additional DPSs of four species—none of which have any hatchery components. Of these four, one DPS merits additional discussion.

Southern DPS 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 4.3% of the annual abundance of juveniles. However, all of this take has already been analyzed in previous opinions and been determined not to jeopardize this DPS. 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 that analysis here.

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 on listed fish species. 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 that would not preclude 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 in the Pacific Northwest have provided resource managers with a wealth of important and useful information regarding anadromous fish populations. For example, juvenile fish trapping efforts have enabled managers to produce population inventories, PIT-tagging efforts have increased our knowledge of anadromous fish abundance, migration timing, and survival, and fish passage studies have enhanced our understanding of how fish behave and survive when moving past dams and through reservoirs. By issuing research 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 endangered to threatened, or (c) have its status changed from threatened to endangered. As a result, it is legally incumbent upon us to monitor the status of every species considered here, and the research program, as a whole, is one of the primary means we have of doing that.

Thus, we expect the detrimental effects on the species to be minimal and those impacts would only be seen in terms of slight reductions in juvenile and adult abundance and productivity. And because these reductions are so slight, the 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, the effects of other activities caused by the proposed action, and the cumulative effects, it is NMFS' biological opinion that the proposed actions are not likely to jeopardize the continued existences of CC, CVS, PS, SacRWR, SnkR spr/sum-run, UCR spring-run, or UWR Chinook salmon; HCS chum salmon; CCC, or OC coho salmon; SnkR sockeye salmon; MCR, PS, SnkR, UCR, CCV, CCC, SCCC, or UWR steelhead, sDPS eulachon, or sDPS green sturgeon, or destroy or adversely modify any of their designated critical habitats.

2.9 Incidental Take Statement

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

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 Seventeen ESA Section 10(a)(1)(A) Scientific Research Permits affecting Salmon, Steelhead, Eulachon, and Green Sturgeon in the West Coast Region."

Under 50 CFR 402.16(a): "Reinitiation of consultation is required and shall be requested by the Federal agency or by the Service where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and: (1) If the amount or extent of taking specified in the incidental take statement is exceeded; (2) If new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) If the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion or written concurrence; or (4) If a new species is listed or critical habitat designated that may be affected by the identified action."

In the context of this opinion, there is no incidental take anticipated and the reinitiation trigger set out in (1) is not applicable. 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 2008b). 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 2008b).

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 2008b; 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 (Krahn *et al.* 2002; Hauser *et al.* 2007; Hanson and Emmons 2010). By late fall, all three pods are seen less frequently in inland waters. Although seasonal movements are somewhat predictable, there can be large inter-annual variability in arrival time and days present in inland waters from spring through fall, with late arrivals and fewer days present in recent years (Hanson and Emmons 2010; Whale Museum unpublished data). In recent years, several sightings and acoustic detections of SRKWs have been obtained off the Washington, Oregon, and California coasts in the winter and spring (Hanson *et al.* 2010; Hanson *et al.* 2013, Hanson *et al.* 2017, Emmons *et al.* 2021, NWFSC unpubl. data). Satellite-linked tag deployments have also provided more data on SRKW movements in the winter indicating that K and L pods use the coastal waters along Washington, Oregon, and California during non-summer months (Hanson *et al.* 2017), while J pod occurred frequently near the western entrance of the Strait of Juan de Fuca but spent relatively little time in other outer coastal areas. In 2021, NMFS published a rule to revise SRKW critical habitat and designate six additional coastal critical habitat areas (86 Fed. Reg. 41668, August 2, 2021). A full description of the geographic area occupied by SRKW can be found in the biological report that accompanies the final critical habitat rule (NMFS 2021c).

SRKWs consume a variety of fish species (22 species) and one species of squid (Ford *et al.* 1998; Ford 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 (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 five 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 five 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 830 juvenile and 16 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 spring-run
- Snake River spring/summer-run
- Upper Willamette River
- California Coastal
- Sacramento River winter-run
- Central Valley spring-run

The fact that the research would kill Chinook salmon could affect prey availability to the whales in future years throughout their range. For the adult take, all of these fish (natural and hatchery-origin) that could, at maximum, be killed from these ESUs would only be taken by research after they return to shallower bays, estuaries, and their natal rivers, and are therefore very unlikely to be available as prey to the whales that typically feed in coastal offshore areas. This would signify that the research is not expected to directly remove any adult Chinook salmon (again, natural and hatchery-origin) from the SRKW's prey base.

Because SRKWs prey on adult salmon, to determine effect the juvenile losses might have on SRKWs, we must convert those fish to adult equivalents: recent ten-year average smolt-to-adult ratio (SAR) from PIT-tagged Chinook salmon returns from the Snake River indicates that SARs are less than 1% (BPA 2018). If one percent of the 830 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 8 adult Chinook salmon 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 any of these salmon. Moreover, that effective loss would only apply if SRKW overlapped in space and time with these individual adult fish and could somehow intercept all the fish that might otherwise reach maturity without the permitted take. Given SRKW are only seasonally present to feed in the offshore areas of Oregon, Washington, and California where most of the juvenile Chinook salmon stocks affected would be expected to migrate through (*i.e.,* the Columbia River plume and offshore California) the likelihood SRKW would be present when all 8 mature adults would be effectively missing from their prey base is so low as to effectively be impossible.

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 general killed roughly 9% of the fish they have been permitted to lethally take. Thus, the actual reduction in prey that could possibly become available to the whales is probably closer to one than 8 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 all 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.

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.

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

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, andR 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.

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.

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). 2018. Chinook Orca Survival – FACTS about Chinook Salmon. Center for Whale Research - Chinook Orca Survival webpage

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.

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.

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., 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.

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. 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. 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.

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.

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, 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.

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.

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.

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.

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. 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.

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.

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.

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.

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.

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. 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). 2008b. Recovery plan for Southern Resident Killer Whales (*Orcinus orca*). National Marine Fisheries Service, Northwest Region, Seattle, Washington.

NMFS (National Marine Fisheries Service). 2009. Middle Columbia Steelhead ESA Recovery Plan. National Marine Fisheries Service, West Coast Region, Portland, OR. 260 pp.

NMFS (National Marine Fisheries Service). 2012. 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). 2013. South-Central California Steelhead Recovery Plan. National Marine Fisheries Service, West Coast Region, Long Beach, California.

NMFS (National Marine Fisheries Service). 2014. 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. 2016 5-Year Review: Summary & Evaluation of Puget Sound Chinook Salmon, Hood Canal Summer-run Chum Salmon, and Puget Sound Steelhead. National Marine Fisheries Service, West Coast Region, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2016b. 2016 5-Year Review: Summary & Evaluation of Upper Willamette River Steelhead and Upper Willamette River Chinook Salmon. National Marine Fisheries Service, West Coast Region, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2016c. 2016 5-Year Review: Summary & Evaluation of Oregon Coast Coho Salmon. National Marine Fisheries Service, West Coast Region, Portland, OR.

NMFS (National Marine Fisheries Service). 2016d. 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). 2016e. Coastal Multispecies Recovery Plan. National Marine Fisheries Service, West Coast Region, Santa Rosa, California.

NMFS (National Marine Fisheries Service). 2016f. 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). 2016g. 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). 2016h. 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). 2016i. 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). 2016j. 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). 2016k. 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). 2016l. 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). 2017a. 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). 2017b. 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). 2018a. Proposed Recovery Plan for the Puget Sound Steelhead Distinct Population Segment (*Oncorhynchus mykiss*). National Marine Fisheries Service. Seattle, WA. 291 pp.

NMFS (National Marine Fisheries Service). 2018b. 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 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). 2022b. 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). 2022c. 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). 2022d. 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). 2022e. 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). 2022f. 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.

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.

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.

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

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

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.

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.

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

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. 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.

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.

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

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

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.

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.

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.