Endangered Species Act Section 7(a)(2) Reinitiated Biological Opinion and Magnuson–Stevens Fishery Conservation and Management Act Essential Fish Habitat Response

NOAA's National Marine Fisheries Service's Continued Implementation of the Mitchell Act FEIS Preferred Alternative and Administration of the Mitchell Act hatchery funding

NMFS Consultation Number: *WCRO-2024-03014*

Action Agency: The National Marine Fisheries Service (NMFS) of the National Oceanic and Atmospheric Administration (NOAA)

Affected Species and NMFS's Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	If likely to adversely affect, Is Action Likely to Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	If likely to adversely affect, is Action Likely to Destroy or Adversely Modify Critical Habitat?
Puget Sound Chinook Salmon (*Oncorhynchus tshawytscha*)	Threatened	Yes	No	No	No
Pacific Eulachon/Smelt-Southern Distinct Population Segment (*Thaleichthys pacificus*)	Threatened	Yes	No	No	No
Lower Columbia River Chinook Salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No
Upper Columbia River Spring-run Chinook Salmon (*O. tshawytscha)*	Endangered	Yes	No	No	No
Snake River Spring/Summer-run Chinook Salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	If likely to adversely affect, Is Action Likely to Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	If likely to adversely affect, is Action Likely to Destroy or Adversely Modify Critical Habitat?
Snake River Fall-run Chinook Salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No
Upper Willamette River Chinook Salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No
California Coastal Chinook Salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No
Central Valley spring-run Chinook Salmon (O. *tshawytscha*)	Threatened	Yes	No	No	No
Lower Columbia River Coho Salmon (*O. kisutch*)	Threatened	Yes	No	No	No
Columbia River Chum Salmon (*O. keta*)	Threatened	Yes	No	No	No
Snake River Sockeye Salmon (*O. nerka*)	Endangered	Yes	No	No	No
Lower Columbia River Steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Upper Columbia River Steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Snake River Basin Steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Middle Columbia River Steelhead (*O. mykiss*)	Threatened	Yes	No	No	No

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	If likely to adversely affect, Is Action Likely to Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	If likely to adversely affect, is Action Likely to Destroy or Adversely Modify Critical Habitat?
Upper Willamette River Steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Puget Sound Steelhead (*O. mykiss*)	Threatened	No	No	No	No
Hood Canal summer-run chum salmon (*O. keta*)	Threatened	No	No	No	No
Southern Resident Killer Whale (*Orcinus orca*)	Endangered	No	No	No	No
Sturgeon, green – Southern Distinct Segment (*Acipenser medirostris*)	Threatened	No	NA	NA	NA

Fishery Management Plan That Identifies EFH in the Project Area	Does Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Coastal Pelagic Species	No	No
Highly Migratory Species	No	No
Pacific Coast Salmon	Yes	Yes
Pacific Coast Groundfish	No	No

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

Issued By: ________________________________ - *see 2018 WCR Quality Assurance Plan*____
ARA signature block for draft or final No Jeopardy/Adverse Modification opinion
Ryan J. Wulff

Assistant Regional Administrator for [*Protected Resources, Sustainable Fisheries, Interior Columbia Basin Office, Oregon–Washington Coastal Office, California Coastal Office, or California Central Valley Office*]
West Coast Region
National Marine Fisheries Service

Date: *December 30, 2024*

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ACRONYMS AND ABBREVIATIONS

AABM Aggregate abundance-based management
ABM Abundance based management
A/P Abundance and productivity
BA Biological Assessment
BC British Columbia
BCR Base Conservation Regime
BKD Bacterial kidney disease
BMP Best Management Practices
BO Biological Opinion
BOR Bureau of Reclamation
BPA Bonneville Power Administration
BRT Biological Review Team
BSAI Bering Sea/Aleutian Islands
C Core
CA California
CAM Chinook Assessment Model
CFR Code of Federal Regulations
CFS/cfs cubic feet per second
CHARTS Critical habitat analytical review teams
CO_2 Carbon dioxide
CoAM Coho Assessment Model
CPUE catch per unit effort
CR Columbia River
CRFMA Columbia River Fisheries Management Agreement
CRITFC Columbia River Inter-tribal Fish Commission
CRS Columbia River System
CSF Conservation and Sustainable Fisheries
CTUIR Confederated Tribes of the Umatilla Indian Reservation
CWA Clean Water Act
CWT Coded-wire tag, coded-wire tagged
DDT dichlorodiphenyltrichloroethane
DEQ Department of Environmental Quality
DIP Demographically Independent Populations
DNA Deoxyribonucleic acid
DPS Distinct Population Segment
DQA Data Quality Act
E Endangered
EEZ Exclusive Economic Zone
EFH Essential Fish Habitat
EIS Environmental Impact Statement
ENSO El Niño Southern Oscillation
EPA Environmental Protection Agency
ER Exploitation rates
ESA Endangered Species Act
ESU Evolutionarily Significant Unit
EWS Early winter steelhead
FA Fall-run
FCRPS Federal Columbia River Power System
FEIS Final Environmental Impact Statement
FERC Federal Energy Regulatory Commission
FMEP Fishery Management and Evaluation Plan
FMP Fishery Management Plan
FR Federal Register
FRAM Fisheries Regulation Assessment Model
G Genetic legacy
GBT Gas bubble trauma
GOA Gulf of Alaska
GSI Genetic Stock Identification
HGMP Hatchery Genetic Management Plan
HOF Hatchery Operation Framework
HOR Hatchery-origin returning
HSRG Hatchery Scientific Review Group
HUC5 Fifth-field hydrologic unit code
IC Interior Columbia
ICTRT Interior Columbia River Technical Recovery Team
IDEQ Idaho Department of Environmental Quality
IDFG Idaho Department of Fish and Game
IGF-1 Insulin-like growth factor 1

IHNV Infectious Hematopoietic Necrosis Virus
IP Intrinsic potential
ISBM Individual stock-based management
ITS Incidental Take Statement
KEWS Kalama Early Winter Steelhead
km kilometer
KRFC Klamath River fall-run Chinook salmon
LAA Likely to be adversely affected
LCR Lower Columbia River
LCFRB Lower Columbia Fish Recovery Board
LHF Lyons Ferry Hatchery
LSRB Lower Snake River Recovery Board
MaSA Major spawning area
MCR Middle Columbia River
MER Monitoring, evaluation, and reform
MF Middle Fork
mi mile
MMPA Marine Mammal Protection Act
MPG Major population group
MSA Magnuson-Stevens Fishery Conservation and Management Act
MSF Mark selective fisheries
MSY Maximum sustainable yield
N Population Size
NEPA National Environmental Policy Act
NFH National Fish Hatchery
NLAA Not likely to be adversely affected
NMFS National Marine Fisheries Service
NOAA National Oceanic and Atmospheric Administration
NOF/WA North of Cape Falcon, OR and WA coast
NOR Natural origin recruits/returning
NPCC Northwest Power and Conservation Council
NPDES National Pollution Discharge Elimination System
NPEA Natural Production Emphasis Areas
NPFMC North Pacific Fishery Management Council
NPGO North Pacific Gyre Oscillation
NPT Nez Perce Tribe
NWCVI Northwest coast of Vancouver Island
NWFSC Northwest Fisheries Science Center
NWIFC Northwest Indian Fisheries Commission
ODFW Oregon Department of Fish and Wildlife
ONI Oceanic Niño Index
OR Oregon
PAC Production Advisory Committee
PAH Polycyclic aromatic hydrocarbons
PBDE polychlorinated diphenyl ethers
PBF Physical or biological features
PBR Potential biological removal
PBT Parental Based Genetic Tagging
PCB Polychlorinated biphenol
PCE Primary constituent element
PDO Pacific Decadal Oscillation
PFMC Pacific Fishery Management Council
PG&E Pacific Gas and Electric
pHOS Percentage hatchery origin spawning
PIT Passive integrated transponder
PNI Proportion natural influence
pNOB Proportion of natural-origin broodstock
PRA Population Recovery Approach
PST Pacific Salmon Treaty
PSTRT Puget Sound Technical Recovery Team
PUD Public Utility District
QET Quasi-extinction threshold
RBW Resistance Board Weirs
RKM River kilometer
RM&E Research, Monitoring and Evaluation
RMP Resource Management Plan
ROD Record of Decision
RPA Reasonable and prudent alternative
RPM Reasonable and prudent measures
RRS Relative reproductive success
RSI Remote site incubators

Ŝ mean escapement
SAB Select Area Brights
SCA Supplemental Comprehensive Analysis
SCARF Salmon Conservation and Research Facility
SEAK Southeast Alaska
SRFB Salmon Recovery Funding Board
SRFC Sacramento River fall-run Chinook salmon
SRKW Southern resident killer whale
SRS Sediment retention structure
SRWC Sacramento River winter-run Chinook salmon
SS/D Spatial structure and diversity risk
STEP Salmon and Trout Enhancement Program
SU Summer-run
SWFSC Southwest Fisheries Science Center
SWCVI southwest coast of Vancouver Island
T Threatened
TAC Technical Advisory Committee
TDG Total dissolved gas
TMDL Total maximum daily load
TRT Technical Recovery Team
TSS Total suspended solids
UCR Upper Columbia River
UCSRB Upper Columbia Salmon Recovery Board
URB Upriver bright
USACE United States Army Corps of Engineers
USFWS US Fish and Wildlife Service
UWR Upper Willamette River
VSP Viable salmonid population
WA Washington
WCR West Coast Region
WCVI West Coast Vancouver Island
WDFW Washington Department of Fish and Wildlife
WLC Willamette Lower Columbia
YN Confederated Tribes and Bands of the Yakama Nation

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 United States Code (USC) 1531 et seq.), and implementing regulations at 50 Code of Federal Regulations (CFR) part 402.

We also completed an essential fish habitat (EFH) consultation on the Proposed Action, in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 USC 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 2 weeks at the NOAA Institutional Repository [https://repository.library.noaa.gov/welcome]. A complete record of this consultation is on file at the Lacey, Washington NMFS office.

This document constitutes the National Marine Fisheries Service's (NMFS) opinion under Section 7 of the ESA and NMFS's MSA EFH consultation for the federal action proposed in Section 1.3 of this Opinion (the Proposed Action). NMFS proposes to continue the implementation of its preferred policy direction for the distribution of Mitchell Act funds as described in the Final Environmental Impact Statement (FEIS) to Inform Columbia Basin Hatchery Operations and the Funding of Mitchell Act Hatchery Programs ((NMFS 2014g), hereafter referred to as "the Mitchell Act EIS"). This Opinion considers effects, including adverse effects, of the Proposed Action on the ESA-listed species and designated critical habitat. The species for which "likely to be adversely affected" (LAA) determinations are reached are cataloged in Table 1 below. A species of Pacific salmon listed under the ESA listing is referred to as an Evolutionarily Significant Unit (ESU). Other ESA-listed species discussed in this Opinion are referred to as Distinct Population Segment(s)(DPS).

In addition, Section 2.12 of this Opinion provides information supporting "not likely to adversely affect" (NLAA) determinations for other ESA-listed species and critical habitat that occur in the Action Area (see Section 2.3). The species for which NLAA determinations are reached are cataloged in Table 2.

Table 1. Species and ESUs or DPSs likely to be adversely affected (LAA) by the Proposed Action considered in this Opinion (Section 1.3), including Federal Register (FR) notices for the final rules that listed the ESUs or DPSs under the ESA, designated critical habitat, and applied protective regulations. An asterisk (*) indicates that designated critical habitat for the species is not likely to be adversely affected.

Species and ESU/DPS	Listing Status[a]	Critical Habitat	Protective Regulations[b]
Chinook salmon *(Oncorhynchus tshawytscha)*			
Lower Columbia River	T: 79 FR 20802, 4/14/14	70 FR 52629, 9/2/05	70 FR 37159, 6/28/05
Snake River Fall-run	T: 79 FR 20802, 4/14/14	58 FR 68543, 12/28/93	70 FR 37159, 6/28/05
Snake River Spring/summer-run	T: 79 FR 20802, 4/14/14	64 FR 57399, 10/25/99	70 FR 37160, 6/28/05
Upper Columbia River Spring-run	E: 70 FR 20816, 4/14/14	70 FR 52732, 9/02/05	Section 9
Upper Willamette River	T: 79 FR 20802, 4/14/14	70 FR 52629, 9/2/05	70 FR 37159, 6/28/05
Puget Sound	T: 79 FR 20802, 4/14/14	70 FR 52629, 9/2/05	70 FR 37159, 6/28/05
California Coastal	T: 79 FR 20802, 4/14/14	70 FR 52488, 9/02/05	70 FR 37160, 6/28/05
Central Valley Spring-run	T: 79 FR 20802, 4/14/14	70 FR 52488, 9/02/05	70 FR 37160, 6/28/05
Chum salmon *(O. keta)*			
Columbia River	T: 79 FR 20802, 4/14/14	70 FR 52746, 9/02/05	70 FR 37160, 6/28/05
Coho salmon *(O. kisutch)*			
Lower Columbia River	T: 79 FR 20802, 4/14/14	81 FR 9252, 02/24/16	70 FR 37160, 6/28/05
Sockeye salmon *(O. nerka)*			
Snake River	E: 79 FR 20802, 04/14/14	70 FR 52630, 9/02/05	Section 9
Steelhead *(O. mykiss)*			
Lower Columbia River	T: 79 FR 20802, 4/14/14	70 FR 52833, 9/02/05	70 FR 37160, 6/28/05
Upper Willamette River	T: 79 FR 20802, 4/14/14	70 FR 52848, 9/02/05	70 FR 37160, 6/28/05
Middle Columbia River	T: 79 FR 20802, 4/14/14	70 FR 52808, 9/02/05	70 FR 37160, 6/28/05
Upper Columbia River	T: 79 FR 20802, 4/14/14	70 FR 52630, 9/02/05	71 FR 5178, 2/01/06
Snake River Basin	T: 79 FR 20802, 4/14/14	70 FR 52769, 9/02/05	70 FR 37160, 6/28/05
Other species			
Eulachon (*Thaleicthys pacificus*), Southern DPS*	T: 75 FR 13012, 3/18/10	76 FR 6532, 10/2/11	-

[a] T = ESA-listed as threatened; E = ESA-listed as endangered.
[b] Where indicated, "Section 9" means that no additional protective regulations apply beyond ESA Section 9 statutory prohibitions.

Table 2. Species and ESUs or DPSs not likely to be adversely affected (NLAA) by the Proposed Action considered in this Opinion (Section 1.3). Also shown are FR notices for the final rules that listed the ESUs or DPSs under the ESA, designated critical habitat, and applied protective regulations.

Species and ESU/DPS	Listing Status[a]	Critical Habitat	Protective Regulations[b]
Puget Sound steelhead (*O. mykiss*)	T: 79 FR 20802, 4/14/14	81 FR 9252, 02/24/16	73 FR 55451, 9/25/08
Hood Canal summer-run Chum salmon *(O. keta)*	T: 79 FR 20802, 4/14/14	70 FR 52630, 9/02/05	70 FR 37160, 6/28/05
Other fish species (non-salmonids)			
Green sturgeon (*Acipenser medirostis*), Southern DPS	T: 71 FR 17757, 4/7/06	74 FR 52300, 10/9/09	75 FR 30714, 6/22/10
Marine mammals			
Killer Whale, Southern Resident DPS (*Orcinus orca*)	E: 70 FR 69903; 11/18/05	71 FR 69054, 11/29/06; 86 FR 41668; 8/2/21	Section 9

[a] T = ESA-listed as threatened; E = ESA-listed as endangered.
[b] Where indicated, "Section 9" means that no additional protective regulations apply beyond ESA Section 9 statutory prohibitions.

Artificial propagation of salmon and steelhead has occurred in the Columbia River Basin since 1876 (Wahle and Smith 1979). Congress enacted the Mitchell Act (16 USC 755-757) in 1938 for the conservation of anadromous (salmon and steelhead) fishery resources in the Columbia River Basin (defined as all tributaries of the Columbia River in the United States and the Snake River Basin). Since 1946, Congress has continued to appropriate Mitchell Act funds on an annual basis to Columbia River Basin hatcheries, and it is one of several federal acts passed in the 1930s and 1940s that led to the federal government's development of Columbia River water resources for major irrigation, flood retention, and hydroelectric projects.

The Mitchell Act authorized the establishment, operation, and maintenance of one or more hatchery facilities in the states of Oregon, Washington, and Idaho, scientific investigations to facilitate the conservation of the fishery resource, and "all other activities necessary for the conservation of fish in the Columbia River Basin in accordance with law." While the Mitchell Act provided the authority for the conservation of fishery resources in the Columbia River Basin, Congress must annually appropriate funds to implement it. Since its inception under the Reorganization Plan No. 4 of 1970, the National Oceanic and Atmospheric Administration (NOAA), an agency of the Department of Commerce, acting through its sub-agency NMFS, has distributed funds appropriated by Congress to help support hatchery program operations, hatchery facility maintenance, and fish screens in the Columbia River Basin, pursuant to the Mitchell Act. Each year, after funding is appropriated by Congress, NMFS must decide which hatchery programs, existing or new, will receive Mitchell Act funding. Most hatchery production funded under the Mitchell Act originally provided fish for ocean and in-river non-treaty commercial and recreational harvest. More recently, the Mitchell Act has also funded hatchery production to support tribal treaty harvest in the Columbia River and to conserve salmon protected under the ESA.

This Opinion describes and assesses the past, present and future role of Mitchell Act funding of hatchery operations in the Columbia River Basin, placed in the context of the numerous threats to the survival and recovery of threatened and endangered species, including salmon and steelhead. Mitchell Act funds serve significant purposes, including supplementing salmon populations in order to support fishing by Indian tribes under applicable treaties.

The evolution of NMFS's policies with respect to distributing Mitchell Act funds, described below, reflects the complexity of the issues and the multitude of co-managers and other stakeholders in the Columbia River Basin. NMFS has strived to adopt and implement its policy for Mitchell Act funds in ways that will help bring about the reform of hatchery practices and, over time, reduce the extent to which hatcheries represent a limiting factor in salmonid recovery. The implications of various policy alternatives were thoroughly explored in the draft Mitchell Act Environmental Impact Statement (EIS), which was completed by NMFS and released for public comment in 2010, and which enabled all co-managers to participate in the development of this policy, as did NMFS's regular interactions with state, tribal, and federal co-managers. The final Mitchell Act EIS was completed in 2014, with the accompanying Record of Decision (ROD) released in 2017.

The outcome—the continued implementation of NMFS's preferred policy directive for the distribution of Mitchell Act funds—reflects a balancing of the various co-manager and conservation interests, with an emphasis on hatchery reform and recovery of ESA-listed fish. For example, NMFS has spent the past several years working with co-managers and hatchery operators to make significant changes to ongoing programs, including large reductions of hatchery smolt releases, as described below. These are arduous decisions for co-managers to make, and the Proposed Action may have effects on harvest in the short term that would not lessen until recovery of natural-origin populations advances. Additionally, by itself the reform of hatchery practices cannot achieve the recovery of salmon and steelhead, or address all of the limiting factors. However, the purpose of NMFS's adopted policy directive is to address the factors implicated by hatchery practices, and to distribute Mitchell Act funds in a way that will not jeopardize threatened or endangered species. NMFS believes that the co-managers and hatchery operators fully support the goal of recovering listed salmon and steelhead, and are committed to making changes that reflect this. We ask all parties to keep these factors in mind when reading the following Opinion.

This Opinion documents the second comprehensive ESA Section 7 consultation evaluating the annual funding of hatcheries under the Mitchell Act in the Columbia River Basin. The first biological opinion covering this funding was issued on January 15, 2017 (see Section 1.2, Consultation History) (the 2017 Mitchell Act Opinion). The 2017 Mitchell Act Opinion evaluated funding to support hatchery program operations and facility maintenance of 50 hatchery programs, operated by the Washington Department of Fish and Wildlife (WDFW), the Oregon Department of Fish and Wildlife (ODFW), the United States Fish and Wildlife Service

(USFWS), Confederated Tribes and Bands of the Yakama Nation (YN), and the Nez Perce Tribe (NPT) throughout the Columbia River Basin through Fiscal Year (FY) 2025. The 2017 Mitchell Act Opinion included an ITS with required terms and conditions for hatchery operators, including reform measures such as the installation of weirs to collect hatchery fish in certain river reaches and maximum percentages of hatchery originated spawning (pHOS) levels in ESA-listed populations intended to reduce breeding interactions (i.e., gene flow) between wild and hatchery fish.

The majority of the terms and conditions contained in the 2017 Mitchell Act Opinion ITS have been and continue to be met by co-managers and hatchery operators throughout the Columbia River Basin. However, in late 2022, NMFS was alerted to the fact that WDFW may not have completed its required actions for Phase 2 of the 2017 Mitchell Act Opinion's Proposed Action[1]. Specifically, NMFS was alerted that WDFW may not have implemented all required weirs in locations in Lower Columbia River (LCR) tributaries, in order to control the straying of hatchery-origin adult salmon (particularly Chinook and coho) to the spawning grounds occupied by natural-origin fish. From January through July 2023, NMFS engaged in discussions with WDFW as to whether these weirs could be correctly implemented or whether an alternate strategy could be deployed immediately to reach the same result in controlling hatchery adults. When the issue was not resolved, NMFS contacted WDFW by letter to inform them that the lack of weirs in the LCR constituted a significant enough change to the 2017 Proposed Action that it was now necessary to reinitiate consultation.

On August 7, 2023, NMFS informed WDFW by letter that WDFW's actions had triggered reinitiation of consultation on the 2017 Mitchell Act Opinion under our ESA implementing regulations at 50 CFR § 402.16. This meant that NMFS would need to reconsider whether any future distribution of Mitchell Act funds would meet the standards of the ESA, which requires federal agency actions to avoid jeopardizing ESA-listed species or adversely modifying their critical habitat. NMFS's letter explained that the lack of weir placement was by itself sufficient to lead NMFS to reinitiate consultation, while also noting that a new consultation to cover future Mitchell Act funds (beyond FY 2025) would be needed. The potential ecological impacts of any failure of all hatchery operators to meet all of the terms and conditions of the 2017 Mitchell Act Opinion are discussed in the Environmental Baseline for this consultation (see Section 2.4) and are considered in the Integration and Synthesis (Section 2.7) of this Opinion as part of the jeopardy and adverse modification analysis. In addition, in the Proposed Action section of this Opinion (see Section 1.3), NMFS describes and incorporates measures intended to mitigate these past impacts, including measures designed to better isolate "segregated" hatchery programs and better integrate "integrated" hatchery programs that were evaluated as part of the Proposed Action in the 2017 Mitchell Act Opinion. Specifically, the Proposed Action refers to the Mitchell Act Hatchery Operational Framework (HOF) (NMFS 2024b), which includes additional measures (such as the termination and/or relocation of certain hatchery programs, implementation of new weirs, and reintroduction efforts) by which the co-managers and hatchery

[1] The 2017 Mitchell Act Opinion was intended to cover activities in two phases: an initial phase, in effect from issuance through 2022, and a second phase, which would extend the coverage through 2025 upon a determination that the Opinion's expectations for species improvements were being met.

operators, including WDFW, intend to build and ultimately improve upon the Proposed Action in the 2017 Mitchell Act Opinion. The goals of these improvements to hatchery programs and operations are two-fold: to ensure 1) that the genetic goals of the 2017 ITS are achieved through this Proposed Action and 2) that the conditions for the recovery of ESA-listed salmon and steelhead that result from this Proposed Action will be better than those that would have been achieved simply through full implementation of the 2017 ITS.

Finally, as part of this consultation process, NMFS completed a review of the information and analysis contained in the Mitchell Act EIS, in light of any changed circumstances since its issuance, including any new environmental conditions, changes in hatchery operations, and basin-wide compliance with the 2017 Mitchell Act Opinion ITS, to determine whether a supplemental National Environmental Policy Act (NEPA) evaluation would be needed to ensure the Proposed Action's compliance with NEPA standards. NMFS has concluded that there is no new information or changed conditions substantial enough to warrant supplementation of the Mitchell Act EIS, and that EIS can therefore be relied upon to evaluate and guide NMFS's future distribution of Mitchell Act funds.

1.2 Consultation History

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

1.2.1 ESA Listing and Consultation History in the Columbia River Basin

The first hatchery consultations in the Columbia River Basin followed the first listings of Columbia River Basin salmon under the ESA. Snake River sockeye salmon were listed as an endangered species on November 20, 1991; Snake River spring/summer Chinook and Snake River fall Chinook salmon were listed as threatened species on April 22, 1992; and the first hatchery consultation and opinion was completed on April 7, 1994 (NMFS 1994); (NMFS 2008j). The 1994 biological opinion was superseded by "Endangered Species Act Section 7 Biological Opinion on 1995-1998 Hatchery Operations in the Columbia River Basin, Consultation Number 383" completed on April 5, 1995 (NMFS 1995a). That opinion determined that hatchery actions jeopardized listed Snake River salmon and required implementation of reasonable and prudent alternatives (RPAs) to avoid jeopardy.

A new biological opinion was completed on March 29, 1999, after Upper Columbia River (UCR) steelhead were listed (62 FR 43937, August 18, 1997) and following the expiration of the previous opinion on December 31, 1998 (NMFS 1999c). This biological opinion concluded that federal and non-federal hatchery programs jeopardized LCR steelhead and Snake River steelhead protected under the ESA and described RPAs necessary to avoid jeopardy. Soon after, NMFS reinitiated consultation when LCR Chinook salmon, UCR spring Chinook salmon, Upper Willamette River (UWR) Chinook salmon, UWR steelhead, Columbia River (CR) chum salmon, and Middle Columbia River (MCR) steelhead were added to the list of endangered and threatened species (Smith 1999).

Between 1991 and the summer of 1999, the number of distinct groups of Columbia River Basin salmon and steelhead listed under the ESA increased from 3 to 12, and this prompted NMFS to reassess its approach to hatchery consultations. In July 1999, NMFS announced that it intended to conduct five consultations and issue five biological opinions "instead of writing one biological opinion on all hatchery programs in the Columbia River Basin." The biological opinions would be issued for hatchery programs in the (1) UWR, (2) MCR, (3) LCR, (4) Snake River, and (5) UCR, with the UCR opinion as NMFS's first priority (Smith 1999). Between August 2002 and October 2003, NMFS completed consultations under the ESA for approximately twenty hatchery programs in the UCR. For the MCR, NMFS completed a draft biological opinion and distributed it to hatchery operators and funding agencies for review on January 4, 2001, but completion of that consultation was put on hold pending several important basin-wide review and planning processes, which are detailed below in Section 1.2.3.

The increase in salmon and steelhead ESA listings during the mid to late 1990s triggered a period of investigation, planning, and reporting across multiple jurisdictions and this served to complicate, at least from a resources and scheduling standpoint, hatchery consultations. A review of federally funded hatchery programs ordered by Congress was underway at about the same time that the 2000 Federal Columbia River Power System (FCRPS) biological opinion was issued by NMFS (NMFS 2000b). The Northwest Power and Conservation Council (NPCC) was asked to develop a set of coordinated policies to guide the future use of artificial propagation, and RPA 169 of the FCRPS biological opinion called for the completion and implementation of NMFS-approved hatchery operating plans (i.e., Hatchery Genetic Management Plans (HGMPs)). The RPA required the action agencies to facilitate this process, first by assisting in the development of HGMPs, and then by helping to implement identified hatchery reforms (Brown 2001). Also at this time, a U.S. v. Oregon Columbia River Fisheries Management Agreement (CRFMA), which included goals for hatchery management, was under negotiation and new information and science on the status and recovery goals for salmon and steelhead was emerging from Technical Recovery Teams (TRTs). Work on HGMPs was undertaken in cooperation with the Pacific Fishery Management Council's Artificial Production Review and Evaluation process, with CRFMA negotiations, and with ESA recovery planning (Jones 2002); (Foster 2004). HGMPs were submitted to NMFS under RPA 169; however, many were incomplete and therefore were not found to be sufficient for ESA consultation.

ESA consultations and a biological opinion were completed in 2007 for nine hatchery programs in the LCR and MCR that produce a substantial proportion of the total number of salmon and steelhead released into the Columbia River annually. These programs are operated by the USFWS and by the WDFW. NMFS's biological opinion (NMFS 2007c) determined that operation of these nine programs would not jeopardize salmon and steelhead protected under the ESA.

On May 5, 2008, NMFS published a Supplemental Comprehensive Analysis (SCA) (NMFS 2008j) and a biological opinion and RPAs necessary for the FCRPS to avoid jeopardizing ESA-listed salmon and steelhead in the Columbia River Basin (NMFS 2008h). Since the Proposed Action evaluated in that opinion did not encompass hatchery operations per se, no incidental take coverage was offered through the FCRPS biological opinion for hatcheries operating in the region. Instead, NMFS advised that the operators of each hatchery program should address its obligations under the ESA in separate consultations, as required (see (NMFS 2008j), p. 5-40).

Because it was aware of the scope and complexity of ESA consultations facing hatchery co-managers and operators basin-wide, NMFS offered substantial advice and guidance to help with the consultations. In September 2008, NMFS announced its intent to conduct a series of ESA consultations and that "from a scientific perspective, it is advisable to review all hatchery programs (i.e., federal and non-federal) in the UCR affecting ESA-listed salmon and steelhead concurrently" (Walton 2008). In November 2008, NMFS expressed again the need for re-evaluation of UCR hatchery programs and provided a "framework for ensuring that these hatchery programs are in compliance with the federal Endangered Species Act" (Jones 2008). NMFS also "promised to share key considerations in analyzing HGMPs" and provided those materials to interested parties in February 2009 (Jones 2008). While NMFS was conducting ESA hatchery consultations in the UCR and elsewhere, in 2013, it reinitiated section 7 consultation for hatchery programs funded under the Mitchell Act, starting with steelhead HGMPs in the LCR. This first stage in the Mitchell Act consultation prompted changes and improvements in the relevant HGMPs, some that were implemented immediately, as well as the termination of several Mitchell Act-funded hatchery programs and the creation of wild steelhead refuges.

On April 28, 2010, NMFS issued a letter to "co-managers, hatchery operators, and hatchery funding agencies" that described how NMFS "has been working with co-managers throughout the Northwest on the development and submittal of fishery and hatchery plans in compliance with the Federal ESA" (Walton 2010). NMFS stated, "In order to facilitate the evaluation of hatchery and fishery plans, we want to clarify the process, including consistency with U.S. v. Oregon, habitat conservation plans and other agreements…." With respect to the "Development of Hatchery and Harvest Plans for Submittal under the ESA," NMFS clarified: "The development of fishery and hatchery plans for review under the ESA should consider existing agreements and be based on best available science; any applicable multiparty agreements should be considered, and the submittal package should explicitly reference how such agreements were considered. In the Columbia River, for example, the U.S. v. Oregon agreement is the starting point for developing hatchery and harvest plans for ESA review…" At that time, many, but not all, of the hatchery programs funded with Mitchell Act dollars were included in the U.S. v. Oregon agreement or CRFMA.

On June 21, 2017, through submission of a biological assessment (BA) assembled by the U.S. v. Oregon Technical Advisory Committee (TAC), the U.S. v. Oregon hatchery co-managers and operators requested formal consultation for those hatchery programs under section 7 of the ESA. In 2018, the U.S. v. Oregon co-managers and hatchery operators entered into a new U.S. v. Oregon management agreement to cover hatchery operations from 2018-2027. The BA (TAC 2017) assessed the effects of implementing the fishery management framework later formalized within the 2018 Agreement, and an addendum assembled by the U.S. v. Oregon Production Advisory Committee (PAC) quantified effects to ESA-listed species associated with hatchery programs referenced in the 2018 Agreement. These hatchery programs amount to 135 HGMPs, for which NMFS has completed site specific coverage under the ESA. Moreover, this PAC addendum included many hatchery programs funded with Mitchell Act dollars. The U.S. v. Oregon TAC submitted supplemental material on December 7, 2017 to clarify certain aspects of the original BA. A final biological opinion on the effects of the 2018-2027 U.S. v. Oregon Management Agreement was then signed on February 23, 2018 (NMFS 2018c).

As of 2024, NMFS has completed ESA consultations for 143 HGMPs in the Columbia River Basin, including 50 Mitchell Act-funded programs.

1.2.2 NMFS's Mitchell Act Action under National Environmental Policy Act (NEPA)

NMFS's annual funding of hatchery programs and facilities in the Columbia River Basin under the Mitchell Act constitutes a major federal action and, as such, requires a review under NEPA of the impacts of the action on the human environment (NMFS 2014g). NMFS published a Federal Register notice of its intent to prepare an EIS to evaluate this federal action on September 3, 2004 (69 Fed. Reg. 53892), opening a 90-day public comment period to gather information on the scope of the issues and develop a range of alternatives to be analyzed in the draft EIS. In addition, NMFS held a series of external meetings to seek input on potential EIS alternatives for continuing to fund hatchery production with Mitchell Act appropriated funds. External meetings were attended by representatives from the WDFW, the ODFW, the USFWS, the NPT, the Pacific Fishery Management Council (PFMC), the Northwest Indian Fisheries Commission (NWIFC), the Confederated Tribes of the Colville Reservation, the Columbia River Inter-tribal Fish Commission (CRITFC), the Institute for Tribal Government, and various fishing and environmental groups. A second notice, published on March 12, 2009 (74 Fed. Reg. 10724), notified the public of NMFS's intent to expand the EIS's scope to include a NEPA analysis of all Columbia River Basin hatchery program operations, regardless of funding source.

NMFS published its draft EIS in August 2010 for a 90-day public review period. The comment period was announced in newspapers, through correspondence with tribes and other interested parties, and by publication in the Federal Register (75 Fed. Reg. 47591, August 6, 2010). This period was extended for an additional 30 days (75 Fed. Reg. 54146, September 3, 2010) for a total of 120 days for public comment. Additionally, NMFS held a series of public meetings where public testimony was taken. These meetings were held in Vancouver, Washington; Kennewick, Washington; Astoria, Oregon; and Lewiston, Idaho, between September 20, 2010 and October 13, 2010. NMFS received more than 1,100 comments on the draft EIS.

NMFS published its final EIS in the Federal Register on September 12, 2014 and made it available for a 60-day public review period. The final Mitchell Act EIS described NMFS's

Preferred Alternative for the policy direction it would use to guide NMFS's future funding of Mitchell Act hatchery programs in the Columbia River Basin. In late 2015, NMFS prepared, and in January of 2016 NMFS published, a Federal Register update on the Mitchell Act EIS process and its intent to publish a ROD (81 FR 2196, January 15, 2016). NMFS signed the ROD for the Mitchell Act EIS on January 23, 2017, after careful consideration of the range of comments received during public review of the final EIS.

As part of this consultation process, NMFS reviewed the information and analysis in the Mitchell Act EIS, in light of any changed circumstances since its issuance to determine whether a supplemental NEPA evaluation would be needed to ensure the Proposed Action's compliance with NEPA standards. NMFS has concluded that there is no new information or changed conditions substantial enough to warrant supplementation of the Mitchell Act EIS, and that EIS can therefore continue to be relied upon to evaluate and guide NMFS's future distribution of Mitchell Act funds.

1.2.3 Consultation History for Hatchery Programs Funded by the Mitchell Act

As described above in Section 1.2.1, there have been a series of ESA consultations on the various federal and non-federally funded hatchery programs throughout the Columbia River Basin since the first ESA-listings of salmon and steelhead in the early 1990s. Several of these consultations have included many or all of the hatchery programs funded by the Mitchell Act.

In 1994, 1995, and 1999, NMFS consulted on all the hatchery production then-funded by the Mitchell Act (NMFS 1994); (NMFS 1995a); (NMFS 1999c). A number of subsequent site-specific reinitiated consultations, pertaining to geographic areas within the Columbia River Basin, also contained analyses of many of the Mitchell Act-funded programs.

NMFS completed consultation on the USFWS-operated hatchery programs in the LCR and MCR in 2007 (NMFS 2007c). That action contained nine Mitchell Act-funded programs and the consultation found that the USFWS's operations of those facilities, hatchery programs, and associated monitoring and evaluation would not jeopardize the LCR Chinook Salmon ESU, UWR Chinook Salmon ESU, Columbia River Chum Salmon ESU, LCR Steelhead DPS, MCR Steelhead DPS, and LCR Coho Salmon ESU, or destroy or adversely modify their respective designated critical habitats. This consultation was subsequently re-authorized in 2016 (NMFS 2016j) to cover NMFS's funding of USFWS-operated Mitchell Act programs for federal fiscal year 2016. That subsequent consultation also reached a no jeopardy or adverse modification determination.

In 2011, NMFS completed a consultation on the Bonneville Power Administration (BPA)-funded hatchery programs operated in the Umatilla River basin by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) and the State of Oregon (ODFW) (NMFS 2011d). This included one program that is supported by the Mitchell Act (Umatilla coho salmon). NMFS found that the operation of these programs would not jeopardize MCR steelhead, Snake River Spring/summer Chinook salmon, or Snake River fall-run Chinook salmon. Nor would it destroy or adversely modify any of their designated critical habitat.

NMFS completed a consultation on the operation of hatchery programs in the Yakima River Basin in 2013 (NMFS 2013a). These hatchery programs are operated by the Yakama Nation and the state of Washington (WDFW). This consultation included programs that are partially funded by the Mitchell Act (Prosser Hatchery coho and Chinook salmon), as well as other programs that are fully funded by NMFS's annual Mitchell Act funding distribution. NMFS found that the Yakama Nation's and WDFW's operations of the hatchery programs and associated monitoring and evaluation would not jeopardize the MCR Steelhead DPS or destroy or adversely modify its designated critical habitat.

Over this period, the Proposed Actions for Mitchell Act-related consultations continued to evolve as NMFS considered potential Mitchell Act funding consultations that were smaller in scope. For example, NMFS initially requested formal consultation on several hatchery programs in the Klickitat River Basin on December 24, 2013. NMFS's requested concurrence, under Section 7(a)(2) of the ESA, with their internal determination of the effects of four hatchery programs operated by the Yakama Nation and the WDFW, which are funded annually by the Mitchell Act (Dixon 2013). NMFS completed its review of the four Klickitat HGMPs cited in the assessment on February 14, 2014, determining them to be sufficient for formal consultation (Jones 2014a).

On April 8, 2014, NMFS requested written concurrence with an internal determination that NMFS's annual Mitchell Act funding of 18 WDFW-operated hatchery programs would likely adversely affect (LAA) ESA-listed Columbia River salmon, steelhead, and Eulachon and Green Sturgeon, but would not jeopardize the continued existence of these ESA-listed species or destroy or adversely modify their designated critical habitat (Dixon 2014). NMFS completed its initial review of the 18 HGMPs (WDFW 2011); (WDFW 2014b);(WDFW 2014d);(WDFW 2014e);(WDFW 2014h);(WDFW 2014j);(WDFW 2014m);(WDFW 2014c);(WDFW 2014k);(WDFW 2014f);(WDFW 2014l);(WDFW 2014g);(WDFW 2014i);(WDFW 2014a) cited in the assessment on April 17, 2014, determining them to be sufficient for formal consultation (Jones 2014b).

In 2014, NMFS completed a consultation on the BPA's MCR Coho Salmon Restoration Program, including operation and construction activities in the Yakima, Wenatchee and Methow river subbasins. The consultation was completed in June of 2014 (NMFS 2014d) and analyzed these programs, which operate in conjunction with annual Mitchell Act-funded hatchery programs and facilities in the LCR. The consultation determined that the Proposed Action in that consultation would not jeopardize the ESA-listed UCR Steelhead DPS, UCR Spring Chinook Salmon ESU, LCR Steelhead DPS, or the LCR Chinook Salmon ESU. Nor would it destroy or adversely modify critical habitat associated with any of these ESA-listed fish.

Also in 2014, NMFS completed a consultation on five hatchery programs operated by the ODFW in the Sandy River (OR) (NMFS 2014e), issuing an ESA Section 4(d) Rule (Limit 5) exemption to the State of Oregon for those programs. This initial authorization for ODFW to operate the Sandy River hatcheries was subsequently replaced by a new authorization and 4(d) determination on June 17, 2016 (Turner 2016). NMFS found that ODFW's operations of the hatchery programs in the Sandy River would not jeopardize the LCR Steelhead DPS, LCR

Chinook Salmon ESU, LCR Coho Salmon ESU, CR Chum Salmon ESU, or the Southern Pacific Eulachon DPS. Nor would it destroy or adversely modify their designated critical habitat.

NMFS's review of hatchery operations since 2010 has taken different forms, depending on how the hatchery program operators organize their applications. Some authorizations are for individual programs, though more frequently NMFS receives joint applications for a bundle of programs, organized by watershed. These are very detailed reviews, under ESA §4(d), and if approved they create comprehensive exemptions for the applicant programs. The review of Mitchell Act-funded hatchery programs is a much broader exercise, triggered by a Federal grants program rather than receipt of an HGMP. This review includes a similar level of detail for the programs that do not have approved HGMPs[2], and incorporates information from the existing approvals for the programs that have existing 4(d) coverage. The resulting Opinion in 2017 was a no jeopardy determination and an incidental take statement for the Federal actions, which permitted the incidental take by the hatchery operations. The 4(d) exemption differs in some respects, so that programs included in this Opinion (and the 2017 version) could also seek a 4(d) approval for additional coverage.

On January 15, 2017, NMFS issued a new comprehensive biological opinion and reached a no jeopardy and no adverse modification conclusion after evaluating the funding of hatcheries under the Mitchell Act in the Columbia River Basin. Since the 2017 Mitchell Act Opinion was issued, ODFW resubmitted a revised HGMP (ODFW 2020) that proposed integrating natural-origin Clackamas River spring Chinook salmon adults into the Clackamas Hatchery's spring Chinook salmon program. NMFS completed the consultation on this Proposed Action in 2021 (NMFS 2021b). The effects associated with the implementation of the Clackamas integrated spring Chinook salmon program on the UWR Spring Chinook Salmon ESU were previously evaluated by NMFS in the 2017 Mitchell Act Opinion (NMFS 2017e), which determined that the program had a minimal likelihood of adverse effects on UWR Spring Chinook Salmon ESU. The 2021 consultation also concluded that the then-Proposed Action was not likely to jeopardize the continued existence of UWR spring Chinook salmon or winter steelhead, LCR Chinook salmon, coho salmon or steelhead, or destroy or adversely modify any designated critical habitat for these species.

On August 7, 2023, NMFS informed WDFW, by letter, that WDFW's failure to meet all terms and conditions under the 2017 Mitchell Act Opinion had triggered reinitiation of consultation on the 2017 Mitchell Act Opinion under 50 CFR § 402.16. NMFS determined that it would need to reconsider – through the reinitiated consultation – whether the future distribution of Mitchell Act funds would meet the standards of the ESA, which requires federal agency actions to avoid jeopardizing ESA-listed species or adversely modifying their critical habitat. Upon determining that reinitiation of consultation was necessary due to WDFW's actions, NMFS informed the

[2] An HGMP is essentially a list of the pertinent information about hatchery program and its potential effects on ESA listed salmon and steelhead, the type of information NMFS would require in any ESA review. An HGMP is required to trigger the 4(d) approval process, and they must adhere to a set format in those approvals. HGMPs are not specifically required for this consultation, which is not a 4(d) approval. However, for this consultation NMFS needs essentially the same information, so we may refer to HGMPs as the source of information here, even if the specific document form is not required.

other Mitchell Act funding recipients, by letter dated September 28, 2023, of the plan to complete a new biological opinion with respect to the future funding and operation of Mitchell Act-funded hatchery programs in the Columbia River Basin. This new biological opinion will supersede the 2017 Mitchell Act Opinion.

1.2.4 Current NMFS Actions Under Consideration

NMFS began discussions to coordinate the submission of all relevant and recent information on the operations and effects of all current Mitchell Act-funded hatchery programs in the Columbia River Basin with all current recipients of Mitchell Act hatchery funding, with the final submission of information from the recipients in November 2024. These discussions – among the States, tribes, and federal agencies – primarily occurred during Tule Workgroup[3] meetings, Columbia River co-manager meetings, and monthly Mitchell Act consultation schedule meetings. Final and draft hatchery program HGMPs and the Mitchell Act HOF (see Proposed Action, Section 1.3), as well as supplemental information requested by NMFS, were submitted to NMFS between September 28, 2023 and November 15, 2024. These materials have been used to develop and assess the Proposed Action evaluated in this Opinion, as well as to evaluate the activities and effects caused by the Proposed Action.

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

1.3 Proposed Federal Action

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

NMFS proposes to continue the implementation of its preferred policy direction (i.e., the Mitchell Act EIS Preferred Alternative) for the distribution of Mitchell Act funds as described in the Mitchell Act EIS (NMFS 2014g). NMFS describes a hatchery program as a group of fish that have a separate purpose and that may have independent spawning, rearing, marking and release strategies (NMFS 2008h). The operation and management of every hatchery program is unique

[3] NMFS identified a Term and Condition in the 2017 Mitchell Act Opinion to convene a multiagency working group (hereafter described as the Tule Workgroup) to continue to assess the natural production status of primary Chinook salmon natural populations in the LCR Coast MPG, in response to reduced pHOS.

in time, and specific to an identifiable stock and its native habitat (Flagg, Mahnken, and Iwamoto 2004).

This Opinion is intended to apply to distributions of future Mitchell Act funds. Those funds may be utilized by Mitchell Act co-managers and hatchery operators to fund operation, maintenance, monitoring and evaluation, and screening for hatchery programs within the Columbia River Basin. Thus, to distinguish between NMFS's proposed federal action of distributing the Mitchell Act funding and the annual hatchery operations described in (NMFS 2024a), the details of the hatchery operations to be funded through the Mitchell Act are described in the HOF, which is found in Appendix A of the Biological Assessment (NMFS 2024a). The HOF includes specific information on the 50 Mitchell Act-funded hatchery programs that are run at 25 hatchery facilities in the Columbia River Basin. Details on what components of the proposed hatchery programs are described in the HOF are provided below.

This Opinion may require amendments if the hatchery programs described in the HOF and evaluated in the Opinion make substantial changes to their operations which impact the effects analysis contained herein. Additionally, there are requirements included in the Proposed Action or the terms and conditions in the ITS which could lead to new information that would necessitate program changes and may trigger the reinitiation of consultation. However, NMFS does anticipate that there may be operational adjustments to the Mitchell Act-funded programs described in the HOF over time, which could include the shifting of production between programs, the termination of individual programs, or other changes necessary to ensure that the programs are meeting their conservation and production goals, and which would be covered by this Opinion. Such changes would result in revisions to the HOF; however, they would not require reinitiation so long as the potential impacts to listed species from those changes fall within the scope of the effects analyzed herein. As with all biological opinions, exceedance in the extent of effects or take of ESA-listed species may lead to reinitiation of consultation and a new opinion. Therefore, in sum, this Opinion will remain in effect to distribute all future Mitchell Act funds, unless new information emerges that requires a reinitiation of consultation consistent with 50 CFR 402.16.

Each year's continued Mitchell Act funding is contingent on the action and its effects remaining consistent with the analysis and conclusions of this document. Thus, although we expect that some operational adjustments to the HOF may occur over time to adjust to new or changing circumstances, if that were to happen, NMFS would evaluate its ongoing funding decisions to ensure that this Opinion and ITS remain applicable. If necessary, NMFS may reconsider whether a program can still be funded in the next cycle of Mitchell Act grants. For example, if NMFS received indication that applicable pHOS[4] goals were not likely to be met, possibly due to changing circumstances or the failure to take an action such as installing a weir, NMFS would

[4] pHOS is the proportion of hatchery-origin fish on spawning grounds, which can be estimated for naturally spawning populations and used as a surrogate measure of genetic and ecological risks from hatchery operations. For the purposes of this Opinion, pHOS is used as a take indicator for multiple effects of the Proposed Action and is discussed in greater detail in Sections 2.5.2.2(Effects of the Action Factor 2), 2.9 (Incidental Take Statement) and 2.9.5 (Terms and Conditions).

have to consider whether issuing future Mitchell Act funds for programs responsible for those missed goals would jeopardize listed species, unless changes could be made (e.g., reductions in program size) that would restore the program's ability to meet pHOS goals as articulated in this Opinion and ITS before the next distribution of Mitchell Act funds takes place.

In addition to covering specific distributions of Mitchell Act grants, the Proposed Action includes the continued implementation of NMFS's policy direction to guide distributions of Mitchell Act funds (NMFS 2017i). In the final ROD for the Selection of Policy Direction for the Funding of Mitchell Act Hatchery Programs in the Columbia River Basin (NMFS 2017i), NMFS identified a preferred policy direction that would be used to guide decisions about the distribution of funds for hatchery production under the Mitchell Act. The preferred policy direction that has been implemented since 2018 is defined by the following goals and/or principles, as described in (NMFS 2017i):

"

- The stronger performance goal would be applied to all [Mitchell Act-funded] hatchery programs that affect primary and contributing [(or equivalent)] salmon and steelhead populations. These stronger performance goals would minimize the risks of hatchery programs on ESA-listed natural-origin salmon and steelhead populations.
    - Integrated hatchery programs would be better integrated [, where necessary,] than under [the conditions described as Alternative 1 in the Mitchell Act FEIS].
    - [Segregated] hatchery programs would be better [segregated, where necessary,] than under [the conditions described as Alternative 1 in the Mitchell Act FEIS].
- Conservation hatchery programs[[5]] would be operated at a level determined by conservation need. Benefits of conservation hatchery programs must outweigh their risks (Section 3.2.3.1, General Risks and Benefits of Hatchery Programs to Salmon and Steelhead Species, in (NMFS 2014g).
- Many hatchery programs are used to meet mitigation agreements. These programs would be aligned with the performance goals for [Alternative 6 of the Mitchell Act FEIS].
- Best Management Practices (BMPs) for facilities would be applied to all hatchery facilities.
- New programs (for conservation, harvest, or both purposes) could be initiated throughout the Columbia River Basin, where appropriate.
- Monitoring, evaluation, and reform [(MER)] would continue to occur. NMFS would continue to work with hatchery operators, basinwide, to develop priorities and strategies for monitoring, evaluation, and reform.

[5] The Mitchell Act FEIS defines a conservation hatchery program as "An artificial production program that produces fish primarily or exclusively for conservation rather than for harvest. Conservation programs can vary widely in approach and may be used to prevent extinction, increase the abundance of natural spawners, or to provide fish for reintroductions." (NMFS 2014g)

- Adaptive management planning, related to risk reduction, would be required for all programs that affect ESA-listed primary and contributing [(or equivalent)] salmon and steelhead populations in the Columbia River Basin.
- Mitchell Act hatchery funds would be disbursed in support of the above goals and/or principles."

The goals and/or principles outlined in the preferred policy direction in the Mitchell Act FEIS are meant as indicators of the direction that NMFS intends to continue moving hatchery programs that receive Mitchell Act funding. The preferred policy direction does not identify specific actions that would be taken consistent with its preferred policy direction because specific hatchery actions are best identified on a hatchery program-by-hatchery program basis.

At this time, NMFS has reviewed the hatchery programs that the co-managers and hatchery operators propose to use the Mitchell Act funds for in the future, as summarized in the HOF (Appendix A of (NMFS 2024g)). Specifically, the Biological Assessment (NMFS 2024g) includes information on the following program details:

- Watershed where fish are released
- Program operator
- Funding Agency
- Operational strategy (i.e., segregated or integrated)
- Broodstock origin and listing status
- Relationship of broodstock to listed salmon and steelhead in watershed of release
- Number of broodstock collected
- Mating protocols
- Incidental handling of ESA-listed natural-origin fish during broodstock collection
- Number of fish released
- Average size of fish released
- Marking protocols for released fish
- Months of acclimation prior to release
- River mile where fish are released
- Whether the fish are volitionally released
- Month of release
- Facilities used by Mitchell Act funded programs
- Source of water for each facility used
- Amount of withdrawn water
- Water diversion distance, if applicable, between water intake and discharge structures
- Whether the water intake structures are screened according to NMFS criteria
- Whether the hatchery facilities have National Pollution and Discharge Elimination System (NPDES) permit

In addition to the hatchery program details contained in the HOF, the Biological Assessment (NMFS 2024g) outlines the ongoing Mitchell Act MER, which is a component of the activities funded through the annual Mitchell Act distributions. For the purposes of this Opinion, MER activities are described as Research, Monitoring and Evaluation (RM&E) activities.

Table 3 lists the programs and the respective details of those programs that have been reviewed as part of the HOF and are scheduled for Mitchell Act funding. Table 4 lists all other hatchery programs that currently exist because of Mitchell Act funded-programs, but are not funded by the Mitchell Act funding).

To limit genetic risks from the hatchery programs funded through the Mitchell Act to primary and contributing populations of ESA-listed salmon and steelhead, hatchery production in the Mitchell Act hatchery programs cannot exceed production levels identified in Table 3, based on release year. The proportion of hatchery fish on spawning grounds, or pHOS, can serve as a surrogate measure for genetic effects from hatchery programs. The production levels provided in Table 3, coupled with other management actions (e.g., fisheries, weir operations), are expected to generate the pHOS levels within the limits presented in Table 5, Table 6, and Table 7 based on analyses described in (NMFS 2024g) and Section 2.5.2.2.2 of this Opinion. Genetic risks from the integrated LCR winter and summer steelhead programs will be measured through proportionate natural influence (PNI), which is a function of both pHOS and the proportion of natural-origin fish used as broodstock (pNOB) and comply with the expected values presented in Table 8.

In addition to operating at the production levels described in Table 3, WDFW will also collect natural-origin fall Chinook salmon fry on Abernathy Creek and transport them to the Abernathy Fish Technology Center (operated by USFWS) for short-term rearing to increase the survival rates of these fish (NMFS 2024h). The trapping, transport, and rearing of juvenile Chinook salmon in Abernathy Creek will occur from day 20 until day 70 of calendar years 2029-2040. During these years, operators will also monitor the number of juvenile chum salmon incidentally captured, transported, and reared at Abernathy Fish Technology Center, not to exceed 450 individuals in any given year.

Table 3. Programs currently included in the HOF with the respective production levels.

Mitchell Act Hatchery Program	Hatchery Program Operator	Integrated or Segregated	Proposed Production Goals	Five Year Average Production Level	Annual Maximum Production Level
Bonneville coho salmon	ODFW	Segregated	250,000	255,000	262,500
Bonneville fall Chinook salmon (tule)	ODFW	Segregated	6,000,000	6,120,000	6,300,000
Big Creek Chinook salmon (tule)	ODFW	Segregated	1,400,000	1,428,000	1,470,000
Big Creek coho salmon	ODFW	Segregated	735,000	749,700	771,750
Big Creek chum salmon	ODFW	Integrated	1,690,000	1,723,800	1,774,500
Big Creek (combined with Gnat Creek and Klaskanine) winter steelhead	ODFW	Segregated	147,000	149,940	154,350
Youngs Bay fall Chinook salmon (tule) (formerly Klaskanine, Big Creek Stock)	ODFW	Segregated	2,300,000	2,346,000	2,415,000
Clackamas summer steelhead	ODFW	Segregated	175,000	178,500	183,750
Clackamas winter steelhead	ODFW	Integrated	265,000	270,300	278,250
Clackamas spring Chinook salmon	ODFW	Integrated	1,100,000	1,122,000	1,155,000
Sandy River spring Chinook salmon	ODFW	Integrated	300,000	306,000	315,000
Sandy River winter steelhead	ODFW	Integrated	170,000	173,400	178,500
Sandy River summer steelhead	ODFW	Segregated	80,000	81,600	84,000
Sandy River coho salmon	ODFW	Segregated	300,000	306,000	315,000
Clatskanie River Tule Fall Chinook Supplementation Program	ODFW	Segregated	200,000	204,000	210,000
Umatilla River coho salmon	CTUIR/ ODFW	Segregated	500,000	550,000	550,000
Lostine River coho restoration project	NPT/ODFW	Segregated	500,000	550,000	550,000
Clearwater River coho restoration project	NPT/USFWS	Segregated	550,000	605,000	605,000
Carson National Fish Hatchery spring Chinook salmon	USFWS	Segregated	1,520,000	1,550,400	1,596,000
Little White Salmon National Fish Hatchery Spring Chinook salmon	USFWS	Segregated	1,800,000	1,836,000	1,890,000

Mitchell Act Hatchery Program	Hatchery Program Operator	Integrated or Segregated	Proposed Production Goals	Five Year Average Production Level	Annual Maximum Production Level
Eagle Creek National Fish Hatchery coho salmon	USFWS	Segregated	350,000	357,000	367,500
Willard National Fish Hatchery URB	USFWS	Segregated	2,000,000	2,040,000	2,100,000
North Fork Toutle fall Chinook salmon (tule)	WDFW	Integrated	1,100,000	1,122,000	1,155,000
North Fork Toutle coho salmon	WDFW	Integrated	90,000	91,800	94,500
Kalama fall Chinook salmon (tule)	WDFW	Segregated	2,000,000	2,040,000	2,100,000
Kalama coho salmon - Type N	WDFW	Segregated	300,000	306,000	315,000
Kalama summer steelhead (integrated)	WDFW	Integrated	90,000	91,800	94,500
Kalama winter steelhead (integrated)	WDFW	Integrated	45,000	45,900	47,250
Kalama winter steelhead (KEWS)	WDFW	Segregated	90,000	91,800	94,500
Washougal fall Chinook salmon (tule)	WDFW	Integrated	1,200,000	1,224,000	1,260,000
Washougal coho salmon	WDFW	Integrated	108,000	110,160	113,400
Ringold Springs steelhead	WDFW	Segregated	180,000	183,600	189,000
Ringold Springs coho salmon	WDFW	Segregated	750,000	765,000	787,500
Beaver Creek summer steelhead	WDFW	Segregated	30,000	30,600	31,500
Beaver Creek winter steelhead	WDFW	Segregated	130,000	132,600	136,500
Beaver Creek (Elochoman R) coho salmon	WDFW	Integrated	225,000	229,500	236,250
South Toutle summer steelhead	WDFW	Segregated	25,000	25,500	26,250
Coweeman winter steelhead	WDFW	Segregated	12,000	12,240	12,600
Klineline winter steelhead (Salmon Creek)	WDFW	Segregated	40,000	40,800	42,000
Washougal summer steelhead (Skamania Hatchery)	WDFW	Segregated	70,000	71,400	73,500
Washougal winter steelhead (Skamania Hatchery)	WDFW	Integrated	60,000	61,200	63,000
Rock Creek winter steelhead	WDFW	Segregated	20,000	20,400	21,000
Kalama Spring Chinook salmon	WDFW	Segregated	750,000	765,000	787,500

Mitchell Act Hatchery Program	Hatchery Program Operator	Integrated or Segregated	Proposed Production Goals	Five Year Average Production Level	Annual Maximum Production Level
Grays River Fall Chinook Conservation Hatchery Program	WDFW	Integrated	361,000	368,220	379,050
Abernathy Fall Chinook Conservation Hatchery Program	WDFW	Integrated	113,000	115,260	118,650
Klickitat upriver bright fall Chinook salmon	YN	Segregated	4,000,000	4,080,000	4,200,000
Klickitat spring Chinook salmon	YN	Integrated	800,000	816,000	840,000
Yakima River - Prosser coho (Eagle Creek stock)	YN	Segregated	500,000	550,000	550,000
Klickitat coho salmon	YN/WDFW	Segregated	3,500,000	3,570,000	3,675,000
Klickitat Skamania summer steelhead	YN/WDFW	Segregated	90,000	91,800	94,500
Total Annual Release Goal	39,011,000				

Table 4. Hatchery programs and release sizes which currently result from Mitchell Act hatchery programs but are not funded through the Mitchell Act.

Hatchery Programs that exist because of Mitchell Act- funded programs	Hatchery Program Operator	Integrated or Segregated	Program Release Level that are a consequence of the Mitchell Act-funded programs
Astoria High School Salmon and Trout Enhancement Program (STEP) coho salmon	ODFW	Segregated	4,000
Astoria High School STEP fall Chinook salmon (tule)	ODFW	Segregated	25,000
Warrenton High School STEP coho salmon	ODFW	Segregated	5,000
Warrenton High School STEP fall Chinook salmon (tule)	ODFW	Segregated	16,500

Table 5. Observed and expected levels of pHOS in ESA-listed Chinook salmon populations that have been and are likely to be affected by Mitchell Act-funded hatchery programs.

Chinook Salmon ESU	Major Population Group (MPG)	Population	Recovery Designation	Recent Avg pHOS (2017-2022)[1]	Expected pHOS levels*
LCR	Coast fall	Elochoman/Skamokawa	Primary	61%	≤50.0%
		Mill/Germany/Abernathy[2]	Primary	87%	≤50.0%
		Grays/Chinook[2]	Contributing	75%	≤50.0%
	Cascade fall and spring	Coweeman	Primary	7%	≤10.0%
		Lower Cowlitz	Contributing	12%	≤30.0%
		Toutle[3]	Primary	43%	≤30.0%
		Kalama (fall)	Contributing	40%	≤10.0%
		Kalama (spring)	Contributing	~4%[4]	≤10.0%
		Lewis	Primary	40%	≤10.0%
		Washougal	Primary	28%	≤30.0%
UWR	Western Cascade	Clackamas	Primary	<10%	≤10.0%

[1] Data source summarized in in (NMFS 2024g)
[2] Because the intention of the Grays River Fall Chinook Salmon Conservation Program, Abernathy Fall Chinook Salmon Conservation Program, and the Clatskanie River Fall Chinook Salmon Supplementation Programs is to produce naturally-spawning hatchery fish, the fish from these programs will not get counted against the pHOS levels identified here.
[3] The expected pHOS levels identified here only apply to river reaches below the Sediment Retention Structure (SRS) on the North Fork Toutle River because recovery efforts for spring and fall Chinook salmon above the SRS plan to use hatchery stocks during reintroduction. That is, because of these reintroduction efforts, NMFS expects pHOS levels to be as high as 100% above the SRS for a limited duration.
[4] This estimate is a median based on information in in (NMFS 2024g)
*Expected pHOS levels are to be evaluated against a 4-year mean of annual estimates, with the mean to be initiated once the relevant pHOS reduction measures described in the HOF have been implemented and the period of their expected effects has been reached.

Table 6. Observed and expected levels of pHOS in ESA-listed coho salmon populations that have been and are likely to be affected by Mitchell Act-funded hatchery programs.

LCR Major Population Group (MPG)	Population	Recovery Designation	Recent mean pHOS (2020-2022)[1]	Expected pHOS levels*
Coast	Grays/Chinook	Primary	42%	≤10.0%
	Elochoman/Skamokawa	Primary	25%	≤30.0%
	Clatskanie	Primary	15%	≤10.0%
	Scappoose	Primary	2%	≤10.0%
Cascade	Lower Cowlitz	Primary	15%	≤30.0%
	Coweeman	Primary	13%	≤10.0%
	SF Toutle	Primary	14%	≤10.0%
	NF Toutle[2]	Primary	16%	≤30.0%
	EF Lewis	Primary	11%	≤10.0%
	Washougal	Contributing	27%	≤30.0%
	Sandy	Primary	3%	≤10.0%
	Clackamas	Primary	9%	≤10.0%

[1] Data source summarized in in (NMFS 2024g)
[2] The expected pHOS levels identified here only apply to river reaches below the SRS on the North Fork Toutle River because recovery efforts for coho salmon above the SRS plan to use hatchery stocks during reintroduction. That is, because of these reintroduction efforts, NMFS expects pHOS levels to be as high as 100% above the SRS for a limited duration.
*Expected pHOS levels are to be evaluated against a 3-year mean of annual estimates, with calculation of the mean to be initiated once the relevant pHOS reduction measures described in the HOF have been implemented and the period of their expected effects has been reached.

Table 7. Expected levels of gene flow and pHOS from segregated LCR steelhead programs from Mitchell Act-funded hatchery programs into ESA-listed steelhead populations.

LCR Major Population Group	Population[1]	Recovery Designation	Segregated Hatchery Program	Recent mean pHOS (2020-2022)[2]	Expected maximum pHOS*	Expected maximum gene flow
Coast	Clackamas winter (P)	Primary	Clackamas summer steelhead**	0.0%	≤5.0%	≤2.0%
Coast	Sandy winter (P)	Primary	Sandy summer steelhead**	0.0%	≤5.0%	≤2.0%
Cascade	South Toutle winter (P)	Primary	Toutle summer steelhead**	0.1%	≤5.0%	≤2.0%
Cascade	Washougal summer (P)	Primary	Skamania summer steelhead**	1.0%	≤5.0%	≤2.0%
Cascade	Kalama winter (P)	Primary	Kalama winter steelhead***	1.8%	≤5.0%	≤2.0%
Cascade	Coweeman winter (P)	Primary	Coweeman winter steelhead***	0.9%	≤5.0%	≤2.0%

[1] Primary (P) or contributing (C) designations are indicated for natural populations (see (NMFS 2013e)).
[2] Data source summarized in (NMFS 2024g).
*Expected pHOS levels are to be evaluated against a 3-year mean of annual estimates, with calculation of the mean to be initiated once the relevant pHOS reduction measures described in the HOF have been implemented and the period of their expected effects has been reached.
**Program uses Skamania summer steelhead stock
***Program uses Kalama Early Winter Steelhead (KEWS) stock

Table 8. Minimum PNI limits for integrated LCR Steelhead hatchery programs from Mitchell Act-funded hatchery programs into ESA-listed steelhead populations.

LCR Major Population Group	Population	Recovery Designation	Integrated Hatchery Program	Recent mean PNI (2020-2022)[1]	Expected Minimum PNI[2]
Cascade	Kalama summer	Primary	Kalama summer steelhead	0.76	≥0.67
Cascade	Kalama winter	Primary	Kalama winter steelhead	0.97	≥0.67
Cascade	Clackamas winter	Primary	Clackamas winter steelhead	0.59	≥0.67
Cascade	Sandy winter	Primary	Sandy winter steelhead	0.90	≥0.67
Cascade	Washougal winter	Contributing	Skamania winter steelhead	NA[3]	≥0.67

[1] Data source summarized in (NMFS 2024g)
[2] PNI estimates are to be calculated as three-year running geometric means and evaluated against these expected values.
[3] No PNI estimates are available for this program, which is to be initiated through the Proposed Action.

Under the HOF, the Mitchell Act co-managers and operators will also operate new and existing weirs in the tributaries listed below. A weir is one type of device that is employed to block upstream migration. Weirs generally force returning adult fish to enter a trap and holding area. Hatchery-origin salmon and steelhead intercepted at these weirs will be identified and may be removed to better isolate hatchery programs, and natural-origin salmon and steelhead may be collected to be used for broodstock for integrated programs. Importantly, fish produced by conservation hatcheries will be passed above weirs in select river systems to support conservation and recovery efforts. NMFS (2024g) includes additional information on the proposed weirs (new weirs denoted by *). These weirs will be implemented in the following tributaries:

- Grays River
- Elochoman River
- Abernathy Creek*
- Germany Creek*
- South Fork Toutle River
- Coweeman River
- North Fork Lewis River
- Washougal River
- Kalama River

WDFW may utilize additional methods (e.g., seining, netting, angling, and new trapping techniques) to remove hatchery fish from the spawning grounds, though in some cases may collect broodstock for hatchery programs in these watersheds.

In addition to the proposed weirs, the HOF and thus the Proposed Action include additional measures to limit the Mitchell Act-funded hatchery programs' adverse impacts to ESA-listed species and to improve overall conditions for listed fish. For example, as part of its Mitchell Act-funded activities, WDFW will preserve its Wild Steelhead Gene Bank in the East Fork Lewis River, Wind River, and North Fork Toutle River, so that at least one primary steelhead population[6] in each LCR steelhead Major Population Group (MPG) is protected from the genetic influence of hatchery programs. Likewise, WDFW has proposed additional measures within the HOF that build and ultimately improve upon the Proposed Action in the 2017 Mitchell Act Opinion, in order to improve conditions for listed fish. These include the proposal to:

- Terminate and/or relocate the following hatchery programs to reduce interactions between natural- and hatchery-origin salmon and steelhead: Washougal Segregated Winter Steelhead, Deep River Net Pens Spring Chinook Salmon, and Deep River Net Pens Coho Salmon;
- Initiate conservation hatchery programs for Chinook salmon in Abernathy Creek and in the Grays River; and

[6] Population designations (i.e., primary and contributing) are identified in the Lower Columbia River Recovery Plan (ODFW 2005)

- Accelerate the reintroduction of Coho salmon and initiate reintroduction of spring and fall Chinook salmon to the upper North Fork Toutle River.

Furthermore, based on the response of pHOS in various LCR tributaries to measures implemented through the HOF (for example, the response of the extant natural-origin populations of fall Chinook in the Coast MPG), NMFS may determine and implement additional changes to the contributing programs in order to benefit listed fish and improve the overall environmental baseline, including:

- Program reductions,
- Program discontinuation,
- Implementation of additional conservation programs to supplement populations, and/or
- Further use of pHOS control measures, such as weirs.

Finally, additional tactics such as seining, netting, angling or new trapping techniques may be used to remove hatchery-origin salmon and steelhead, to further reduce pHOS.

As part of the Proposed Action, NMFS also proposes to fund the operation of intake screens for the Idaho Department of Fish and Game (IDFG) facilities. The effect of this operational activity has been analyzed in (NMFS 2000c), which determined that the operation is not likely to have an adverse effect on ESA-listed species (NMFS 2000c).

In addition to analyzing the effects of the programs described in the HOF and Table 3 and Table 4, this Opinion also analyzes the impacts of fisheries that exist because of the programs described in Table 8 (see Section 2.5.2.7). Certain terminal fisheries within the tributaries of the LCR downstream of Bonneville Dam meet the "but for" test, meaning these fisheries would not occur "but for" the Proposed Action. The majority (in some cases 100%) of the hatchery salmon and steelhead produced in these tributaries are a direct result of current Mitchell Act funding, and this will continue under the Proposed Action. While NMFS analyzes the effects of these fisheries on listed species and their critical habitat in this Opinion, it is important to note that we are not authorizing the fisheries through this consultation.

Finally, NMFS may consider new proposals for hatchery programs in the future if there are available Mitchell Act funds. All newly proposed hatchery programs would need to be reviewed for ESA and NEPA compliance prior to receiving funding, which would include a review of whether anticipated impacts would fall within the scope of those evaluated in this Opinion and the Mitchell Act FEIS, and thus whether the existing ESA and NEPA coverage would be sufficient for such programs to proceed. If insufficient funds are available to support all hatchery programs identified in Table 3, NMFS will engage in discussions with the Tribes and States to review and revise the Mitchell Act program in light of the actual Fiscal Year appropriation. Under such circumstances, NMFS would ensure good faith consideration to all *U.S. v. Oregon* parties' recommendations, the United States trust responsibility to the Tribes, and Mitchell Act history before deciding which Mitchell Act program actions would be funded. NMFS may also request a meeting with all grant recipients to review progress and compliance with requirements of this Biological Opinion. All hatchery programs funded through the Mitchell Act must comply with all terms and conditions identified in any applicable NMFS and/or USFWS biological opinions, as well as meet the requirements imposed through the Mitchell Act grant process, including that funds may only be expended for the activities as outlined in the HOF, and that no funds shall be drawn down until the recipient provides proof that they are in compliance with environmental approvals (ESA, NEPA, etc.).

2. Endangered Species Act: Biological Opinion And Incidental Take Statement

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. As required by Section 7(a)(2) of the ESA, each federal agency must ensure that its actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, federal action agencies consult with NMFS and Section 7(b)(3) requires that, at the conclusion of consultation, NMFS provides 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.

NMFS has determined that the Proposed Action is not likely to adversely affect the species listed in Table 2 or their critical habitat. Our concurrence is documented in the "Not Likely to Adversely Affect" Determination Section of this Opinion (Section 2.12).

2.1. Analytical Approach

This 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 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 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 designation(s) of critical habitat for Puget Sound Chinook Salmon ESU, UWR Chinook Salmon ESU, LCR Chinook Salmon ESU, LCR Coho Salmon ESU, LCR Steelhead DPS, UWR Steelhead DPS, Columbia River Chum Salmon ESU, Snake River Spring/Summer-run Chinook Salmon ESU, Snake River Fall-run Chinook Salmon ESU, UCR Spring-run Chinook Salmon ESU, Snake River sockeye Salmon ESU, MCR Steelhead DPS, UCR Steelhead DPS, and Snake River Basin Steelhead DPS use(s) the term primary constituent element (PCE) or essential features. The 2016 final rule (81 FR 7414; February 11, 2016) that revised the critical habitat regulations (50 CFR 424.12) replaced this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a “destruction or adverse modification” analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this 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:

1. Identify the rangewide status of the species and critical habitat expected to be adversely affected by the Proposed Action

Section 2.2 describes the current status of each adversely affected listed species and critical habitat relative to the conditions needed for recovery. For listed salmon and steelhead, NMFS has developed specific guidance for analyzing the status of the listed species’ component populations in a “viable salmonid populations” (VSP) paper (McElhany et al. 2000). The VSP approach considers the abundance, productivity, spatial structure, and diversity of each population as part of the overall review of a species’ status. For listed salmon and steelhead, the VSP criteria therefore encompass the species’ “reproduction, numbers, or distribution” (50 CFR 402.02). In describing the rangewide status of listed species, we rely on viability assessments and criteria in technical recovery team documents and recovery plans, and other information where available, that describe how VSP criteria are applied to specific populations, MPGs, and species. We determine the rangewide status of critical habitat by examining the condition of its physical or biological features (also called “primary constituent elements” or PCEs in some designations) which were identified when the critical habitat was designated.

2. Describe the environmental baseline in the Action Area

The Environmental Baseline (Section 2.4) includes the past and present impacts of federal, state, or private actions and other human activities in the Action Area (Section 2.2.9). It includes the anticipated impacts of proposed federal projects that have already undergone formal or early Section 7 consultation and the impacts of state or private actions that are contemporaneous with the consultation in process.

3. *Analyze the effects of the Proposed Action on both species and their habitat using an “exposure-response-risk” approach*

In this step (Section 2.5.2), NMFS considers how the Proposed Action would affect the species' reproduction, numbers, and distribution or, in the case of salmon and steelhead, their VSP and other relevant characteristics. NMFS also evaluates the Proposed Action's effects on critical habitat features.

4. *Describe any cumulative effects in the Action Area*

Cumulative effects, as defined in our implementing regulations (50 CFR 402.02 and 402.17(a)), are the effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the Action Area. Future federal actions that are unrelated to the Proposed Action are not considered because they require separate Section 7 consultation. Cumulative effects are described in Section 2.6.

5. *Integrate and synthesize the above factors*

This is accomplished by adding the effects of the Proposed Action and cumulative effects to the environmental baseline, and, in light of the status of the species and critical habitat, analyzing whether the Proposed Action is likely to: (1) appreciably reduce, either directly or indirectly, 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. Integration and synthesis is described in Section 2.7.

6. *Conclude whether species are jeopardized or critical habitat is adversely modified*

Based on the logic and rationale presented in the integration and synthesis (Section 2.7), we conclude whether species are jeopardized or critical habitat is adversely modified (Section 2.8).

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 designated critical habitat, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated critical habitat, and discusses the function of the PBFs that are essential for the species' conservation.

2.2.1. Status of Listed Species

2.2.1.1. Viability Approach

NMFS commonly uses four parameters to assess the viability of the populations that, together, constitute the species: abundance, productivity, spatial structure, and diversity (McElhany et al. 2000). These VSP criteria therefore encompass the species' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. When these parameters are collectively at appropriate levels, they maintain a population's capacity to adapt to various environmental conditions and allow it to sustain itself in the natural environment. These attributes are substantially influenced by habitat and other environmental conditions.

"Abundance" generally refers to the number of naturally-produced adults (i.e., the progeny of naturally-spawning parents) in the natural environment.

"Productivity," as applied to viability factors, refers to the entire life cycle; i.e., the number of naturally-spawning adults (i.e., progeny). 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.

"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 accessibility to the habitat, 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 deoxyribonucleic acid (DNA) sequence variation at single genes to complex life history traits (McElhany et al. 2000).

2.2.1.2. Listed Salmonids

In describing the range-wide status of listed salmon and steelhead species, we rely on viability assessments, status reviews, and criteria in TRT documents, recovery plans, and other available information when available, that describe VSP criteria at the population, MPG, and species scales (i.e., salmon ESUs and steelhead DPSs). For species with multiple populations, once the biological status of a species' populations and MPGs has been determined, NMFS assesses the status of the entire species. 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 to allow functioning as meta-populations (McElhany et al. 2000).

In order to describe a species' status, it is first necessary to define what the term "species" means in this context. In addition to defining "species" as including an entire taxonomic species or subspecies of animals or plants, the ESA also recognizes listing units that are a subset of the species as a whole. As described above, the ESA allows a DPS (or in the case of salmon, an ESU) of a species to be listed as threatened or endangered. In terms of determining the status of a species, the Willamette Lower Columbia TRT (WLC TRT) developed a hierarchical approach for determining ESU-level viability criteria (Figure 1).

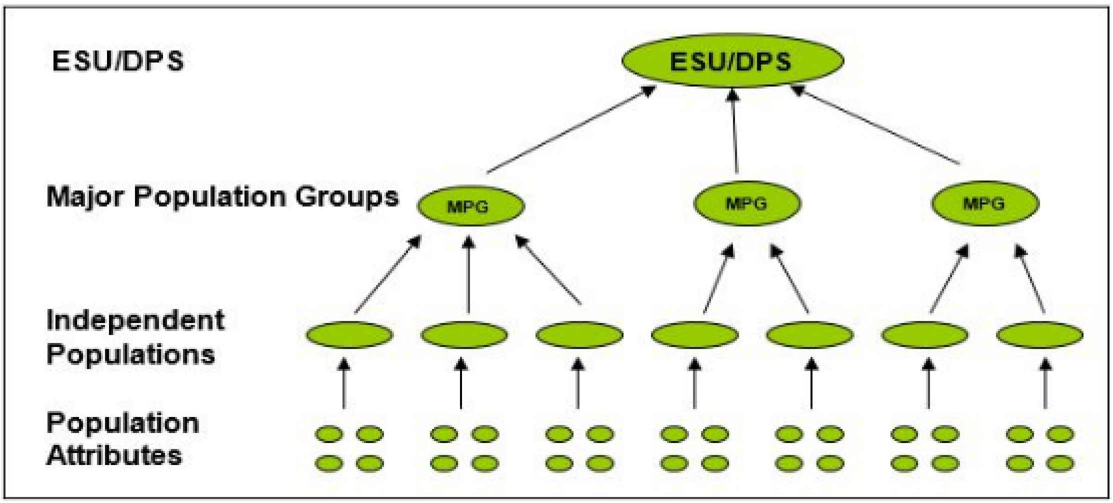

Figure 1. Hierarchical approach to ESU viability criteria.

Briefly, an ESU or DPS is divided into natural populations (McElhany et al. 2000). The risk of extinction of each population is evaluated, taking into account population-specific measures of abundance, productivity, spatial structure, and diversity. Natural populations are then grouped into ecologically and geographically similar *strata,* referred to as MPGs which are evaluated on the basis of population status. In order to be considered viable, an MPG generally must have at least half of its historically present natural populations meeting their population-level viability criteria (McElhany et al. 2006). At the MPG-level each of the ESU's MPGs also must be viable. A viable salmonid ESU or DPS is naturally self-sustaining, with a high probability of persistence over a 100-year time period.

NMFS has used this approach for the various salmon ESUs and steelhead DPSs discussed in this section, except for Puget Sound Chinook, which uses a very similar approach, but there are some differences in the details related to recovery criteria.

In assessing status, we start with the information used in its most recent ESA status review for the salmon and steelhead species considered in this opinion, and if applicable consider more recent data that are relevant to the species' rangewide status. Many times, this information exists in ESA recovery plans or annual performance reports from existing ESA authorizations. Recent information from recovery plans, where they are developed for a species, is often relevant and is used to supplement the overall review of the species' status. This step of the analysis tells us how well the species is doing over its entire range in terms of trends in abundance and productivity, spatial distribution, and diversity. It also identifies the causes for the species' decline.

The status review starts with a description of the general life history characteristics and the population structure of the ESU or DPS including the MPGs where they occur. We review VSP information that is available including abundance, productivity and trends (information on trends supplements the assessment of abundance and productivity parameters), and spatial structure and diversity. We also summarize available estimates of extinction risk that are used to characterize the viability of each natural population leading-up to a risk assessment for the ESU or DPS, and the limiting factors and threats. This section concludes by examining the status of critical habitat. Recovery plans are an important source of information that describe, among other things, the status of the species and its component populations, limiting factors, recovery goals and actions that are recommended to address limiting factors. Recovery plans are not regulatory documents. Consistency of a proposed action with a recovery plan, therefore, does not by itself provide the basis for determining that an action does not jeopardize the species. However, recovery plans do provide a perspective encompassing all human impacts that is important when assessing the effects of an action. Information from existing recovery plans for each respective ESA-listed salmon and steelhead is discussed where it applies in various sections of this Opinion.

Recovery domains are the geographically-based areas within which NMFS prepares recovery plans (Figure 2). The LAA species analyzed in this consultation occur in five recovery domains (Table 1) and NLAA species occur in additional recovery domains as detailed in the NLAA section (see Section 2.12).

For each recovery domain, a TRT appointed by NMFS has developed, or is developing, criteria necessary to identify independent populations within each species, recommended viability criteria for those species, and descriptions of factors that limit species survival. Viability criteria are prescriptions of the biological conditions for populations, biogeographic strata, and ESUs and DPSs that, if met, would indicate that an ESU or DPS will have a negligible risk of extinction over a 100-year time frame.[7]

Although the TRTs dealing with anadromous fish species operated from the common set of biological principles described in McElhany et al. (2000), they worked semi-independently from each other and developed criteria suitable to the species and conditions found in their specific recovery domains. All of the criteria have qualitative as well as quantitative aspects. The diversity of salmonid species and populations makes it impossible to set narrow quantitative guidelines that will fit all populations in all situations.

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[7] For Pacific salmon, NMFS uses its 1991 ESU policy, which states that a population or group of populations will be considered a DPS if it is an ESU. An ESU represents a DPS of Pacific salmon under the ESA that: (1) is substantially reproductively isolated from conspecific populations, and (2) represents an important component of the evolutionary legacy of the species. The species *O. mykiss* is under the joint jurisdiction of NMFS and the United States Fish and Wildlife Service (USFWS), so in making its January 2006 listing determinations NMFS elected to use the 1996 joint FWS-NMFS DPS policy for this species.

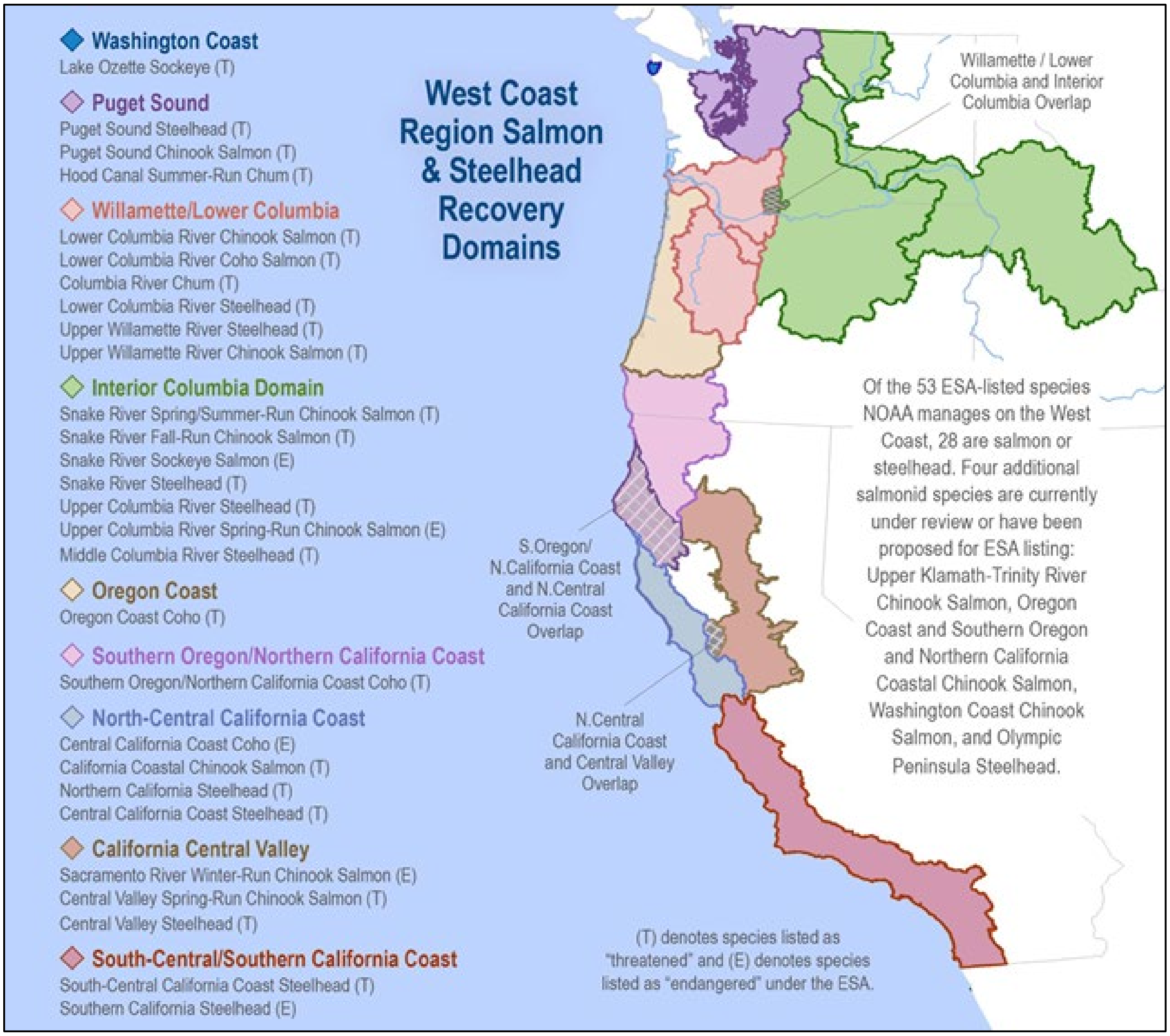

Figure 2. Map showing the range of NMFS' West Coast Region and the encompassed recovery domains for salmon and steelhead listed under the ESA. The ESUs and DPSs of ESA-listed salmon and steelhead addressed in this Opinion (either in the LAA or NLAA sections) are a subset of those listed on the left side of the figure. T indicates ESUs and DPSs that are listed as Threatened and E indicates an Endangered listing.

For this and other reasons, viability criteria vary among species, mainly in the number and type of metrics and the scales at which the metrics apply (i.e., population, MPG, or ESU/DPS) (Busch, McElhany, and Ruckelshaus 2008).

Most TRTs included in their viability criteria a combined risk rating for abundance and productivity (A/P), and an integrated spatial structure and diversity (SS/D) risk rating (*e.g.*, Interior Columbia TRT) or separate risk ratings for spatial structure and diversity (e.g., WLC TRT).

The boundaries of each population were defined using a combination of genetic information, geography, life-history traits, morphological traits, and population dynamics that indicate the extent of reproductive isolation among spawning groups. The overall viability of a species is a function of the VSP attributes of its constituent populations. Until a viability analysis of a species is completed, the VSP guidelines recommend that all populations should be managed to retain the potential to achieve viable status to ensure a rapid start along the road to recovery, and that no significant parts of the species are lost before a full recovery plan is implemented (McElhany et al. 2000).

Viability status or probability or population persistence is described below for each of the populations considered in this Opinion. The sections that follow describe the status of the ESA-listed species, and their designated critical habitats, that occur within the geographic area of this proposed action and are considered in this Opinion.

2.2.2. Status of the Chinook Salmon ESUs

Chinook salmon have a wide variety of life-history patterns that include: variation in age at seaward migration; length of freshwater, estuarine, and oceanic residence; ocean distribution; ocean migratory patterns; and age and season of spawning migration. Two distinct races of Chinook salmon are generally recognized: “stream-type” and “ocean-type” (Healey 1991); (Myers et al. 1998). Ocean-type Chinook salmon reside in coastal ocean waters for three to four years before returning to freshwater and exhibit extensive offshore ocean migrations, compared to stream-type Chinook salmon that spend two to three years in coastal ocean waters. The ocean-type also enter freshwater to return for spawning later (May and June) than the stream-type (February through April). Ocean-type Chinook salmon use different areas in the river – they spawn and rear in lower elevation mainstem rivers, and typically reside in freshwater for no more than three months compared to stream-type Chinook salmon that spawn and rear high in the watershed and reside in freshwater for a year.

Chinook salmon species evaluated in this consultation are detailed in Table 9. The TRTs identified 93 demographically independent populations of Pacific Chinook salmon (Table 9). These populations were further aggregated into strata or MPGs, groupings above the population level that are connected by some degree of migration, based on ecological subregions.

Table 9. Chinook salmon ESA-listed salmon populations considered in this Opinion.

Recovery Domain	ESU	MPGs[a]	Populations
Puget Sound	Puget Sound Chinook salmon	5	22
Willamette/Lower Columbia	Lower Columbia River Chinook salmon	6	32
	Upper Willamette River Chinook salmon	1	7
Interior Columbia	Snake River fall-run Chinook salmon	1	1
	Snake River spring/summer-run Chinook salmon	5	28
	Upper Columbia River spring-run Chinook salmon	3	3
North-Central California Coast	California Coastal Chinook	4[a]	17
California Central Valley	Central Valley spring-run	4[a]	18[b]
Totals	**8 ESUs**	**29**	**128**[b]

[a] Note that the term MPG is not used for either California ESU. The terms used for the overarching population groups are Diversity Strata and Diversity Groups for California Coastal Chinook salmon and Central Valley spring-run Chinook salmon respectively.
[b] Depending on the classification of the Mill Creek and Deer Creek populations, there may be 19 Central Valley spring-run populations (and therefore 129 total in this table).

Many Chinook salmon ESUs include hatchery programs as part of the ESU. In general, hatchery programs can provide short-term demographic benefits to salmon and steelhead, 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 may pose risks to natural productivity and diversity. The magnitude and type of risk depends on the status of affected populations and on specific practices in the hatchery program (NMFS 2022h). Hatchery programs can affect naturally produced populations of salmon and steelhead in a variety of ways, including competition (for spawning sites and food) and predation effects, disease effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge) (NMFS 2018c). Genetic resources can be housed in a hatchery program, but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS see NMFS (2005d).

2.2.2.1. Puget Sound Recovery Domain

2.2.2.1.1. Puget Sound Chinook Salmon ESU

This ESU was listed as a threatened species on March 24, 1999 (64 FR 14308). Its threatened status was reaffirmed June 28, 2005 (70 FR 37160), and again on April 14, 2014 (79 FR 20802). Critical habitat for Puget Sound Chinook salmon was designated on September 2, 2005 (70 FR

52629). There are 61 watersheds within the range of this ESU. Habitat areas for this ESU include 2,216 mi (3,566 kilometers (km)) of stream and 2,376 mi (3,824 km) of nearshore marine areas, which include the zone from extreme high water out to a depth of 30 meters. The Puget Sound Chinook Salmon ESU includes all naturally spawned populations of Chinook salmon from rivers and streams flowing into Puget Sound, including the Strait of Juan de Fuca from the Elwha River, westward, including rivers and streams flowing into Hood Canal, South Sound, North Sound and the Strait of Georgia in Washington (64 FR 14208).

The ESU also includes Chinook salmon from certain artificial propagation programs. Artificial propagation (hatchery) programs (26) were added to the listed Puget Sound Chinook Salmon ESU in 2005, as part of the final listing determinations for 16 ESUs of West Coast Salmon and Final 4(d) Protective Regulations for Threatened Salmonid ESUs (70 FR 37160). In October of 2016, NMFS proposed revisions to the hatchery programs included as part of some Pacific salmon ESUs and steelhead DPSs listed under the ESA (81 FR 72759). NMFS issued its final rule in December of 2020 (85 FR 81822). This final rule includes 25 hatchery programs as part of the listed Puget Sound Chinook Salmon ESU (Table 10).

NMFS published a 2016 5-year review for Puget Sound Chinook salmon (NMFS 2016c). The Northwest Fisheries Science Center (NWFSC) finalized its updated biological viability assessment for Northwest Pacific salmon and steelhead listed under the ESA (Ford 2022) in January of 2022. NMFS's West Coast Region (WCR) is currently preparing the 5-year status-review document for Puget Sound Chinook salmon.

NMFS's guidance classified Puget Sound Chinook salmon populations into three tiers based on a systematic framework that considers the genetic legacy of the population, the population's life history, and production and watershed characteristics (NMFS 2010b)(Figure 3). This framework, termed the *Population Recovery Approach* (PRA), carries forward the biological viability and delisting criteria described in the Supplement to the Puget Sound Salmon Recovery Plan (Ruckelshaus et al. 2002); (NMFS 2006b). The assigned tier indicates the relative role of each of the 22 populations comprising the ESU with respect to the viability of the ESU and its recovery. Tier 1 populations are most important for preservation, restoration, and ESU recovery. Tier 2 populations play a less important role in recovery of the ESU. Tier 3 populations play the least important role. When we analyze proposed actions, we first evaluate impacts at the individual population scale, then consider how those population-level impacts affect the survival and recovery of the ESU. We expect that impacts to Tier 1 populations would be more likely to affect the survival and recovery of the ESU, as a whole, than similar impacts to Tier 2 or 3 populations, because of the relatively greater importance of Tier 1 populations to overall ESU survival and recovery. NMFS has incorporated this and similar approaches in previous ESA Section 4(d) determinations and opinions on Puget Sound salmon fisheries and regional recovery planning (NMFS 2005b); (NMFS 2008g); (NMFS 2008f); (NMFS 2010a); (NMFS 2011e); (NMFS 2013e); (NMFS 2014c); (NMFS 2015d); (NMFS 2016h); (NMFS 2017b); (NMFS 2018e); (NMFS 2019d); (NMFS 2020a); (NMFS 2021c).

Table 10. Puget Sound Chinook Salmon ESU description and MPGs (Ford 2022). NMFS has determined that the bolded populations, in particular, are essential to recovery of the Puget Sound Chinook Salmon ESU (Ruckelshaus et al. 2006).

ESU Description	
Threatened	Listed under ESA in 1999; updated in 2014
5 MPGs	31 historical populations, 22 extant
MPG	***Populations***
Strait of Juan de Fuca	**Elwha (fall)**, **Dungeness (summer)**
Hood Canal	**Mid-Hood Canal (fall)**, **Skokomish (fall)**
Central/South Sound	**Nisqually (fall)**, Puyallup (fall), **White (spring)**, Green/Duwamish (fall), Cedar (fall), North Lake Washington/Sammamish (fall)
Whidbey Basin	Skykomish (summer), Snoqualmie (fall), North Fork Stillaguamish (summer), South Fork Stillaguamish (fall), Lower Skagit (fall), Upper Skagit (summer), Lower Sauk (summer), Upper Sauk (spring), **Suiattle (spring)**, Cascade (spring)
Strait of Georgia	**North Fork Nooksack (spring)**, **South Fork Nooksack (spring)**
Artificial production	
Hatchery programs included in ESU (25)	Kendall Creek Hatchery Program, Marblemount Hatchery Program (spring-run), Marblemount Hatchery Program (summer-run), Brenner Creek Hatchery Program (fall-run), Harvey Creek Hatchery Program (summer-run), Whitehorse Springs Hatchery Program (summer-run), Wallace River Hatchery Program (yearlings and subyearlings), Issaquah Creek Hatchery Program, White River Hatchery Program, White River Acclimation Pond Program, Voights Creek Hatchery Program, Clarks Creek Hatchery Program, Clear Creek Hatchery Program, Kalama Creek Hatchery cwtProgram, George Adams Hatchery Program, Hamma Hamma Hatchery Program, Dungeness/Hurd Creek Hatchery Program, Elwha Channel Hatchery Program, Skookum Creek Hatchery Spring-run Program, Bernie Kai-Kai Gobin (Tulalip) Hatchery-Cascade Program, North Fork Skokomish River Spring-run Program, Soos Creek Hatchery Program (subyearlings and yearlings), Fish Restoration Facility Program, Bernie Kai-Kai Gobin (Tulalip) Hatchery-Skykomish Program, Hupp Springs Hatchery-Adult Returns to Minter Creek Program
Hatchery programs not included in ESU (9)	Samish River Hatchery Fall Program, Glenwood Springs Hatchery Fall Program, George Adams Fall Program, Hoodsport Fall Program, Gorst Creek Fall Program, Grovers Creek Hatchery Fall Program, Minter Creek Fall Program, Tumwater Falls Program, Chambers Creek Fall Program

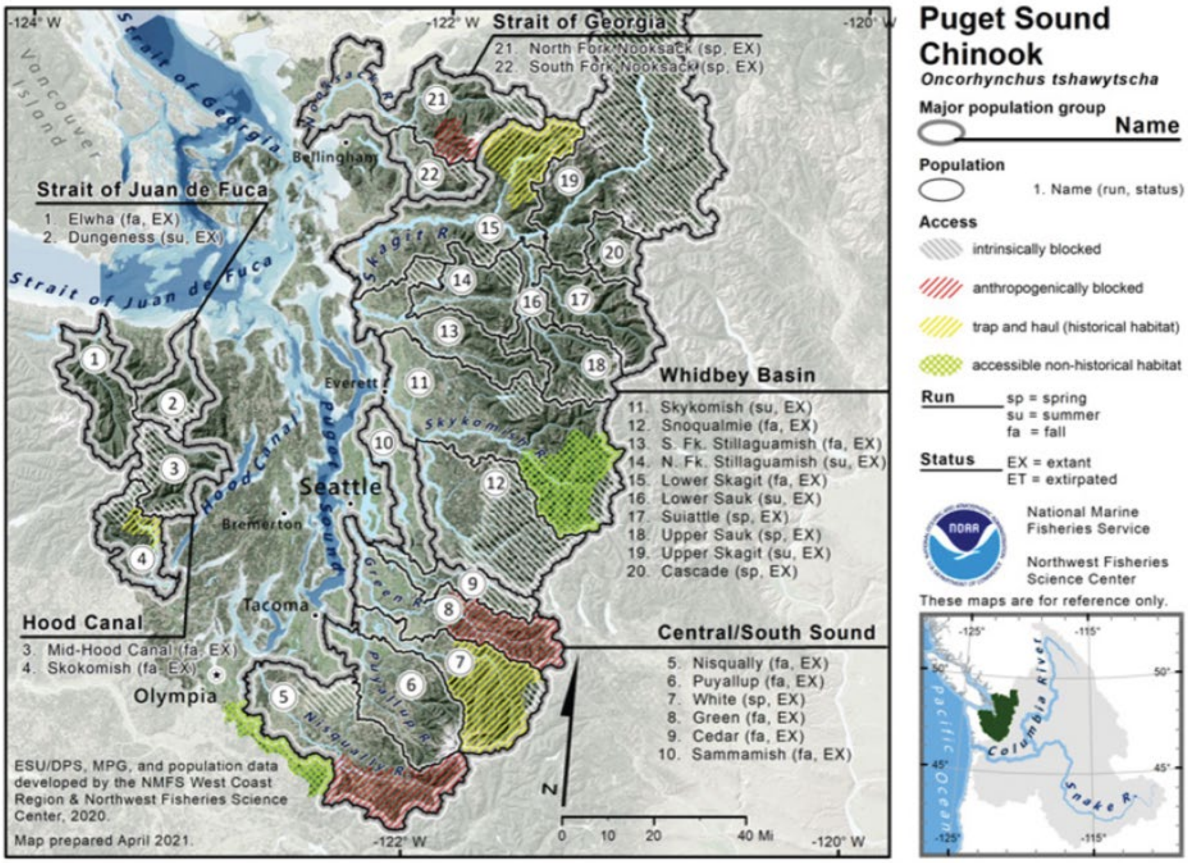

Figure 3. Map of the Puget Sound Chinook Salmon ESU's spawning and rearing areas, illustrating populations and MPGs (Ford 2022).

NMFS adopted the recovery plan for Puget Sound Chinook on January 19, 2007 (72 FR 2493). The recovery plan consists of two documents: the Puget Sound Salmon Recovery Plan (SSDC 2007) and Final Supplement to the Shared Strategy's Puget Sound Salmon Recovery Plan. The recovery plan adopts ESU and population level viability criteria recommended by the PSTRT (Ruckelshaus et al. 2006). The Puget Sound Technical Recovery Team's (PSTRT) Biological Recovery Criteria will be met when the following conditions are achieved:

1. All watersheds improve from current conditions, resulting in improved status for the species;

2. At least two to four Chinook salmon populations in each of the five biogeographical regions of Puget Sound attain a low-risk status over the long-term[8];

3. At least one or more populations from major diversity groups historically present in each of the five Puget Sound regions attain a low-risk status;

[8] The number of populations required to be at low-risk status depends on the number of diversity groups in the region. For example, three of the regions only have two populations generally of one diversity type; the Central Sound Region has two major diversity groups; the Whidbey/Main Region has four major diversity groups.

4. Tributaries to Puget Sound not identified as primary freshwater habitat for any of the 22 identified populations are functioning in a manner that is sufficient to support an ESU-wide recovery scenario;

5. Production of Chinook salmon from tributaries to Puget Sound not identified as primary freshwater habitat for any of the 22 identified populations occurs in a manner consistent with ESU recovery.

2.2.2.1.1.1 Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the Puget Sound Chinook Salmon ESU, is at moderate risk and remains at threatened status.

2.2.2.1.1.1.1. Abundance and Productivity

Abundance of the 22 extant natural spawning populations in the Puget Sound Chinook Salmon ESU varies considerably between populations (Figure 4). Total abundance in the ESU over the entire time series shows that individual populations have varied in increasing or decreasing abundance. Several populations (North and South Fork Nooksack, Sammamish, Green, White, Puyallup, Nisqually, Skokomish, Dungeness, and Elwha Rivers) are dominated by hatchery returns (Ford 2022). Generally, many populations experienced increases in total abundance during the years 2000–08, and more recently in 2015–17, but general declines during 2009–14, and a downturn again in the two most-recent years, 2017–18 (Figure 4). Abundance across the Puget Sound Chinook Salmon ESU has generally increased since the last status review, with only two of the 22 populations (Cascade River and North and South Fork Stillaguamish Rivers) showing a negative percentage change in the five-year geometric mean for natural-origin spawner abundances since the prior status review (Ford 2022). Fifteen of the remaining 20 populations with positive percentage changes since the prior status review have relatively low natural spawning abundances (<1,000 fish), so some of these increases represent small changes in total abundance (Ford 2022). Given lack of high confidence in survey techniques, particularly with small populations, there remains substantial uncertainty in detecting trends in small populations.

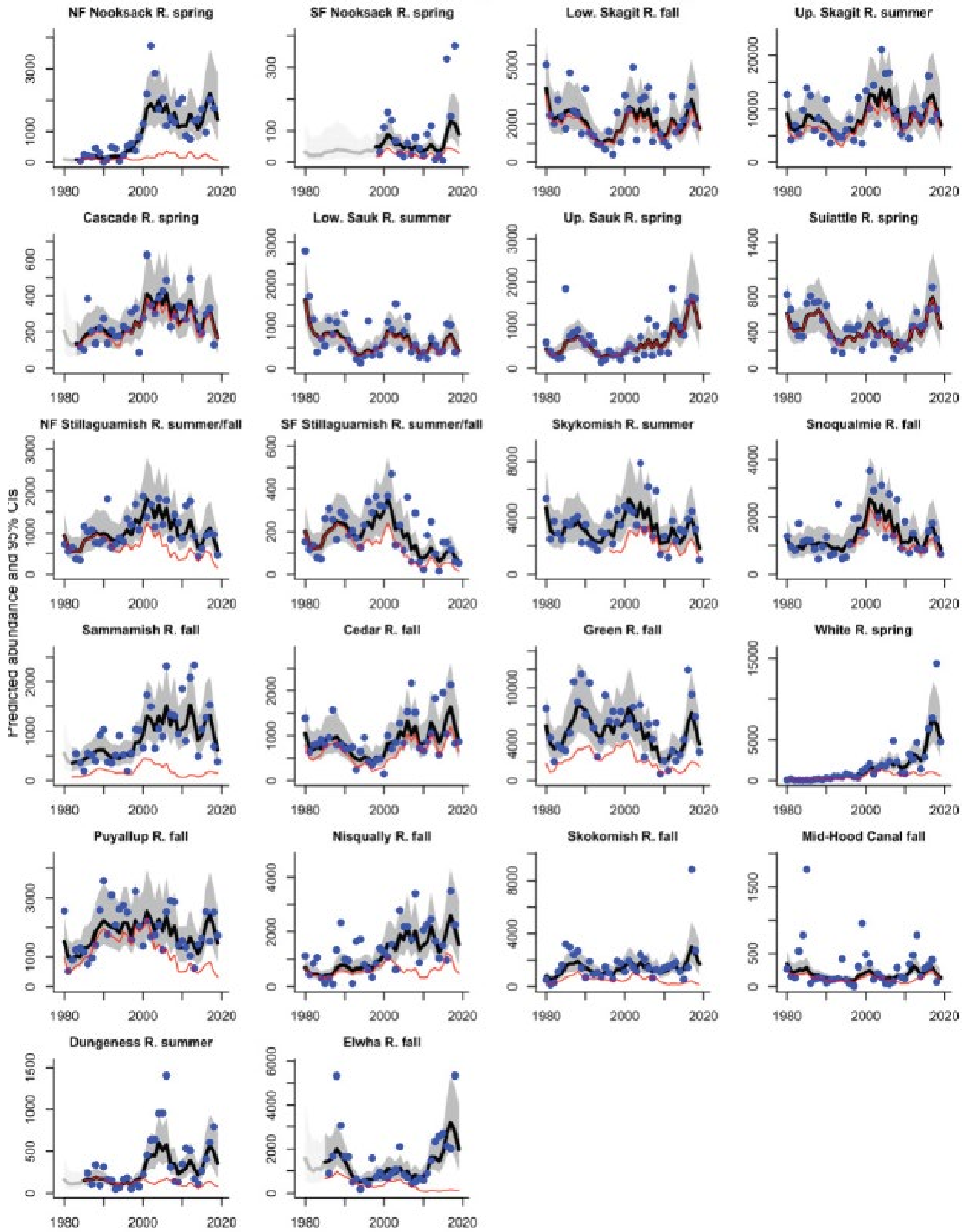

Figure 4. Smoothed trend in estimated total (thick black line, with 95% confidence interval in gray) and natural (thin red line) population spawning abundance. In portions of a time series where a population has no annual estimates but smoothed spawning abundance is estimated from correlations with other populations, the smoothed estimate is shown in light gray. Points show the annual raw spawning abundance estimates. For some trends, the smoothed estimate may be influenced by earlier data points not included in the plot (Ford 2022).

Fifteen-year trends in log natural-origin spawner abundance were computed over two time periods (1990–2005 and 2004–19) for each Puget Sound Chinook salmon population {Ford, 2022 #2432}. Trends were negative for four of the populations in the earlier period, and for 16 of the 22 populations in the later period. Thus, there is a general decline in natural-origin spawner abundance across all MPGs in the most-recent fifteen years {Ford, 2022 #2432}. Upper Sauk and Suiattle Rivers (Whidbey Basin MPG), Nisqually River (Central/South Sound MPG), and Mid-Hood Canal (Hood Canal MPG) are the only populations with positive trends, though Mid-Hood Canal has an extremely low population size. Further, no change in trend between the two time periods was detected in South Fork Nooksack River (Strait of Georgia MPG) or Green and Nisqually Rivers (Central/South MPG). The average trend across the ESU for 1990–2005 was 0.03. The average trends for the MPGs are: Strait of Georgia, 0.03; Whidbey Basin, 0.04; Central/South Sound, 0.04; Hood Canal, 0.03; and Strait of Juan de Fuca, 0.01. The average trend across the ESU for 2004–19 was –0.02. The average trends for the MPGs are: Strait of Georgia, –0.02; Whidbey Basin, –0.02; Central/South Sound, –0.02; Hood Canal, –0.02; and Strait of Juan de Fuca, –0.08. The previous viability status review {NWFSC, 2015 #6584} concluded that there were widespread negative trends for the total ESU, despite variable escapements and trends for individual populations. The addition of the data to 2018 now shows even more substantially either flat or negative trends for the entire ESU in natural-origin Chinook salmon spawner population abundances {Ford, 2022 #2432}.

Productivity in the Puget Sound Chinook Salmon ESU has been variable across the time period (1980–2018) (Ford 2022). Across the Puget Sound Chinook Salmon ESU, ten of 22 Puget Sound populations show natural productivity below replacement in nearly all years since the mid-1980s (Ford 2022). These include the North and South Fork Nooksack Rivers (Strait of Georgia MPG), North and South Fork Stillaguamish and Skykomish Rivers (Whidbey Basin MPG), Sammamish, Green, and Puyallup Rivers (Central/South Sound MPG), Skokomish River (Hood Canal MPG), and Elwha River (Strait of Juan de Fuca MPG). Productivity in the Whidbey Basin MPG populations was above zero in the mid-to-late 1990s, with the exception of the Skykomish and North and South Fork Stillaguamish River populations. The White River population in the Central/South Sound MPG was above replacement from the early 1980s to 2001, but has dropped in productivity consistently since the late 1980s. In recent years, only five populations have had productivities above zero. These are Lower and Upper Skagit, Lower and Upper Sauk, and Suiattle Rivers in the Whidbey Basin MPG. This is consistent with, and continues the decline reported in, the 2015 status review (NWFSC 2015).

2.2.2.1.1.1.1.1. Harvest

Puget Sound Chinook Salmon are harvested in ocean salmon fisheries, in Puget Sound fisheries, and in terminal fisheries in the rivers (Ford 2022). They migrate to the north, so for most Puget Sound Chinook salmon populations, nearly all of the ocean fishery impacts occur in Canada and Alaska, where they are subject to the U.S.–Canada Pacific Salmon Treaty (PST)(Ford 2022). Some populations are also harvested at lower rates in the coastal fisheries off Washington and Oregon. Fisheries within Puget Sound are managed by the state and tribal co-managers under a resource management plan. Fishery impact rates vary considerably among MPGs within Puget Sound, primarily due to different terminal-area management and variable exploitation rates in the

Canadian and Alaskan fisheries. For populations in the Hood Canal (Skokomish River) and Central/South Sound MPGs (Nisqually, White, Puyallup, and Green Rivers), substantial terminal-area fisheries are directed at hatchery fish that are produced largely to support tribal and recreational fisheries. For populations in the Whidbey Basin (Skokomish, Stillaguamish, and Skagit Rivers) and Strait of Georgia MPGs (Nooksack River), harvest in the northern fisheries accounts for a large portion of the exploitation.

Chinook salmon populations in Puget Sound generally show a similar pattern: declining exploitation rates in the 1990s, and relatively stable-to-increasing exploitation rates since then (Figure 5). This is primarily a result of Canadian interceptions of Puget Sound Chinook salmon off the West Coast Vancouver Island (WCVI) (Ford 2022). During the 1990s, Canada sharply reduced WCVI fisheries in response to depressed domestic stocks. Since then, WCVI stock status has improved somewhat, and Canadian managers have changed the temporal pattern of fishing to avoid WCVI stocks. This has resulted in increased impacts on Puget Sound stocks. A notable exception to this pattern is the North Puget Sound region (Nooksack, Skagit, and Stillaguamish Rivers). These stocks have not seen increased impacts because they migrate through the Strait of Georgia. Canadian stocks in the Strait of Georgia have not recovered, and most fisheries in Canadian inside waters for Chinook and coho salmon have been shut down.

The Chinook salmon agreement under the PST, which took effect in 2009, included 30% reductions in Chinook salmon catch ceilings off WCVI and 15% reductions in southeast Alaska (NMFS 2008f). The PST was revised again in 2018, and a new ten-year agreement (2019–28) now specifies further reductions in these catch ceilings at low abundances (NMFS 2019f). Since the 1999 PST Chinook salmon agreement, an abundance-based Chinook salmon management regime, under which fisheries are classified as either aggregate abundance-based management (AABM) or individual stock-based management (ISBM) regimes, has been in place. AABM fisheries constrain catch to a numerical limit computed from either a pre-season forecast or an in-season estimate of abundance; ISBM fisheries constrain annual impacts, within the fisheries of a jurisdiction, for a naturally spawning Chinook salmon stock or stock group (Pacific Salmon Commission 2020). Goals of the current PST management regime include an abundance-based framework and the ability to respond to significant changes in the productivity of Chinook salmon stocks, both to preserve the biological diversity of the Chinook salmon resource and to contribute to the restoration of depressed stocks (Pacific Salmon Commission 2020).

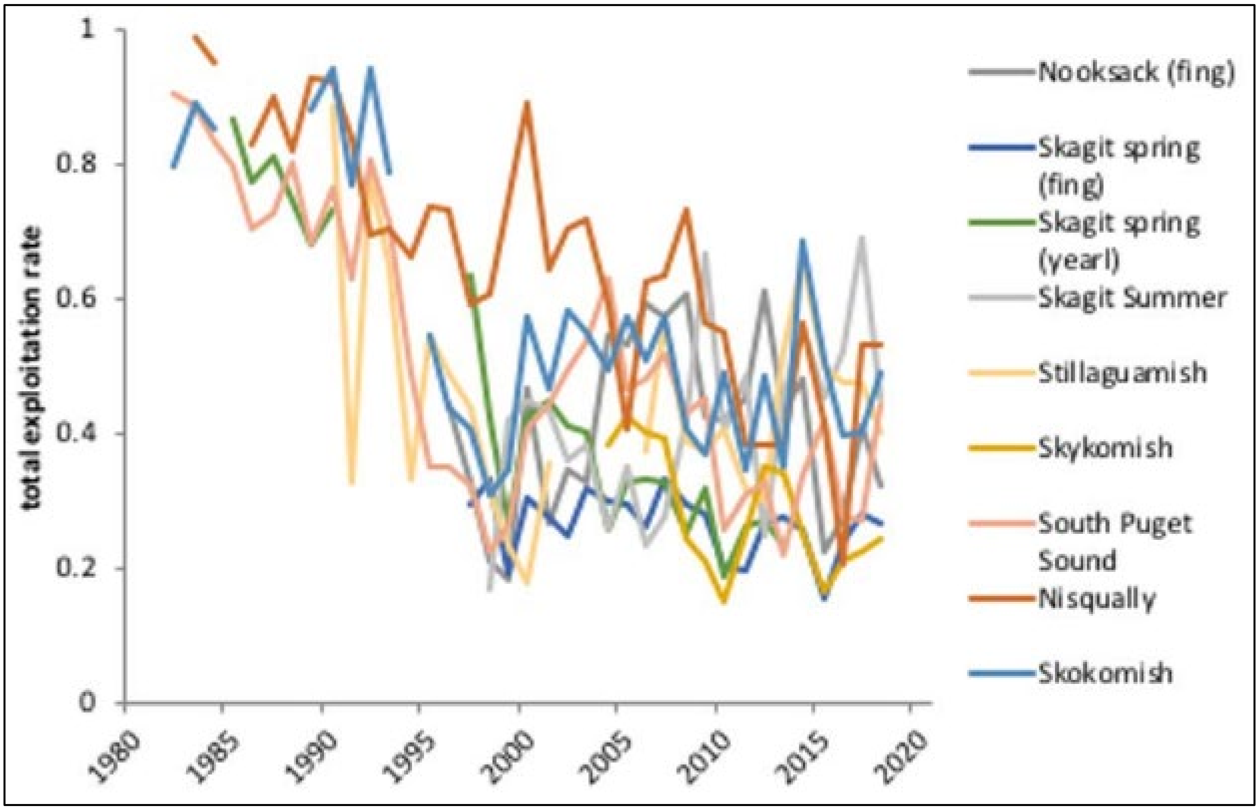

Figure 5. Coded-wire tag (CWT)-based exploitation rates for Chinook salmon indicator stocks in Puget Sound. Recreated from Ford (Ford 2022).

2.2.2.1.1.1.2. Spatial Structure and Diversity

Measures of spatial structure and diversity can give some indication of the resilience of a population to sustain itself. In assessing spatial structure within a population, the TRT recommended that human activities should not change the spatial structure in a way that significantly deviates from the historical pattern (SSDC 2007). The spatial distribution of habitat within a watershed must maintain enough quality, quantity and connectivity of habitat patches to support spawning, rearing, and upstream and downstream migration. The risk of extinction for Puget Sound salmon populations is thus affected by the quality, quantity, and geographic structure of habitat now, and in the future (SSDC 2007). Habitat monitoring and adaptive management planning efforts to develop monitoring plans was undertaken in all individual watersheds of Puget Sound in 2014 (NMFS 2016c). These reports and prior annual three-year workplans document the many habitat actions that were initially identified in the Puget Sound Chinook salmon recovery plan (SSDC 2007). The expected benefits will take years or decades to produce significant improvement in natural population viability parameters (NMFS 2016c). Development of a monitoring and adaptive management program was recommended by NMFS in the 2007 Recovery Plan (SSDC 2007). This program is not yet fully functional for providing assessment of watershed habitat restoration/recovery programs, nor for properly integrating the essentially discrete habitat, harvest and hatchery programs (NMFS 2016c).

Although the spatial distribution of naturally-spawning populations is difficult to determine due to hatchery influence, the remaining populations with significant numbers of natural-origin spawners are concentrated in the region containing the Skagit and Stillaguamish River basins (SSDC 2007). Spatial structure can be measured in various ways, but Ford (Ford 2022) analyzed the proportion of natural- vs. hatchery-origin spawners on the spawning grounds, as discussed below. Quantitative viability criteria for spatial structure and diversity are largely unavailable at the population level (SSDC 2007).

2.2.2.1.1.1.2.1. Hatcheries

The proportion of natural-origin spawners across the ESU started declining in approximately 1990, and continued to decline through 2018 (Table 11). The populations with the highest fractions of natural-origin spawners across the entire 1980 to 2018 time period are the six Skagit River populations (Ford 2022). The Skykomish, Snoqualmie, and Cedar River populations had a lower proportion of natural-origin spawners in the late 1990s, but they have rebounded and stayed between 60–90% since the early 2000s (Ford 2022). All other populations vary considerably across the whole time period. A number of populations (North and South Fork Nooksack, North and South Fork Stillaguamish, Skykomish, Snoqualmie, White, Puyallup, Nisqually, Skokomish, Dungeness, and Elwha Rivers) show recent declining trends in the fraction natural-origin estimates (Table 11).

It is important to note that the quality of hatchery contribution data in the earlier time periods (prior to mass marking programs) may be poor, so the long-term trends may lack accuracy in the earlier years (Ford 2022). In the Whidbey Basin MPG, the fraction natural-origin abundance has been consistently high in the six Skagit River populations. With ongoing hatchery programs in the Stillaguamish and Snohomish Rivers, there has been a decrease in five-year mean fraction natural-origin in the last two time periods (2010–14 and 2015–19), particularly in the Stillaguamish River (Table 11). In Ford (2022), the fraction natural-origin estimates prior to mass hatchery marking (pre-1997 and 2002–05) in the Skykomish and Snoqualmie Rivers population data were removed due to concerns by tribal co-managers regarding data quality. Estimates of hatchery and natural-origin proportions of fish since the implementation of mass marking are considered more robust (NMFS 2022n).

However, the average five-year mean fraction natural-origin estimates for the entire Whidbey Basin MPG remain relatively consistent across all time periods. The Strait of Georgia MPG (North and South Fork Nooksack Rivers) has had increased hatchery influence since the late 1990s and across all time periods. The South Fork Nooksack River population has had extremely small natural fish returns through 2015, but has had increased numbers of natural-origin spawners in the last three years relative to increased supplementation program efforts conducted at Skookum Hatchery (Ford 2022). This population is at high risk of extinction (Ford 2022). The Central/South Sound MPG has had decreasing fraction natural-origin estimates in the Sammamish, Green, White, and Puyallup Rivers populations, and increases in the Cedar population in the three most-recent five-year time periods (2005–09, 2010–14, 2015–19) (Table 11). The Nisqually River population data here represent the total volitional escapement, but in the three most-recent years, a supplementation program has been instituted trucking hatchery fish upstream for release on the spawning grounds. This is an effort to supplement natural spawning.

Table 11. Five-year mean of fraction natural-origin spawners (sum of all estimates divided by the number of estimates) (Ford 2022). Sp indicates Spring-run, FA indicates Fall-run, and SU indicates Summer-run.

Population	MPG	1995–99	2000–04	2005–09	2010–14	2015–19
North Fork Nooksack River SP	Strait of Georgia	0.28	0.11	0.19	0.14	0.13
South Fork Nooksack River SP	Strait of Georgia	0.26	0.55	0.57	0.42	0.45
Lower Skagit River FA	Whidbey Basin	0.94	0.91	0.86	0.92	0.84
Upper Skagit River SU	Whidbey Basin	0.91	0.87	0.84	0.95	0.91
Cascade River SP	Whidbey Basin	0.98	0.92	0.89	0.94	0.86
Lower Sauk River SU	Whidbey Basin	0.94	0.97	0.95	0.91	0.98
Upper Sauk River SP	Whidbey Basin	0.99	1.00	0.98	0.97	0.99
Suiattle River SP	Whidbey Basin	0.99	0.97	0.99	0.99	0.97
North Fork Stillaguamish River SU/FA	Whidbey Basin	0.59	0.70	0.40	0.43	0.45
South Fork Stillaguamish River SU/FA	Whidbey Basin	0.59	0.70	0.40	0.54	0.46
Skykomish River SU	Whidbey Basin	0.49	0.52	0.76	0.69	0.62
Snoqualmie River FA	Whidbey Basin	0.81	0.89	0.81	0.78	0.75
Sammamish River FA	Central/ South Sound	0.29	0.36	0.16	0.07	0.16
Cedar River FA	Central/ South Sound	0.61	0.59	0.82	0.78	0.71
Green River FA	Central/ South Sound	0.55	0.47	0.43	0.39	0.30
White River SP	Central/ South Sound	0.54	0.79	0.43	0.32	0.15
Puyallup River FA	Central/ South Sound	0.88	0.79	0.52	0.41	0.32
Nisqually River FA	Central/ South Sound	0.80	0.61	0.30	0.30	0.47
Skokomish River FA	Hood Canal	0.40	0.46	0.45	0.10	0.16
Mid-Hood Canal FA	Hood Canal	0.76	0.79	0.61	0.33	0.89
Dungeness River SU	Strait of Juan de Fuca	1.00	0.32	0.43	0.25	0.25
Elwha River FA	Strait of Juan de Fuca	0.41	0.53	0.35	0.06	0.05

In the Hood Canal and Strait of Juan de Fuca MPGs, three of four populations had declining five-year mean fraction natural-origin estimates of fish returns to the spawning grounds (Table

11). Skokomish River had a slight increase in the most recent five-year time period, but still a very low fraction natural-origin for the population. This population is heavily impacted by the George Adams Salmon Hatchery program (Ford 2022). The Mid-Hood Canal population had a higher five-year mean fraction natural estimate in the most recent time period (2014–19) because the hatchery supplementation program was ended in the Hamma Hamma River in 2015 (Ford 2022). Some supplementation fish continued to return through 2019; however, the population has not proven to be self-sustaining and viable, and recent returns have been very low (Ford 2022). Genetics data show this population highly correlated to the George Adams Salmon Hatchery and Green River stocks that have been used. State managers conclude from the long-term supplementation program and the genetics composition that if there was an independent population of Chinook salmon that utilized the Mid-Hood Canal streams, then it is most certainly extinct at this point in time. Thus, considering populations by MPG, Whidbey Basin is the only MPG with a consistently high fraction natural-origin spawner abundance, in six of 10 populations (Ford 2022). All other MPGs have either variable or declining spawning populations that have high proportions of hatchery-origin spawners (Ford 2022).

2.2.2.1.1.1.3. Summary

All Puget Sound Chinook salmon populations continue to remain well below the PSTRT planning ranges for recovery escapement levels (Ford 2022). Most populations also remain consistently below the spawner–recruit levels identified by the PSTRT as necessary for recovery. Across the ESU, most populations have increased somewhat in abundance since the last 5-year status review in 2016 (NMFS 2016c), but have small negative trends over the past 15 years. Productivity remains low in most populations. Hatchery-origin spawners are present in high fractions in most populations outside the Skagit River watershed, and in many watersheds, the fraction of spawner abundances that are natural-origin have declined over time (Table 11). 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. Biannual four-year work plans document the many completed habitat actions that were initially identified in the Puget Sound Chinook salmon recovery plan. The expected benefits will take years or decades to produce significant improvements in natural population viability parameters. Development of a monitoring and adaptive management program was required by NMFS in the supplement to the shared strategy recovery plan (NMFS 2006b), and since the last review, the Puget Sound Partnership has completed this task. However, the program is still not fully functional, neither for providing assessment of watershed habitat restoration/recovery programs, nor for fully integrating the essentially discrete habitat, harvest, and hatchery programs (Ford 2022). A number of watershed groups are in the process of updating their recovery plan chapters, and this includes prioritizing and updating recovery strategies and actions as well as assessing prior accomplishments. Overall, the Puget Sound Chinook Salmon ESU remains at “moderate” risk of extinction, and viability is largely unchanged from the prior NWFSC (2015) review (Ford 2022).

2.2.2.1.1.2. Limiting Factors

Limiting factors described in SSDC (SSDC 2007) and reiterated in NMFS (NMFS 2016c) relate to present or threatened set of conditions within certain habitat parameters that inhibit the viability of salmon as defined by the VSP criteria, including the following:

- Degraded nearshore and estuarine habitat: Residential and commercial development has reduced the amount of functioning nearshore and estuarine habitat available for salmon rearing and migration. The loss of mudflats, eelgrass meadows, and macroalgae further limits salmon foraging and rearing opportunities in nearshore and estuarine areas.
- Degraded freshwater habitat: Floodplain connectivity and function, channel structure and complexity, riparian areas and large wood supply, stream substrate, impaired passage conditions and water quality have been degraded for adult spawning, embryo incubation, and rearing as a result of cumulative impacts of agriculture, forestry, and development. Some improvements have occurred over the last decade for water quality and removal of forest road barriers.

Additional factors affecting Puget Sound Chinook salmon viability include the following:

- Anadromous salmonid hatchery programs: Salmon and steelhead released from Puget Sound hatcheries operated for harvest augmentation purposes pose ecological, genetic, and demographic risks to natural-origin Chinook salmon populations. The risk to the species' persistence that may be attributable to hatchery-related effects has decreased since the 2015 status review (NWFSC 2015), based on hatchery risk reduction measures that have been implemented (Ford 2022). Improvements in hatchery operations associated with on-going ESA review and determination processes are expected to further reduce hatchery-related risks.
- Salmon harvest management: Total fishery exploitation rates (ERs) on most Puget Sound Chinook salmon populations have decreased substantially since the late 1990s when compared to years prior to listing – 1992–1998 (average reduction = -21%, range = -49 to +33%), Fisheries Regulation Assessment Model (FRAM) base period validation results, version 7.1.1) – but weak natural-origin Chinook salmon populations in Puget Sound still require protective measures to reduce the risk of overharvest. The risk to the species' persistence because of harvest remains the same since the 2015 status review, meaning that for some of the populations with minimal abundance, even low rates of harvest impact can pose demographic and genetic risks. However, there has been greater uncertainty associated with this threat due to shorter term harvest plans for Puget Sound fisheries (uncertainty about future harvest plans) and exceedance of Rebuilding ERs for many Chinook salmon populations essential to recovery.
- Concerns regarding existing regulatory mechanisms, including: lack of documentation or analysis of the effectiveness of land-use regulatory mechanisms and land-use management plans, lack of reporting and enforcement for some regulatory programs, certain state, local, or private land and water use actions continue to occur without protective measures for ESA-listed Chinook salmon. State, local, and private actions have no Federal nexus to trigger the ESA Section 7 consultation requirement, nor are ESA Section 10 permits sought for those actions, thus ESA measures are not protecting listed

species and their habitat from those actions.

2.2.2.2. Willamette/Lower Columbia Recovery Domain

2.2.2.2.1. Lower Columbia River Chinook Salmon ESU

On March 24, 1999, NMFS listed the LCR Chinook Salmon ESU as a threatened species (64 FR 14308). The threatened status was reaffirmed on June 28, 2005 (70 FR 37159) and on April 14, 2014 (79 FR 20802). Critical habitat for LCR Chinook salmon was designated on September 2, 2005 (70 FR 52706). In 2022, NMFS completed its most recent 5-year review for LCR Chinook salmon (SWFSC 2022).

On February 6, 2015, we announced the initiation of five-year reviews for 17 ESUs of salmon and 11 DPSs of steelhead in Oregon, California, Idaho, and Washington (80 FR 6695). We requested that the public submit new information on these species that has become available since our original listing determinations or since the species' status was last updated. In response to our request, we received information from federal and state agencies, Native American Tribes, conservation groups, fishing groups, and individuals. We considered this information, as well as information routinely collected by our agency, to complete these five-year reviews. The most recent five-year status review of the LCR Chinook Salmon ESU was released October 21, 2022 (SWFSC 2022), and this section summarizes the current findings of that review.

The LCR Chinook Salmon ESU includes natural populations in Oregon and Washington from the ocean upstream to, and including, the White Salmon River (river mile 167.5) in Washington and Hood River (river mile 169.5) in Oregon, except for salmon in the Willamette River (which enters the Columbia River at river mile 101). Within the Willamette River Chinook salmon are listed separately as the UWR Salmon ESU, and not as part of the Lower Columbia River Chinook Salmon ESU.

Thirty-two historical populations, within six MPGs, comprise the Lower Columbia River Chinook Salmon ESU (Table 12). These are distributed through three ecological zones[9]. A combination of life-history types, based on run timing and ecological zones, result in six MPGs, some of which are considered extirpated or nearly extirpated (Table 13). The run timing distributions across the 32 historical populations are: nine spring populations, 21 early-fall populations, and two late-fall populations (Table 14, Figure 6).

[9] There are a number of methods of classifying freshwater, terrestrial, and climatic regions. The WLC TRT used the term ecological zone as a reference, in combination with an understanding of the ecological features relevant to salmon, to designate four ecological areas in the domain: (1) Coast Range zone, (2) Cascade zone, (3) Columbia Gorge zone, and (4) Willamette zone. This concept provides geographic structure to ESUs in the domain. Maintaining each life-history type across the ecological zones reduces the probability of shared catastrophic risks. Additionally, ecological differences among zones reduce the impact of climate events across entire ESUs (Myers et al. 2003).

Within the geographic range of the Lower Columbia River Chinook Salmon ESU, during the interim since the 2015 status review update, there have been a number of changes in both the quality and quantity of hatchery production in the lower Columbia River (Ford 2022). Currently 18 of these hatchery programs are included in the ESU (Table 12), while the remaining programs are excluded (70 FR 37159; (SWFSC 2022)). For a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS, see NMFS (2005d).

Lower Columbia River Chinook salmon are classified into three life-history types including spring runs, early-fall runs (“tules”, pronounced too-lees), and late-fall runs (“brights”) based on when adults return to freshwater (Table 14). Lower Columbia River spring Chinook salmon are stream-type, while Lower Columbia River early-fall and late-fall Chinook salmon are ocean-type. Other life-history differences among run types include the timing of: spawning, incubation, emergence in freshwater, migration to the ocean, maturation, and return to freshwater. This life-history diversity allows different runs of Chinook salmon to use streams as small as 10 feet wide and rivers as large as the mainstem Columbia (NMFS 2013e).

Stream characteristics determine the distribution of run types among Lower Columbia River streams. Depending on run type, Chinook salmon may rear anywhere from a few months to a year or more in freshwater streams, rivers, or the estuary before migrating to the ocean in spring, summer, or fall. All runs migrate far into the north Pacific on a multi-year journey along the continental shelf to Alaska before circling back to their river of origin. The spawning run typically includes three or more age classes. Adult Chinook salmon are the largest of the salmon species, and Lower Columbia River Chinook salmon can reach sizes of up to 25 kilograms (55 pounds). Chinook salmon require clean gravels for spawning, and pool and side-channel habitats for rearing. All Chinook salmon die after spawning once (NMFS 2013e).

Fall Chinook salmon (tules and brights) historically were found throughout the entire range, while spring Chinook salmon historically were only found in the upper portions of basins with snowmelt driven flow regimes (western Cascade Crest and Columbia Gorge tributaries) (NMFS 2013e). Bright Chinook salmon were identified in only two basins in the western Cascade Crest tributaries. In general, bright Chinook salmon mature at an older average age than either Lower Columbia River spring or tule Chinook salmon, and have a more northern oceanic distribution. Currently, the abundance of all fall Chinook salmon greatly exceeds that of the spring component (Ford 2022).

Table 12. Lower Columbia River Chinook Salmon ESU description and MPGs (Ford 2022); (SWFSC 2022). The designations "(C)" and "(G)" identify Core[a] and Genetic Legacy populations, respectively.

ESU Description	
Threatened	Listed under ESA in 1999; updated in 2014.
6 MPGs	32 historical populations
MPG	***Populations***
Cascade Spring	Upper Cowlitz (C,G), Cispus (C), Tilton, Toutle, Kalama, NF Lewis (C), Sandy (C,G)
Gorge Spring	(Big) White Salmon (C), Hood
Coast Fall	Grays/Chinook, Elochoman (C), Mill Creek, Youngs Bay, Big Creek (C), Clatskanie, Scappoose
Cascade Fall	Lower Cowlitz (C), Upper Cowlitz, Toutle (C), Coweeman (G), Kalama, EF Lewis (G), Salmon Creek, Washougal, Clackamas (C), Sandy River early
Gorge Fall	Lower Gorge, Upper Gorge (C), (Big) White Salmon (C), Hood
Cascade Late Fall	North Fork Lewis (C,G), Sandy (C,G)
Artificial production	
Hatchery programs included in ESU (18)	Big Creek Tule Fall Chinook; Astoria High School Salmon-Trout Enhancement Program (STEP) Tule Chinook Program; Warrenton High School (STEP) Tule Chinook Program; Cowlitz Tule Chinook Program; North Fork Toutle Tule Chinook Program; Kalama Tule Chinook Program; Washougal River Tule Chinook Program; Spring Creek National Fish Hatchery (NFH) Tule Chinook Program; Cowlitz Spring Chinook Program in the Upper Cowlitz River and in the Cispus River; Friends of the Cowlitz Spring Chinook Program; Kalama River Spring Chinook Program; Lewis River Spring Chinook Program; Fish First Spring Chinook Program; Sandy River Hatchery Program; Deep River Net Pens-Washougal Program; Klaskanine Hatchery Program; Bonneville Hatchery Program; and the Cathlamet Channel Net Pens Program.
Hatchery programs not included in ESU (12)	Clatsop County Fisheries (CCF) Select Area Brights Program Fall Chinook, CCF Spring Chinook salmon Program, Carson NFH Spring Chinook salmon Program, Little White Salmon NFH Tule Fall Chinook salmon Program, Bonneville Hatchery Tule Fall Chinook salmon Program, Hood River Spring Chinook salmon Program[b], Deep River Net Pens Tule Fall Chinook, Klaskanine Hatchery Tule Fall Chinook, Bonneville Hatchery Fall Chinook, Little White Salmon NFH Tule Fall Chinook, Cathlamet Channel Net Pens Spring Chinook, Little White Salmon NFH Spring Chinook

[a] Core populations are defined as those that, historically, represented a substantial portion of the species' abundance. Genetic legacy populations are defined as those that have had minimal influence from non-endemic fish due to artificial propagation activities, or may exhibit important life-history characteristics that are no longer found throughout the ESU (McElhany et al. 2003).

[b] The ongoing Hood River Spring Chinook Salmon Program is currently integrating returning natural-origin spring Chinook salmon into the broodstock. The program had been using only spring Chinook salmon returning to the Hood River for broodstock since the release year 2013 when the last release of out-of-basin Deschutes River spring Chinook salmon occurred (NMFS 2022b). NMFS will continue to monitor the status of the natural-origin population to determine if the Hood River spring Chinook salmon artificially propagated stock is no more divergent relative to the local natural population(s) than what would be expected between closely related natural populations within the ESU (70 FR 37204, June 28, 2005).

Table 13. Lower Columbia River Chinook salmon populations and recommended status under the recovery scenario (NMFS 2013e).

MPG	Population (State)	Contribution[b]	Recovery Scenario[a]	
			Target Persistence Probability	Abundance Target[c]
Cascade Spring	Upper Cowlitz (Washington (WA))	Primary	H+	1,800
	Cispus (WA)	Primary	H+	1,800
	Tilton (WA)	Stabilizing	VL	100
	Toutle (WA)	Contributing	M	1,100
	Kalama (WA)	Contributing	L	300
	North Fork Lewis (WA)	Primary	H	1,500
	Sandy (Oregon (OR))	Primary	H	1,230
Gorge Spring	White Salmon (WA)	Contributing	L+	500
	Hood (OR)	Primary[d]	VH[d]	1,493
Coast Fall	Youngs Bay (OR)	Stabilizing	L	505
	Grays/Chinook (WA)	Contributing	M+	1,000
	Big Creek (OR)	Contributing	L	577
	Elochoman/Skamokawa (WA)	Primary	H	1,500
	Clatskanie (OR)	Primary	H	1,277
	Mill/Aber/Germ (WA)	Primary	H	900
	Scappoose (OR)	Primary	H	1,222
Cascade Fall	Lower Cowlitz (WA)	Contributing	M+	3,000
	Upper Cowlitz (WA)	Stabilizing	VL	--
	Toutle (WA)	Primary	H+	4,000
	Coweeman (WA)	Primary	H+	900
	Kalama (WA)	Contributing	M	500
	Lewis (WA)	Primary	H+	1,500
	Salmon (WA)	Stabilizing	VL	--
	Clackamas (OR)	Contributing	M	1,551
	Sandy (OR)	Contributing	M	1,031
	Washougal (WA)	Primary	H+	1,200
Gorge Fall	Lower Gorge (WA/OR)	Contributing	M	1,200
	Upper Gorge (WA/OR)	Contributing	M	1,200
	White Salmon (WA)	Contributing	M	500
	Hood (OR)	Primary[d]	Hd	1,245
Cascade Late Fall	North Fork Lewis (WA)	Primary	VH	7,300
	Sandy (OR)	Primary	VH	3,561

[a] Overall persistence probability of the population under the delisting scenario to achieve VSP criteria, including abundance target. VL =very low, L = low, M = moderate, H = high, VH = very high. These are adopted in the recovery plan (NMFS 2013e).
b Primary, contributing, and stabilizing designations reflect the relative contribution of a population to recovery goals and delisting criteria. Primary populations are targeted for restoration to a high or very high persistence probability. Contributing populations are targeted for medium or medium-plus viability. Stabilizing populations are those that will be maintained at current levels (generally low to very low viability), which is likely to require substantive recovery actions to avoid further degradation.
[c] Abundance objectives account for related goals for productivity (NMFS 2013e).
[d] Oregon analysis indicates a low probability of meeting the delisting objectives for these populations.

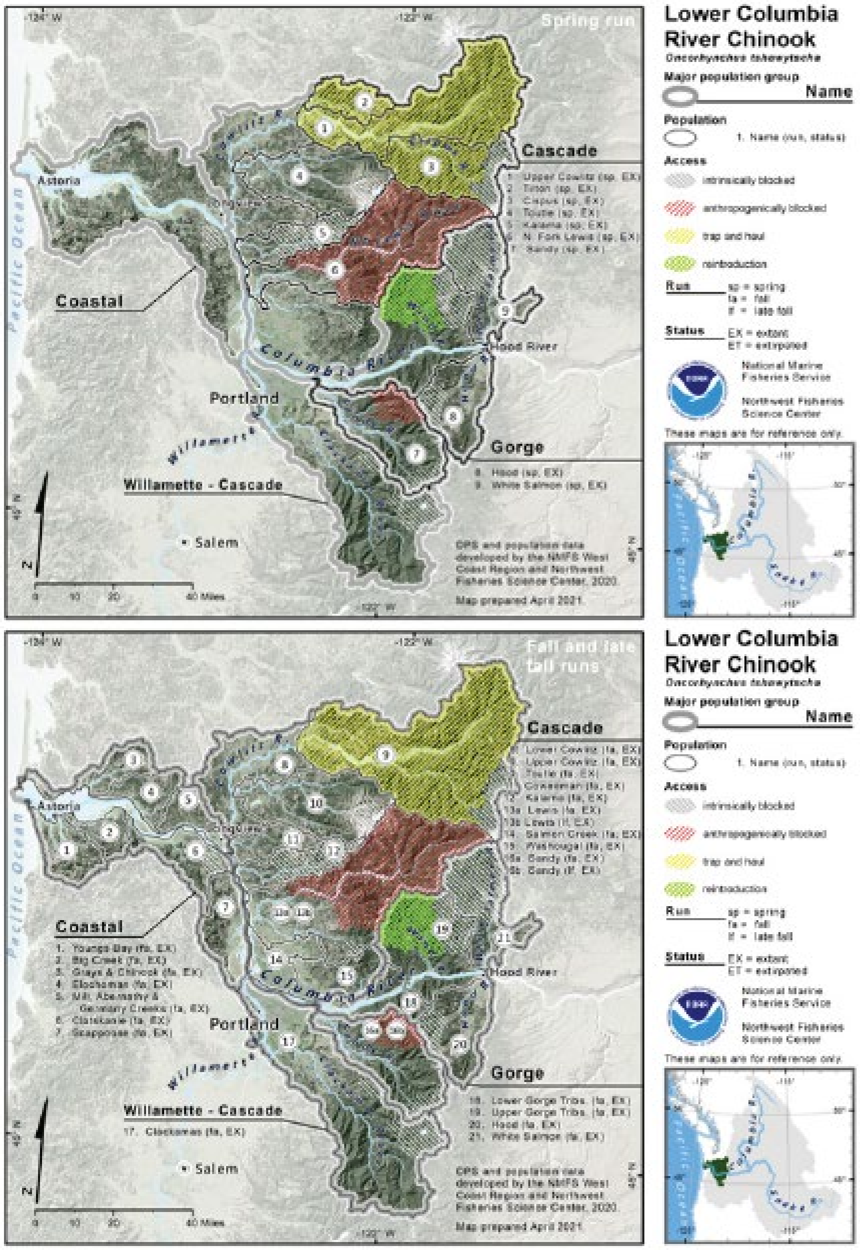

Figure 6. Maps of the Lower Columbia River Chinook Salmon ESU's spawning and rearing areas for Chinook salmon Demographically Independent Populations (DIPs or 'populations'), illustrating populations and MPGs. Several watersheds contain, or historically contained, both fall and spring runs. The upper figure illustrates spring-run populations and the lower figure illustrates fall-run populations (Ford 2022).

Table 14. Life-history and population characteristics of Lower Columbia River Chinook salmon.

Characteristic	Life-History Features		
	Spring	Early-fall (tule)	Late-fall (bright)
Number of extant populations	9	21	2
Life-history type	Stream	Ocean	Ocean
River entry timing	March–June	August–September	August–October
Spawn timing	August–September	September–November	November–January
Spawning habitat type	Headwater large tributaries	Mainstem large tributaries	Mainstem large tributaries
Emergence timing	December–January	January–April	March–May
Duration in freshwater	Usually 12–14 months	1–4 months, a few up to 12 months	1–4 months, a few up to 12 months
Rearing habitat	Tributaries and mainstem	Mainstem, tributaries, sloughs, estuary	Mainstem, tributaries, sloughs, estuary
Estuarine use	A few days to weeks	Several weeks up to several months	Several weeks up to several months
Ocean migration	As far north as Alaska	As far north as Alaska	As far north as Alaska
Age at return	4–5 years	3–5 years	3–5 years
Recent natural spawners	800	6,500	9,000
Recent hatchery adults	12,600 (1999–2000)	37,000 (1991–1995)	NA

2.2.2.2.1.1. Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Each Lower Columbia River Chinook salmon natural population target persistence probability level is summarized in Table 13. Additionally, Table 13 provides the target abundance for each population that would be consistent with delisting. Persistence probability is measured over a 100-year time period and ranges from very low (probability < 40%) to very high (probability >99%).

The WLC TRT established recovery criteria as two primary populations with high target persistence probability in each MPG to achieve ESU viability. If the recovery scenario in Table 13 were achieved, it would exceed the WLC TRT's MPG-level viability criteria for the Coast and Cascade fall MPGs, the Cascade spring MPG, and the Cascade late-fall MPG. However, the recovery scenario in Table 13 for the Gorge spring and Gorge MPGs does not meet WLC TRT criteria. Within each of these MPGs, the scenario targets only one population (the Hood) for high persistence probability because Bonneville Dam spans the Gorge fall and spring MPGs affecting passage of fish to these areas. Exceeding the WLC TRT criteria, particularly in the Cascade fall and Cascade spring Chinook salmon MPG, was intentional on the part of recovery planners to compensate for uncertainties about meeting the WLC TRT's criteria in the Gorge fall and spring MPGs. In addition, multiple spring Chinook salmon natural populations are prioritized for aggressive recovery efforts to balance risks associated with the uncertainty of success in reintroducing spring Chinook salmon populations above tributary dams in the Cowlitz and Lewis systems.

NMFS (2013e) commented on the uncertainties and practical limits to achieving high viability for the spring and tule populations in the Gorge MPGs. Recovery opportunities in the Gorge were limited by the small numbers of natural populations and the high uncertainty related to restoration, due to Bonneville Dam passage and inundation of historically productive habitats. NMFS also recognized the uncertainty regarding the TRT's MPG delineations between the Gorge and Cascade MPG populations, and that several Chinook salmon populations downstream from Bonneville Dam may be quite similar to those upstream of Bonneville Dam. As a result, the recovery plan recommends that additional natural populations in the Coast and Cascade MPGs achieve recovery status, as it will help to offset the anticipated shortcomings for the Gorge MPGs. This was considered a more precautionary approach to recovery than merely assuming that efforts related to the Gorge MPG would be successful. The information provided by the WLC TRT and the management unit recovery planners led NMFS to conclude in the recovery plan that the recovery scenario (Table 13) represents one of multiple possible scenarios that would meet biological criteria for delisting. The similarities between the Gorge and Cascade MPG, coupled with compensation in the other strata for not meeting TRT criteria in the Gorge stratum, would provide an ESU no longer likely to become endangered.

Expanded spawner surveys begun after the 2010 review, especially in regard to abundance time series and hatchery contribution to the naturally spawning adults. Presently, there is some level of monitoring for all Chinook salmon populations except those that are functionally extinct (Ford 2022). Table 15 captures the geometric mean of natural spawner counts available, indicating that in more recent years more populations are being monitored.

2.2.2.2.1.1.1. Abundance and Productivity

Out of the 32 populations that make up this ESU, only seven populations are at or near the recovery viability goals (Table 15) set in the recovery plan (refer above to Table 13). Six of these seven populations were located in the Cascade stratum; most of the populations in the Coastal and Gorge strata are doing rather poorly (Ford 2022).Overall, there has been modest change since the 2015 viability review (NWFSC 2015) in the biological status of Chinook salmon populations in the Lower Columbia River Chinook salmon ESU (Ford 2022). Increases in abundance were noted in about half of the fall-run populations, and in 75% of the spring- run populations for which data were available (Figure 7). Decreases in hatchery contribution were also noted for several populations. Relative to baseline VSP levels identified in the recovery plan (NMFS 2013e), there has been an overall improvement in the status of a number of spring and fall-run populations (Table 15), although most are still far from the recovery plan goals.

Many of the populations in this ESU remain at "high risk," with low natural-origin abundance levels. Although many of the populations in this ESU are at "high" risk, it is important to note that poor ocean and freshwater conditions existed during the 2015–19 period and, despite these conditions, the status of a number of populations improved, some remarkably so from the previous status review (Grays River Tule, Lower Cowlitz River Tule, and Kalama River Tule fall runs) (Ford 2022).

Table 15. Current 5-year geometric mean of raw natural-origin spawner abundances compared to the recovery scenario presented in the recovery plan (NMFS 2013e) for Lower Columbia River Chinook salmon populations (Ford 2022). Colors indicate the relative proportion of the recovery target currently obtained: red = <10%, orange = 10% > x < 50%, yellow = 50% > x < 100%, green = >100%.

MPG	Population	Abundance	
		2015–19	Recovery Target
Coastal	Grays River Tule FA (WA)	228	1,000
	Youngs Bay FA (OR)	145	505
	Big Creek FA (OR)	0	577
	Elochoman River/Skamokawa Tule FA (WA)	95	1,500
	Clatskanie River FA (OR)	3	1,277
	Mill/Abernathy/Germany Creeks Tule FA (WA)	28	900
	Scappoose Creek FA (OR)	n/a	1,222
Cascade	Upper Cowlitz/Cispus Rivers SP (WA)	171	1,800
	Kalama River SP (WA)	43	300
	North Fork Lewis River SP (WA)	-112	1,500
	Sandy River SP (OR)	3,359	1,230
	Toutle River SP (WA)	n/a	1,100
	Cispus River SP (WA)	n/a	1,800
	Tilton River SP (WA)	n/a	100
	Lower Cowlitz River Tule FA (WA)	3,208	3,000
	Coweeman River Tule FA (WA)	543	900
	Toutle River Tule FA (WA)	280	4,000
	Upper Cowlitz River Tule FA (WA)	1,761	n/a
	Kalama River Tule FA (WA)	2,142	500
	Lewis River Tule FA (WA)	2,003	1,500
	Clackamas River FA (OR)	236	1,551
	Sandy River FA (OR)	-2,074	1,031
	Washougal River Tule FA (WA)	914	1,200
	Salmon Creek FA (WA)	n/a	n/a
	Lewis River Bright LFR (WA)	8,725	7,300
	Sandy River Bright LFR (OR)	n/a	3,561
Gorge	Big White Salmon River SP (WA)	8	500
	Hood River SP (OR)	n/a	1,493
	Lower Gorge Tributaries Tule FA (WA & OR)	4,528	1,200
	Upper Gorge Tributaries Tule FA (WA & OR)	537	1,200
	Big White Salmon River Tule FA (WA)	283	500
	Hood River FA (OR)	n/a	1,245

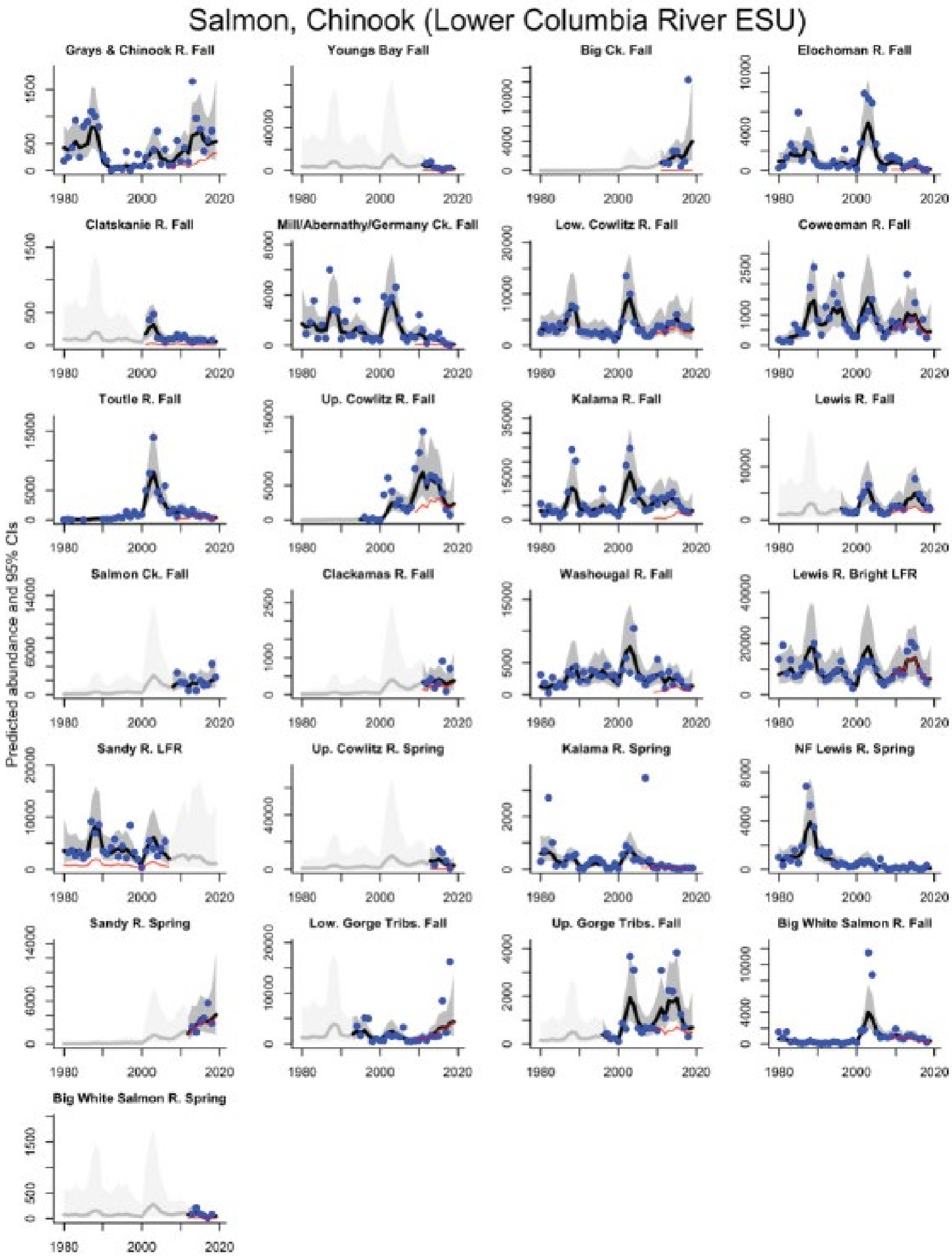

Figure 7. Smoothed trend in estimated total (thick black line, with 95% confidence interval in gray) and natural (thin red line) population spawning abundance. In portions of a time series where a population has no annual estimates but smoothed spawning abundance is estimated from correlations with other populations, the smoothed estimate is shown in light gray. Points show the annual raw spawning abundance estimates. For some trends, the smoothed estimate may be influenced by earlier data points not included in the plot (Ford 2022).

2.2.2.2.1.1.1.1. <u>Harvest</u>

Harvest rates for populations with different run timings share similar ER patterns, but differ in absolute harvest rates. With each run timing, tributary-specific harvest rates may differ. All populations saw a drop in ERs in the early 1990s in response to decreases in abundance. There has been a modest increase since then (Figure 8). Ocean fishery impact rates have been relatively stable in the past few years, with the exception of the bright (late fall) component of the ESU. The different MPGs are subject to different in-river fisheries (mainstem and tributary) because of differences in life histories and therefore river entry timing, but share relatively similar ocean distributions.

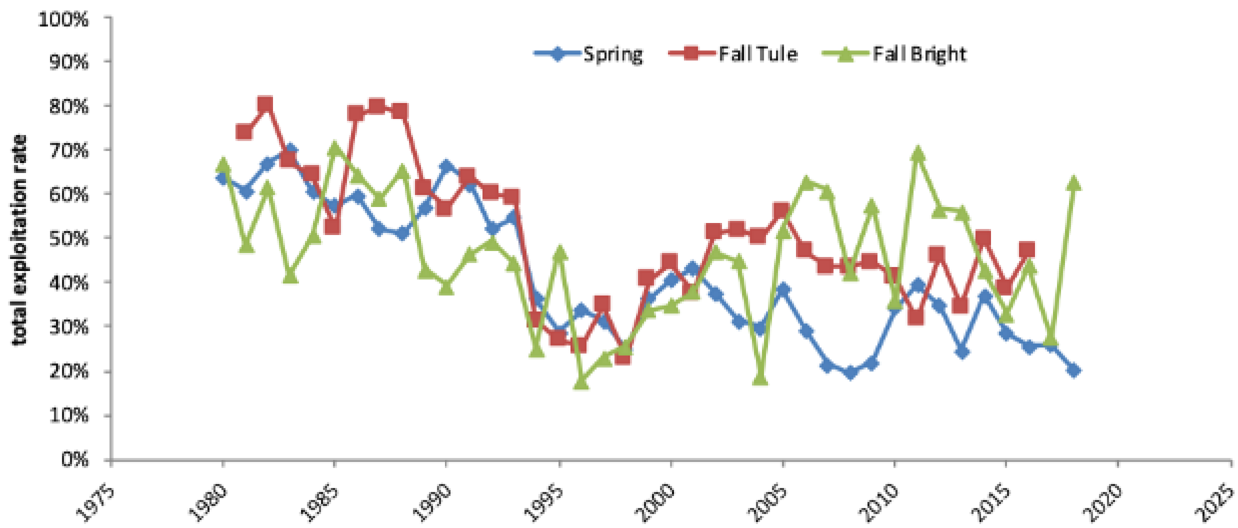

Figure 8. Total ERs on the three components of the Lower Columbia River Chinook salmon ESU (Ford 2022) (see Section 2.4, Environmental Baseline for geographic distribution of the ERs).

2.2.2.2.1.1.2. Spatial Structure and Diversity

There have been a number of large-scale efforts to improve accessibility, one of the primary metrics for spatial structure, in this ESU. These include: passage efforts on the Cowlitz River at Cowlitz Falls starting in 1996, collection of juvenile fall-run Chinook salmon from the Tilton River at Mayfield Dam, removal of the Powerdale Dam on the Hood River in 2010, removal of the Condit Dam on the White Salmon River in 2011, and fish passage operations for spring-run Chinook salmon (trap-and-haul) on the Lewis River beginning in 2012 (Ford 2022). Once passage actions are undertaken, it may still take several years for the benefits to become evident. Still, several programs continue to improve their operations and may achieve fish collection efficiencies suitable to support sustainable populations in previously inaccessible habitat sometime in the near future (5–10 years) (Ford 2022). In addition to these large-scale efforts, there have been a number of recovery actions throughout the ESU to remove or improve thousands of sub-standard culverts and other small-scale passage barriers, as well as breaching dikes to provide access to juvenile habitat (Ford 2022).

Although the spatial structure contribution to Lower Columbia River Chinook salmon ESU viability has improved during the current review period (2015–19), effective access to upstream habitat in the Cowlitz and Lewis River basins remains the major limitation (Ford 2022). Overall, the viability of the Lower Columbia River Chinook salmon ESU has increased since the 2015 viability review (NWFSC 2015), although the ESU remains at “moderate” risk of extinction.

2.2.2.2.1.1.2.1. Hatcheries

In 2017 NMFS adopted a Record of Decision (“Mitchell Act ROD”) that would be used to guide NMFS’ decision on the distribution of funds for hatchery production under the Mitchell Act (16 U.S.C. §§755-757), which NMFS administers. NMFS’s continued funding of Mitchell Act hatchery programs, under the Mitchell Act ROD, was analyzed under the ESA and found not likely to jeopardize the continued existence of any species in the Columbia Basin (NMFS 2017e). The Mitchell Act ROD directs NMFS to strengthen performance goals to all Mitchell Act-funded, Columbia River Basin, hatchery programs that affect ESA-listed primary and contributing salmon and steelhead populations. These stronger performance goals reduced the risks of hatchery programs to natural-origin salmon and steelhead populations, including the Lower Columbia River Chinook Salmon ESU, and primarily to the tule Chinook salmon MPGs. It required integrated hatchery programs to be better integrated and isolated hatchery programs to be better isolated than was the practice at the time. While this action is expected to decrease multiple MPGs high relative dominance of hatchery-origin spawners, this will take some time to occur, and is not likely to show up in the data until the middle of this decade (mid 2020s at the earliest).

Hatchery contributions remain high for a number of populations (Table 16), and it is likely that many returning unmarked adults are the progeny of hatchery-origin parents, especially where large hatchery programs operate (Ford 2022). While overall hatchery production has been reduced slightly, hatchery-produced fish still represent a majority of fish returning to the ESU (Ford 2022). The continuing high proportions of hatchery-origin fish in spawning populations has been purposeful in some areas, e.g., for reintroduction purposes in the Hood, Cowlitz, and Lewis subbasins. The continued release of out-of-ESU stocks, including upriver bright fall-run, Rogue River Basin fall-run, UWR spring-run, Carson Hatchery spring-run, and Deschutes River spring-run, remains a concern (Ford 2022). Hatchery managers have continued to implement and monitor changes in Lower Columbia River Chinook salmon hatchery management (SWFSC 2022). Although several measures have been implemented to reduce risk, the pHOS remains high in the Coastal and Gorge MPGs (SWFSC 2022). NMFS has completed ESA consultations that have resulted in changes to the programs to reduce hatchery effects on natural-origin populations within the ESU (NMFS 2017e). We conclude that hatchery effects continue to present risks to the persistence of the Lower Columbia River Chinook salmon ESU, but they are likely less of a risk than at the time of the previous status review (NMFS 2016d).

Table 16. Five-year mean of fraction natural-origin spawners (sum of all estimates divided by the number of estimates) for Lower Columbia River Chinook salmon ESU populations (Ford 2022). Blanks mean no estimate available in that 5-year range.

Population[a]	MPG	1995–99	2000–04	2005–09	2010–14	2015–19
Upper Cowlitz/Cispus Rivers SP	Spring-run Cascade	—	—	—	0.08	0.06
Kalama River SP	Spring-run Cascade	—	—	—	1	1
North Fork Lewis River SP	Spring-run Cascade	—	—	—	—	—
Sandy River SP	Spring-run Cascade	—	—	—	0.89	0.92
Big White Salmon River SP	Spring-run Gorge	—	—	—	0.13	0.18
Grays River Tule FA	Fall-run Coastal	—	—	0.36	0.22	0.43
Youngs Bay FA	Fall-run Coastal	—	—	—	0.04	0.14
Big Creek FA	Fall-run Coastal	—	—	—	0.03	0.04
Elochoman River/ Skamokawa Tule FA	Fall-run Coastal	—	—	—	0.17	0.45
Clatskanie River FA	Fall-run Coastal	—	0.1	0.19	0.09	0.05
Mill/Abernathy/Germany Creeks Tule FA	Fall-run Coastal	—	—	—	0.11	0.22
Lower Cowlitz River Tule FA	Fall-run Cascade	—	—	—	0.7	0.77
Coweeman River Tule FA	Fall-run Cascade	—	—	—	0.82	0.91
Toutle River Tule FA	Fall-run Cascade	—	—	—	0.31	0.55
Upper Cowlitz River Tule FA	Fall-run Cascade	—	—	—	0.35	0.82
Kalama River Tule FA	Fall-run Cascade	—	—	—	0.08	0.57
Lewis River Tule FA	Fall-run Cascade	—	—	—	0.67	0.56
Clackamas River FA	Fall-run Cascade	—	—	—	0.6	0.68
Sandy River FA	Fall-run Cascade	—	—	—	—	—
Washougal River Tule FA	Fall-run Cascade	—	—	—	0.3	0.58
Lower Gorge Tributaries Tule FA	Fall-run Gorge	—	—	—	0.89	0.96
Upper Gorge Tributaries Tule FA	Fall-run Gorge	—	—	—	0.4	0.58
Big White Salmon River Tule FA	Fall-run Gorge	—	—	—	0.8	0.57
Lewis River Bright LFR	Late fall-run Cascade	—	—	—	1	1
Sandy River Bright LFR	Late fall-run Cascade	0.24	0.24	0.24	—	—

[a] Note that the Tilton (Spring-run Cascade), Toutle (Spring-run Cascade), Hood (Spring-run Gorge), Scapoose (Fall-run Coastal), Salmon (Fall-run Cascade), and Hood (Fall-run Gorge) populations are not included due to low abundances or lack of monitoring and available data, as discussed further in Ford (Ford 2022).

2.2.2.2.1.2. Limiting Factors

There are many factors that affect the abundance, productivity, spatial structure, and diversity of the Lower Columbia River Chinook Salmon ESU. Lower Columbia River Chinook salmon populations began to decline by the early 1900s because of habitat alterations and harvest rates that were unsustainable, particularly given these changing habitat conditions. Human impacts and limiting factors come from multiple sources, including hydropower development on the Columbia River and its tributaries, habitat degradation, hatchery effects, fishery management and harvest decisions, and ecological factors, including predation and environmental variability. The recovery plan consolidates available information regarding limiting factors and threats for the Lower Columbia River Chinook Salmon ESU (NMFS 2013e).

The recovery plan provides a detailed discussion of limiting factors and threats and describes strategies for addressing each of them. Chapter 4 of the recovery plan (NMFS 2013e) describes limiting factors on a regional scale, and how they apply to the four ESA-listed species from the Lower Columbia River considered in the plan, including the Lower Columbia River Chinook Salmon ESU. Chapter 4 (NMFS 2013e) includes details on large scale issues including:

- Ecological interactions,
- Climate change, and
- Human population growth.

Chapter 7 of the recovery plan discusses the limiting factors that pertain to Lower Columbia River Chinook salmon spring, fall, and late fall natural populations and the MPGs in which they reside. The discussion of limiting factors in Chapter 7 (NMFS 2013e) is organized to address:

- Tributary habitat,
- Estuary habitat,
- Hydropower,
- Hatcheries,
- Harvest, and
- Predation.

Rather than repeating the extensive discussion from the recovery plan, this discussion in Chapters 4 and 7 is incorporated here by reference.

In our recent five-year status review (SWFSC 2022), based on Section 4(a)(1) of the ESA, we determine if the listed species listing factors have changed. While there have been improvements in the abundance of some populations, we found that the overall viability trends remain low, and well below abundance recovery objectives for Lower Columbia River Chinook Salmon ESU. Some improvements have been made in listing factors, though slight increases in risk in some listing factors are contemporaneous with restoration work and some regulatory improvements, and the recent improvements (particularly habitat restoration work) require time to manifest measurable increases in population viability. The risk from predation and disease to the Lower

Columbia River Chinook Salmon ESU remains. For harvest, the risk is increasing for Lower Columbia River Chinook salmon due to modest upward trend in harvest impacts on fall and bright fall-run components of the ESU (SWFSC 2022). Additionally, the risk to the species persistence from climate change is an increasing concern (SWFSC 2022).

Accordingly, when all listing factors and current viability are considered, specific to the Lower Columbia River Chinook Salmon ESU, our recent five-year status review indicates that the collective risk to the persistence of the Lower Columbia River Chinook Salmon ESU has not changed significantly since our listing determination in 2006 and should remain listed as threatened (SWFSC 2022).

2.2.2.2.2. Upper Willamette River Chinook Salmon ESU

On March 24, 1999, NMFS listed the UWR Chinook Salmon ESU as a threatened species (64 FR 14308). The threatened status was reaffirmed on June 28, 2005 (70 FR 37160) and again on April 14, 2014 (79 FR 20802). Critical habitat was designated on September 2, 2005 (70 FR 52629). In 2024, NMFS published the most recent 5-year status review for UWR Chinook salmon (NMFS 2024b). The NWFSC finalized its updated biological viability assessment for Northwest Pacific salmon and steelhead listed under the ESA in 2022 (Ford 2022).

The ESU includes all naturally spawned populations of spring-run Chinook salmon in the Clackamas River, the Willamette River and its tributaries above Willamette Falls, Oregon (Figure 9). Critical habitat encompasses 60 watersheds within the range of this ESU as well as the lower Willamette/Columbia River rearing/migration corridor, occurring in the counties of Benton, Clackamas, Clatsop, Columbia, Lane, Linn, Marion, Multnomah, Polk, and Yamhill, in the State of Oregon, and Clark, Cowlitz, Pacific, and Wahkiakum in the State of Washington (70 FR 52629). The ESU contains seven historical populations, within a single MPG, as well as six artificial propagation programs (western Cascade Range, Table 17).

The UWR Chinook Salmon ESU only has one MPG (Table 17), containing the seven populations listed in Table 17. A recovery plan was finalized for this species on August 5, 2011 (ODFW and NMFS 2011). The broad sense recovery goal for the ESU is to achieve for all UWR salmon populations a “very low” extinction risk, and would therefore lead to a “highly viable” population (i.e. over 100 years throughout their range). In the Lower Columbia River Chinook salmon ESU, this type of population designation is termed “primary”. As no such designation or stratification was done for the UWR Chinook Salmon ESU, the adopted approach treats all populations in the ESU as if they were primary populations.

Upper Willamette River Chinook salmon’s genetics have been shown to be strongly differentiated from nearby populations, and are considered one of the most genetically distinct groups of Chinook salmon in the Columbia River Basin (Waples 2004); (Beacham et al. 2006). For adult Chinook salmon, Willamette Falls historically acted as an intermittent physical barrier to upstream migration into the UWR basin, where adult fish could only ascend the falls at high spring flows. It has been proposed that the falls served as a zoogeographic isolating mechanism for a considerable period of time (Waples 2004). This isolation has led to, among other attributes, the unique early run timing of these populations relative to other Lower Columbia River spring-run populations. Historically, the peak migration of adult salmon over the falls occurred in late May. Low flows during the summer and autumn months prevented fall-run salmon and coho salmon from reaching the UWR basin (ODFW and NMFS 2011).

Table 17. Upper Willamette River Chinook Salmon ESU description and MPG (Jones 2015); (NWFSC 2015); (Ford 2022); (NMFS 2024b).

ESU Description	
Threatened	Listed under ESA in 1999; updated in 2014.
1 MPG	7 historical populations
MPG	**Populations**
Western Cascade Range	Clackamas River, Molalla River, North Santiam River, South Santiam River, Calapooia River, McKenzie River, Middle Fork (MF) Willamette River
Artificial production	
Hatchery programs included in ESU (6)	McKenzie River spring, North Santiam spring, Molalla spring, South Santiam spring, MF Willamette spring, Clackamas spring

The generalized life history traits of UWR Chinook salmon are summarized in Table 18. Typically, adult UWR Chinook salmon begin appearing in the lower Willamette River in January, with fish entering the Clackamas River as early as March. The majority of the run ascends Willamette Falls from late April through May, with the run extending into mid-August (Myers et al. 2006).

Chinook salmon now ascend the falls via a fish ladder at Willamette Falls. Through 2017, ODFW conducted comprehensive spawner surveys (redds and carcasses) both below and above dams in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette Rivers. Direct adult counts are also made at Willamette Falls, Bennett Dam, and Minto Fish Facility (North Santiam River), Foster Fish Facility (South Santiam River), Leaburg and Cougar Dams and the McKenzie Hatchery (McKenzie River), and Fall Creek Dam and Dexter Fish Facility (Middle Fork Willamette River). Intermittent spawner surveys have been conducted in the Molalla and Calapooia Rivers, but are insufficient to estimate population abundance. Beginning in 2018, there has been a transition in the methodology and extent of adult spawner surveys. In 2018 and 2019, parallel spawner survey efforts were undertaken by ODFW and Environmental Assessment Services (Ford 2022).

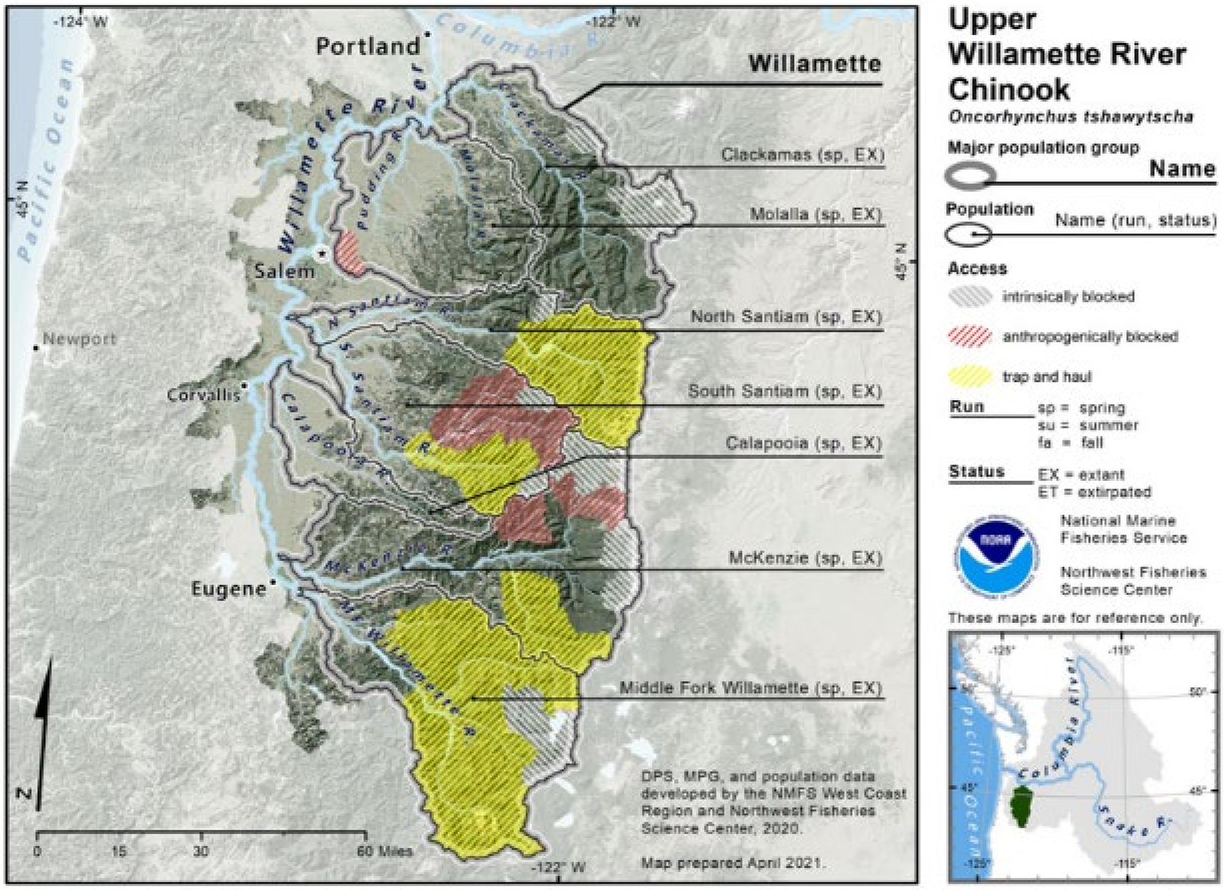

Figure 9. Map of the seven populations within the Upper Willamette River Chinook salmon ESU. Areas that are accessible (green), accessible only via trap-and-haul programs (yellow), or blocked (cross-hatched), are indicated accordingly (Ford 2022).

Table 18. A summary of the general life-history characteristics and timing of Upper Willamette River Chinook Salmon[a].

Life-History Trait	Characteristic
Willamette River entry timing	January-April; ascending Willamette Falls April-August
Spawn timing	August-October, peaking in September
Spawning habitat type	Larger headwater streams
Emergence timing	December-March
Rearing habitat	Rears in larger tributaries and mainstem Willamette
Duration in freshwater	12–14 months; rarely 2–5 months
Estuarine use	Days to several weeks
Life-history type	Stream
Ocean migration	Predominantly north, as far as southeast Alaska
Age at return	3–6 years, primarily 4–5 years

[a] Data are from numerous sources (ODFW and NMFS 2011).

2.2.2.2.2.1. Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. The Willamette Valley was not glaciated during the last epoch (McPhail and Lindsey 1970), and Willamette Falls likely served as a physical barrier for reproductive isolation of Chinook salmon populations. This isolation had the potential to produce local adaptation relative to other Columbia River populations (Myers et al. 2006). Fish ladders were constructed at the falls in 1872 and again in 1971, but it is not clear what role they may have played in reducing localized adaptations in UWR fish populations. Little information exists on the life-history characteristics of the historical UWR Chinook salmon populations, especially since early fishery exploitation (starting in the mid-1880s), habitat degradation in the lower Willamette Valley (starting in the early 1800s), and pollution in the lower Willamette River (by early 1900s) likely altered life-history diversity before data collection began in the mid-1900s. Nevertheless, there is ample reason to believe that UWR Chinook salmon still contain a unique set of genetic resources compared to other Chinook salmon stocks in the WLC Domain (ODFW and NMFS 2011).

2.2.2.2.2.1.1. Abundance and Productivity

According to the most recent viability assessment (Ford 2022), abundance levels for five of the seven natural-origin populations in this ESU decreased (Figure 10) relative to the 2015 status review (NWFSC 2015). Chinook salmon counts at Willamette Falls have been undertaken since 1946, when 53,000 Chinook salmon were counted; however, not until 2002, with the return of the first cohort of mass-marked hatchery-reared fish, was it possible to inventory naturally produced fish with any accuracy. Cohorts returning from 2015–19 outmigration were strongly influenced by warmer-than-normal and less-productive ocean conditions, in addition to warmer-and drier-than-normal freshwater conditions. The five-year average abundance geomean for 2015–19 was 6,916 natural-origin (unmarked) adults, a 31% decrease from the previous period. Abundances, in terms of adult returns, in the Clackamas and McKenzie Rivers have risen since the 2015 viability review (Ford 2022). Improvements in the status of the Middle Fork Willamette River population is due to the sole return of natural-origin adults to Fall Creek basin. However, the capacity of the Fall Creek basin alone is insufficient to achieve the recovery goals for the Middle Fork Willamette River individual population.

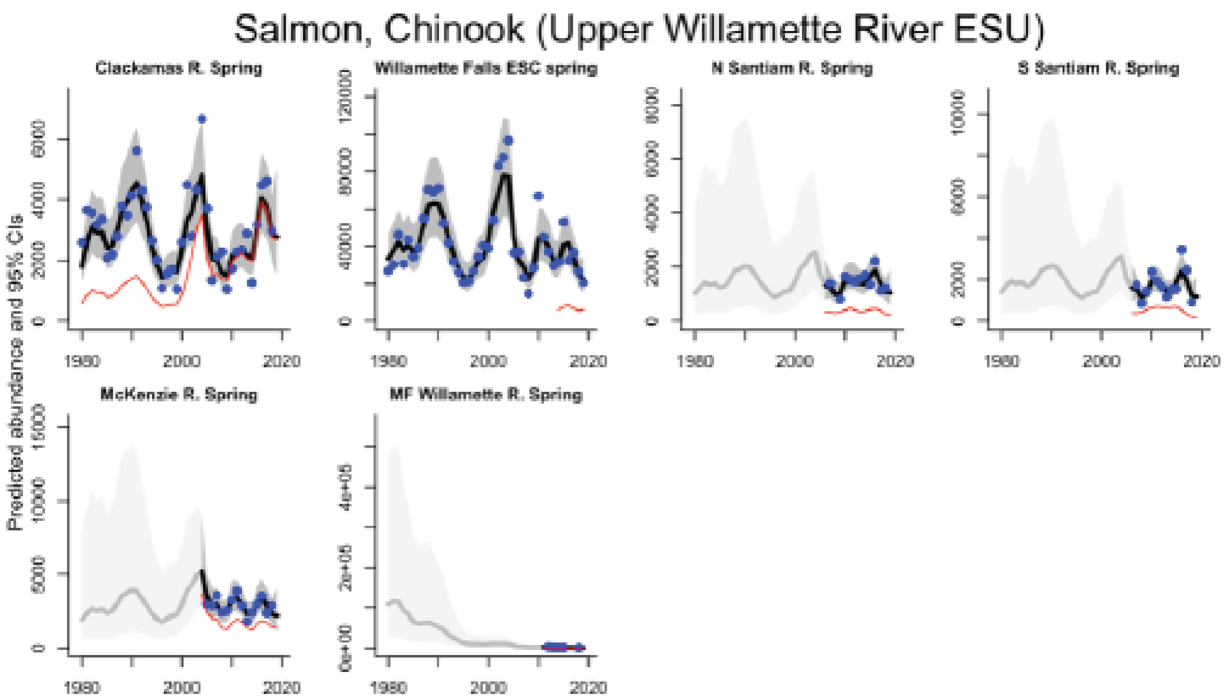

Figure 10. Smoothed trend in estimated total (thick black line, with 95% confidence interval in gray) and natural (thin red line) population spawning abundance. In portions of a time series where a population has no annual estimates but smoothed spawning abundance is estimated from correlations with other populations, the smoothed estimate is shown in light gray. Points show the annual raw spawning abundance estimates. For some trends, the smoothed estimate may be influenced by earlier data points not included in the plot (Ford 2022).

While there was a substantial downward trend in total and natural-origin spring-run abundance at Willamette Falls from 2003 to just before 2010 (Figure 10), there were some indications of improving abundance in 2019 and 2020. Improvements in abundance corresponded with improved ocean and freshwater conditions, as well as changes in pinniped predation. In recent years, counts of spring-run Chinook salmon at Willamette Falls have been impacted by pinniped predation at the base of the falls. For the return years 2014–18, pinnipeds were estimated to consume 6–10% of the unmarked Chinook salmon escapement; however, in 2019, when a pinniped removal program was initiated, the rate dropped to approximately 4% (Ford 2022). Over the last 15 years, the long-term trend for natural-origin returns was negative 4% (Ford 2022), suggesting an overall decline in those populations above Willamette Falls.

Limited data are available for natural-origin spawner abundance for UWR Chinook salmon populations. Table 19 includes the most up-to-date available data for natural-origin Chinook salmon spawner estimates from UWR subbasins relative to their recovery scenario expectation in the recovery plan.

Table 19. Current 5-year geometric mean of raw natural-origin spawner abundances compared to the recovery scenario presented in the recovery plan (ODFW and NMFS 2011) for Upper Willamette River Chinook salmon populations (Ford 2022). Colors indicate the relative proportion of the recovery target currently obtained: red = <10%, orange = 10% > x < 50%, yellow = 50% > x < 100%, green = >100%.

MPG	Population	Abundance	
		2015–19	Recovery Target
Willamette	Clackamas River SP	3,617	2,317
	Molalla River SP	n/a	696
	North Santiam River SP	354	5,400
	South Santiam River SP	337	3,100
	Calapooia River SP	n/a	590
	McKenzie River SP	1,664	8,376
	Middle Fork Willamette River SP	20	5,820

2.2.2.2.2.1.1.1. Harvest

Upper Willamette River spring-run Chinook salmon are taken in ocean fisheries primarily in Canada and Alaska. They are also taken in lower mainstem Columbia River commercial gillnet fisheries, and in recreational fisheries in the mainstem Columbia River and the Willamette River. The distribution of mortality accrued in marine fisheries is described in detail in the Environmental Baseline (Section 2.4). The in-river fisheries are directed at hatchery production, but historically could not discriminate between natural and hatchery fish. In the late 1990s, ODFW began mass-marking the hatchery production, and recreational fisheries within the Willamette River switched over to retention of only hatchery fish, with mandatory release of unmarked fish. ERs in ocean fisheries, with the exception of 2016, have been low (Figure 11). The Fishery Management and Evaluation Plan (FMEP) for the Willamette River sets the maximum freshwater mortality rate for naturally produced Chinook salmon at 15% (ODFW and WDFW 2020). The FMEP proposed to limit the harvest rate on natural-origin fish in all freshwater fisheries to no more than 15%. NMFS concluded in that review that managing UWR spring Chinook salmon according to the provisions of the FMEP is not likely to jeopardize the continued existence of the ESU (NMFS 2001a).

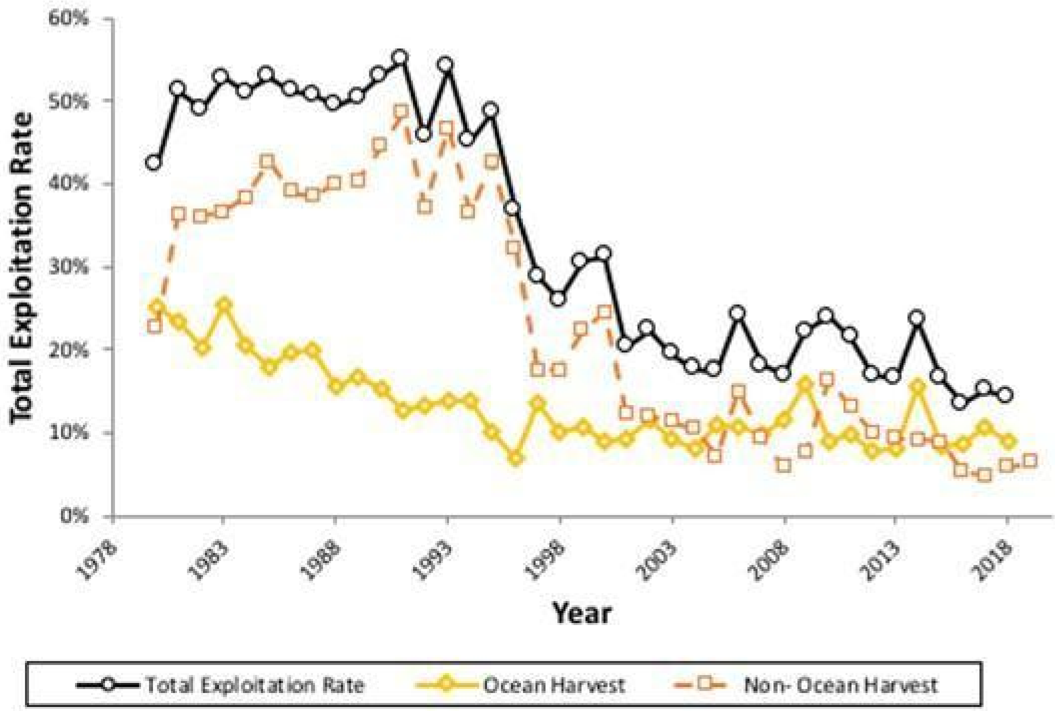

Figure 11. Ocean harvest, terminal harvest, and escapement rates for spring-run Upper Willamette River Chinook salmon, based on coded-wire tag (CWT) recoveries (Ford 2022). Ocean harvest rates for hatchery and unmarked naturally produced fish are assumed to be comparable; terminal fisheries have been mark-selective since 2001, and unmarked fish mortality rates will be considerably lower: hooking mortality in the Willamette River is assumed to be 12.2% (Ford 2022).

2.2.2.2.2.1.2. Spatial Structure and Diversity

Spatial structure, specifically access to historical spawning habitat, continues to be a concern. Major dams block volitional passage to historical Chinook salmon habitat in five of the seven populations in the ESU. In most cases, effective passage programs are limited by low collection rates for emigrating juveniles. Recovery plans target key limiting factors for future actions. However, there have been no significant actions taken since the 2011 status review to restore access to historical habitat above dams (Ford 2022). Restoration of access to upper watersheds remains a key element in risk reduction for this ESU.

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, in turn limiting the potential for fry and subyearling “movers” emigrating to the estuary (Schroeder et al. 2016).

2.2.2.2.2.1.2.1. Hatcheries

For UWR Chinook salmon, diversity and productivity concerns include interaction and introgression with hatchery-origin Chinook salmon (Ford 2022). There have been a number of changes in hatchery operations since the initial status review (Myers et al. 1998). In general, production levels are based on mitigation agreements related to the construction of dams in the Willamette River basin. Mass marking of hatchery-origin Chinook salmon began in 1997, with all returning adults being marked by 2002. Off-station releases within some basins have been curtailed in an effort to limit natural spawning by hatchery-origin fish. More recently, NMFS finalized an opinion on hatchery operations in the UWR basin evaluating a number of changes to minimize the potential influence of hatchery-origin fish on natural-origin Chinook salmon and steelhead (NMFS 2019h). Through the provisions of NMFS (2019b) and individual HGMPs, hatcheries in the UWR have reduced releases of spring-run Chinook salmon in the McKenzie and North Santiam Rivers (Figure 12 and Table 20), while shifting production to other basins (Ford 2022). In addition, NMFS (2019b) calls for further action in the McKenzie River to further reduce the number of hatchery fish spawning naturally.

In concert with improvements in collection efficiency at various dams throughout the Willamette River basin, the number of hatchery fish released has decreased in most basins where there is natural spawning, with increased releases in westside tributaries (Ford 2022). In general, the influence of hatchery-origin Chinook salmon on the spawning grounds has shown a slight improvement (meaning less influence), with the exception of the South Santiam River, where fish collection at the new facility has been poor leaving more hatchery-origin fish to spawn below Foster Dam (Ford 2022).

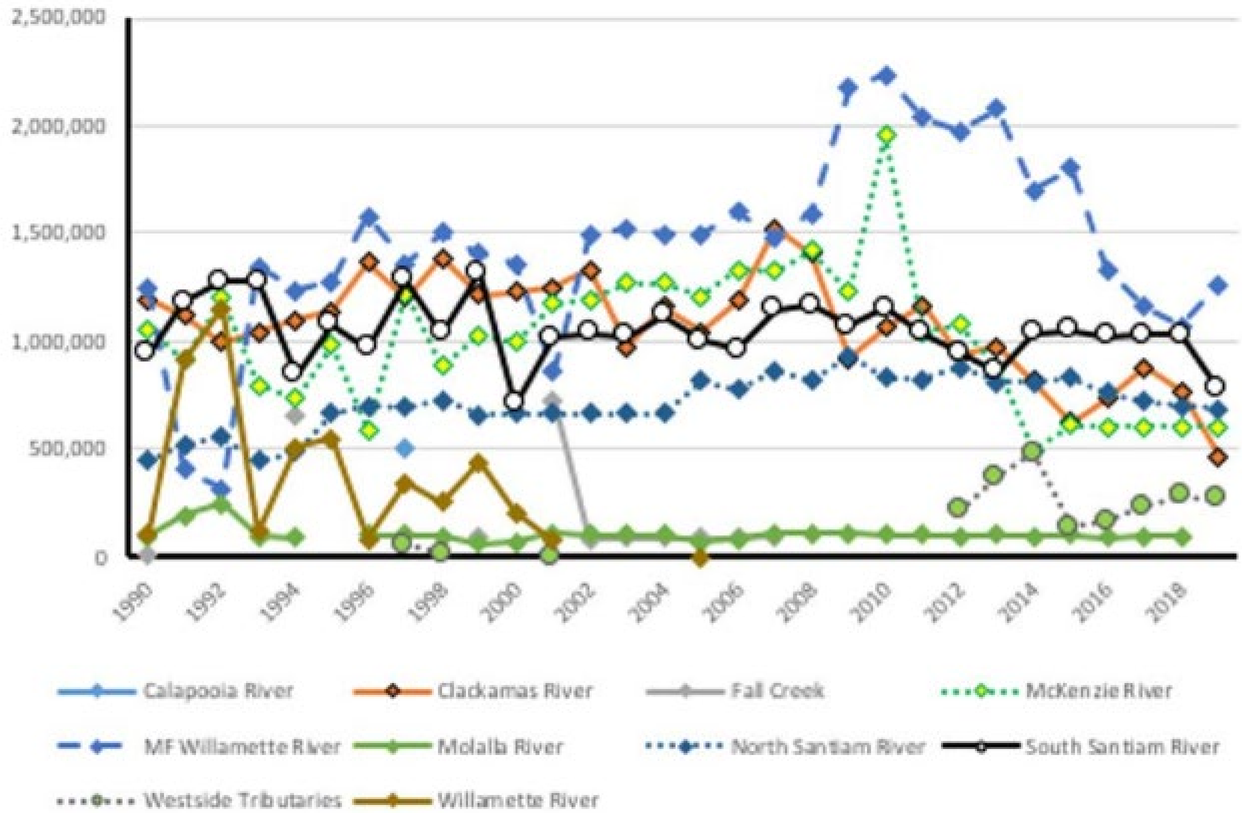

Figure 12. Hatchery releases of juvenile spring-run Chinook salmon into basins of the Upper Willamette River Chinook salmon ESU, 1990–2019. Data for 2019 may be incomplete. Releases of juveniles weighing <2.5 g were not included. Releases into the Row and Coast Fork Rivers were combined under Westside Tributaries (Ford 2022). Data from the Regional Mark Information System (https://www.rmpc.org, June 2020).

Table 20. Five-year mean of fraction natural-origin Chinook salmon spawning naturally in the Upper Willamette River Chinook Salmon ESU (Ford 2022). A dash ("-") means that no estimate is available in that 5-year range.

Population[a]	MPG	1995–1999	2000–2004	2005–2009	2010–2014	2015–2019
Willamette Falls[b]	Willamette	-	0.24	0.30	0.24	0.22
Clackamas River	Willamette	0.33	0.58	0.79	0.94	0.97
North Santiam River	Willamette	-	-	0.33	0.26	0.26
South Santiam River	Willamette	-	-	0.39	0.40	0.21
McKenzie River	Willamette	-	-	0.64	0.55	0.57
Middle Fork Willamette River	Willamette	-	-	-	0.08	0.07

[a] Note that Molalla River and Calapooia River populations are not included due to low abundances or lack of monitoring and available data, as discussed further in Ford (Ford 2022).
[b] Willamette Falls is not considered one of the seven populations in this ESU but was included in the above table in Ford (Ford 2022) due to many years of available data at that particular location

2.2.2.2.2.1.3. Summary

Access to historical spawning and rearing areas is still restricted by high-head dams in five of the historically most-productive tributaries. Only in the Clackamas River does the current system of adult trap-and-haul and juvenile collection appear to be effective enough to sustain a naturally spawning population (although current juvenile passage efficiencies are still below NMFS criteria). In the McKenzie River, the spring-run Chinook salmon population appears to be relatively stable, having reversed a short-term downward abundance trend that was of concern during the 2015 review. The McKenzie River remains well below its recovery goal, despite having volitional access to much of its historical spawning habitat. The North and South Santiam River DIPs both experienced declines in abundance. The Calapooia and Molalla Rivers are constrained by habitat conditions, and natural reproduction is likely extremely low.

Demographic risks remain "high" or "very high" for most populations, except the Clackamas and McKenzie Rivers, which are at "low" and "low-to-moderate" risk, respectively. The Clackamas River spring-run Chinook salmon population maintains a low pHOS through the removal of all marked hatchery-origin adults at North Fork Dam. Elsewhere, hatchery-origin fish comprise the majority or, in the case of the McKenzie River, nearly half of the naturally spawning population. Diversity risks continue to be a concern (Ford 2022).

Overall, there has likely been a declining trend in the viability of the UWR Chinook salmon ESU since the 2015 viability review (NWFSC 2015). The magnitude of this change is not sufficient to suggest a change in risk category, however, so the UWR Chinook salmon ESU remains at "moderate" risk of extinction (Ford 2022).

2.2.2.2.2.2. Limiting Factors

There are many factors that affect the abundance, productivity, spatial structure, and diversity of the UWR Chinook Salmon ESU. Understanding the limiting factors and threats that affect the UWR Chinook Salmon ESU provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. Factors that affect the ESU and its populations have been, and continue to be, dams that block access to major production areas, loss and degradation of accessible spawning and rearing habitat, and degraded water quality and increased water temperatures (Ford 2022). Improvements have been made in operations and fish passage at tributary dams, and numerous habitat restoration projects have been completed in many UWR tributaries. These actions eventually will provide benefit to the UWR Chinook salmon ESU (Ford 2022). However, the scale of habitat improvements needed is greater than the scale of habitat actions implemented to date, and we remain concerned about impaired passage at multiple dams and degraded habitat through-out the watershed. Most land in the UWR is in private ownership, making successful efforts to protect and restore habitat on private lands key to recovery in the UWR, particularly in the face of continuing development. There are also substantial portions of federal land in the UWR, so the protection and restoration of salmon habitat on federal lands is also crucial to recovery.

Additionally, overall ERs reflect changes in fisheries to more conservative management regimes. ERs dropped from a range of 50–60% in the 1980s and early 1990s, to around 30% since 2000, with reductions observed in both ocean and freshwater fisheries. Harvest rates on UWR Chinook salmon have remained stable and relatively low since the status review in 2016. Post-release mortality from hooking is generally estimated at 10% in the Willamette River, although river temperatures likely affect this rate. Illegal take of unmarked fish is thought to be low (NWFSC 2015).

The recovery plan for UWR Chinook salmon (ODFW and NMFS 2011) provides a detailed discussion of limiting factors and threats, and describes strategies for addressing each of them (Chapter 5 in ODFW et al. (ODFW and NMFS 2011)). Rather than repeating the extensive discussion from the recovery plan, this discussion in Chapter 5 is incorporated here by reference.

Additionally, the NWFSC outlines in Ford (Ford 2022) additional limiting factors for the UWR Chinook Salmon ESU which include the following:

- Significantly reduced access to spawning and rearing habitat because of tributary dams,
- Degraded freshwater habitat, especially floodplain connectivity and function, channel structure and complexity, and riparian areas and large wood recruitment as a result of cumulative impacts of agriculture, forestry, and development,
- Degraded water quality and altered water temperatures as a result of both tributary dams and the cumulative impacts of agriculture, forestry, and urban development,
- Hatchery-related effects,

- Anthropogenic introductions of non-native species and out-of-ESU races of salmon or steelhead have increased predation on, and competition with, native UWR Chinook salmon, and
- Historic ocean harvest rates of approximately 30%.

There has likely been an overall decrease in population VSP scores since the 2015 review for the North Santiam, Calapooia, and Middle Fork Willamette rivers populations. However, the magnitude of this change is not sufficient to suggest a change in risk category for the ESU, as the other three populations for which we have data have shown slight improvements in abundance during the last five years (Table 20). Given current climatic conditions, and the prospect of long-term climatic change, the inability of many populations to access historical headwater spawning and rearing areas may put this ESU at greater risk in the near future. The collective risk to the UWR salmon persistence has not changed significantly since our previous status review for the UWR Chinook Salmon ESU, and they remain listed as threatened (Ford 2022).

2.2.2.3. Interior Columbia Recovery Domain

2.2.2.3.1. Snake River Fall-Run Chinook Salmon ESU

On April 22, 1992, NMFS listed the Snake River Fall-Run Chinook Salmon ESU as a threatened species (57 FR 14653). The threatened status was reaffirmed on June 28, 2005 (70 FR 37159) and on May 26, 2016 (81 FR 33468). Critical habitat was designated on December 28, 1993 (58 FR 68543). It includes spawning and rearing areas limited to the Snake River below Hells Canyon Dam, and within the Clearwater, Hells Canyon, Imnaha, Lower Grand Ronde, Lower North Fork Clearwater, Lower Salmon, Lower Snake, Lower Snake-Asotin, Lower Snake-Tucannon, and Palouse hydrologic units. However, this critical habitat designation includes all river reaches presently or historically accessible to this species (except reaches above impassable natural falls, and Dworshak and Hells Canyon Dams). On October 4, 2019 NMFS announced the initiation of a new 5-year status review process including review of the Snake River Fall-Run Chinook Salmon ESU (84 FR 53117), which it completed and published on August 16, 2022 (NMFS 2022e).

The Snake River Fall-Run Chinook Salmon ESU includes naturally spawned fish in the lower mainstem of the Snake River and the lower reaches of several of the associated major tributaries, including the Tucannon, the Grande Ronde, Clearwater, Salmon, and Imnaha Rivers, along with 4 artificial propagation programs (Ford 2022). Table 21 lists the natural and hatchery populations included in the ESU.

Two historical populations (1 extirpated) within one MPG comprise the Snake River Fall-Run Chinook Salmon ESU. The extant natural population spawns and rears in the mainstem Snake River, and its tributaries, below Hells Canyon Dam. The Interior Columbia River Technical Recovery Team (ICTRT) identified five major spawning areas (MaSAs) which are: Upper Hells Canyon MaSA (Hells Canyon Dam on Snake River downstream to confluence with Salmon River); Lower Hells Canyon MaSA (Snake River from Salmon River confluence downstream to Lower Granite Dam pool); Clearwater River MaSA; Grande Ronde River MaSA; and Tucannon

River MaSA (Ford 2022). Figure 13 shows a map of the ESU area. The recovery plan (NMFS 2017k) provides three scenarios that represent a range of potential strategies that can be pursued simultaneously that address the entire life cycle of the species that would achieve delisting criteria (Table 22).

The decline of this ESU was due to heavy fishing pressure beginning in the 1890s and loss of habitat with the construction of Swan Falls Dam in 1901. Additionally, construction of the Hells Canyon Complex from 1958 to 1967 led to the extirpation of one of the historical populations. Hatcheries mitigating for losses caused by the dams have played a major role in the production of Snake River Fall-Run Chinook salmon since the 1980s (NMFS 2022e).

Snake River Fall-Run Chinook Salmon spawning and rearing occurs primarily in larger mainstem rivers, such as the Salmon, Snake, and Clearwater Rivers. Historically, the primary fall-run Chinook salmon spawning areas were located on the upper mainstem Snake River (Connor et al. 2005). Now a series of Snake River mainstem dams block access to the Upper Snake River and about 85% of ESU's spawning and rearing habitat (NMFS 2022e). Swan Falls Dam was the first barrier to upstream migration in the Snake River, followed by the Hells Canyon Complex, composed of Brownlee Dam (completed in 1958), Oxbow Dam (completed in 1961), and Hells Canyon Dam (completed in 1967). Natural spawning is currently limited to the Snake River from the upper end of Lower Granite River to Hells Canyon Dam, the lower reaches of the Imnaha, Grande Ronde, Clearwater, Salmon, and Tucannon rivers, and small areas in the tailraces of the Lower Snake River hydroelectric dams (NMFS 2022e).

Table 21. Snake River Fall-Run Chinook Salmon ESU description and MPGs (Ford 2022).

ESU Description	
Threatened	Listed under ESA in 1992; updated in 2022
1 MPG	2 historical populations (1 extirpated)
MPG	***Population***
Snake River	Lower Mainstem Fall-Run
Artificial production	
Hatchery programs included in ESU (4)	Lyons Ferry National Fish Hatchery (LFH) fall, Acclimation Ponds Program fall, Nez Perce Tribal Hatchery fall, Idaho Power fall

Table 22. Potential ESA Viability Scenarios for Snake River Fall-Run Chinook salmon (NMFS 2017f).

Viability Scenarios and Viability Criteria	Abundance and Productivity Metrics	Spatial Structure and Diversity Metrics
Scenario A ─ Two Populations: Achieve highly viable status for the extant Lower Snake River population and viable status for the currently extirpated Middle Snake River population.	a. Lower Snake River population most recent 10-year geometric mean > 3,000 natural origin spawners and 20-year geometric mean intrinsic productivity > 1.5 b. Middle Snake River population most recent 10-year geometric mean > 3,000 natural origin spawners and 20-year geometric mean intrinsic productivity > 1.27	a. Four of five MaSAs in the Lower Snake River population and one or more spawning areas in the Middle Snake River population are occupied. b. Hatchery influence on spawning grounds is low (e.g., pHOS < 30%) for at least one population and hatchery programs are operated to limit genetic risk (e.g., the proportion of natural influence [PNI] > 67% c. Numbers of fish showing the historically dominant subyearling life-history pattern are stable or increasing. d. Adult and juvenile run timing patterns are stable or adaptive. e. Indicators of genetic substructure are trending toward patterns expected for a natural origin dominated population.
Scenario B ─ Single Population: Achieve highly viable status for Lower Snake River population (measured in the aggregate).	a. Most recent 10-year geometric mean abundance > 4,200 natural-origin spawners. b. Most recent 20-year geometric mean intrinsic productivity > 1.7	a. Four of five MaSAs in the Lower Snake River population are occupied. b. Recent (2 or more brood cycles) hatchery influence on spawning ground is low (e.g., pHOS < 30%) for the population as a whole and hatchery program is operated to limit genetic risk (e.g., PNI > 67%). c. Numbers of fish showing the historically dominant subyearling life-history pattern are stable or increasing. d. Adult and juvenile run timing patterns are stable or adaptive. e. Indicators of genetic substructure are trending toward patterns expected for a natural origin dominated population

Viability Scenarios and Viability Criteria	Abundance and Productivity Metrics	Spatial Structure and Diversity Metrics
Scenario C ─ Single Population: Achieve highly viable status for Lower Snake River population (with Natural Production Emphasis Areas [NPEAs])	a. Population-level abundance metrics under Scenario C would need to be higher than under Scenario B to accommodate meeting the NPEA requirements. Metrics will vary depending on the proportion of natural production coming from NPEAs and the level of hatchery influence remaining in the NPEAs. b. Population-level productivity metrics for Scenario B would apply: most recent 20-year geometric mean intrinsic productivity > 1.7	a. Four of five MaSAs in the Lower Snake River population are occupied. b. NPEA PNI ≥ 0.67 and NPEA production accounting for at least 40% of the natural production in the population. c. Numbers of fish showing the historically dominant subyearling life-history pattern are stable or increasing. d. Adult and juvenile run timing patterns are stable or adaptive. e. Indicators of genetic substructure are trending toward patterns expected for a natural origin dominated population.

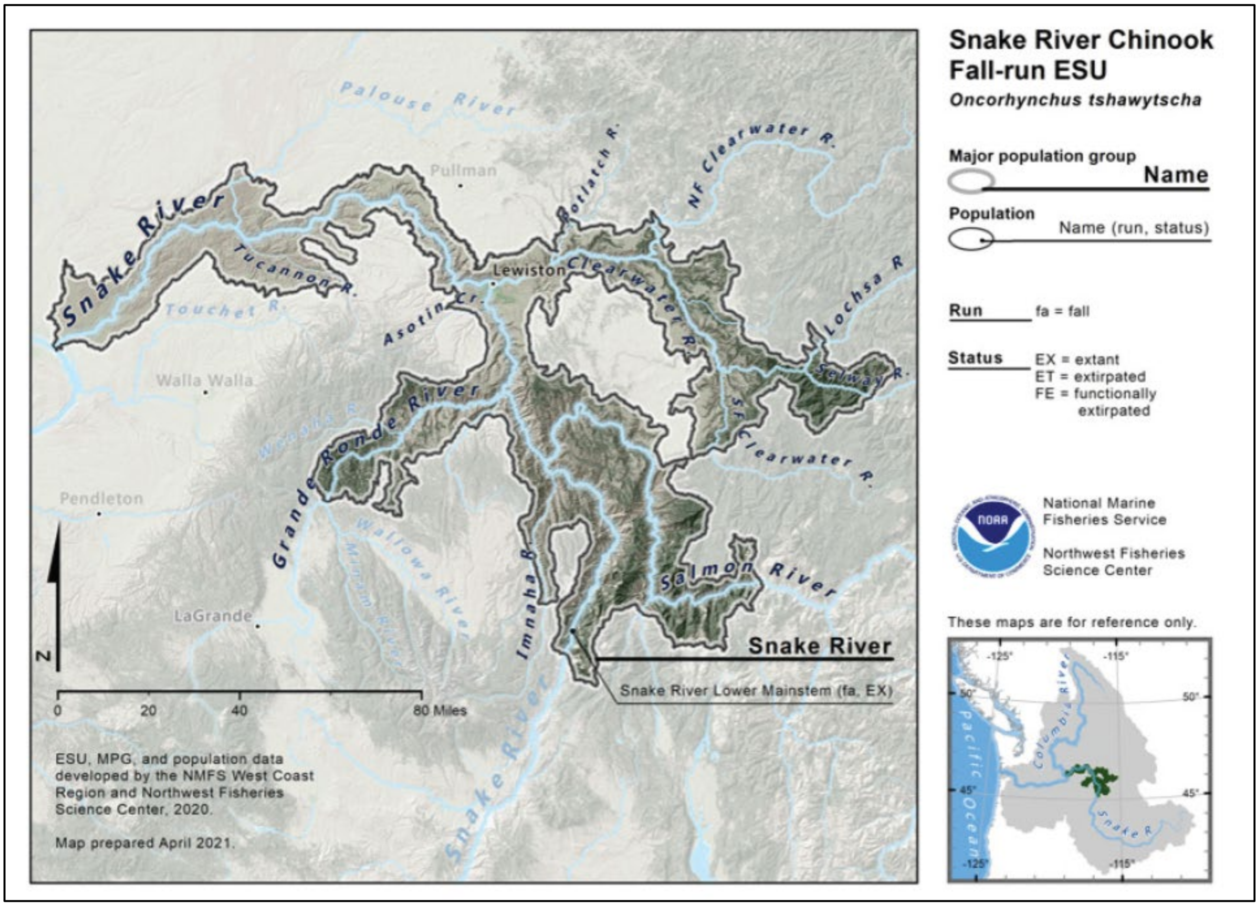

Figure 13. Map of the Snake River Fall-Run Chinook Salmon ESU's spawning and rearing areas, illustrating populations and MPGs (Ford 2022).

Some fall-run Chinook salmon also spawn in smaller streams such as the Potlatch River, and Asotin and Alpowa Creeks, and may spawn elsewhere as well. However, annual redd surveys show that fall Chinook salmon spawning occurs in all five of the historical MaSAs that are accessible within the current range of the population (Ford 2022). Snake River Fall-Run Chinook salmon also spawned historically in the lower mainstem of the Clearwater, Grande Ronde, Salmon, Imnaha, and Tucannon River systems. At least some of these areas probably supported production, but at much lower levels than in the mainstem Snake River. Smaller portions of habitat in the Imnaha and Salmon Rivers have supported Snake River Fall-Run Chinook salmon. Some limited spawning occurs in all of these areas (NMFS 2012d).

As a consequence of losing access to historic spawning and rearing sites (heavily influenced by the influx of ground water in the Upper Snake River), as well as the effects of the dams on downstream water temperatures, Snake River Fall-Run Chinook salmon now reside in waters that may have thermal regimes which differ from historical regimes (Ford 2022). In addition, alteration of the Lower Snake River by hydroelectric dams has created a series of low-velocity pools that did not exist historically. Both of these habitat alterations have created obstacles to Snake River Fall-Run Chinook salmon survival. Before alteration of the Snake River Basin by dams, Snake River Fall-Run Chinook salmon exhibited a largely ocean-type life- history, where they migrated downstream during their first year. Today, fall-run Chinook salmon in the Snake River Basin exhibit one of two life- histories that Connor et al. (2005) have called ocean-type and reservoir-type. Juveniles exhibiting the reservoir-type life-history overwinter in the pools created by the dams before migrating out of the Snake River. The reservoir-type life-history is likely a response to early development in cooler temperatures, which prevents juveniles from reaching a suitable size to migrate out of the Snake River and to the ocean.

2.2.2.3.1.1. Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Spawner abundance, productivity, and proportion of natural-origin fish abundance estimates for the Lower Mainstem Snake River population are based on counts and sampling at Lower Granite Dam. Separate estimates of the numbers of adult (age 4 and older) and jack (age 3) fall-run Chinook salmon passing over Lower Granite Dam are derived using ladder counts, in addition to the results of sampling a portion of each year's run using a trap associated with the ladder. A portion of the fish sampled at the trap are retained and used as hatchery broodstock. Historically, the data from trap sampling, including coded-wire tag (CWT) recovery results, passive integrated transponder (PIT) tag detections, and the incidence of fish with adipose-fin clips, were used to construct daily estimates of hatchery proportions in the run (Ford 2022). At present, estimates of natural-origin returns are made from a Parental Based Genetic Tagging (PBT)[10] program (Ford 2022), which is a more direct assessment of natural returns and ESU abundance risk (Ford 2022). Sampling methods and statistical procedures used in generating the estimated escapements have improved substantially over the past 10 to 15 years.

2.2.2.3.1.1.1. Abundance and Productivity

In 2013, adult spawner abundance reached over 20,000 fish (Figure 14). From 2012–15, natural-origin returns were over 10,000 adults. Spawner abundance has declined since 2016 to 4,998 adult natural-origin spawners in 2019 (Figure 14). In 2018, natural-origin spawner abundance was 4,916, a quarter of the return in 2013. This appears as a high negative percent change in the five-year geometric mean (Table 23), but, when looking at the trend in longer time frames, across more than one brood cycle, it shows an increase in the ten-year geometric mean relative to the 2015 viability review (NWFSC 2015), and a near-zero population change for the 15-year trend in abundance (Ford 2022). The geometric mean natural adult abundance for the most recent ten years (2010–19) is 9,034 (0.15 standard error), higher than the ten-year geomean reported in the NWFSC (2015) status review (6,418, 0.19 standard error, 2005–14; Ford (Ford 2022)). While

[10] PBT is whereby each parent in a hatchery program, both male and female, are genotyped for polymorphic molecular markers. By genotyping each parent all of their offspring are effectively identifiable, and the method requires no juvenile handling. This allows for assignments back to individual parents when the hatchery releases return as adults wherever they are found, so long as they are genetically sampled.

the population has not been able to maintain the higher returns it achieved in 2010 and 2013–15, abundance has maintained at or above the ICTRT defined Minimum Abundance Threshold (3,000)[11] during climate challenges in the ocean and rivers. Escapements have been increasing since 2020 and have continued through 2022 (WDFW and ODFW 2022).

Productivity, defined in the ICTRT viability criteria as the expected replacement rate at low to moderate abundance relative to a population's minimum abundance threshold, is a key measure of the potential resilience of a natural population to annual environmentally driven fluctuations in survival. The ICTRT Viability Report (ICBTRT 2007) provided a simple method for estimating population productivity based on return-per-spawner estimates for the most recent 20 years. To assure that all sources of mortality are accounted for, the ICTRT recommended that productivities used in interior Columbia River viability assessments be expressed in terms of returns to the spawning grounds. Snake River Fall-Run Chinook salmon have been above the ICTRT defined minimum abundance threshold since 2001 (Ford 2022). Productivity, as seen in broodyear returns-per-spawner, has been below replacement (1:1) in recent years.

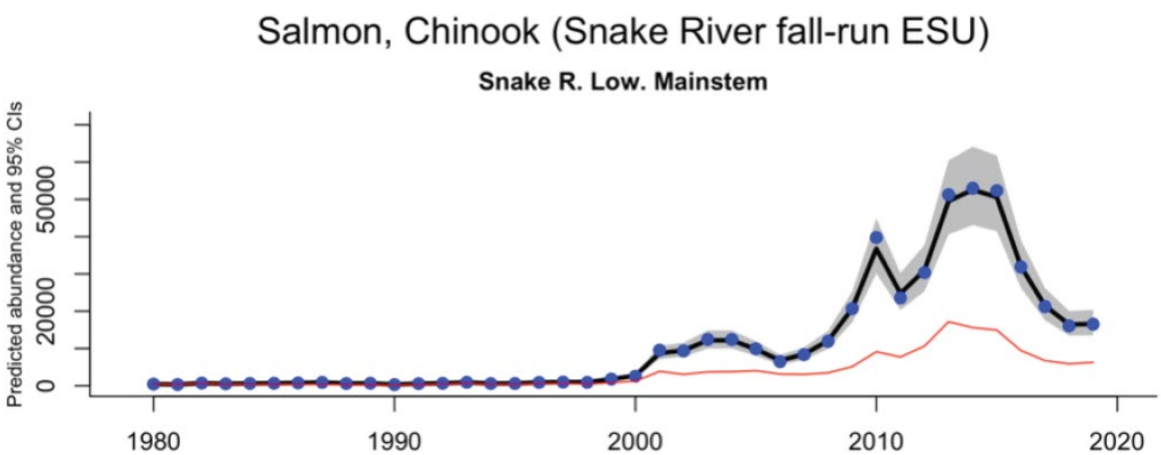

Figure 14. Smoothed trend in estimated total (thick black line, with 95% confidence interval in gray) and natural (thin red line) population spawning abundance (Ford 2022). Points show the annual raw spawning abundance estimates.

[11] The ICTRT (ICBTRT 2007) incorporated minimum abundance thresholds into population viability curves to "promote achieving the full range of abundance objectives across the recovery scenarios including utilization of multiple spawning areas, avoiding problems associated with low population densities (e.g. Allee effects) and maintaining populations at levels where compensatory processes are functional." The ICTRT recommended using 10-year geometric means of recent natural-origin spawners as a measure of current abundance. It also recommended that current intrinsic productivity should be estimated using spawner-to-spawner return pairs from low-to-moderate escapements over a recent 20-year period. The ICTRT adopted a recommendation from Bevan et al. (1994) as the minimum abundance threshold for the extant Lower Snake River Fall-Run Chinook salmon population.

Table 23. Five-year mean of fraction natural-origin fish in the population (sum of all estimates divided by the number of estimates) (Ford 2022).

Population	1995–1999	2000–2004	2005–2009	2010–2014	2015-2019
Lower Snake River Fall-run Chinook	0.58	0.34	0.37	0.31	0.33

2.2.2.3.1.1.1.1. Harvest

Since the species were originally listed in 1992, fishery impacts have been reduced in both ocean and river fisheries. Total ER has been relatively stable in the range of 40% to 50% (Figure 15) since the mid-1990s (Ford 2022). Ocean fisheries are currently managed to achieve a minimum of a 30.0% reduction in the age-3 and age-4 adult equivalent total ER in ocean salmon fisheries relative to the 1988–1993 base period standard; approximately equivalent to an ocean ER limit of 29% on age-3 and age-4 Snake River Fall-Run Chinook salmon. NMFS evaluated this approach under the ESA and found it not likely to jeopardize the continued existence of the Snake River Fall-Run Chinook Salmon ESU or destroy or adversely modify its designated critical habitat (NMFS 1996b). Freshwater harvest rates have averaged 31.8% since 2009 when the current management framework was first implemented under the 2008–2017 *U.S. v. Oregon* Management Agreement (TAC 2022).

2.2.2.3.1.1.2. Spatial Structure and Diversity

In terms of spatial structure and diversity, the Lower Mainstem Snake River Fall-Run Chinook salmon population was rated at low risk for recovery Scenario A (allowing natural rates and levels of spatially mediated processes) and moderate risk for recovery Scenario B (maintaining natural levels of variation) in the status review update (Ford 2022), resulting in an overall spatial structure and diversity rating of moderate risk. Annual redd surveys show that fall Chinook salmon spawning occurs in all five of the historical MaSAs, and that the natural origin fraction has remained relatively stable during the last 10 years across the ESU (Figure 16).

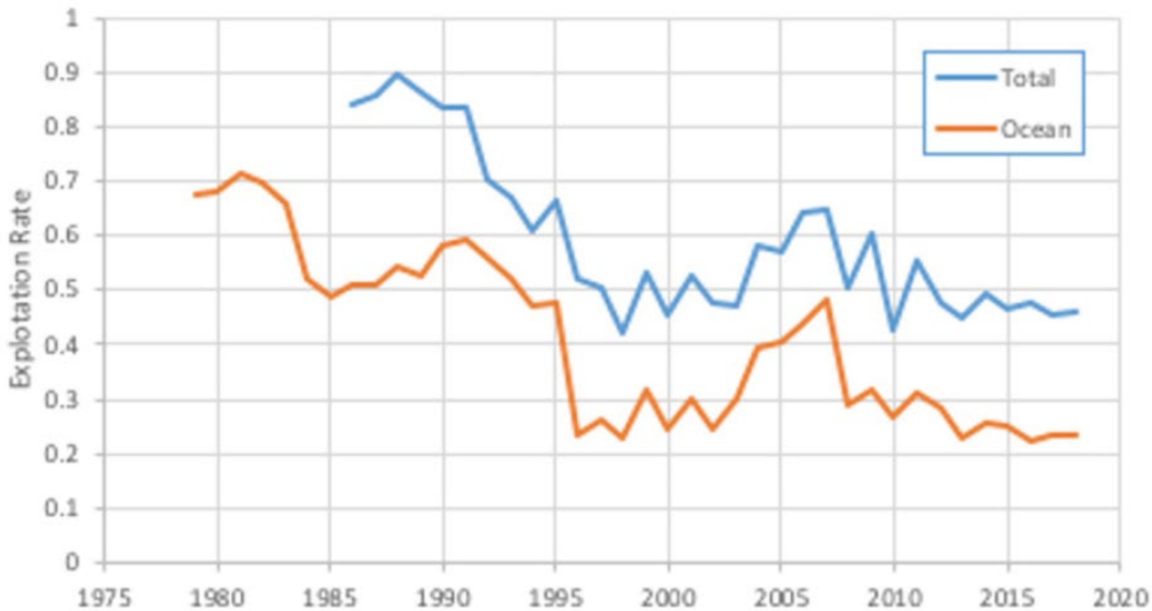

Figure 15. Total ER for Snake River Fall-Run Chinook salmon. Data for marine ERs from the Chinook Technical Committee (CTC) model (Calibration 1503) and for in-river harvest rates from the Columbia River Technical Advisory Committee (Ford 2022).

2.2.2.3.1.1.2.1. Hatcheries

Parental Based Tagging of hatchery fish has allowed for spawning-ground sampling for parentage analysis. Fidelity studies have indicated there is spawner dispersal within the population from different release sites (Ford 2022). Natural-origin return levels declined substantially following the completion of the three-dam Hells Canyon Complex (1959–67), which completely blocked access to major production areas above Hells Canyon Dam, and the construction of the lower Snake River dams (1962–75). Based on extrapolations from sampling at Ice Harbor Dam (1977–90), the Lyons Ferry Hatchery (LFH) (1987–present), and at Lower Granite Dam (1990–present), hatchery strays made up an increasing proportion of returns at Lower Granite Dam (the uppermost Snake River mainstem dam) through the 1980s (Bugert et al. 1990). Strays from out-planting Priest Rapids hatchery-origin fall-run Chinook salmon (an out-of-ESU stock from the mid-Columbia River) and Snake River Fall-Run Chinook salmon from the LFH program (on-station releases initiated in the mid-1980s) were the dominant contributors. Returns to the Tucannon River are predominantly releases and strays from the LFH program (NMFS 2012d). Estimated natural-origin returns reached a low of less than 100 fish in 1990. The initiation of the supplementation program in 1998 increased returns allowed to naturally spawn. In recent years, naturally spawning fall-run Chinook salmon in the lower Snake River have included returns both originating from naturally spawning parents, and from returning hatchery releases (Ford 2022). The fraction of natural-origin fish on the spawning grounds has remained relatively stable for the last ten years, with five-year means of 31% (2010–14) and 33% (2015–19; Figure 16).

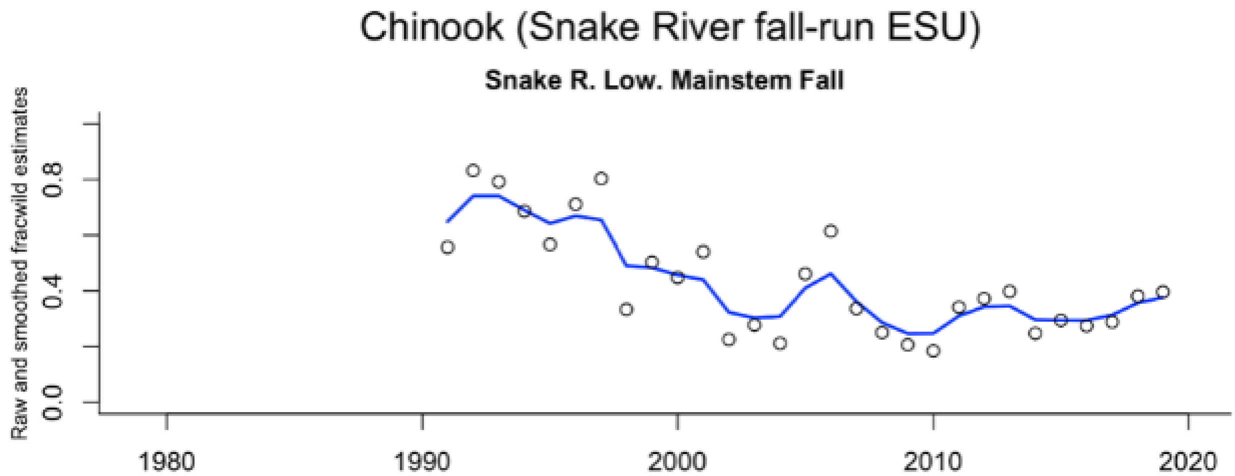

Figure 16. Smoothed trend in the estimated fraction of the natural spawning population consisting of fish of natural origin. Points show the annual raw estimates (Ford 2022).

The NMFS Snake River Fall-run Chinook Recovery Plan (NMFS 2017f) proposes that a single population viability scenario could be possible given the unique spatial complexity of the Lower Mainstem Snake River Fall-Run Chinook salmon population (Table 22). The recovery plan notes that a single population viability scenario could be possible if major spawning areas, supporting the bulk of natural returns, are operating consistently with long-term diversity objectives in the proposed plan. Under this single population scenario, the requirements for a sufficient combination of natural abundance and productivity could be based on a combination of total population natural abundance distributed among the MaSas as described in Table 22 above (while meeting total specific pHOS criteria; see Table 22 above), and relatively high production from one or more major spawning areas with relatively low hatchery contributions to spawning (i.e., low hatchery influence for at least one major natural spawning production area).

2.2.2.3.1.1.3. Summary

The overall current risk rating for the Lower Mainstem Snake River Fall-Run Chinook salmon population is viable, as indicated by the bold outlined cell in Table 24. The single population delisting options provided in the Snake River Fall Chinook Salmon Recovery Plan would require the population to meet or exceed minimum requirements for a risk rating of “Highly Viable with a high degree of certainty”. The current rating of viable is based on evaluating current status against the criteria for the aggregate population. The overall risk rating is based on a low-risk rating for A/P and a moderate risk rating for SS/D. To achieve “highly viable” status with a high degree of certainty, the SS/D rating needs to be “low risk.” For abundance/productivity, the rating reflects remaining uncertainty that current increases in abundance can be sustained over the long run. While natural-origin spawning levels are above the highest delisting criteria (the minimum abundance threshold of 4,200 under recovery Scenario B) and estimated productivity is also high, neither measure is high enough to achieve the very low risk rating necessary to buffer against significant remaining uncertainty (Ford 2022).

Considering the most recent information available, an increase in estimated productivity (or a decrease in the year-to-year variability associated with the estimate) would be required to achieve delisting status for the ESU, assuming that natural-origin abundance of the single extant Snake River Fall-Run Chinook salmon population remains relatively high.

Table 24. Matrix used to assess natural population viability risk rating across VSP parameters for the Lower Mainstem Snake River Fall-Run Chinook Salmon ESU (NWFSC 2015)[a]

		Spatial Structure/Diversity Risk			
		Very Low	**Low**	**Moderate**	**High**
Abundance/ Productivity Risk [b]	**Very Low (<1%)**	HV	HV	V	M
	Low (1–5%)	V	V	V Lower Mainstem Snake R.	M
	Moderate (6 – 25%)	M	M	M	HR
	High (>25%)	HR	HR	HR	HR

[a] Viability Key: HV-Highly Viable; V-Viable; M-Maintained; HR-High Risk. The darkest cells indicate combinations of A/P and SS/D at greatest risk (NWFSC 2015).
[b] Percentage represents the probability of extinction in a 100-year time period.

2.2.2.3.1.2. Limiting Factors

Understanding the limiting factors and threats that affect the Snake River Fall-Run Chinook Salmon ESU provides important information and perspective regarding the status of a species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. This ESU has been reduced to a single remnant population with a narrow range of available habitat. However, the overall adult abundance has been increasing from the mid-1990s, with substantial growth since the year 2000 (NMFS 2017f).

There are many factors that affect the abundance, productivity, spatial structure, and diversity of the Snake River Fall-Run Chinook Salmon ESU. Factors that limit the ESU have been, and continue to be, hydropower projects, predation, harvest, degraded estuary habitat, and degraded mainstem and tributary habitat (Ford et al. 2011). Ocean conditions have also affected the status

of this ESU. Ocean conditions affecting the survival of Snake River Fall-Run Chinook salmon were generally poor during the early part of the last 20 years (NMFS 2017f).
The recovery plan (NMFS 2017f) provides a detailed discussion of limiting factors and threats and describes strategies for addressing each of them. Section 3.3 of the plan provides criteria for addressing the underlying causes of decline. Furthermore, Section 4.1.2 B.4. of the plan (NMFS 2017f) describes the changes in current impacts on Snake River Fall-Run Chinook salmon. These changes include the following:

- Hydropower systems,
- Juvenile migration timing,
- Adult migration timing,
- Harvest,
- Age-at-return,
- Selection caused by non-random removals of fish for hatchery broodstock, and
- Habitat.

Rather than repeating the extensive discussion from the recovery plan, the discussions in sections 3.3 and 4.1.2.B.4 are incorporated here by reference.

Overall, the single extant population in the ESU is currently meeting the criteria for a rating of “viable” developed by the ICTRT, but the ESU as a whole is not meeting the recovery goals described in the recovery plan for the species, which require the single population to be “highly viable with high certainty” and/or will require reintroduction of a viable population above the Hells Canyon Complex (Ford 2022). The Snake River Fall-Run Chinook Salmon ESU therefore is considered to be at a moderate-to-low risk of extinction, with viability largely unchanged from the prior review.

2.2.2.3.2. Snake River Spring/summer-run Chinook Salmon ESU

On June 3, 1992, NMFS listed the Snake River Spring/summer-run Chinook Salmon ESU as a threatened species (57 FR 23458). More recently, the threatened status was reaffirmed on June 28, 2005 (70 FR 37160) and on April 14, 2014 (79 FR 20802). Critical habitat was originally designated on December 28, 1993 (58 FR 68543) but updated most recently on October 25, 1999 (65 FR 57399). In 2022, NMFS completed its most recent 5-year review for Snake River Spring/summer-run Chinook salmon (NMFS 2022g).

The Snake River Spring/summer-run Chinook Salmon ESU includes all naturally spawned populations of spring/summer-run Chinook salmon in the mainstem Snake River and the Tucannon River, Grande Ronde River, Imnaha River, and Salmon River subbasins, as well as 13 artificial propagation programs (NMFS 2022g). However, inside the geographic range of the ESU, there are a total of 18 hatchery spring/summer-run Chinook salmon programs currently operational (NMFS 2022g). Table 25 lists the natural and hatchery populations included (or excluded) in the ESU.

Twenty-eight historical populations (four extirpated) within five MPGs comprise the Snake River spring/summer-run Chinook Salmon ESU. The natural populations are aggregated into the five extant MPGs based on genetic, environmental, and life-history characteristics. Figure 17 shows a map of the current ESU and the MPGs within the ESU.

Table 25. Snake River spring/summer-run Chinook Salmon ESU description and MPGs (NMFS 2022g).

ESU Description	
Threatened	Listed under ESA in 1992; updated in 2014.
5 MPGs	28 historical populations (4 extirpated)
MPG	***Populations***
Lower Snake River	Tucannon River
Grande Ronde/Imnaha River	Wenaha, Lostine/Wallowa, Minam, Catherine Creek, Upper Grande Ronde, Imnaha
South Fork Salmon River	Secesh, East Fork/Johnson Creek, South Fork Salmon River Mainstem, Little Salmon River
Middle Fork	Bear Valley, Marsh Creek, Sulphur Creek, Loon Creek, Camas Creek, Big Creek, Chamberlain Creek, Lower Middle Fork (MF) Salmon, Upper MF Salmon
Upper Salmon	Lower Salmon Mainstem, Lemhi River, Pahsimeroi River, Upper Salmon Mainstem, East Fork Salmon, Valley Creek, Yankee Fork, North Fork Salmon
Artificial production	
Hatchery programs included in ESU (13)	Tucannon River Spr/Sum, Lostine River Spr/Sum, Catherine Creek Spr/Sum, Lookingglass Hatchery Reintroduction Spr/Sum, Upper Grande Ronde Spr/Sum, Imnaha River Spr/Sum, McCall Hatchery summer, Johnson Creek Artificial Propagation Enhancement summer, Pahsimeroi Hatchery summer, Sawtooth Hatchery spring, Yankee Fork Program, South Fork Salmon River Eggbox Program, Panther Creek Program
Hatchery programs not included in ESU (5)	Rapid River Hatchery spring, Dworshak National Fish Hatchery (NFH) spring, Kooskia spring, Clearwater Hatchery spring, Nez Perce Tribal Hatchery spring

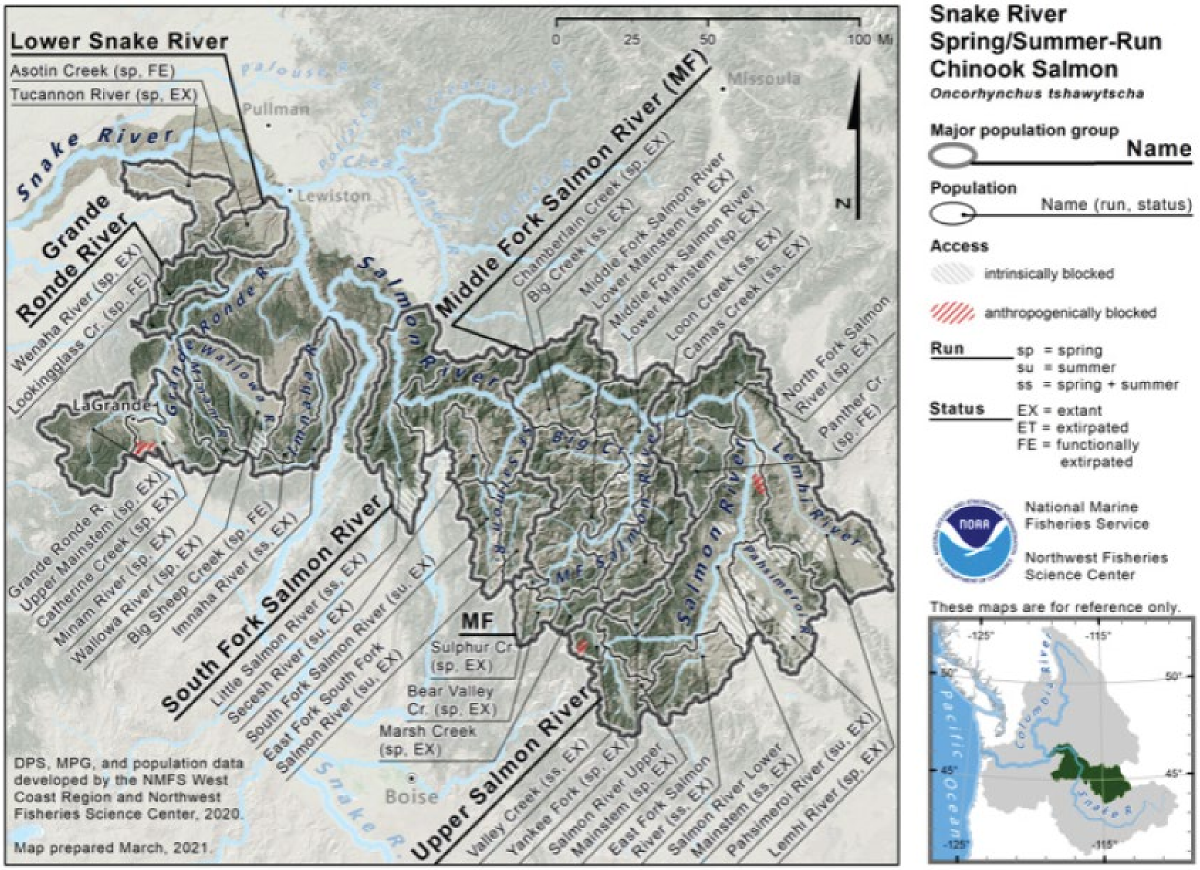

Figure 17. The Snake River spring/summer-run Chinook salmon ESU's spawning and rearing areas, illustrating populations and MPGs (Ford 2022).

The Snake River Spring/summer-run Chinook Salmon ESU consists of "stream-type" Chinook salmon, which spend two to three years in ocean waters and exhibit extensive offshore ocean migrations (Myers et al. 1998). For a general review of stream-type Chinook salmon, see the UWR Chinook Salmon ESU life-history and status description. In general, Chinook salmon tend to occupy streams with lower gradients than steelhead, but there is considerable overlap between the distributions of the two species (NMFS 2012d).

Historically, the Snake River drainage is thought to have produced more than 1.5 million adult spring/summer-run Chinook salmon in some years during the late 1800s (Matthews and Waples 1991). By the 1950s, the abundance of spring/summer-run Chinook salmon had declined to an annual average of 125,000 adults, and continued to decline through the 1970s. In 1995, only 1,797 spring/summer-run Chinook salmon adults returned (hatchery and wild fish combined). Returns at Lower Granite Dam (hatchery and wild fish combined) dramatically increased after 2000, with 185,693 adults returning in 2001. The large increase in 2001 was due primarily to hatchery returns, with only 10% of the returns from fish of natural-origin (NMFS 2012d).

The causes of oscillations in abundance are uncertain, but likely are due to a combination of factors. Over the long-term, population size is affected by a variety of factors, including: ocean conditions, harvest, increased predation in riverine and estuarine environments, construction and continued operation of Snake and Columbia River Dams; increased smolt mortality from poor downstream passage conditions; competition with hatchery fish; and widespread alteration of spawning and rearing habits. Spawning and rearing habits are commonly impaired in places from factors such as agricultural tilling, water withdrawals, sediment from unpaved roads, timber harvest, grazing, mining, and alteration of floodplains and riparian vegetation. Climate change is also recognized as a possible factor in Snake River salmon declines (Tolimieri and Levin 2004); (Scheuerell and Williams 2005; NMFS 2012d).

2.2.2.3.2.1. Abundance, Productivity, Spatial Structure, and Diversity

NMFS has finalized recovery planning for the Snake River drainage, organized around a subset of management unit plans corresponding to state boundaries (NMFS 2017g). A tributary recovery plan for one of the major management units, the Lower Snake River tributaries within Washington state boundaries, was developed under the auspices of the Lower Snake River Recovery Board (LSRB). The LSRB Plan provides recovery criteria, targets, and tributary habitat action plans for the two populations of the spring/summer-run Chinook salmon in the Lower Snake MPG in addition to the populations in the Touchet River (MCR Steelhead DPS) and the Washington sections of the Grande Ronde River (NWFSC 2015).

The recovery plan developed by NMFS incorporated viability criteria recommended by the ICTRT (NMFS 2017g). The ICTRT recovery criteria are hierarchical in nature, with ESU/DPS level criteria being based on the status of natural-origin Chinook salmon assessed at the population level. The population level assessments are based on a set of metrics designed to evaluate risk across the four VSP elements – abundance, productivity, spatial structure, and diversity (McElhany et al. 2000). The ICTRT approach calls for comparing estimates of current natural-origin abundance and productivity against predefined viability curves (NWFSC 2015). Achieving recovery (i.e., delisting the species) of each ESU via sufficient improvement in the abundance, productivity, spatial structure, and diversity is the longer-term goal of the recovery plan.

2.2.2.3.2.1.1. Abundance and Productivity

The majority of populations in the Snake River spring/summer Chinook salmon ESU remain at high overall risk, with three populations (Minam River, Bear Valley Creek, and Marsh Creek) improving from the previous status review (NMFS 2016d) to an overall rating of maintained due to an increase in abundance/productivity (Table 26). However, natural-origin abundance has generally decreased from the levels reported in the prior review for most populations in this ESU, in many cases sharply (Figure 18). The most recent 5-year geometric mean abundance estimates for 26 out of the 27 populations are lower than the corresponding estimates for the previous 5-year period by varying degrees; the estimate for the 27th population was a slight increase from a very low abundance in the prior 5-year period (Ford 2022). The entire ESU abundance data shows a consistent and marked pattern of declining population size, with the recent 5-year abundance levels for the 27 populations declining by an average of 55%. Medium-term (15-year) population trends in total spawner abundance were positive over the period 1990 to 2005 for all of the population natural-origin abundance series, but are all declining over the more recent time interval (2004–2019; Table 26 and Figure 18 in Ford (2022)). The consistent and sharp declines for all populations in the ESU are concerning, with the abundance levels for some populations approaching similar levels to those of the early 1990s when the ESU was listed.

No population in the ESU currently meets the Minimum Abundance Threshold designated by the ICTRT, with nine populations under 10% of Minimum Abundance Threshold and three populations under 5% Minimum Abundance Threshold for recent 5-year geometric means. Populations with 5-year geometric mean abundances below 50 fish are at extremely high risk of extinction from chance fluctuations in abundance, depensatory processes, or the long-term consequences of lost genetic variation according to the ICTRT defined quasi-extinction threshold[12] (Waples 1991); (ICBTRT 2007); (Crozier et al. 2021). These populations include the Tucannon River, Middle Fork Salmon River lower mainstem, Camas Creek, Loon Creek, Sulphur Creek, North Fork Salmon River, Salmon River lower mainstem, and Yankee Fork populations. Productivity remained the lowest for the Grande Ronde and Lower Snake River MPGs. Relatively low ocean survivals in recent years were a major factor in recent abundance patterns.

2.2.2.3.2.1.1.1. Harvest

Harvest impacts on the spring component of this ESU are essentially the same as those on the UCR Chinook Salmon ESU. Harvest occurs in the lower portion of the mainstem Columbia River. Mainstem Columbia River fisheries represent the majority of harvest impacts on this ESU. In some years, additional harvest occurs in the Snake River basin on specific populations within the ESU. Snake River summer Chinook salmon share the ocean distribution patterns of the upper basin spring runs and are only subject to significant harvest in the mainstem Columbia River (Ford 2022). Harvest of summer Chinook salmon has been more constrained than that of spring Chinook salmon, with consequently lower exploitation rates on the summer component of this ESU. However, the overall pattern of exploitation rates calculated by the total allowable catch is nearly identical to that of the UCR spring-run Chinook salmon ESU.

Systematic improvements in fisheries management since the 2016 5-year review include implementation of a new U.S. v. Oregon Management Agreement for years 2018–2027 (NMFS 2018c). This agreement replaces the previous 10-year agreement. It maintains the limits and reductions in harvest impacts for the listed Snake River ESUs/DPSs that were secured in previous agreements (NMFS 2018c).

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[12] The quasi-extinction thresholds (QET) used by the ICTRT were for purposes of population viability modeling and reaching these levels does not equate with biological extinction but rather increased concern and uncertainty about the likelihood of population persistence. QET is defined as less than 50 spawners on average for four years in a row (Waples 1991); (ICBTRT 2007).

Table 26. Snake River spring/summer-run Chinook salmon population status relative to ICTRT viability criteria, grouped by MPG. Natural spawning abundance: most recent 10-yr geometric mean (range). ICTRT productivity: 20-yr geometric mean for parent escapements below 75% of population threshold. Current abundance and productivity estimates are geometric means. Range in annual abundance, standard error, and number of qualifying estimates for productivities in parentheses. Populations with no abundance and productivity data are given a default High A/P Risk rating (Ford 2022). Note that Panther Creek is considered functionally extirpated (Ford 2022).

Population	Abundance/productivity (A/P) metrics			Integrated A/P risk	Spatial structure/diversity (SS/D) metrics			Overall risk rating
	ICTRT threshold	Natural spawning	ICTRT productivity		Natural processes	Diversity risk	Integrated SS/D risk	
Lower Snake MPG								
Tucannon River	750	116 (SD 205)	1.09 (0.31, 17/20)	High	Low	Moderate	Moderate	High
Grande Ronde/Imnaha MPG								
Wenaha River	750	437 (SD 191)	1.21 (0.16, 15/20)	High	Low	Moderate	Moderate	High
Lostine River	1,000	654 (SD 400)	0.97 (0.21, 18/20)	High	Low	Moderate	Moderate	High
Minam River	750	544 (SD 256)	1.44 (0.15, 15/20)	Moderate	Low	Moderate	Moderate	Maintained
Catherine Creek	1,000	200 (SD 207)	0.76 (0.27, 20/20)	High	Moderate	Moderate	Moderate	High
Grande Ronde River Upper Mainstem	1,000	80 (SD 157)	0.47 (0.25, 20/20)	High	High	Moderate	High	High
Imnaha River Mainstem	750	513 (SD 214)	0.65 (0.27, 14/20)	High	Low	Moderate	Moderate	High
South Fork Salmon River MPG								
South Fork Salmon River Mainstem	1,000	381 (SD 514)	0.96 (0.20, 12/20)	High	Low	Moderate	Moderate	High
Secesh River	750	472 (SD 396)	—	High	Low	Low	Low	High

Population	Abundance/productivity (A/P) metrics			Integrated A/P risk	Spatial structure/diversity (SS/D) metrics			Overall risk rating
	ICTRT threshold	Natural spawning	ICTRT productivity		Natural processes	Diversity risk	Integrated SS/D risk	
East Fork South Fork Salmon River	1,000	483 (SD 265)	—	High	Low	Low	Low	High
Little Salmon River	750	Insufficient data	—	—	Low	Low	Low	High
Middle Fork Salmon River MPG								
Chamberlain Creek	750	342 (SD 171)	1.36 (0.34, 17/20)	High	Low	Low	Low	High
Middle Fork Salmon R. Lower Mainstem	1,000	163 (SD 114)	1.47 (0.34, 20/20)	High	Very Low	Moderate	Moderate	High
Big Creek	500	45 (SD 37)	1.95 (0.33, 13/20)	High	Low	Moderate	Moderate	High
Camas Creek	500	42 (SD 27)	1.37 (0.42, 17/20)	High	Low	Moderate	Moderate	High
Loon Creek	500	Insufficient data	Insufficient data	—	Moderate	Moderate	Moderate	High
Middle Fork Salmon R. Upper Mainstem	750	71 (SD 43)	1.30 (0.34, 17/20)	High	Low	Moderate	Moderate	High
Sulphur Creek	500	67 (SD 65)	1.02 (0.25, 13/20)	High	Low	Moderate	Moderate	High
Marsh Creek	500	333 (SD 262)	2.11 (0.32, 7/20)	Moderate	Low	Low	Low	Maintained
Bear Valley Creek	750	428 (SD 327)	2.22 (0.26, 13/20)	Moderate	Very Low	Low	Low	Maintained
Upper Salmon River MPG								
North Fork Salmon River	2,000	71 (SD 87)	1.30 (0.23, 20/20)	High	Low	Low	Low	High
Lemhi River	1,000	326 (SD 270)	1.13 (0.31, 18/20)	High	Low	Low	Low	High
Salmon River Lower Mainstem	1,000	218 (SD 168)	1.26 (0.20 20/20)	High	Moderate	High	High	High

Population	Abundance/productivity (A/P) metrics			Integrated A/P risk	Spatial structure/diversity (SS/D) metrics			Overall risk rating
	ICTRT threshold	Natural spawning	ICTRT productivity		Natural processe s	Diversity risk	Integrated SS/D risk	
Pahsimeroi River	2,000	250 (SD 159)	1.63 (0.28, 19/20)	High	High	High	High	High
East Fork Salmon River	500	113 (SD 100)	1.63 (0.26, 17/20)	High	Low	Moderate	Moderate	High
Yankee Fork	1,000	288 (SD 291)	2.00 (0.28, 17/20)	High	Low	High	high	High
Salmon River Upper Mainstem	500	62 (SD 139)	0.99 (0.51, 17/20)	High	Moderate	High	High	High
Valley Creek	500	Insufficient data	Insufficient data	—	Low	Low	Low	High
Panther Creek	750	Insufficient data	Insufficient data	—	—	—	—	See caption

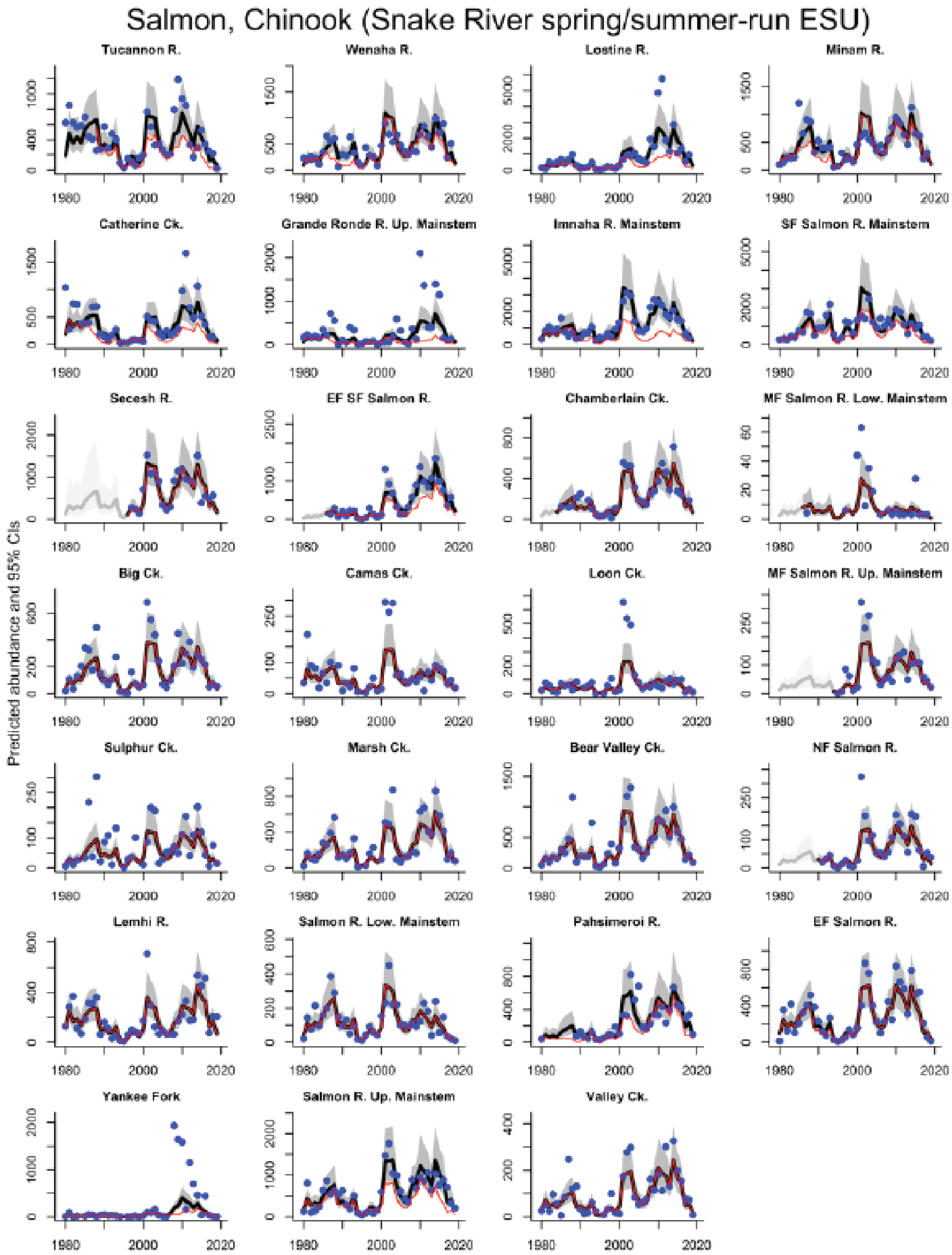


Figure 18. Smoothed trend in estimated total (thick black line, with 95% confidence interval in gray) and natural (thin red line) population spawning abundance. In portions of a time series where a population has no annual estimates but smoothed spawning abundance is estimated from correlations with other populations, the smoothed estimate is shown in light gray. Points show the annual raw spawning abundance estimates. For some trends, the smoothed estimate may be influenced by earlier data points not included in the plot.

Contributions of Snake River spring/summer Chinook salmon are considered negligible in fisheries managed by the PFMC (PFMC 2016); (PFMC 2020c), and the fisheries are not likely to jeopardize the ESU (Thom 2020). Snake River spring/summer Chinook salmon are encountered in fisheries in the Columbia River, the Snake River, and some tributaries. The majority of the harvest-related impacts to this ESU occur in mixed stock Columbia River fisheries. These fisheries are limited to an incidental take of 5.5 to 17% (depending on run size) of Snake River spring/summer Chinook salmon returning to the Columbia River mouth (NMFS 2018c). Actual incidental take has remained the same since the 2016 5-year review and averaged 11.0% for the years 2014–2019 (NMFS 2022g). Estimated harvest rates for Snake River spring/summer Chinook salmon over the last four decades are shown in Figure 19.

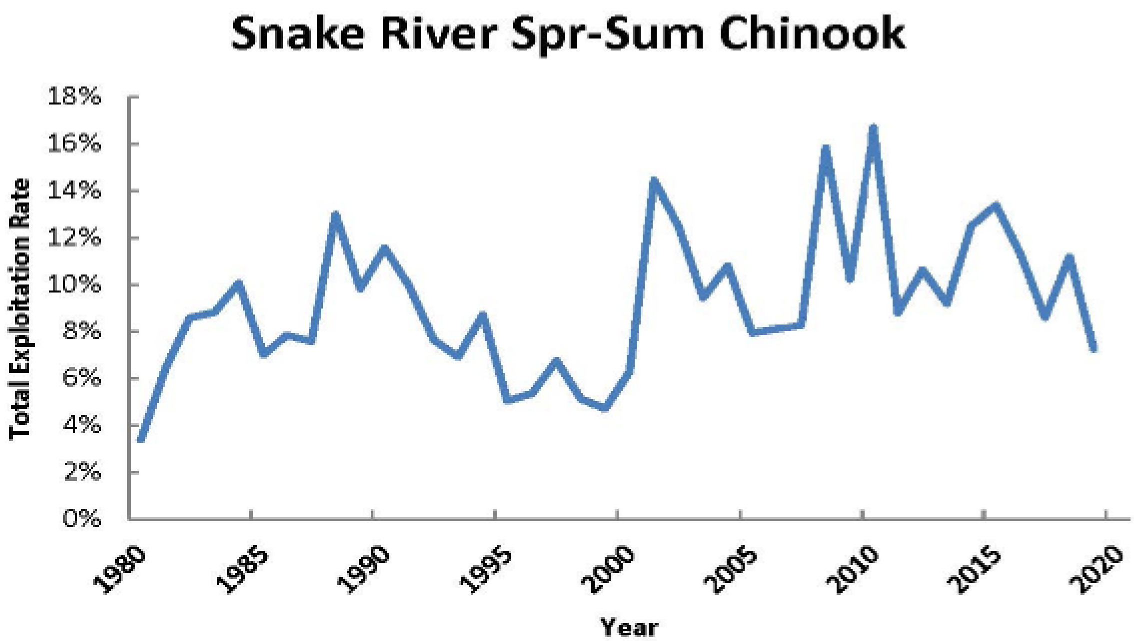


Figure 19. Total exploitation rates for Snake River spring/summer Chinook salmon in the mainstem Columbia River fisheries (NMFS 2022g). Data from the Columbia River Technical Advisory Team, recreated from NMFS (NMFS 2022g).

2.2.2.3.2.1.2. Spatial Structure and Diversity

Spatial structure and diversity ratings remain relatively unchanged from the prior reviews, with low or moderate risk levels for the majority of populations in the ESU. Four populations from three MPGs (Catherine Creek, Upper Grande Ronde River, Lemhi River, and Middle Fork Salmon River lower mainstem) remain at high risk for spatial structure loss. Three of the four extant MPGs in this ESU have populations that are undergoing active supplementation with local broodstock hatchery programs. In most cases, those programs evolved from mitigation efforts and include some form of sliding-scale management guidelines designed to maximize potential benefits in low abundance years and reduce potential negative impacts at higher spawning levels.

Efforts to evaluate key assumptions and impacts are underway for several programs, but it appears likely that these programs are reducing the risk of extinction in the short term.

2.2.2.3.2.1.2.1. Hatcheries

The hatchery programs that affect the Snake River spring-run Chinook salmon ESU have changed over time, and these changes have likely reduced adverse effects on ESA-listed species (NMFS 2022g). The proportion of hatchery-origin spawners within populations varies considerably across MPGs (Table 27). Over the years, hatchery programs that supplement natural-origin populations in the Snake River have improved their hatchery programs. In particular, program managers have better integrated natural-origin fish into their broodstock and limited the number of hatchery-origin spawners, when appropriate. Integration of hatchery programs is typically done using sliding scales sensitive to population abundance. Under the sliding scales, the programs allow some hatchery-origin fish to spawn in the wild at all abundance levels but reduce the proportions of hatchery-origin spawners as natural-origin abundance increases. In addition, the proportion of natural-origin fish used in broodstock increases as abundance increases, as determined by the sliding scales. This strategy attempts to balance the risk of extinction (low natural-origin abundance) with the risk of hatchery influence.

Similarly, hatchery programs that are segregated from the natural-origin population have improved release and collection strategies to reduce straying. This reduction in straying has reduced the potential for these segregated programs to impact naturally spawning Chinook salmon.

Table 27. Five-year mean of fraction natural-origin spawners (sum of all estimates divided by the number of estimates) (Ford 2022).

Population[a]	MPG	1995–99	2000–04	2005–09	2014–19	2015–19
Tucannon River	Lower Snake	0.64	0.61	0.69	0.68	0.27
Wenaha River	Grande Ronde/Imnaha	0.89	0.96	0.97	0.73	0.74
Lostine River	Grande Ronde/Imnaha	0.97	0.61	0.39	0.40	0.42
Minam River	Grande Ronde/Imnaha	0.97	0.98	0.98	0.89	0.94
Catherine Creek	Grande Ronde/Imnaha	1.00	0.57	0.35	0.49	0.38
Grande Ronde River Upper Mainstem	Grande Ronde/Imnaha	1.00	0.76	0.33	0.22	0.24
Imnaha River Mainstem	Grande Ronde/Imnaha	0.53	0.44	0.23	0.34	0.41
South Fork Salmon River Mainstem	South Fork Salmon River	0.59	0.64	0.56	0.77	0.32
Secesh River	South Fork Salmon River	0.91	0.97	0.95	0.98	0.96
East Fork South Fork Salmon River	South Fork Salmon River	0.99	0.76	0.43	0.62	0.58
Chamberlain Creek	Middle Fork Salmon River	1.00	1.00	1.00	1.00	1.00

Population[a]	MPG	1995–99	2000–04	2005–09	2014–19	2015–19
Middle Fork Salmon River Lower Mainstem	Middle Fork Salmon River	1.00	1.00	1.00	1.00	1.00
Big Creek	Middle Fork Salmon River	1.00	1.00	1.00	1.00	1.00
Camas Creek	Middle Fork Salmon River	1.00	1.00	1.00	1.00	1.00
Loon Creek	Middle Fork Salmon River	1.00	1.00	1.00	1.00	1.00
Middle Fork Salmon River Upper Mainstem	Middle Fork Salmon River	1.00	1.00	1.00	1.00	1.00
Sulphur Creek	Middle Fork Salmon River	1.00	1.00	1.00	1.00	1.00
Marsh Creek	Middle Fork Salmon River	1.00	1.00	1.00	1.00	1.00
Bear Valley Creek	Middle Fork Salmon River	1.00	1.00	1.00	1.00	1.00
North Fork Salmon River	Upper Salmon River	1.00	1.00	1.00	1.00	1.00
Lemhi River	Upper Salmon River	1.00	1.00	1.00	1.00	1.00
Salmon River Lower Mainstem	Upper Salmon River	1.00	1.00	1.00	1.00	1.00
Pahsimeroi River	Upper Salmon River	0.65	0.51	0.79	0.93	0.54
East Fork Salmon River	Upper Salmon River	0.77	1.00	1.00	1.00	1.00
Yankee Fork	Upper Salmon River	1.00	1.00	0.52	0.39	0.93
Salmon River Upper Mainstem	Upper Salmon River	0.80	0.62	0.58	0.71	0.36
Valley Creek	Upper Salmon River	1.00	1.00	1.00	1.00	1.00

[a] Note that the Little Salmon River (South Fork Salmon River) population is not included due lack of available data, as discussed further in Ford (2022)

2.2.2.3.2.1.3. Summary

While there have been improvements in abundance/productivity in several populations relative to the time of listing, the majority of populations experienced sharp declines in abundance in the recent five-year period, primarily due to variation in ocean survival (Ford 2022). If ocean survival rates remain low, the ESU's viability will clearly become much more tenuous. If survivals improve in the near term, however, it is likely the populations could rebound quickly. Overall, at this time the most recent viability review concluded that the Snake River spring/summer-run Chinook salmon ESU continues to be at moderate-to-high risk (Ford 2022).

2.2.2.3.2.2. Limiting Factors

Understanding the limiting factors and threats that affect the Snake River Spring/summer-run Chinook Salmon ESU provides important information and perspective regarding the status of a species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. The abundance of spring/summer-run Chinook salmon had already begun to decline by the 1950s, and it continued declining through the 1970s. In 1995, only 1,797 spring/summer-run Chinook salmon total adults (both hatchery and natural-origins combined) returned to the Snake River (NMFS 2017g).

There are many factors that affect the abundance, productivity, spatial structure, and diversity of the Snake River spring/summer-run Chinook Salmon ESU. Factors that limit the ESU have been, and continue to be, survival through the FCRPS; the degradation and loss of estuarine areas that help the fish survive the transition between fresh and marine waters, spawning and rearing areas that have lost deep pools, cover, side-channel refuge areas, and high-quality spawning gravels; and interbreeding and competition with hatchery fish that far outnumber fish of natural-origin.

Based on the information identified above, NMFS (2022g) recommended that the Snake River spring/summer Chinook Salmon ESU maintain its classification as a threatened species.

2.2.2.3.3. Upper Columbia River Spring-run Chinook Salmon ESU

On March 24, 1999, NMFS listed the UCR Spring-run Chinook Salmon ESU as an endangered species (64 FR 14308). The endangered status was reaffirmed on June 28, 2005 (70 FR 37160) and most recently on April 14, 2014 (70 FR 20816). Critical habitat for the UCR Spring-run Chinook salmon was designated on September 2, 2005 (70 FR 2732). In 2022, NMFS completed its most recent 5-year review for UCR Spring-run Chinook salmon (NMFS 2022h).

Inside the geographic range of this ESU, eight natural populations within three MPGs have historically comprised the UCR Spring-run Chinook Salmon ESU, but the ESU is currently limited to one MPG (North Cascades MPG) and three extant populations (Wenatchee, Entiat, and Methow populations). Ten hatchery spring-run Chinook salmon programs are currently operational, but only seven are included in the ESU (Table 5 in NMFS (2022h)). Table 28 lists the hatchery and natural populations included (or excluded) in the ESU.

Table 28. Upper Columbia River Spring-run Chinook Salmon ESU description and MPG (updated data from NMFS (2022h)).

ESU Description	
Endangered	Listed under ESA in 1999; updated in 2014.
1 MPG	8 historical populations
MPG	***Populations***
North Cascades	Wenatchee River, Entiat River, Methow River.
Artificial production	
Hatchery programs included in ESU (7)	Twisp River Program, Chief Joseph spring Chinook Hatchery Program (Okanogan River release), Methow Program, Winthrop National Fish Hatchery Program, Chiwawa River Program, White River Program, Nason Creek Program
Hatchery programs not included in ESU (3)	Leavenworth National Fish Hatchery, Okanogan spring (10)(j), Chief Joseph Hatchery (Mainstem Columbia River release)

Approximately half of the area that originally produced spring-run Chinook salmon in this ESU is now blocked by dams. What remains of the ESU includes all naturally spawned fish upstream of Rock Island Dam and downstream of Chief Joseph Dam in Washington State, excluding the Okanogan River (64 FR 14208, March 24, 1999). Figure 20 shows the map of specific basins within the current ESU.

ESA-listed UCR Spring-run Chinook Salmon are known as "stream-type"; they spend 2 to 3 years in coastal ocean waters, whereas "ocean-type" Chinook salmon spend 3 to 4 years at sea and exhibit offshore ocean migrations. Spring-run Chinook salmon begin returning from the ocean in the early spring, with the run into the Columbia River peaking in mid-May. Spring-run Chinook salmon enter the Upper Columbia tributaries from April through July, and they hold in freshwater tributaries after migration until they spawn in the late summer (peaking in mid to late August) (UCSRB 2007). Juvenile spring-run Chinook salmon spend a year in freshwater before migration to saltwater in the spring of their second year of life.

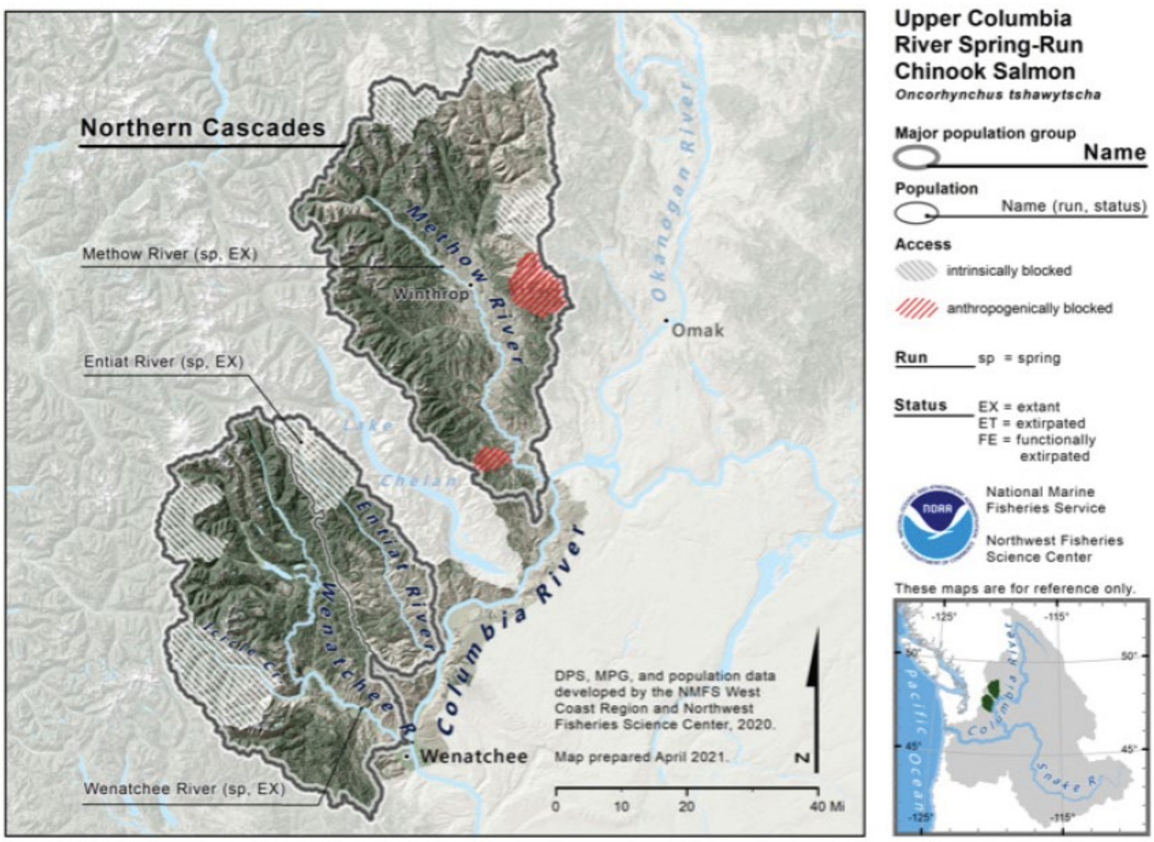


Figure 20. Map of the Upper Columbia River Spring-run Chinook Salmon ESU's spawning and rearing areas, illustrating populations and MPGs (Ford 2022).

2.2.2.3.3.1. Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the UCR Spring-run Chinook Salmon ESU, is at high risk and remains at endangered status (Ford 2022); (NMFS 2022h). The ESA Recovery Plan, developed by the Upper Columbia Salmon Recovery Board (UCSRB) (UCSRB 2007) calls for improvement in each of the three extant spring-run Chinook salmon populations (no more than 5% risk of extinction in 100 years) and for a level of spatial structure and diversity that restores the distribution of natural populations to previously occupied areas and that allows natural patterns of genetic and phenotypic diversity to be expressed. This corresponds to a threshold of at least "viable" status for each of the three natural populations. None of the three populations are viable with respect to abundance and productivity, and they all have a greater than 25% chance of extinction in 100 years (Table 29) (UCSRB 2007).

Table 29. Upper Columbia River Spring Chinook Salmon ESU: North Cascades MPG population risk ratings integrated across the four VSP parameters. Viability key: Dark Green = highly viable; Green = viable; Orange = maintained; and Red = high risk (does not meet viability criteria) (Table from NMFS (2022h), data adapted from Table 5 in Ford (2022)).

		Risk Rating for Spatial Structure/Diversity			
		Very Low	**Low**	**Moderate**	**High**
Risk Rating for Abundance/ Productivity	Very Low (<1%)	Highly Viable	Highly Viable	Viable	Maintained
	Low (1–5%)	Viable	Viable	Viable	Maintained
	Moderate (6–25%)	Maintained	Maintained	Maintained	High Risk
	High (>25%)	High Risk	High Risk	High Risk	High Risk *Wenatchee Entiat Methow*

2.2.2.3.3.1.1. Abundance and Productivity

All three populations in the UCR Spring-run Chinook Salmon ESU remain at high overall risk (Table 29). Natural origin abundance has decreased over the levels reported in the prior review (NMFS 2016e) for all populations in this ESU, in many cases sharply (Figure 21). The abundance data for the entire ESU show a downward trend over the last 5 years, with the recent 5-year abundance levels for all three populations declining by an average of 48% (NMFS 2022h). The consistent and sharp declines for all populations in the ESU are concerning. Relatively low ocean survivals in recent years were a major factor in recent abundance patterns.

Given the high degree of year-to-year variability in life stage survivals and the time lags resulting from the 5-year life cycle of the populations, it is not possible to detect incremental gains from habitat actions implemented to date in population level measures of adult abundance or productivity (NMFS 2022h). Efforts are underway to develop life stage specific estimates of performance (survival and capacities) and to use a life cycle model framework to evaluate progress (Zabel and Jordan 2020). Based on the information available for the 2022 review (Ford 2022), the risk category for the UCR Spring-run Chinook Salmon ESU remains unchanged from the prior review (NWFSC 2015). Although the recent decline of population abundances is concerning, each population remains well above the abundance levels of when they were listed. All three populations remain at high risk (Table 29).

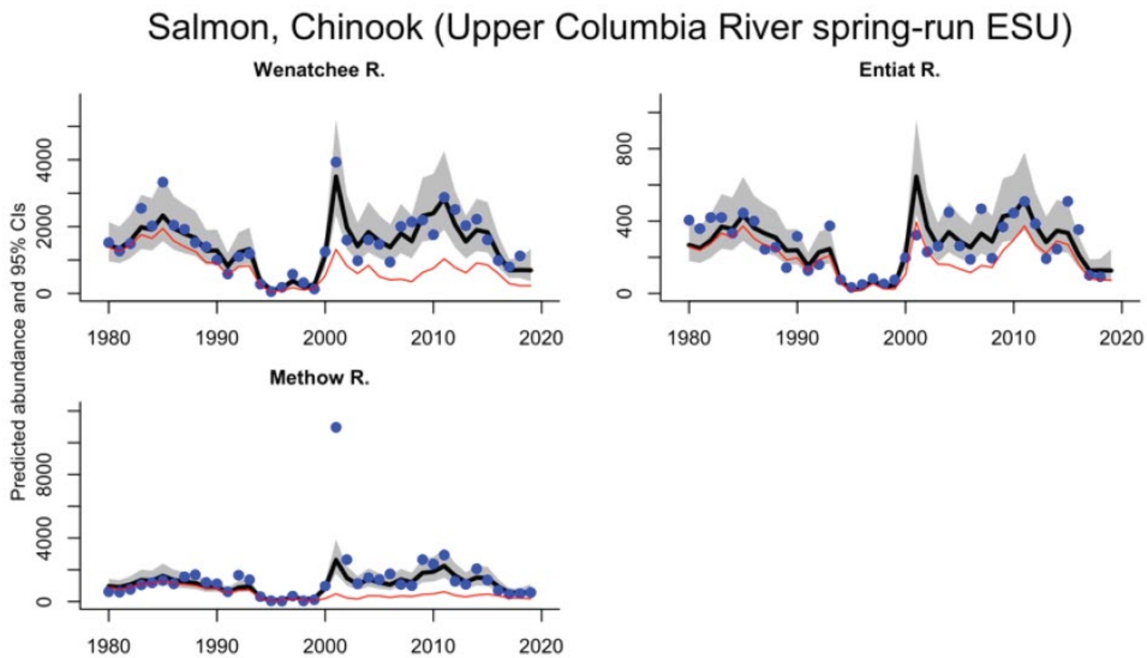


Figure 21. Smoothed trend in estimated total (thick black line, with 95% confidence internal in gray) and natural (thin red line) population spawning abundance. In portions of a time series where a population has no annual estimates but smoothed spawning abundance is estimated from correlations with other populations, the smoothed estimate is shown in light gray. Points show the annual raw spawning abundance estimates. For some trends, the smoothed estimate may be influenced by earlier data points not included in the plot (Ford 2022).

2.2.2.3.3.1.1.1. Harvest

Spring Chinook salmon from the UCR basin migrate offshore in marine waters and where impacts in ocean salmon fisheries are too low to be quantified. Contributions of UCR Spring-run Chinook Salmon are considered negligible in PFMC fisheries, and NMFS has determined that these fisheries are not likely to jeopardize the ESU (Thom 2020); (PFMC 2022). The only significant harvest in salmon fisheries occurs in the mainstem Columbia River in tribal and non-tribal fisheries directed at hatchery spring-run Chinook salmon from the Columbia and Willamette Rivers (Ford 2022). These fisheries are limited to an incidental take of 5.5 to 17% (depending on run size) of UCR spring-run Chinook salmon returning to the Columbia River mouth (NMFS 2018c). Actual incidental take has remained the same since the 2016 5-year review and averaged 11% for the years 2014–2019 (NMFS 2022h). Exploitation rates have remained relatively low for non-treaty harvest, generally below the target rate of 2% (Figure 22).

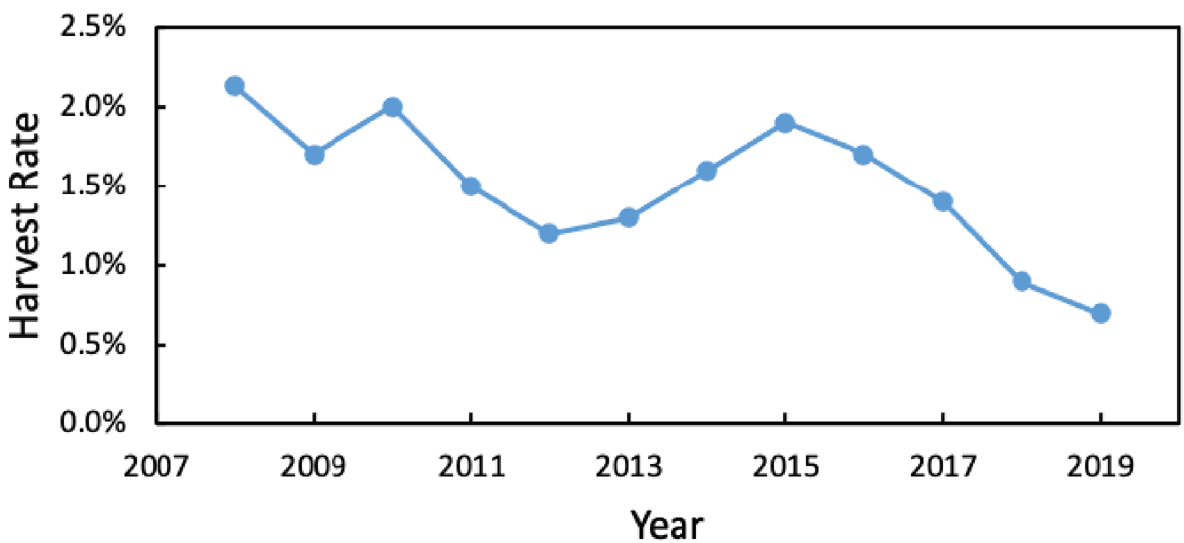


Figure 22. Non-treaty harvest rate for Upper Columbia River spring-run Chinook salmon. Data from the Columbia River Technical Advisory Committee (Figure reproduced from Ford (Ford 2022)).

2.2.2.3.3.1.2. Spatial Structure and Diversity

Spatial structure and diversity ratings remain unchanged from the prior review (NMFS 2016e) and continue to be rated at low to moderate risk for spatial structure but at high risk for diversity criteria (NMFS 2022h). Large-scale supplementation efforts in the Methow and Wenatchee Rivers are ongoing, intended to counter short-term demographic risks given current survival levels (NMFS 2022h). Under the current recovery plan, habitat protection and restoration actions are being implemented that are directed at key limiting factors.

2.2.2.3.3.1.2.1. Hatcheries

Hatchery managers have continued to implement and monitor changes in their management actions since the 2016 5-year review for the hatchery programs within this ESU (Table 28). Although several measures have been implemented to reduce risk, the pHOS remains high in the Wenatchee and Methow Basins (Table 30). However, a better measure of hatchery genetic risk is the PNI within the population, which balances the incorporation of natural-origin fish into the broodstock with pHOS. For example, in the Methow River Basin, specific pHOS goals and genetically linking the two spring Chinook salmon programs in the basin have shown improvement in the estimated PNI for the program (NMFS 2022h). We conclude that hatchery effects continue to present risks to the persistence of the UCR Spring-run Chinook Salmon ESU, but they are likely less of a risk compared to the 2016 5-year review (NMFS 2016e) because several additional reform measures have been implemented, such as terminating the Entiat National Fish Hatchery spring Chinook salmon hatchery program and genetically linking the two spring Chinook salmon programs in the Methow River subbasin (NMFS 2022h).

The hatchery programs that affect the UCR Spring-run Chinook salmon ESU have also changed over time, and these changes have likely reduced adverse effects on ESA-listed species. Specifically, the hatchery programs funded by the Public Utility Districts (PUDs) were reduced in size starting in 2012 because of a revised calculation of their mitigation responsibility, based on increased survival through the PUD dams. Reducing hatchery production has reduced the number of natural-origin fish used for broodstock, as well as the proportion of hatchery fish on the spawning grounds and associated genetic risk (NMFS 2022h).

Table 30. Five-year mean of fraction natural-origin (sum of all estimates divided by number of estimates).

Population	1995–99	2000–04	2005–09	2010–14	2015–19
Wenatchee River SP	0.56	0.42	0.23	0.40	0.43
Entiat River SP	0.70	0.56	0.47	0.77	0.70
Methow River SP	0.61	0.16	0.27	0.25	0.37

2.2.2.3.3.1.3. Summary

Current estimates of natural-origin spawner abundance decreased substantially relative to the levels observed in the prior review (NWFSC 2015) for all three extant populations (Ford 2022). Productivities also continued to be very low, and both abundance and productivity remained well below the viable thresholds called for in the UCSRB Recovery Plan (UCSRB 2007) for all three populations. Short-term patterns in those indicators appear to be largely driven by year-to-year fluctuations in survival rates in areas outside of these watersheds—in particular, a recent run of poor ocean condition years. All three populations continued to be rated at low risk for spatial structure, but at high risk for diversity criteria (Ford 2022). Large-scale supplementation efforts in the Methow and Wenatchee Rivers are ongoing, intended to counter demographic risks given current average survival levels and the associated year-to-year variability (Ford 2022). Under the current recovery plan, habitat protection and restoration actions are being implemented that are directed at key limiting factors.

2.2.2.3.3.2. Limiting Factors

Understanding the limiting factors and threats that affect the UCR Spring-run Chinook Salmon ESU provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting is for all involved parties to ensure that the underlying limiting factors and threats have been addressed. Natural populations of spring-run Chinook salmon within the UCR Basin were first affected by intensive commercial fisheries in the LCR. These fisheries began in the late 1800s and continued into the 1900s, nearly eliminating many salmon stocks. With time, the construction of dams and diversions, some without passage, blocked salmon migrations and killed upstream and downstream migrating fish. Early hatcheries, constructed to mitigate for fish loss at dams and loss of habitat for spawning and rearing, were operated without a clear understanding of population genetics, where fish were transferred to hatcheries without consideration of their actual origin. Although hatcheries were increasing the total number of fish returning to the basin, there was no evidence that they were increasing the abundance of natural populations and it is considered likely that they were decreasing the diversity and productivity of populations they intended to supplement (UCSRB 2007). Concurrent with these historic activities, human population growth within the basin was increasing, and land uses (in many cases, encouraged and supported by government policy) were in some areas impacting salmon spawning and rearing habitat. In addition, non-native species (for a list of non-native species refer to the recovery plan) were introduced by both public and private interests throughout the region that directly or indirectly affected salmon and trout. These activities acting in concert with natural disturbances decreased the abundance, productivity, spatial structure, and diversity of spring-run Chinook salmon in the UCR Basin (UCSRB 2007).

There are many factors that affect the abundance, productivity, spatial structure, and diversity of the UCR Spring-run Chinook Salmon ESU. According to the recovery plan factors that limit the ESU have been, and continue to be, destruction of habitat, overutilization for commercial/recreational/scientific/educational purposes, disease, predation, inadequacy of existing regulatory mechanisms, and other natural or human-made factors affecting the populations continued existence (UCSRB 2007).

The UCSRB (UCSRB 2007) provides a detailed discussion in Section 5, Strategy for Recovery, of limiting factors and threats and describes strategies for addressing each of them. Rather than repeating this extensive discussion from the recovery board, the discussion in Section 5 of the recovery plan is incorporated here by reference. Section 5 of the recovery plan is organized specifically to discuss threats and limiting factors relative to the following:

- Harvest Actions
- Hatchery Actions
- Hydro Project Actions
- Habitat Actions

The risk category for the UCR Spring-run Chinook Salmon ESU remains unchanged from the prior review (NMFS 2016e). Although the status of the ESU is improved relative to measures available at the time of listing, all three populations remain at high risk (NMFS 2022h).

2.2.2.4. North-Central California Coast Recovery Domain

2.2.2.4.1. California Coastal Chinook Salmon ESU

The California Coastal Chinook Salmon ESU was listed as threatened under the ESA on September 16, 1999 (64 FR 50394). Protective regulations were issued in 2002 and 2005 (67 FR 1116; January 9 2002 and 70 FR 37159; August, 29, 2005). Critical habitat for the ESU was designated in 2000 (65 FR 7764; March 17, 2000) and reaffirmed in 2005 (70 FR 52487; September 2, 2005). The ESA listing status was reaffirmed in 2014 (79 FR 20802; April 14, 2014).

NMFS reviewed the status of the species in 2005, 2011, 2016 (Good, Waples, and Adams 2005); (Williams et al. 2011); (NMFS 2016a), and 2024 (NMFS 2024a). Additionally, viability assessments for the ESU were completed in 2005, 2008, and 2016 (Bjorkstedt, 2005 #1445}; (Spence et al. 2008); (Williams et al. 2016). A recovery plan was finalized in 2016 (NMFS 2016g). In the most recent 5-year status review, NMFS (NMFS 2016g) concluded that no change in the status of the species was warranted. The ESU remains listed as threatened at the time of this Opinion. An updated five-year status review is currently underway but was not finalized before this Opinion was completed. However, information from a recent viability assessment (SWFSC 2022) and draft technical memorandum (O'Farrell et al. 2022) are incorporated into the following status information for this Opinion.

The California Coastal Chinook Salmon ESU includes naturally spawned Chinook salmon originating from rivers and streams south of the Klamath River to (and including) the Russian River in California (Figure 23) (70 FR 37159, June 28, 2005). The ESU historically comprised 38 populations including 32 fall-run populations and 6 spring-run populations (Spence et al. 2008). All six of the spring-run populations are considered extinct (Williams et al. 2011). For recovery planning, the ESU is divided into four diversity strata (North Coastal, North Mountain-Interior, North-Central Coastal, and Central Coastal) comprising 17 populations (Figure 23 and Table 31)(NMFS 2016g). Several hatchery programs were included as part of the ESU when the listing was affirmed in 2005 (70 FR 37159; August, 29, 2005) but those programs are no longer active.

Table 31. California Coastal Chinook Salmon ESU description and MPGs ((NMFS 2016a); (NMFS 2016g)).

ESU Description	
Threatened	Listed under ESA in 1999; reaffirmed in 2014
4 diversity strata	38 historical populations, 17 extant
Diversity Strata	Populations
North Coastal	Redwood Creek, Little River, Mad River, Humboldt Bay Tributaries, Lower Eel and South Fork Eela, Bear River, Mattole River
North-Mountain Interior	Van Duzen River and Larabee Creek[a], Upper Eel River
North-Central Coastal	Ten Mile River, Noyo River, Big River, Albion River
Central Coastal	Navarro River, Garcia River, Gualala River, Russian River
Artificial production	
Hatchery programs included in ESU (0)	No active hatcheries in ESU
Hatchery programs not included in ESU (0)	No active hatcheries in ESU

[a] The Lower Eel River population is divided between the North Coastal Strata (Lower Eel River mainstem and South Fork Eel River) and the North-Mountain Interior Strata (Van Duzen River and Larabee Creek).

2.2.2.4.1.1. Abundance, Productivity, Spatial Structure, and Diversity

Viability is the likelihood that a population will sustain itself over a 100-year time frame (McElhany et al. 2000). We assess the status of the California Coastal Chinook Salmon ESU using criteria based on the VSP concept developed by McElhany et al. (2000). The VSP concept is described above in Section 2.2.1.1. VSP criteria for California Coastal Chinook salmon are described in NMFS viability assessments, 5-Year Status Reviews, and the Recovery Plan for California Coastal Chinook Salmon (Good, Waples, and Adams 2005); (Spence et al. 2008) ; (Williams et al. 2011); (NMFS 2016g); (NMFS 2016a); (Williams et al. 2016).; (SWFSC 2022). While the VSP criteria were designed to address all of the VSP parameters (abundance, productivity, spatial structure, and diversity), the available metrics for California Coastal Chinook salmon are primarily based on abundance because of the paucity of information (SWFSC 2022). Best available information indicates that the species, in this case the California Coastal Chinook Salmon ESU, is at moderate risk and remains at threatened status.

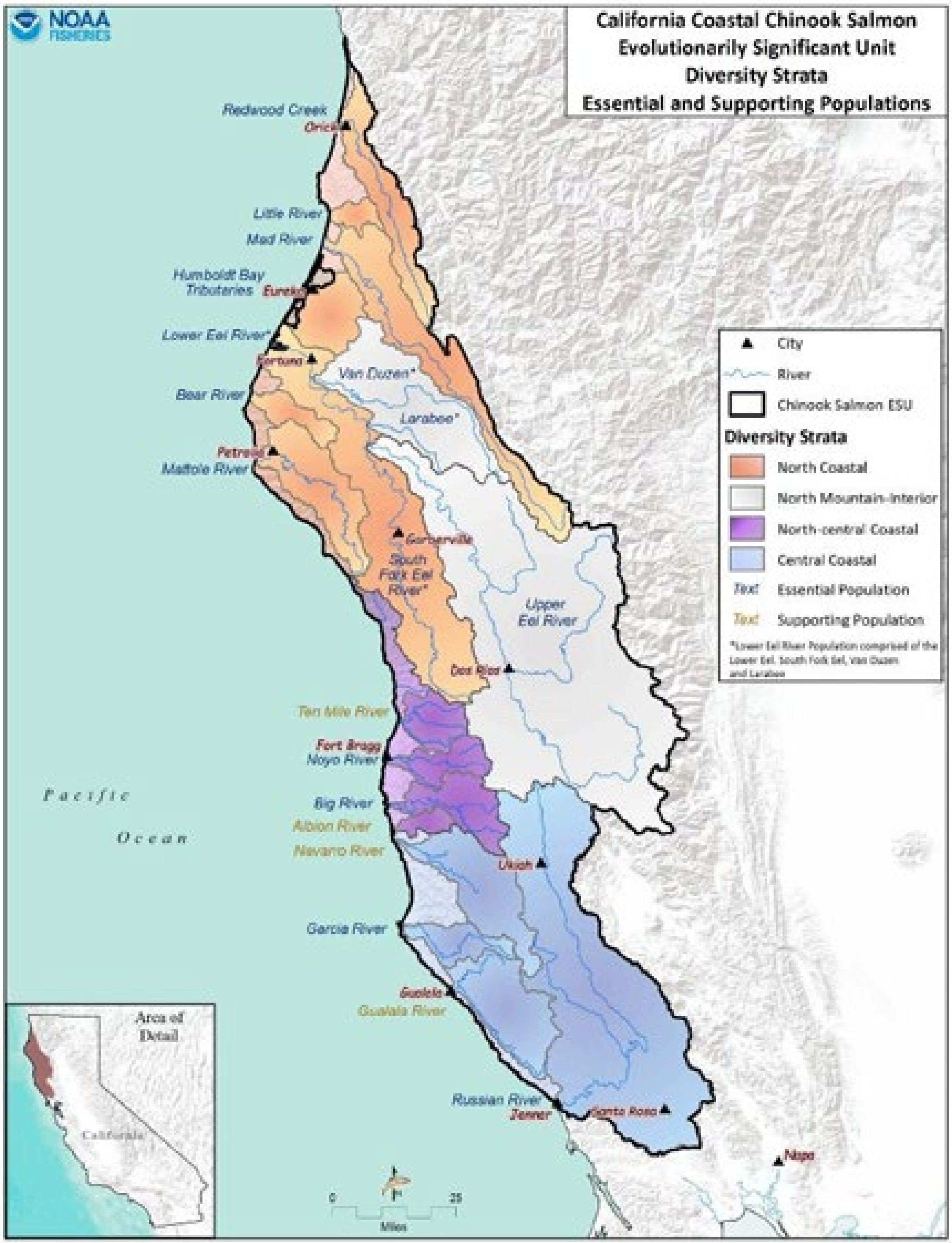


Figure 23. Map of the California Coastal Chinook Salmon ESU's spawning and rearing areas, illustrating populations and diversity strata (NMFS 2016a).

2.2.2.4.1.1.1. Abundance and Productivity

Populations of California Coastal Chinook salmon are categorized as “essential” and “supporting” depending on their role in rebuilding the ESU to recovery (NMFS 2016g). Essential populations must attain low risk of extinction to achieve ESU recovery. Supporting independent populations must attain moderate extinction risk to achieve ESU recovery. Supporting dependent populations will contribute to redundancy and occupancy.

Myers et al. (Myers et al. 1998) and Good et al. (Good, Waples, and Adams 2005) concluded that California Coastal Chinook salmon were likely to become endangered in the foreseeable future. (Good, Waples, and Adams 2005) cited continued evidence of low population sizes relative to historical abundance, mixed trends in the few available time series of abundance indices available, low abundance and extirpation of populations in the southern part of the ESU, and the apparent loss of the spring-run life-history type throughout the entire ESU as significant concerns. (Williams et al. 2011) concluded that there was no evidence to indicate a substantial change in conditions since the previous review of (Good, Waples, and Adams 2005.), but noted that the lack of population-level estimates of adults continued to hinder assessments of status. They further noted that although independent populations persisted in the North Coastal and North Mountain Interior diversity strata, there was high uncertainty about the current abundance of these populations. They also cited the apparent extirpation of populations in the North-Central Coastal Stratum and the loss of all but one population (Russian River) in the Central Coastal Stratum as significant concerns since this gap reduced connectivity among strata across the ESU (Williams et al. 2011). The 2016 viability assessment (Williams et al. 2016) concluded there was a lack of compelling evidence to suggest that the viability of these populations has improved or deteriorated since the previous assessment in 2011. The assessment reiterated concerns about the high uncertainty in northern populations such as the Eel and Mad rivers, but noted that improved monitoring indicated that low numbers of Chinook salmon were returning to watersheds (North-Central Coastal and Central Coastal strata) where they were previously believed extirpated (SWFSC 2022).

Prior status reviews and viability assessments for California Coastal Chinook salmon have noted the paucity of long-term population-level estimates of abundance for California Coastal Chinook salmon populations anywhere in the ESU (Myers et al. 1998); (Good, Waples, and Adams 2005); (Williams et al. 2011). Additionally, there are challenges with the reliability of some data sets throughout all four strata. However, data availability and reliability has improved somewhat since previous status and viability reviews (NMFS 2016a). Adult Chinook salmon abundance estimates include (1) sonar-based estimates on Redwood Creek and the Mad and Eel rivers, (2) weir counts at Freshwater Creek (one tributary of the Humboldt Bay population), (3) trap counts at the Van Arsdale Fish Station[13] (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 Dam on the Russian River (SWFSC 2022). A summary of available data from (SWFSC 2022) are presented for each

[13] The Van Arsdale Fish Station is located at the terminus of anadromous access on the mainstem Eel River.

diversity stratum in the following subsections. The abundance estimates are for natural-origin fish as hatchery programs within the ESU were discontinued by the early 2000s.

<u>*North Coastal Stratum*</u>

The North Coastal Stratum includes coastal Chinook salmon populations from Redwood Creek to the Mattole River (Figure 23 and Table 31) except for the interior portions of the Eel River basin. All 7 populations are independent and are considered essential to recovery. Estimates of population-level abundance are currently available for three populations (Redwood Creek, Mad River, and Mattole River) of Chinook salmon in the North Coastal Stratum and shown in Table 27. Estimates of Chinook salmon in Redwood Creek are available beginning in spawning year[14] 2010. Population estimates have averaged 2,896 (range 1,455–4,541) showing a slightly positive, but not significant trend ($p = 0.31$)(Table 32, Figure 24, and Figure 25). The population mean represents 85% of the recovery target of 3,400 spawners. Estimates of Chinook salmon abundance are available for the Mad River since 2014. Estimates have averaged 7,059 fish (range 2,169–12,667) and, though the time series is too short for formal trend analysis, numbers have increased during this brief period (Table 32 and Figure 24). The mean estimated abundance exceeds the recovery target of 3,000 for this population. Spawner surveys have been conducted in the Mattole River since 2013, with results reported as total redd estimates. Redd estimates have averaged 862 (range 331–2,202) with a slightly positive trend (Table 32 and Figure 24).

In addition to the population-level estimates, longer time series of partial abundance estimates are available for two populations. Weir counts have been conducted in Freshwater Creek (part of the Humboldt Bay population) since 2001. Counts have averaged 29 fish (range 0–154) over the period of record, and there has been a negative and significant downward trend ($p = 0.0001$) (Figure 25). This trend was driven by high numbers of returns in the early part of the time series, which likely reflects the legacy of a small hatchery program that was discontinued in the early 2000s. Counts have been very low but relatively stable since the late 2000s. Estimates of Chinook salmon redds are available for the South Fork Eel River (part of the Lower Eel River population) since 2011. The average estimate has been 768 (range 68–1829) during this period and trends appear to be increasing, however the trend is not statistically significant ($p = 0.709$) (Figure 25).

Table 32. Average abundance, population trend, and spawner density for independent populations of California Coastal Chinook salmon (SWFSC 2022).

Strata	Population	Number of Years	Average Abundance	Population Trend	Spawner Density
North Coastal	Redwood Creek	8	2,896	0.049	24.9
	Mad River	5	7,059	NA	74.8
	Mattole River	7	862	0.121	4.9
North-Central Coastal	Ten Mile River	11	92	0.351	NA

[14] The spawning year (as defined in SWFSC (SWFSC 2022)) is the calendar year at the end of the spawning season (e.g., spawning year 2010 refers to the 2009–2010 spawning season).

Strata	Population	Number of Years	Average Abundance	Population Trend	Spawner Density
	Noyo River	11	19	-0.161	0.3
	Big River	10	16	-0.249	0.2
Central Coastal	Navarro River	10	2	-0.174	NA
	Garcia River	10	34	**0.442**	0.6
	Russian River	18	2,947	NA	6.8
NA = Not available or not applicable Population trends shown only for populations where time series is ≥ 6 years Bold number indicates significant population trend.					

North Mountain Interior Stratum

The North Mountain Interior Stratum includes Chinook salmon populations in the upper Eel River and in two tributaries to the lower Eel River, Van Duzen River, and Larabee Creek (Table 31 and Figure 23). Both populations in this stratum are independent and considered essential to recovery. A long-running time series (since 1947) of adult counts is available from the Van Arsdale Fish Station giving a partial abundance estimate for the Upper Eel River population. An average of 680 Chinook salmon (range 26–3,471) have been counted annually (Figure 25). The trend in abundance appears to be increasing but is not significant ($p = 0.709$) (SWFSC 2022). A new program for estimating abundance of the Upper Eel River Chinook salmon population was initiated in 2019 and produced an estimate of 3,844 fish (36% of the recovery target). This same year, only 94 fish were counted at the Van Arsdale Fish Station. These new data highlight the fact that the Van Arsdale Fish Station count represents only a small (and potentially variable) fraction of the total Upper Eel River population.

North-Central Coastal Stratum

The North-Central Coastal Stratum includes Chinook salmon populations in Ten Mile River, Noyo River, Big River, and Albion River (Table 31 and Figure 23). The Ten Mile River population is independent and considered supporting to recovery rather than essential. Adult estimates have averaged 92 fish (range 0–638) over the years of record with no significant trend ($p > 0.10$) (Table 31 and Figure 24). The mean represents 11–22% of the recovery target for the Ten Mile River population. The Noyo River and Big River are independent populations and considered essential to recovery. The Noyo River estimate has averaged 19 (range 0–98) and Big River has averaged 16 (range 0–60) (Table 32 and Figure 24) and trends appear to be declining. These mean values are less than 1% of proposed recovery targets and fall below the depensation thresholds for high risk. Likewise, the generational averages fall below the high-risk threshold for effective population size.

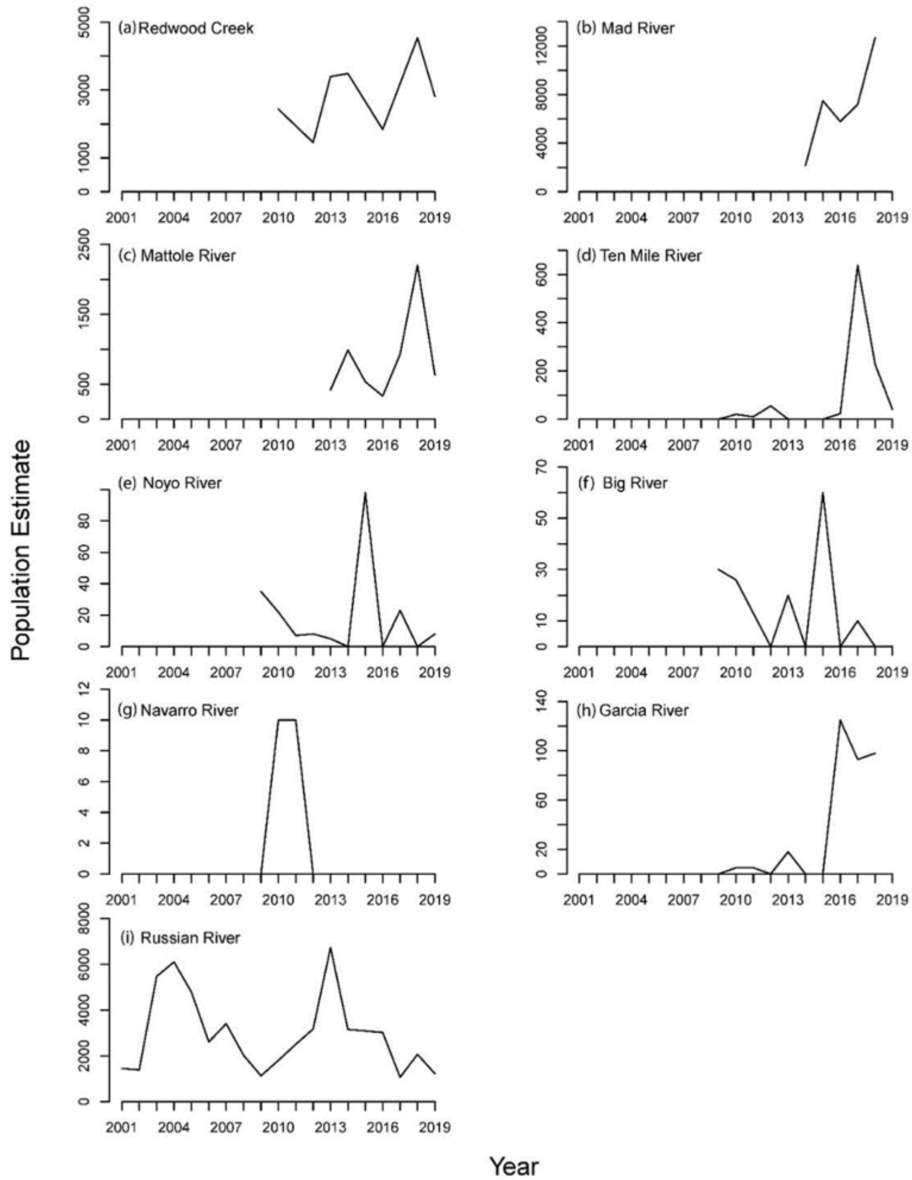


Figure 24. Time series of abundance estimates for independent populations of California Coastal Chinook salmon. (SWFSC 2022).

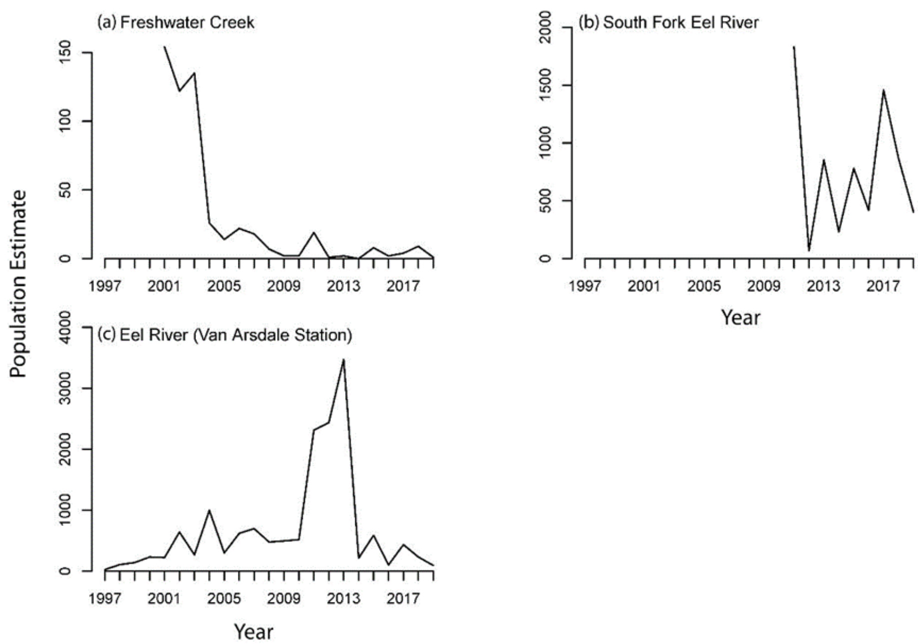


Figure 25. Time series of partial abundance estimates for independent populations of California Coastal Chinook salmon (SWFSC 2022).

Central Coastal Stratum

The Central Coastal Stratum includes Chinook salmon populations from the Navarro River, Garcia River, Gualala River, and the Russian River in the south (Table 31 and Figure 23). All 4 populations are independent, and the Garcia River and Russian River populations are considered essential to recovery. The Gualala and Navarro populations are considered supporting to recovery. Population monitoring has continued for three populations of Chinook salmon in the Central Coastal Stratum. Monitoring of the Navarro and Garcia River populations was initiated in spawn year 2009. In the Navarro River, small numbers (n = 10) of Chinook salmon were reported in 2010 and 2011, but they have not been observed since (Table 32 and Figure 24). In the Garcia River, estimates have averaged 34 (range 0–125) with a significant positive trend (p = 0.04) (Table 32 and Figure 24). However, the population mean is currently less than 2% of the recovery target. Both the Navarro and Garcia river populations are categorized as high risk based on depensation and effective population size criteria (Table 33).

Monitoring of adult Chinook salmon on the Russian River has been conducted since 2001. An average of 2,947 (range 1,062–6,730) Chinook salmon have been counted annually over the 18-year period of record (Table 32 and Figure 24). However, counts for 2015, 2016, and 2017 were derived using alternative methods due to issues with video cameras. Consequently, the statistical significance of this trend cannot be evaluated. However, the trend appears relatively stable over the period of record (SWFSC 2022.). The average count represents about 32% of the recovery target for the Russian River and the population is considered low risk based on the effective population size criterion (SWFSC 2022).

2.2.2.4.1.1.1.1. Harvest

Very limited data exists on the harvest of California Coastal Chinook salmon. Instead, proxies are used, as for ocean fisheries, the Klamath River fall-run Chinook salmon (KRFC) age-4 ocean harvest rate is used as a fishery management proxy to limit harvest impacts on California Coastal Chinook salmon. The current limit for California Coastal Chinook salmon in the PFMC ocean fishery is a maximum predicted KRFC age-4 ocean harvest rate of 16% (SWFSC 2022).

The KRFC age-4 ocean harvest rate fell sharply from its average value of 44% over the 1981–1990 period (Figure 26). Very low KRFC age-4 ocean harvest rates were observed between 2008 and 2012, partially reflecting the widespread fishery closures in California and Oregon from 2008 to 2010. Since 2013, the KRFC age-4 ocean harvest rate has ranged from 4% to 34%, with annual rates exceeding 16% in five of seven years (SWFSC 2022). The harvest rates were particularly high in 2018 (24%) and 2019 (34%), noting that the 2019 estimate is still preliminary (PFMC 2020b). The average KRFC age-4 ocean harvest rate estimated over the years since the previous viability assessment update (2015–2019) is 19% (SWFSC 2022.). In contrast, the average KRFC age-4 ocean harvest rate estimated for years 2011–2014, as reported in the last viability assessment, was 13% (Williams et al. 2016).

Table 33. Diversity strata, populations, historical status, population's role in recovery, current Intrinsic Potential (IP), recovery criteria, and current extinction risk for California Coastal Chinook salmon (Spence et al. 2008).; (NMFS 2016g).; (SWFSC 2022). Recovery target corresponds to the spawner density target multiplied by the IP. Depensation threshold corresponds to 1 spawner per IP-km.

Diversity Strata	Population	Historical Status	Role in Recovery	Intrinsic Potential (IP-km)	Spawner Density Target	Recovery (Low-Risk) Target	Depensation (High-Risk) Threshold	Extinction Risk
North Coastal	Redwood Creek	Independent	Essential	116.1	29.3	3,400	116	Data Deficient
	Little River	Independent	Essential	17.4	40.0	700	17	Data Deficient
	Mad River	Independent	Essential	94.4	31.7	3,000	94	Data Deficient
	Humboldt Bay Tributaries	Independent	Essential	76.6	33.7	2,600	77	Data Deficient
	Lower Eel and South Fork Eel*	Independent	Essential	368.4	20.0	7,400	368	Data Deficient
	Bear River	Independent	Essential	39.4	37.8	1,500	39	Data Deficient
	Mattole River	Independent	Essential	177.5	22.5	4,000	178	Moderate/ High

Diversity Strata	Population	Historical Status	Role in Recovery	Intrinsic Potential (IP-km)	Spawner Density Target	Recovery (Low-Risk) Target	Depensation (High-Risk) Threshold	Extinction Risk
North Mountain-Interior	Van Duzen River and Larabee Creek*	Independent	Essential	144.0	20.0	2,900	144	Data Deficient
	Upper Eel River	Independent	Essential	528.5	20.0	10,600	529	Data Deficient
North-Central Coastal	Ten Mile River	Independent	Supporting	67.2	6-12	401-804	67	High
	Noyo River	Independent	Essential	62.2	35.3	2,200	62	High
	Big River	Independent	Essential	104.3	30.6	3,200	104	High
	Albion River	Dependent	Supporting	17.6	6-12	104-209	18	N / A
Central Coastal	Navarro River	Independent	Supporting	131.5	6-12	787-1,576	132	High
	Garcia River	Independent	Essential	56.2	36.0	2,000	56	High
	Gualala River	Independent	Supporting	175.6	6-12	1,052-2,105	176	High
	Russian River	Independent	Essential	465.2	20.0	9,300	465	Low

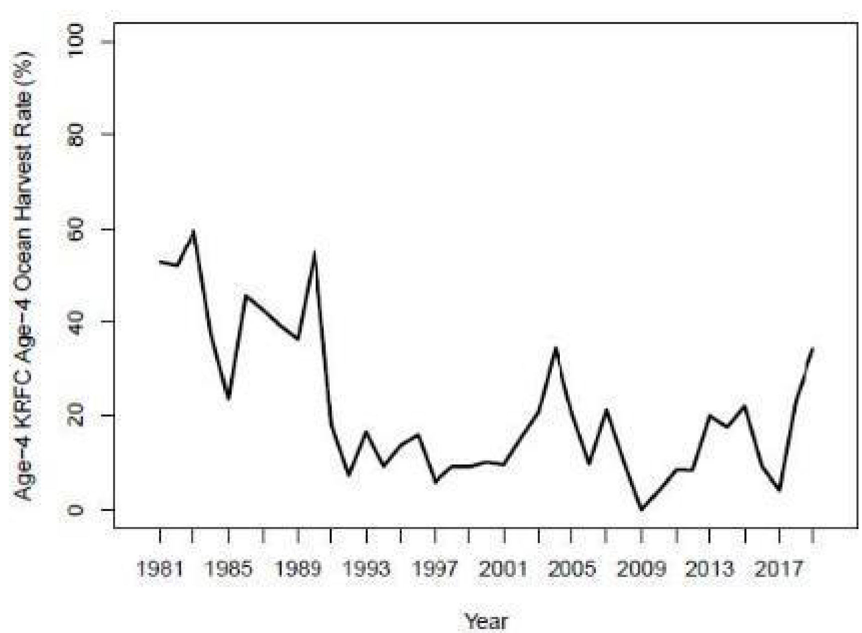


Figure 26. Klamath River fall-run Chinook salmon (KRFC) age-4 ocean harvest rate for years 1981–2019 (PFMC 2020c).

Freshwater fishery impacts on California Coastal Chinook salmon are likely low because retention of Chinook salmon is prohibited across its range; thus, impacts from freshwater fisheries are limited to incidental handling and mortality from anglers targeting steelhead (SWFSC 2022). Low-flow fishing closure regulations have been adopted in portions of the California Coastal Chinook salmon ESU to better protect both ESA-listed and target species. In 2016, low-flow fishing thresholds in the South Fork Gualala River were established and have been used to trigger closures for streams in Mendocino, Sonoma, and Marin counties (in prior years, flows in the Russian River were used to trigger low-flow fishing closures in these areas, but these were deemed inadequate to protect these populations). A low-flow fishing threshold for the Russian River was also adopted in 2016 to regulate closures in the Russian River. These fishery closures have likely reduced incidental capture and handling of California Coastal Chinook salmon during closure periods; however, the overall effect of these closures is difficult to quantify, as the data needed to evaluate potential temporal shifts in angler effort and encounter rates associated with the closures are not currently available (SWFSC 2022).

In summary, the recent increases in the KRFC age-4 ocean harvest rate suggests that the level of California Coastal Chinook salmon ocean fishery impacts has likely increased since the 2016 salmon and steelhead status review update (NMFS 2016a).

2.2.2.4.1.1.2. Spatial Structure and Diversity

As noted above, the majority of VSP criteria metrics available relate to abundance for the California Coastal Chinook Salmon ESU. Therefore, available information regarding spatial structure and diversity is limited. Concerns remain about maintenance of connectivity across the ESU (SWFSC 2022).

2.2.2.4.1.1.2.1. <u>Hatcheries</u>

There are no current hatcheries within the California Coastal Chinook Salmon ESU, but if California Coastal Chinook salmon populations continue to decline, studies are needed to investigate the need and feasibility of a broodstock conservation hatchery, especially along the Mendocino coast (NMFS 2016a).

2.2.2.4.1.1.3. Summary

In the North Coastal Stratum, improved monitoring programs indicate that some populations are doing better than believed in prior 5-year status reviews and viability assessments (Myers et al. 1998); (Good, Waples, and Adams 2005) ; (Williams et al. 2011); (Williams et al. 2016) and trends appear to be increasing where population-level estimates are available (NMFS 2016a);(SWFSC 2022). All North Coastal populations are considered essential to recovery. The Redwood Creek population is approaching the recovery target in some years with average abundance at 85% of the recovery target. The Mad River population is exceeding the recovery target. The Mattole River population appears to be increasing based on positive trends in redd estimates. Partial abundance estimates exist for Freshwater Creek and the South Fork Eel populations, which are part of the Humboldt Bay and Lower Eel populations, respectively. In Freshwater Creek, long term trends in abundance have declined, but this is heavily influenced by hatchery releases during the early part of the time series. In the South Fork Eel River, estimates of redds have shown an increasing trend.

In the North Mountain Interior Stratum, data are extremely limited, and long-term trends only exist for a portion of the Upper Eel River population (essential to recovery). The partial abundance estimate from data collected at the Van Arsdale Fish Station has shown an increasing trend despite high variability and low reliability. A new monitoring program has been implemented to estimate population-level abundance for the Upper Eel River, and early results indicate significantly higher abundance than the partial abundance estimate.

In the North-Central Coastal Stratum, trends are mixed. Trends in abundance for the Noyo River have been relatively stable while the trends for the Big River have declined. Both the Noyo and Big River populations are essential to recovery and are at high risk of extinction due to depensation. The North Central-Coastal populations are all at low abundance. However, previous viability assessments and status reviews indicated the apparent extirpation of populations in this stratum, so presence even at low levels appears to be an improvement ((Myers et al. 1998); (Good, Waples, and Adams 2005); (Williams et al. 2011); (Williams et al. 2016).

In the Central Coastal Stratum, overall trends appear to be improving. The Garcia River population is essential to recovery and has shown a significant positive trend despite being at high risk due to depensation. The Russian River population is essential to recovery, is at low risk of extinction, and its trends in abundance appear relatively stable. This population has consistently numbered in the low thousands of fish in most years, making it the largest population south of the Eel River. Similar to the North-Central Coastal Stratum, populations in the Central Coastal Stratum (except for the Russian River) were thought to be extirpated in previous viability assessment and status reviews (Myers et al. 1998); (Good, Waples, and Adams 2005); (Williams et al. 2011); (Williams et al. 2016).

Abundance trends across the California Coastal Chinook Salmon ESU have been mixed but several populations appear to be stable or increasing. Overall extinction risk for the ESU is moderate and has not changed appreciably since the previous (Williams, 2011 #783}; (Williams et al. 2016)) viability assessment (SWFSC 2022).

2.2.2.4.1.2. Limiting Factors

The 2016 recovery plan (NMFS 2016g) determined the limiting factors and threats of greatest concern to the ESU. These threats include: channel modification, roads and railroads, logging and wood harvesting, water diversion and impoundments, and severe weather patterns (Table 34). Threats from hatcheries and aquaculture are not applicable within the ESU given the termination of hatchery programs for Chinook salmon. Fishing was identified as a medium threat for most of the populations of California Coastal Chinook salmon because of freshwater fishing. While retention of Chinook salmon is prohibited in the freshwater areas of the ESU, poaching and encounters during steelhead fisheries (especially during low flow conditions) remains a concern (NMFS 2016g). To address this, CDFW has implemented low flow fishing closures, including additional closures in 2022, to reduce the impact on Chinook salmon across the ESU. The specific threats to the California Coastal Chinook Salmon ESU are discussed in detail in the Threats section of Volume II of the recovery plan (NMFS 2016g) and status reviews (Good, Waples, and Adams 2005);(Williams et al. 2011);(NMFS 2016a);(Williams et al. 2016);(SWFSC 2022).

Table 34. Threats to essential populations of California Coastal Chinook salmon. Cells with [-] were not rated or not applicable (NMFS 2016g.).

Threat	Diversity Strata / Population													
	North Coastal							North Mountain Interior			North-Central Coastal		Central Coastal	
	Redwood Creek	Little River	Mad River	Humboldt Bay	Lower Eel / South Fork Eel	Bear River	Mattole River	Van Duzen River	Larabee Creek	Upper Eel River	Noyo River	Big River	Garcia River	Russian River
Agriculture	M	M	M	M	M	M	L	M	M	L	L	-	M	M
Channel Modification	VH	H	H	H	H	M	M	H	M	L	L	L	M	H
Disease, Predation and Competition	H	M	M	M	M	M	M	H	H	M	-	-	M	M
Fire, Fuel Management and Fire Suppression	M	M	M	L	M	M	M	M	M	M	L	L	L	L
Fishing and Collecting	M	M	M	M	M	M	M	M	M	H	M	M	H	M
Hatcheries and Aquaculture	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Livestock Farming and Ranching	M	M	M	M	M	H	M	M	M	L	-	-	M	L
Logging and Wood Harvesting	H	H	M	H	M	H	M	M	M	M	M	M	H	L
Mining	H	-	H	L	M	M	M	M	M	L	-	-	L	M
Recreational Areas and Activities	M	M	M	L	M	M	M	M	M	L	L	L	L	L
Residential and Commercial Development	M	M	M	M	M	M	M	M	M	L	L	L	M	H
Roads and Railroads	H	H	H	M	H	H	M	M	M	H	M	M	H	H
Severe Weather Patterns	H	M	M	H	H	M	H	M	M	M	M	M	M	M
Water Diversion and Impoundments	M	M	M	M	H	M	H	H	M	L	L	L	M	H

Recovery goals objectives and criteria for California Coastal Chinook salmon are outlined in Volume II of the 2016 Recovery Plan in the Recovery Goals section (NMFS 2016g).

Recovery plan objectives are to:

1) Reduce the present or threatened destruction, modification, or curtailment of habitat or range;
2) Ameliorate utilization for commercial, recreational, scientific, or educational purposes;
3) Abate disease and predation;
4) Establish the adequacy of existing regulatory mechanisms for protecting California Coastal Chinook salmon now and into the future (i.e., post-delisting);
5) Address other natural or manmade factors affecting the continued existence of California Coastal Chinook salmon; and,
6) Ensure the status of California Coastal Chinook salmon is at a low risk of extinction based on abundance, growth rate, spatial structure and diversity.

Rather than repeating the extensive discussion from the recovery plan, it is incorporated here by reference.

2.2.2.5. Central Valley Recovery Domain

2.2.2.5.1. Central Valley Spring-run Chinook Salmon ESU

The Central Valley Spring-run Chinook Salmon ESU was listed as threatened on September 16, 1999 (64 FR 50394). On June 28, 2005 NMFS published the final hatchery listing policy (70 FR 37204) and reaffirmed the threatened status of the ESU (70 FR 37160)(Table 35). The Central Valley Spring-run Chinook Salmon ESU includes spring-run Chinook salmon populations spawning in the Sacramento River and its tributaries and spring-run Chinook salmon in the Feather River Hatchery (Figure 27). Critical habitat was designated on September 2, 2005 (70 FR 52488). The San Joaquin River watershed and Delta are excluded as critical habitat and San Joaquin basin populations are considered extirpated (78 FR 79622). NMFS completed a recovery plan for the ESU in 2014 (NMFS 2014h), and the most recent 5-year status review was completed in 2016 (NMFS 2016f.). A viability assessment for the ESU was completed by the Southwest Fisheries Science Center (SWFSC) in 2022 (SWFSC 2022).

Table 35. Central Valley Spring-run Chinook Salmon ESU description and MPGs. "I" indicates independent populations and "D" indicates dependent populations (Lindley et al. 2004); (NMFS 2014h); (NMFS 2016f); (SWFSC 2022).

ESU Description	
Threatened	Listed under ESA in 1999; reaffirmed in 2005
4 diversity groups	26 historical populations (18–19 independent), 9 extant (4 independent)
Diversity Group	***Populations***

ESU Description	
Basalt and Porous Lava	Battle (I)
Northwestern California	Clear (D), Cottonwood (D)
Northern Sierra Nevada	Mill (I), Deer (I), Butte (I), Yuba (D), Antelope (D), Big Chico (D)
Southern Sierra Nevada	No extant populations
Artificial production	
Hatchery programs included in ESU (1)	Feather River Hatchery Spring-run Chinook Program
Hatchery programs not included in ESU (1)	San Joaquin Experimental Population

2.2.2.5.1.1. Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. No criteria exist to assess whether this ESU is at moderate or high risk of extinction (SWFSC 2022). Best available information and judgment indicates that the species, in this case the Central Valley Spring-run Chinook Salmon ESU, is likely at either moderate or high risk and remains at threatened status. The process for making this determination is further discussed below.

The Central Valley TRT delineated four diversity groups and 18 or 19 historical independent populations of Central Valley spring-run Chinook salmon (depending on the classification of Mill Creek and Deer Creek populations), along with a number of smaller dependent populations (Lindley et al. 2004). The primary criteria used to identify independent from dependent populations were data on historical accounts of the presence of spring-run Chinook salmon, isolation from other populations that exceeded a critical dispersal distance (>50 km), minimum basin size (500 km2), and genetic information (Lindley et al. 2004.).

The TRT considered multiple lines of evidence to evaluate the extent to which Mill and Deer creeks were historically independent from one another or a single panmictic population and reached no definitive conclusion. The TRT did conclude that Central Valley spring-run Chinook salmon in Mill and Deer creeks are currently independent from other Central Valley spring-run Chinook salmon populations and together with populations on Butte Creek could serve as salmon strongholds in the Northern Sierra Nevada diversity group.

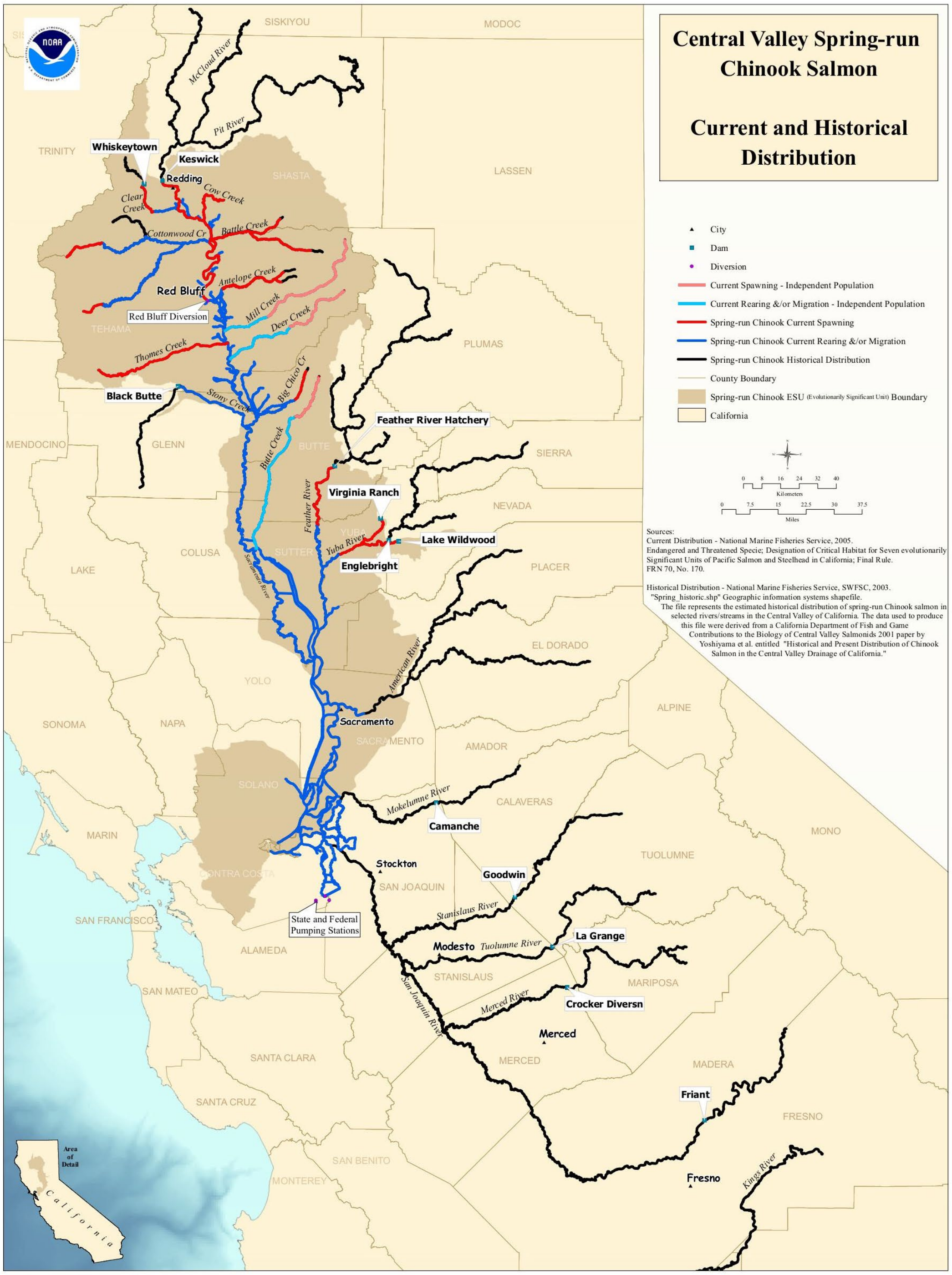


Figure 27. Map of the Central Valley Spring-run Chinook Salmon ESU's spawning and rearing areas, illustrating historical populations and diversity groups (NMFS 2014h).

2.2.2.5.1.1.1. Abundance and Productivity

Lindley et al. (2007) provides criteria to assess the level of risk of extinction of Central Valley salmon based on population size, recent population decline, occurrences of catastrophes within the last 10 years that could cause sudden shifts from a low risk state to a higher one, and the impacts of hatchery influence (Table 36). Figure 28 shows the escapement of Central Valley spring-run Chinook salmon to various areas of the Central Valley, and Table 32 shows abundance and trend statistics related to viability criteria. All historically independent populations remaining (Battle, Deer, Mill, and Butte creeks) show substantially lower total population sizes (N) and mean escapement ($\hat{S}$) than the (Williams et al. 2016) viability assessment (SWFSC 2022). The rate of decline over the past decade coupled with low abundances place Battle, Deer, and Mill creek populations at a high risk of extinction. The Butte Creek population remains at a low risk of extinction despite having a recent decline of 76% in a single generation. All populations experienced recent declines in one generation that exceeded previous year maximums, with the exception of Deer and Antelope creeks whose largest declines in a single generation (84% and 88%), occurred at the beginning of the decadal time series (Table 37). Butte Creek's total population size is 17,740, which is double what was estimated in 2010 and remains by far the most abundant Central Valley spring-run Chinook salmon population (Table 37). While data for the Yuba River was included in the 2015 viability assessment (Williams et al. 2016) and showed a low extinction risk based on population size, no data were provided for escapement years 2015–2019 and therefore omitted from the 2022 viability assessment (SWFSC 2022).

Table 36. Criteria for assessing the level of risk of extinction for populations of Pacific salmonids in the Central Valley of California. Overall risk is determined by the highest risk score for any criterion (modified from Lindley et al. (2007)).

Criterion	High	Moderate	Low
Extinction risk and PVA	> 20% within 20 yrs - or any ONE of -	> 5% within 100 yrs - or any ONE of -	< 5% within 100 yrs - or ALL of -
Population size[a]	Ne ≤ 50 - or - N ≤ 250	50 < Ne ≤ 500 - or - 250 < N ≤ 2500	Ne > 500 - or - N > 2500
Population decline	Precipitous decline[b]	Chronic decline or depression[c]	No decline apparent or probable
Catastrophe, rate, and effect[d]	Order of magnitude decline within one generation	Smaller but significant decline[e]	Not apparent
Hatchery influence[f]	High	Moderate	Low

[a] Census size N can be used if direct estimates of effective size Ne are not available, assuming Ne/N = 0.2.
[b] Decline within last two generations to annual run size ≤500 spawners, or run size >500 but declining at ≥10% per year. Historically small but stable population not included.
[c] Run size has declined to ≤500, but now stable.
[d] Catastrophes occuring within the last 10 years.
[e] Decline <90% but biologically significant.
[f] See Figure 1 in Lindley et al. (2007) for assessing hatchery impacts.

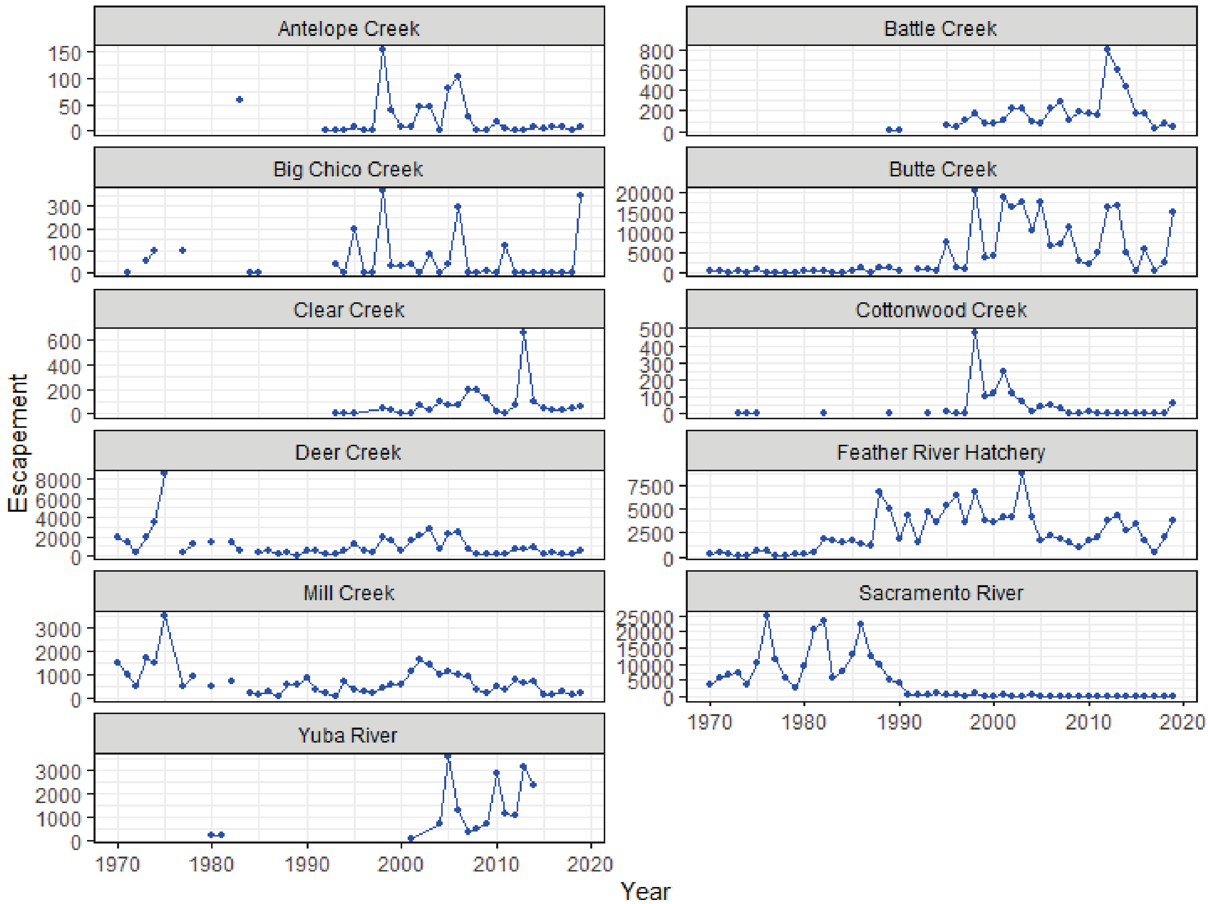


Figure 28. Escapement for Central Valley spring-run Chinook salmon over time. For Butte Creek populations, the mark-recapture estimates are used beginning in 2001. No data were provided for escapement years 2015–2019 for the Yuba River. Figure from (SWFSC 2022).

All populations of Central Valley spring-run Chinook salmon are still exhibiting declines in population size over time, with the exception of two dependent populations — Antelope and Clear creeks that have positive point estimates of population growth (Table 37). In 2015, Central Valley spring-run Chinook salmon showed strong signs of repopulating Battle Creek, home to a historical independent population in the Basalt and Porous Lava diversity group that had been extirpated for many decades (SWFSC 2022). Current viability metrics show a significant declining trend (23% decline per year) and low population size (N<250) for the Battle Creek spring-run Chinook salmon population placing it at a high extinction risk (SWFSC 2022). Similarly, the Central Valley spring-run Chinook salmon population in Clear Creek, previously identified as increasing in abundance, has experienced recent declines in population size (N=136) down from N=822 in 2015, placing it at a high risk of extinction (SWFSC 2022). Mill Creek and Deer Creek spring-run Chinook salmon populations reached low population sizes (N=590 and N=956, respectively) placing them at a moderate risk of extinction (SWFSC 2022). Yet, the low run sizes in consecutive years for Mill Creek spring-run Chinook salmon following the recent droughts (~150 individuals) and precipitous decline (16% over the decade) places Mill Creek at a high risk of extinction using the criteria in Table 31(SWFSC 2022). The highest risk score for any criterion determines the overall extinction risk for a given population. Recent declines of population size in all populations have been substantial and almost qualify as catastrophes under the criteria (>90% decline) with the main independent populations of Central Valley spring-run Chinook salmon reaching all-time declines over one generation (Battle Creek = 77%, Butte Creek = 76%, Deer Creek = 84%, and Mill Creek = 68%) (SWFSC 2022).

Beginning in 2009, estimates of spawning escapement of Upper Sacramento River spring-run Chinook salmon were no longer monitored. Historically, this estimate was derived by the total Red Bluff Diversion Dam counts minus the spring-run numbers in the upper Sacramento tributaries. Beginning in 2009, Red Bluff Diversion Dam gates were partially operated in the up position and in 2012 they were entirely removed and thus spring-run estimates were no longer available. Central Valley spring-run Chinook salmon on the mainstem Sacramento River are not thought to be numerous, yet in some years, the majority of fish collected in the spring and summer months in the Keswick trap as adults are genetically assigned as non-winter-run Chinook salmon. Based on when they are sampled, they are likely Central Valley spring-run Chinook salmon. Consideration should be given to the use of genetics to improve viability assessments of Central Valley spring-run Chinook salmon in the Keswick trap sampling as well as the Sacramento River winter- and fall-run carcass survey to quantify Central Valley spring-run Chinook salmon spawning on the mainstem Sacramento River ((Prince et al. 2017) ; (Thompson et al. 2019); (Meek et al. 2020)). In some years, the Sacramento River mainstem population could be more abundant than the other independent Central Valley spring-run Chinook salmon populations.

Table 37. Viability metrics for the Central Valley Spring-run Chinook Salmon ESU populations through escapement year 2019[a]. Figure from (SWFSC 2022).

Population	N	Ŝ	10-year trend (95% CI)	Recent decline (%)
Antelope Creek spring-run	16	5.3	0.181 (-0.949, 1.312)	87.8
Battle Creek spring-run	157	52.3	-0.228 (-0.446, 0.009)	76.5
Big Chico Creek spring-run	350	116.7	-0.411 (-2.404, 1.581)	100.0
Butte Creek spring-run	17740	5913.3	-0.059 (-0.400, 0.283)	76.3
Clear Creek spring-run	136	45.3	0.044 (-0.266, 0.354)	82.9
Cottonwood Creek spring-run[b]	62	20.7	-1.073 (-2.672, 0.527)	100.0
Deer Creek spring-run	956	318.7	-0.037 (-0.191, 0.117)	83.3
Feather River Hatchery spring-run	6509	2169.7	-0.026 (-0.192, 0.140)	45.8
Mill Creek spring-run	590	196.7	-0.158 (-0.288, -0.028)	67.9
Sacramento River spring-run[c]	-	-	-	

[a] Total population size (N) is estimated as the sum of estimated run sizes over the most recent three years for independent populations (bold) and dependent populations. The mean population size (Ŝ) is the average of the estimated run sizes for the most recent 3 years (2017–2019). Population growth rate (or decline; 10-year trend) is estimated from the slope of log-transformed estimated run sizes. In order to log-transform the run data, any ‘0’s’ were replaced with ‘0.00001’. The catastrophic metric (Recent decline) is the largest decline in a single generation over the most recent 10 such ratios (see supplemental for detailed calculations).
[b] Data from 2015–2018
[c] Beginning in 2009, estimates of spawning escapement of Upper Sacramento River spring-run Chinook were no longer monitored. Historically, this estimate was derived by the total Red Bluff Diversion Dam (RBDD) counts minus the spring-run numbers in the upper Sacramento tributaries. Beginning in 2009, RBDD gates were partially operated in the up position and in 2012 they were entirely removed and thus spring-run estimates were no longer available.

*Erratum: Butte Creek and Yuba River viability metrics using data from 2005-2015 reported in the 2015 viability assessment are revised below (see Chapter 5 in Williams et al. (2016)). These changes do not influence the interpretations of the status or trends provided in the previous viability assessment:

Population	N	Ŝ	10-year trend (95% CI)	Recent decline (%)
Butte Creek spring-run	38182	12727.3	-0.018 (-0.224, 0.187)	51
Yuba River spring-run			0.067 (-0.138, 0.272)	

2.2.2.5.1.1.1.1. Harvest

Attempts have been made to estimate Central Valley spring-run Chinook salmon ocean fishery exploitation rates using CWT recoveries from natural origin Butte Creek fish (Grover et al. 2004), but due to the low number of recoveries the uncertainty of these estimates is too high for them to be reliable (SWFSC 2022). Because Central Valley spring-run Chinook salmon have a relatively broad ocean distribution, generally from central California to Cape Falcon, Oregon, that is similar to that of Sacramento River fall-run Chinook salmon, trends in the Sacramento River fall-run Chinook salmon ocean harvest rate may provide a reasonable proxy for trends in the Central Valley spring-run Chinook salmon ocean harvest rate (SWFSC 2022). While the

Sacramento River fall-run Chinook salmon ocean harvest rate can provide information on trends in Central Valley spring-run Chinook salmon fishing mortality, it has been inferred that Central Valley spring-run Chinook salmon likely experiences lower ocean fishing mortality than Sacramento River fall-run Chinook salmon (SWFSC 2022). If maturation rates are similar between Central Valley spring-run Chinook salmon and Sacramento River fall-run Chinook salmon, the ocean exploitation rate on Central Valley spring-run Chinook salmon would be lower than Sacramento River fall-run Chinook salmon in the last year of life because spring-run Chinook salmon escape ocean fisheries in the spring, prior to the most extensive ocean salmon fisheries in summer (SWFSC 2022). Furthermore, Central Valley spring-run Chinook salmon tend to be smaller at age than Sacramento River fall-run Chinook salmon, which would imply lower age-specific ocean fishery mortality for Central Valley spring-run Chinook salmon (Myers et al. 1998); (O'Farrell, Satterthwaite, and Spence 2012)).

Since the last 5-year status review ((NMFS 2016f); (Satterthwaite et al. 2018)) reviewed available data for Central Valley spring-run Chinook salmon and explored assessment and management options. Included in this paper was the suggestion that until Central Valley spring-run Chinook salmon-specific stock assessments are developed, and exploitation rates can be directly estimated, trends in ocean fishing mortality rates for co-mingling stocks (Sacramento River fall-run Chinook salmon, Klamath River fall-run Chinook salmon, and Sacramento River winter-run Chinook salmon can provide information on how levels of exploitation have changed for Central Valley spring-run Chinook salmon). Figure 29 displays trends in ocean fishery mortality rates for these stocks. Fishing mortality rates generally peaked in the 1980s and 1990s. Very low fishing mortality rates were estimated for 2008–2010, as fishing opportunity was either eliminated or heavily scaled back due to the collapse of the Sacramento River fall-run Chinook salmon stock (SWFSC 2022). Following 2010, fishing mortality rates have returned to levels generally similar to those estimated in the early to mid-2000s, but with notable increases in fishing mortality rates for Sacramento River fall-run Chinook salmon and Klamath River fall-run Chinook salmon in 2019 (SWFSC 2022).

The level of Central Valley spring-run Chinook salmon fishery impacts inferred from patterns in Sacramento River fall-run Chinook salmon, Sacramento River winter-run Chinook salmon, and Klamath River fall-run Chinook salmon mortality rates is mixed, with recent increases in Sacramento River fall-run Chinook salmon and Sacramento River winter-run Chinook salmon, but little change for Sacramento River winter-run Chinook salmon (SWFSC 2022). In summary, the available information suggests that ocean fishery impacts have not changed appreciably since the 2016 5-year status review update (NMFS 2016f).

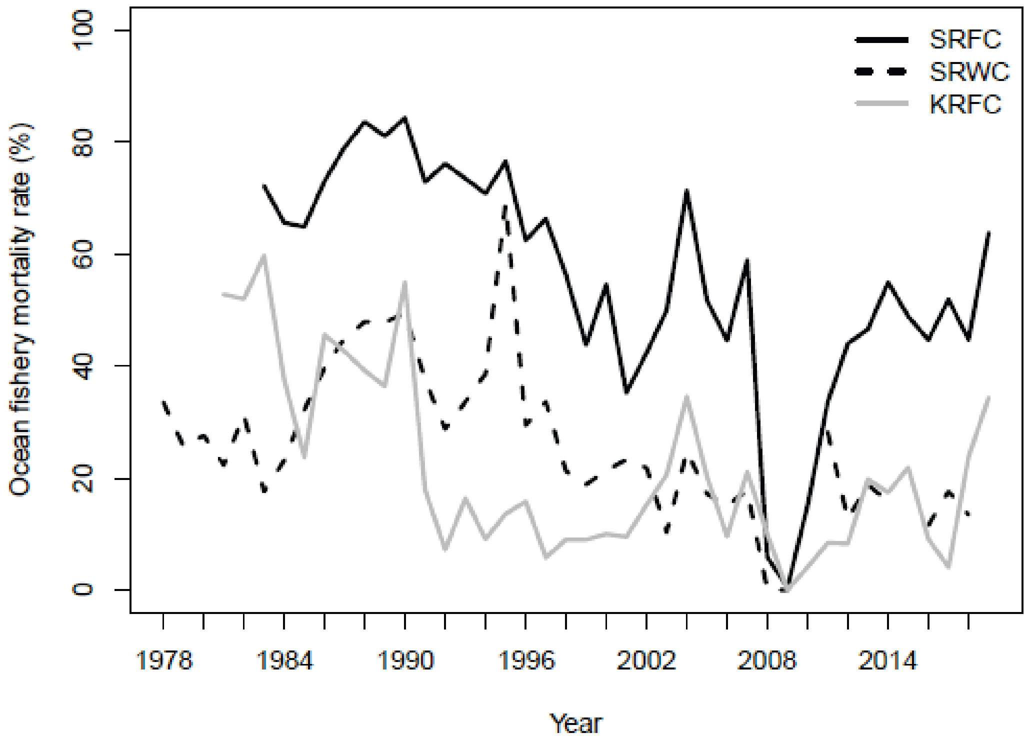


Figure 29. Ocean fishing mortality rates estimated for Sacramento River fall-run Chinook salmon (SRFC), Sacramento River winter-run Chinook salmon (SRWC), and Klamath River fall-run Chinook salmon (KRFC). For SRFC, the fishing mortality rate is determined by the estimated ocean harvest divided by the Sacramento Index. For SRWC, the fishing mortality rate is represented by the age-3 ocean impact rate. For KRFC, the fishing mortality rate is determined by the age-4 ocean harvest rate. Figure from (SWFSC 2022.).

2.2.2.5.1.1.2. Spatial Structure and Diversity

Spatial structure promotes life-history diversity and phenotypic variation that is critical for the long-term persistence of species and populations, especially in highly variable environments. Central Valley spring-run Chinook salmon express significant diversity in the duration of freshwater rearing (3–15 months) with some juveniles leaving the freshwater as sub-yearlings while others over-summer until they are much larger and migrate as yearlings (SWFSC 2022). Yearlings are difficult to monitor, but have been observed in screw traps on Mill, Deer, and Butte creeks (SWFSC 2022).

The extent to which the yearling vs. sub-yearling strategies currently function to create population resilience in Central Valley spring-run Chinook salmon populations is the source of on-going research. Unlike fall-run Chinook salmon that are not occupying the freshwater habitats in the summer, Central Valley spring-run Chinook salmon need cold water as adults and yearlings in the summer. In order to support the yearling life history, cold over-summer temperatures are required, which are lacking on much of the valley floor. This temperature constraint in low elevation habitats likely restricts the expression and/or success of the yearling strategies to tributaries like Mill and Deer creeks that, if adequate flows remain in the streams after water diversions, retain higher elevation access and cooler summer stream temperatures. Further, juvenile smolt outmigration survival in Central Valley spring-run Chinook salmon appears to be linked to higher springtime outmigration flows (Notch et al. 2020) which are regularly suppressed during May to store water in Shasta Reservoir for summer agricultural deliveries, Delta water quality, and Sacramento River temperature management (NMFS 2019i). For example, survival of tagged smolts from Mill Creek had 8-fold higher survival during the high flows in 2017 (42.3% ± 9.1) than during the 2015 drought (4.9% ± 1.6). Further, there is often a mismatch between the ideal timing and outmigration conditions the smolts experience in Mill and Deer creeks and the poorer conditions in the Sacramento River, which is most pronounced near Tisdale Weir. Current efforts are underway to evaluate the extent to which pulse flows in the Sacramento River during May can improve Central Valley spring-run Chinook salmon outmigration survival (NMFS 2019i).

Successful reestablishment of Central Valley spring-run Chinook salmon into multiple populations in the Southern Sierra Nevada Group would significantly increase their spatial diversity and decrease extinction risk of the ESU (SWFSC 2022). Central Valley spring-run Chinook salmon were essentially extirpated from the San Joaquin River after Friant Dam was built in the 1940s, leaving the river dry for 60 miles. For many decades, Central Valley spring-run Chinook salmon were considered extirpated from the Southern Sierra Nevada diversity group in the San Joaquin River Basin, despite their historical numerical dominance in the Basin (Fry 1961) ; (SWFSC 2022). In 2017, the first Central Valley spring-run Chinook salmon redds were observed in the San Joaquin River restoration area and in 2019, 168 Central Valley spring-run Chinook salmon carcasses were detected below Friant Dam for the first time in 65 years (SWFSC 2022). This is a result of a reintroduction program for Central Valley spring-run Chinook salmon was initiated in 2014 as part of the San Joaquin River Restoration Program; 54,000 juvenile spring-run Chinook salmon from Feather River Hatchery broodstock were released into the San Joaquin River. This population of Central Valley spring-run Chinook salmon is designated as an experimental population in accordance with the section 10(j) of the ESA allowing the release of threatened Central Valley spring-run Chinook salmon outside of their current range (78 FR 79622).

These fish were confirmed to have originated as juveniles from the Salmon Conservation and Research Facility (SCARF) reintroduction efforts through CWT recoveries (SWFSC 2022). In addition to the active reintroduction of Central Valley spring-run Chinook salmon below Friant Dam, there have been recent reports of adult Chinook salmon exhibiting typical spring-run life-history characteristics including springtime migration, over-summering in deep pools, spawning in the early fall, and the occurrence of yearling sized juveniles to tributaries of the San Joaquin River including Mokelumne, Stanislaus, and Tuolumne rivers (see Chapter 5 in (Williams et al. 2016); and see Franks (2014). The extent to which these phenotypic spring-run have a similar genetic lineage as other extant spring-run Chinook salmon populations and stray each generation from the Sacramento River Basin remains unknown and is the source of on-going research. It is conceivable that progeny from spring-run adults return to their natal tributaries on the San Joaquin River and thus represent early stages of reestablishing a population and a process trending towards a self-sustaining population (SWFSC 2022).

2.2.2.5.1.1.2.1. Hatcheries

Historical and continued introgression between Feather River spring- and fall-run Chinook salmon ESUs in the breeding program at the Feather River Hatchery compromises the long-term genetic integrity of the spring-run Chinook salmon population on the Feather River and poses a high extinction risk (Hedgecock et al. 2001); (Palmer-Zwahlen, Gusman, and Kormos 2019). Since 2004, spring-run Chinook salmon broodstock have been identified as phenotypic spring run trapped and tagged at the Feather River Hatchery between April 1 and June 30 (SWFSC 2022). As a result of this practice, fall run are very effectively excluded from the spring-run broodstock. Additionally, Feather River Hatchery has been using genetic testing of gametes of their fall-run broodstock to ensure spring-run Chinook salmon are excluded. They have effectively implemented practices to reduce introgression between spring and fall run in the hatchery. In the river, large numbers of fall- and spring-run Chinook salmon individuals from the Feather River Hatchery potentially spawn with natural-origin Feather River spring and fall-run Chinook salmon (Palmer-Zwahlen, Gusman, and Kormos 2019).

The majority of the Feather River Hatchery spring-run Chinook salmon broodstock and in-river spawning population on the Feather River were produced in the hatchery (Palmer-Zwahlen and Kormos 2013) ; (SWFSC 2022). The proportion of natural-origin fish in the broodstock is estimated to be 2% in 2015 (Palmer-Zwahlen, Gusman, and Kormos 2019). The lack of naturally produced fish can disrupt the balance of adaptive gene flow between hatchery and natural-area spawning populations (California HSRG 2012). The proportion of hatchery-origin spring- or fall-run Chinook salmon contributing to the natural area spawning spring-run Chinook salmon population on the Feather River remains unknown due to overlap in the spring- and fall-run spawn timing. However, the hatchery component is likely to be high. For example, 83% of spawners in the 2015 spring-/fall-run carcass survey were estimated to be from the Feather River Hatchery respectively ((Palmer-Zwahlen and Kormos 2013).

Genetic studies suggest that hybridization between Feather River Hatchery spring-run and other Chinook salmon run types (winter-, spring-, and late fall-) in other streams has not occurred, where evaluated. For example, if Feather River Hatchery Central Valley spring-run Chinook salmon have been straying extensively, the effect is not apparent in the genetic structure described by microsatellite markers for Central Valley spring-run Chinook salmon runs in Mill, Deer and Butte creeks, or on winter- and late fall-runs of Chinook salmon that spawn in the mainstem Sacramento River (Banks et al. 2000). These findings are consistent with the generally low stray rates estimated by recovery of CWTs (Palmer-Zwahlen, Gusman, and Kormos 2019); (SWFSC 2022). Yet, there continues to be an increased stray rate associated with hatchery fish that are trucked and released off-site ((Huber and Carlson 2015) ; (Palmer-Zwahlen, Gusman, and Kormos 2019) ; (Sturrock et al. 2019)). Indeed, Feather River Hatchery Central Valley spring-run Chinook salmon adults have been recovered in other Central Valley spring- and fall-run Chinook salmon populations outside of the Feather River. Over 400 Feather River Hatchery spring-run Chinook salmon from fish raised in net pens in the San Francisco Bay strayed as adults and were recovered in the Upper Sacramento River and other natural areas, including Clear Creek, Mill Creek, Deer Creek, and Butte Creek and potentially impacted the genetic integrity of other Central Valley spring-run Chinook salmon populations (Palmer-Zwahlen, Gusman, and Kormos 2019).

In the past, Feather River Hatchery strays to the Yuba River have been significant, yet in 2015 no Feather River Hatchery Central Valley spring-run Chinook salmon were recovered in the Yuba River carcass survey (Palmer-Zwahlen, Gusman, and Kormos 2019). Research suggests that the practice of trucking hatchery fish downstream to the Delta and Bay for release, rather than on-site releases, increases adult straying (Huber and Carlson 2015). Prolonged influx of Feather River Hatchery spring-run Chinook salmon strays to other spring-run Chinook salmon populations even at levels <1% is undesirable and can cause the receiving population to shift to a moderate risk after four generations of such impact (Lindley et al. 2007)(Figure 30). Beginning in 2014, all Feather River Hatchery spring-run Chinook salmon have been released in the Feather River, likely reducing straying to watersheds outside of the Feather River ((California HSRG 2012); (Huber and Carlson 2015); (Palmer-Zwahlen, Gusman, and Kormos 2019);(Sturrock et al. 2019)). Additional information on the incidence of Feather River Hatchery spring-run Chinook salmon straying is desirable to more accurately estimate the extent to which spawning and introgression is occurring between fall- and spring-run Chinook salmon and/or between Feather River Hatchery Central Valley spring-run Chinook salmon and natural-origin spring-run Chinook salmon outside of the Feather River (SWFSC 2022).

2.2.2.5.1.1.3. Summary

The viability of Central Valley spring-run Chinook salmon has declined since the 2015 assessment with an increased risk of extinction for all independent Central Valley spring-run Chinook salmon populations (SWFSC 2022). In fact, Mill, Deer, and Battle creeks changed from low/moderate to a high risk of extinction using one or more viability criteria (Table 38). The total abundance of Central Valley spring-run Chinook salmon for the Sacramento River watershed in 2019 was 26,553, approximately half of the population size in 2014 (N=56,023), and close to the decadal lows of approximately 14,000 which occurred as recently as the last two years (Azat 2020). The Central Valley-wide abundance was driven largely by the annual variation in Butte Creek returns. Butte Creek remains at low extinction risk, yet all viability metrics (except hatchery influence) are trending in a negative direction relative to 2015 (SWFSC 2022). The Butte Creek spring-run Chinook salmon population has become the most abundant population of Central Valley Spring-run Chinook Salmon ESU in part due to extensive habitat restoration and the accessibility of floodplain habitat in the Butte Sink and Sutter Bypass for juvenile rearing in the majority of years (SWFSC 2022). Most of the dependent spring-run populations in the ESU have been experiencing continued and in some cases drastic declines in abundance (SWFSC 2022). For example, while adults were observed in Big Chico Creek between 2014–2018, they likely didn't survive to spawn due to high summer temperatures resulting in zeros (0) in the escapement estimates (Azat 2020); (SWFSC 2022). These results underscore the need for improved passage so that these dependent populations and habitats do not become demographic sinks for Central Valley spring-run Chinook salmon. No adults were observed in Cottonwood Creek in 2015–2018, reflecting total loss of cohorts produced in those drought years (SWFSC 2022). Counteracting these developments, Central Valley spring-run Chinook salmon have repopulated Battle Creek, Clear Creek, and the San Joaquin River where they were once extirpated. These Battle and Clear creeks in 2015 suggest they have the potential to establish a self-sustaining population without significant hatchery supplementation (see Chapter 5 in Williams et al. (2016).

Central Valley Spring-run Chinook Salmon ESU populations have experienced a series of droughts over the past decade. From 2007–2009 and 2012–2016, the Central Valley experienced drought conditions and low river and stream discharges, which are strongly associated with lower survival of Chinook salmon (Michel et al. 2015). The impacts of the recent drought series, and warm ocean conditions on the juvenile life stage, seems to have manifested in the low run sizes in 2015–2018 for most Central Valley spring-run Chinook salmon populations (SWFSC 2022). For example, the recent drought impacted Central Valley spring-run Chinook salmon adults on Butte Creek, which experienced lethal temperatures in holding habitats during the summer. A large number of adults (903 and 232) were estimated to have died prior to spawning in the 2013 and 2014 drought respectively ((NMFS 2016f);(SWFSC 2022)). Pre-spawn mortality was also observed during the 2007–2009 drought with an estimate of 1,054 adults dying before spawning in 2008 (NMFS 2016f); (SWFSC 2022). In 2015, late-arriving adults observed in sections of Butte Creek near the city of Chico experienced exceptionally warm June air temperatures, shutdown of a Pacific Gas and Electric (PG&E) flume, and a corresponding fish mortality event ((NMFS 2016f);(SWFSC 2022). These conditions likely influenced juvenile production and low adult returns in 2015–2018. Fortunately, the favorable hydroclimatic conditions in 2017 appear to have bolstered returns on Butte Creek to pre-drought run sizes of approximately 15,000 adults.

Current introgression between fall- and spring-run Chinook salmon in the Feather River Hatchery breeding program and straying of Feather River Hatchery spring-run Chinook salmon to other spring-run populations where genetic introgression would be possible is unfavorable and reduces population viability. However, beginning in 2014, and expected to continue, the Feather River Hatchery has begun releasing spring-run production into the Feather River rather than releasing in the San Francisco Bay which is expected to reduce straying ((California HSRG 2012); (Huber and Carlson 2015) ; (Palmer-Zwahlen, Gusman, and Kormos 2019) ; (Sturrock et al. 2019)).

At the ESU level, the spatial diversity within the Central Valley Spring-run Chinook Salmon ESU is increasing and spring-run Chinook salmon are present (albeit at low numbers in some cases) in all diversity groups (SWFSC 2022). The reestablishment of Central Valley spring-run Chinook salmon to Battle Creek and increasing abundance of Central Valley spring-run Chinook salmon on Clear Creek observed in some years is benefiting the viability of Central Valley spring-run Chinook salmon. Similarly, the reappearance of early migrating Chinook salmon to the San Joaquin River tributaries may be the beginning of natural dispersal processes

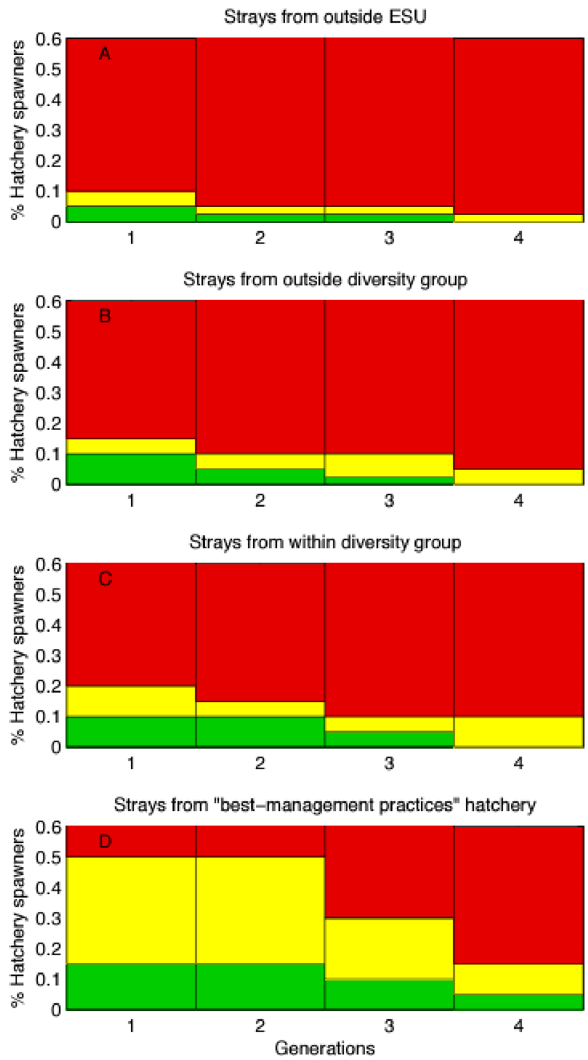


Figure 30. Percentage of hatchery-origin spawners and the resulting risk of extinction due to hatchery introgression from different sources of strays over multiple generations - low (green), moderate (yellow), and high (red). Model using "best-management practices" was used in the winter-run assessment based on the breeding protocols at the Livingston Stone National Fish Hatchery for Sacramento River winter-run Chinook salmon. The parameter "strays from outside ESUs" was used to assess impacts of introgression between Central Valley Spring- and Fall-run Chinook Salmon ESUs at the Feather River Hatchery. Figure reproduced from Lindley et al. (Lindley et al. 2007).

Table 38. Summary of Central Valley spring-run Chinook salmon extinction risk by population criteria described in Lindley et al. (Lindley et al. 2007) for the 2010, 2015, and 2020 viability assessment periods. Overall risk is determined by the highest risk score for any criterion. Table from (SWFSC 2022.).

Population	2010	2015	2020
Mill Creek	High	Moderate	High
Deer Creek	High	Moderate	High
Butte Creek	Low	Low	Low
Battle Creek	High	Moderate	High
Clear Creek	High	Moderate	High
Feather River Hatchery	High	High	High

into rivers where they were once extirpated. On one hand, the Central Valley Spring-run Chinook Salmon ESU is trending in a positive direction towards achieving at least two populations in each of the four historical diversity groups necessary for recovery with the Northern Sierra Nevada region necessitating four populations (NMFS 2014h). On the other hand, Central Valley spring-run Chinook salmon populations have declined sharply in recent years to in most cases worryingly low levels of abundance (SWFSC 2022).

Emerging threats to the Central Valley spring-run Chinook salmon populations may include thiamine deficiency. Thiamine-consistent mortality was seen in both the Feather River Hatchery and in screw trap data, and an increase in juvenile mortality from 2018 to 2019 corresponded with a decrease in juvenile abundance (SWFSC 2022). It is unclear the extent to which this was a basin-wide nutritional deficiency for all Central Valley spring-run Chinook salmon spawning in 2019. Direct mortality or latent effects that would lead to increased mortality in that cohort would not be detected in viability criteria until the dominant age class of 3-year-olds return to spawn in 2022.

The only independent population of Central Valley spring-run Chinook salmon that is not at a high risk of extinction is the population on Butte Creek. Yet, the continued existence of the Butte Creek Central Valley spring-run Chinook salmon population is wholly dependent on the reliable, long-term import of cold water from the West Branch of the Feather River to the anadromous habitat in Butte Creek provided by the operation of the PG&E's DeSabla Centerville Project (SWFSC 2022). Considerable uncertainty remains for the future of the PG&E project and the ability to transfer water from the West Branch Feather River to the anadromous habitat in Butte Creek to support the survival of Central Valley spring-run Chinook salmon.

To conclude, the viability of the Central Valley Spring-run Chinook Salmon ESU has declined since the 2015 viability assessment (Williams et al. 2016) and the ESU is at greater risk of extinction (SWFSC 2022). The largest impacts are likely due to the freshwater drought conditions and unusually warm ocean conditions experienced by these cohorts, resulting in weakening viability metrics and greater risks of extinction to the majority of the populations since the 2015 viability assessment. The recent declines of many of the dependent populations, high pre-spawn mortality and poor juvenile survival during the 2012–2016 drought, unknown impacts due to warm ocean conditions and reorganization of coastal marine food webs, are all causes for increased concern for the long-term viability of the Central Valley Spring-run Chinook Salmon ESU (SWFSC 2022). Overall, new information on abundance, productivity, rate of population decline, spatial structure, hatchery influence, and diversity, indicate the viability of the majority of populations in the ESU has declined since the 2015 viability assessment (Williams et al. 2016).

A FEMAT assessment was conducted to rate extinction risk. The specifics of this assessment are detailed in (SWFSC 2022). Results of the assessment are summarized in Table 39. It should be noted that the combined weights in the “Low” and “Moderate” categories is greater than the single category of “High” risk of extinction. Unlike ESA-listed Endangered Sacramento River Winter-run Chinook salmon and Central California Coast coho salmon, historically independent populations of Central Valley spring-run Chinook salmon occupy all diversity groups albeit at low numbers; it is at the diversity group spatial scale where catastrophic events are best buffered for the ESU (SWFSC 2022). Extinction risks are of concern due to the low abundance of individuals, the magnitude of the abundance decline observed since the last assessment, and the ESU’s pre-existing vulnerability. In the context of the occupied diversity groups yet declining populations and one population disproportionally contributing to the number of fish in the ESU, FEMAT scoring captured the uncertainty of the (SWFSC 2022) authors to conclude that the Central Valley Spring-run Chinook Salmon ESU is at moderate to high risk of extinction.

Table 39. Tally of the FEMAT vote distribution for extinction risk for Central Valley Spring-run Chinook Salmon ESU. Each of four members allocated 10 points among the three viability categories (low, moderate, high). Table from (SWFSC 2022).

Risk category	Number of votes	Percent of total
Low	3	10%
Moderate	13	43%
High	14	47%

2.2.2.5.1.2. Limiting Factors

The recovery plan (NMFS 2014h) provides a detailed discussion of limiting factors and threats and describes strategies for addressing each of them. Chapters 2 and 4 and Appendix B of the recovery plan (NMFS 2014h)describe the limiting factors and threats, and how they apply to the four diversity groups in the Central Valley Spring-run Chinook Salmon ESU. Chapters 2 and 4 and Appendix B (NMFS 2014h) include details on threats in three main categories, listed below:

1) Loss of historical spawning habitat,
2) Degradation of remaining habitat,
3) Threats to genetic integrity.

Chapters 2 and 4 and Appendix B of the recovery plan discuss the limiting factors that pertain to Central Valley spring-run Chinook salmon. The discussion of limiting factors and threats in Chapters 2 and 4 and Appendix B (NMFS 2014h) includes details surrounding the following specific threats:

1) Agricultural diversions,
2) Warm water temperatures,
3) Dams and blocked access/passage impediments,
4) Entrainment,
5) Ocean harvest,
6) Loss of rearing habitat,
7) Predation,
8) Lack of spawning habitat.

Rather than repeating the extensive discussion from the recovery plan (NMFS 2014h), this discussion in Chapters 2 and 4, as well as Appendix B, is incorporated here by reference.

2.2.3. Status of the Coho Salmon ESUs

Only one ESU of coho salmon was evaluated in this Opinion, the LCR Coho Salmon ESU. The recovery domain and population information for this ESU is detailed below in Table 40.

Table 40. Coho salmon ESA-listed salmon populations considered in this Opinion.

Recovery Domain	ESU	MPGs	Populations
Willamette/Lower Columbia	LCR coho salmon	3	24
Totals	1 ESU	3	24

Although run time variation is considered inherent to overall coho salmon life-history, LCR coho salmon typically display one of two major life-history types, either early or late returning freshwater entry. Freshwater entry timing for this ESU is also associated with ocean migration patterns based on the recovery of CWT hatchery fish north or south of the Columbia River (Myers et al. 2006). Early returning (Type-S) coho salmon generally migrate south of the Columbia River once they reach the ocean, returning to freshwater in mid-August and to the spawning tributaries in early September. Spawning peaks from mid-October to early November. Late returning (Type-N) coho salmon have a northern distribution in the ocean, returning to the LCR from late September through December and enter the tributaries from October through January. Most of the spawning for Type-N occurs from November through January, but some spawning occurs in February and as late as March (NMFS 2013e). In general, early returning fish (Type-S) spawn further upstream than later migrating fish (Type-N), although Type-N fish enter rivers in a more advanced state of sexual maturity (Table 41) (Sandercock 1991).

Regardless of adult freshwater entry timing, coho salmon fry move to shallow, low velocity rearing areas after emergence, primarily along the stream edges and inside channels. All coho salmon juveniles remain in freshwater rearing areas for a full year after emerging from the gravel. Most juvenile coho salmon migrate seaward as one-year smolts from April to June. Salmon with stream-type life-histories, like coho salmon, typically do not linger for extended periods in the Columbia River estuary, but the estuary is critical habitat used for foraging during the physiological adjustment to the marine environment (NMFS 2013e). Coho salmon typically spend 18 months in the ocean before returning to freshwater to spawn. Jacks (i.e., precocial males) spend five to seven months in the ocean before returning to freshwater to spawn.

Table 41. Life-History and population characteristics of Lower Columbia River coho salmon.

Characteristic	Life-History Features	
	Early-returning (Type-S)	Late-returning (Type-N)
Number of extant populations	10	23
Life-history type	Stream	Stream
River entry timing	August–September	September–December
Spawn timing	October–November	November–January
Spawning habitat type	Higher tributaries	Lower tributaries
Emergence timing	January–April	January–April
Duration in freshwater	Usually 12–15 months	Usually 12–15 months
Rearing habitat	Smaller tributaries, river edges, sloughs, off-channel ponds	Smaller tributaries, river edges, sloughs, off-channel ponds
Estuarine use	A few days to weeks	A few days to weeks
Ocean migration	South of the Columbia River, as far south as northern California	North of the Columbia River, as far north as British Columbia
Age at return	2–3 years	2–3 years

2.2.3.1. Willamette/Lower Columbia Recovery Domain

2.2.3.1.1. Lower Columbia River Coho Salmon ESU

On June 28, 2005, NMFS listed the LCR Coho Salmon ESU as a threatened species (70 FR 37160). The threatened status was reaffirmed on April 14, 2014 (79 FR 20802). Critical Habitat was originally proposed January 14, 2013 and was finalized on February 24, 2016 (81 FR 9251). In 2022, NMFS completed its most recent 5-year review for LCR coho salmon (SWFSC 2022).

Inside the geographic range of the ESU, 23 hatchery coho salmon programs are currently operational (Table 42). Table 42 lists the 21 hatchery programs currently included in the ESU and the two excluded programs (SWFSC 2022). LCR coho salmon are primarily limited to the tributaries downstream of Bonneville Dam (Figure 31).

Twenty-four historical populations within three MPGs comprise the LCR Coho Salmon ESU with generally low baseline persistence probabilities (Ford 2022); (SWFSC 2022). The ESU includes all naturally spawned populations of coho salmon in the Columbia River and its tributaries from the mouth of the Columbia River up to and including the White Salmon and Hood Rivers, and including the Willamette River to Willamette Falls, Oregon (Figure 31). Coho salmon in the Willamette River spawning above Willamette Falls are not considered part of the LCR Coho Salmon ESU (70 FR 37160).

In contrast to Chinook salmon and steelhead, LCR coho salmon run timing was not used to establish differences between MPGs. Some tributaries historically supported spawning by both run types; therefore Myers et al. (2006) indicated that, regardless of whether run timing is an element of diversity on a subpopulation or population level, the run timing was a factor that needed consideration in recovery planning for LCR coho salmon. NMFS' recovery plan took this into consideration by identifying each LCR coho salmon population's proposed life-history component(s).

Table 42. Lower Columbia River Coho Salmon ESU description and MPGs (Ford 2022); (SWFSC 2022)[a].

ESU Description	
Threatened	Listed under ESA in 2005; updated in 2014.
3 MPGs	24 historical populations
MPG	***Population***
Coastal	Youngs Bay, Grays/Chinook, Big Creek, Elochoman/Skamokawa, Clatskanie, Mill/Abernathy/Germany Creeks, Scappoose
Cascade	Lower Cowlitz, Upper Cowlitz, Cispus, Tilton, South Fork Toutle, North Fork Toutle, Coweeman, Kalama, North Fork Lewis, East Fork Lewis, Salmon Creek, Clackamas, Sandy, Washougal
Gorge	Lower Gorge, Washington Upper Gorge/White Salmon, Oregon Upper Gorge/Hood
Artificial production	
Hatchery programs included in ESU (21)[b]	Grays River Program, Peterson Coho Project, Big Creek Hatchery Program, Astoria High School Salmon-Trout Enhancement Program (STEP) Coho Program, Warrenton High School STEP Coho Program, Cowlitz Type-N Coho Program in the Upper and Lower Cowlitz Rivers, Cowlitz Game and Anglers Coho Program, Friends of the Cowlitz Coho Program, North Fork Toutle River Hatchery Type-S Hatchery Program, Kalama River Type-N Coho Program, Lewis River Type-N Coho Program, Lewis River Type-S Coho Program, Fish First Wild Coho Program, Fish First Type-N Coho Program, Syverson Project Type-N Coho Program, Washougal River Type-N Coho Program, Eagle Creek National Fish Hatchery Program, Sandy Hatchery Program, Bonneville/Cascade/Oxbow

ESU Description	
	Complex Hatchery Program, Clatsop County Fisheries Net Pen Program, Clatsop County Fisheries/Klaskanine Hatchery Program
Hatchery programs not included in ESU (2)[c]	Deep River Net Pens (Elochoman River and Lewis River Type-S), Beaver Creek (Elochoman River Type-N)

[a] Because NMFS had not yet listed this ESU in 2003 when the WLC TRT designated core and genetic legacy populations for other ESUs, there are no such designations for Lower Columbia River coho salmon.
[b] Note that NMFS (2022h) indicates the Fish First Wild Coho Program has been terminated, with the last releases in 2017.
[c] The Deep River Net Pens program is transitioning to using only stocks included in the ESU. The Beaver Creek program includes both an integrated and segregated program.

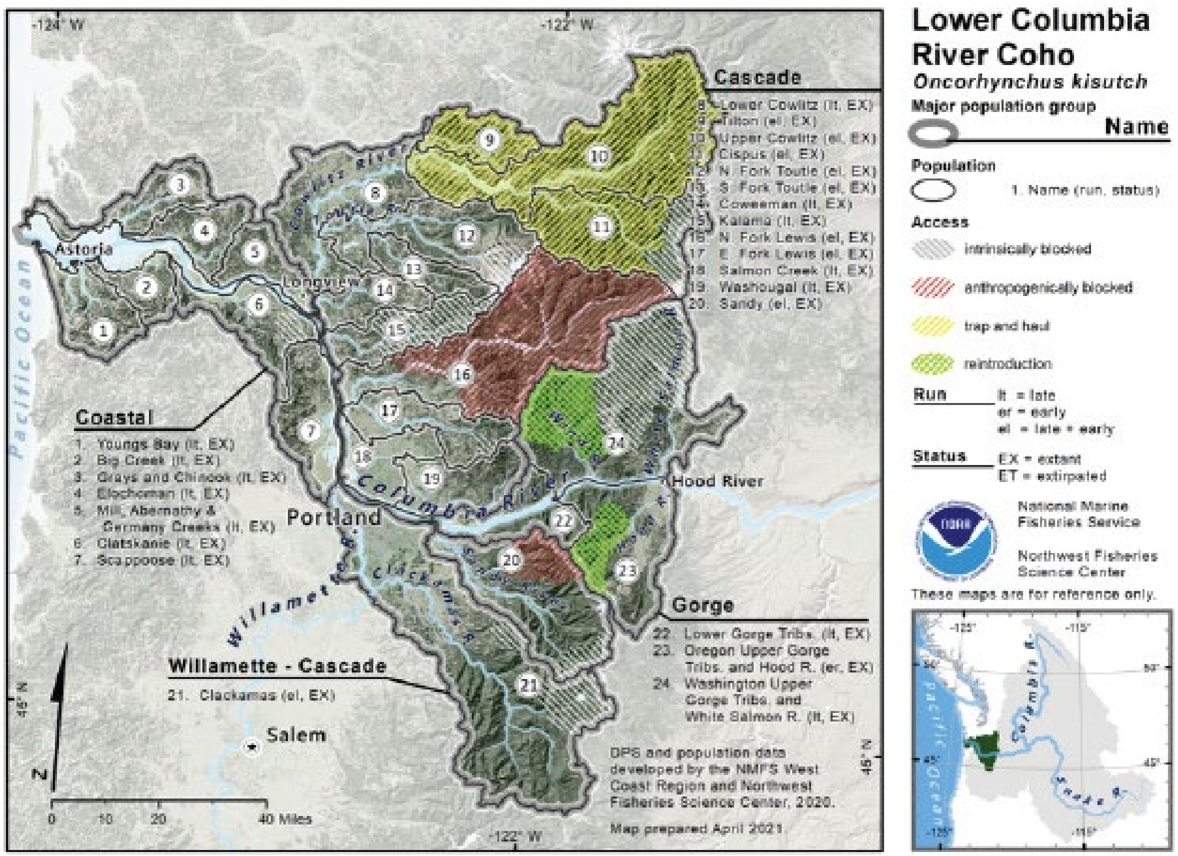


Figure 31. Map of the Lower Columbia River Coho Salmon ESU's spawning and rearing areas, illustrating demographically independent populations and MPGs. Areas that are accessible (green), accessible only via trap-and-haul programs (yellow), or blocked (cross-hatched) are indicated accordingly (Ford 2022).

In 2017 NMFS adopted the Mitchell Act ROD for a policy direction that would be used to guide NMFS' decision on the distribution of funds for hatchery production under the Mitchell Act (16 U.S.C.§§ 755-757), which NMFS administers. NMFS' continued funding of Mitchell Act hatchery programs, under the Mitchell Act ROD was analyzed under the ESA and was found to not likely to jeopardize the continued existence of any species in the Columbia Basin (NMFS 2017e). The Mitchell Act ROD directs NMFS to apply stronger performance goals to all Mitchell Act-funded, Columbia River Basin hatchery programs that affect ESA-listed primary and contributing salmon and steelhead populations. These stronger performance goals reduced the risks of hatchery programs on natural-origin salmon and steelhead populations, including the LCR Coho Salmon ESU. It required integrated hatchery programs to be better integrated and isolated hatchery programs to be better isolated. While the following information presented is a review of updated status information available, NMFS expects the prevalence of hatchery-origin coho salmon spawning contribution to decrease over the course of the 2018 Agreement due to the ITS limits and terms and conditions required by the opinion (NMFS 2017e).

2.2.3.1.1.1. Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the LCR Coho Salmon ESU, is at high risk and remains at threatened status. Each population's target abundance, consistent with delisting the species, is compared against recent abundance estimates in Table 43. Persistence probability is generally measured over a 100-year time period and ranges from very low (probability of less than 40%) to very high (probability of greater than 99%).

2.2.3.1.1.1.1. Abundance and Productivity

NMFS conducted viability status reviews of the LCR Coho Salmon ESU in 1996 (NMFS 1996a), in 2001 (NMFS 2001c), in 2005 (Good, Waples, and Adams 2005), in 2011 (Ford et al. 2011), in 2015 (NWFSC 2015), and most recently in 2022 (Ford 2022). In contrast to the previous 5-year review (NWFSC 2015), which occurred at a time of near record returns for several populations, the ESU abundance has declined during the last five years (Figure 32). Only 6 of the 23 populations for which we have data appear to be above their recovery goals (Ford 2022). This includes the Youngs Bay demographically independent population and Big Creek demographically independent population, which have very low recovery goals, and the Salmon Creek demographically independent population and Tilton River demographically independent population, which were not assigned goals but have relatively high abundances (Ford 2022). Of the remaining demographically independent populations in the ESU, three are at 50–99% of their recovery goals, seven are at 10–50% of their recovery goals, and seven are at less than 10% of their recovery goals (this includes the Lower Gorge demographically independent population for which there are no data, but it is assumed that the abundance is low) (Ford 2022).

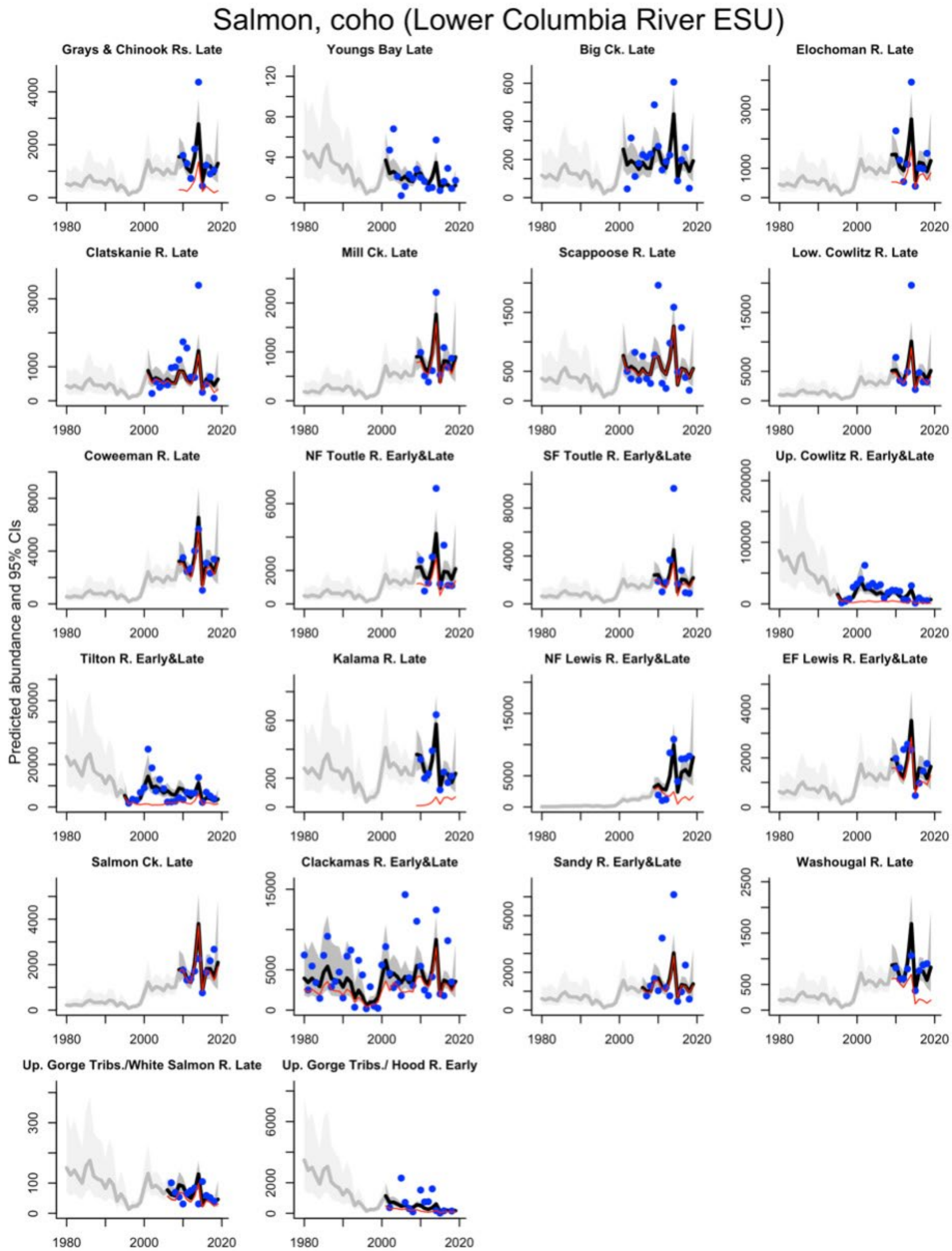


Figure 32. Smoothed trend in estimated total (thick black line, with 95% confidence interval in gray) and natural (thin red line) population spawning abundance. In portions of a time series where a population has no annual estimates but smoothed spawning abundance is estimated from correlations with other populations, the smoothed estimate is shown in light gray. Points show the annual raw spawning abundance estimates. For some trends, the smoothed estimate may be influenced by earlier data points not included in the plot (Ford 2022).

Table 43. Current 5-year geometric mean of raw natural-origin spawner abundances and recovery targets for Lower Columbia River coho salmon DIPs. Numbers in parentheses represent total (hatchery- and natural-origin) spawners. Colors indicate the relative proportion of the recovery target currently obtained: red = <10%, orange = 10% > x < 50%, yellow = 50% > x < 100%), green = >100% (Ford 2022).

		Abundance	
Stratum	**Population**	**2015–19**	**Target**
Coastal	Grays/Chinook River (WA)	212	2,400
	Youngs Bay (OR)	(14)	7
	Big Creek (OR)	(122)	12
	Elochoman/Skamokawa (WA)	558	2,400
	Clatskanie River (OR)	199	3,201
	Mill/Abernathy/Germany Creeks (WA)	685	1,800
	Scappoose Creek (OR)	448	3,208
Cascade	Lower Cowlitz River (WA)	2,622	3,700
	Coweeman River (WA)	1,987	1,200
	North Fork Toutle River (WA)	819	1,900
	South Fork Toutle River (WA)	1,075	1,900
	Upper Cowlitz River (WA)	631	2,000
	Cispus River (WA)	n/a	2,000
	Tilton River (WA)	1,932	n/a
	Kalama River (WA)	43	500
	North Fork Lewis River (WA)	1,275	500
	East Fork Lewis River Tule (WA)	686	2,000
	Salmon Creek (WA)	1,546	n/a
	Clackamas River (OR)	2,889	11,232
	Sandy River (OR)	854	5,685
	Washougal River (WA)	174	1,500
Gorge	Lower Gorge (WA & OR)	n/a	1,900
	Upper Gorge/White Salmon River (WA & OR)	45	1,900
	Upper Gorge/Hood River (OR)	29	5,162

2.2.3.1.1.1.1.1. Harvest

Lower Columbia River coho salmon are part of the Oregon Production Index and are harvested in ocean fisheries primarily off the coasts of Oregon and Washington, with some harvest that historically occurred off of the West Coast Vancouver Island (Ford 2022). Canadian coho salmon fisheries were severely restricted in the 1990s to protect upper Fraser River coho salmon and have remained so ever since. Ocean fisheries off California were closed to coho salmon retention in 1993 and have remained closed ever since. Ocean fisheries for coho salmon off of Oregon and Washington were dramatically reduced in 1993 in response to the depressed status of Oregon Coast natural coho salmon and subsequent listing and moved to mark-selective fishing beginning in 1999. Lower Columbia River coho salmon benefitted from the more restrictive management of ocean fisheries. Overall exploitation rates regularly exceeded 80% in the 1980s but have remained below 30% since 1993 (Figure 33). In addition, freshwater fisheries impacts on naturally produced coho salmon have been markedly reduced through the implementation of selective fisheries. The total allowable marine and mainstem Columbia River exploitation rate for Lower Columbia River coho salmon was 23.0% in 2019 (PFMC 2019); (Ford 2022).

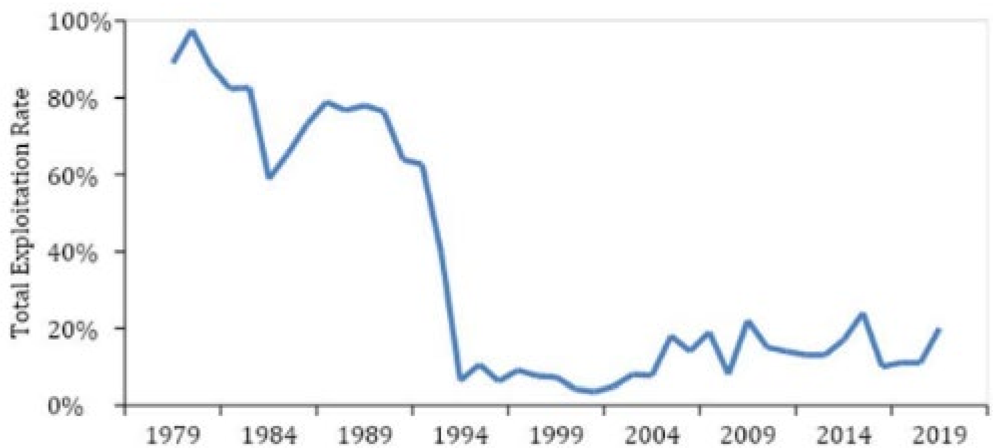


Figure 33. Total exploitation rate on natural Lower Columbia River coho salmon. Data (2005–19) from ODFW et al. (ODFW and WDFW 2020). Figure reproduced from Ford (Ford 2022).

2.2.3.1.1.1.2. Spatial Structure and Diversity

There have been a number of large-scale efforts to improve accessibility, one of the primary metrics for spatial structure, in this ESU. On the Hood River, Powerdale Dam was removed in 2010 and, while this dam previously provided fish passage, its removal is thought to eliminate passage delays and injuries. Condit Dam, on the White Salmon River, was removed in 2011, providing access to previously inaccessible habitat. Current monitoring is limited, but screw trap results indicate that coho salmon are successfully spawning in the White Salmon River (Jezorek and Hardiman 2018). Fish passage operations (trap-and-haul) were begun on the Lewis River in 2012, reestablishing access to historically occupied habitat above Swift Dam (river kilometer (RKM) 77.1) (Ford 2022). Juvenile passage efficiencies were initially poor, but have improved considerably, with the 2019 juvenile collection rate estimated at 64% (PacifiCorp and Public Utility District No 1 of Cowlitz County 2020). Nearly 150,000 juvenile coho salmon were produced and collected from the upper North Fork Lewis River (Ford 2022).

Similarly, efforts to provide downstream juvenile passage at the Cowlitz Dam complex collection sites began in the 1990s, and since that time there have been a number of modifications in the facilities at Cowlitz Falls Dam. Juvenile collection efficiency for coho salmon at the Cowlitz Falls facility in 2019 was 90.4% (Ford 2022). Coho salmon from the Tilton River are collected separately at Mayfield Dam. A trap-and-haul program also currently maintains access to the North Toutle River above the sediment retention structure, with coho salmon and steelhead being passed above the dam (Liedtke, Kock, and Rondorf 2013). This sediment retention structure transportation program relocates coho salmon into the North Fork Toutle population; however, there are limited release sites and only a portion of the upper watershed is accessible. Fish access to the upper Clackamas River basin continues to improve, with recent (2019) estimates for fish guidance efficiency of 94.1% at the North Fork Dam (Ford 2022). Improvements in juvenile collection on the Clackamas River at Portland General Electric projects, with nearly 200,000 juvenile coho salmon collected annually, are likely to result in increased abundances in the future under more productive ocean conditions (Ford 2022). On a more general basis, there have been a number of actions throughout the ESU to remove or improve culverts and other small-scale passage barriers.

There have been incremental improvements in spatial structure during this review period, but poor ocean and freshwater conditions have been such as to mask any benefits from these activities (Ford 2022). Similarly, fish passage at culverts has improved, with 132 km (79 mi) of stream habitat being opened up in Washington State alone since 2015, but a large number of small-scale fish barriers still remain to be upgraded or removed (Ford 2022).

2.2.3.1.1.1.2.1. Hatcheries

Hatchery releases have remained relatively steady at 10–17 million since the 2005 biological review team report, with approximately 14 million coho salmon juveniles released in 2019 (Ford 2022). Many of the populations in the ESU contain a substantial number of hatchery-origin spawners (Table 44). Production has been shifted into localized areas (e.g., Youngs Bay, Big Creek, and Deep Creek) in order to reduce the influence of hatchery fish in other nearby populations (Scappoose and Clatskanie Rivers). There were no spawner surveys conducted in the Youngs Bay or Big Creek demographically independent populations, but it can be assumed that the proportion of natural spawners is very low (Ford 2022). Hatchery influence is also relatively high in the Grays River, with a recent decline in fraction natural origin spawners (Table 44). The influence of hatchery programs on naturally spawning fish has been reduced in a number of basins with the removal of marked adults at weirs, but other basins indicate an increase in the proportion of hatchery fish spawning naturally (Table 44), perhaps as a result of increased hatchery releases (Ford 2022). Mass marking of hatchery-released fish, in conjunction with expanded coho salmon spawning surveys, has provided more accurate estimates of hatchery straying.

Integrated hatchery programs have been developed in a number of basins to limit the loss of genetic diversity. The integrated program in the Cowlitz River was developed for reintroductions into the upper Cowlitz River basin. Large-scale releases of these hatchery-origin coho salmon adults into the upper Cowlitz, Cispus, and Tilton Rivers were used to recolonize stream habitat above the mainstem dams. A segregated program exists for coho salmon releases into the lower Cowlitz River. Overall, juvenile releases into the Cowlitz River basin were reduced some 10 years ago, but have been fairly steady since then (Ford 2022). A large integrated program for Type-N coho salmon has been ongoing in the Lewis River for over a decade, while the Type-S (early) coho salmon program in the Lewis River is operated as a segregated program. Both early- and late-run hatchery-origin coho salmon are transported above Swift Dam in the Lewis River to reestablish production in headwater areas (PacifiCorp and Public Utility District No 1 of Cowlitz County 2020).

Other hatchery programs in the Cascade MPG have releases less than 500,000; most operate as integrated programs, except for the Kalama River Hatchery (Ford 2022). Hatchery-origin spawners contribute to escapement in a number of basins, substantially so in some basins, while the Salmon Creek, Clackamas River, and Sandy River populations have hatchery-origin spawner rates of less than 10% (Table 44). Releases into the Gorge MPG have remained fairly steady at slightly over 3 million annually (Ford 2022). Natural production in this MPG is limited, and the influence of hatchery-origin fish on the spawning grounds remains higher than in other regions (Table 44).

Table 44. Five-year mean of fraction natural Lower Columbia River coho salmon spawners (sum of all estimates divided by number of estimates). Blanks mean no estimate available in that 5-year range (Ford 2022).

Population[a]	MPG	1995–99	2000–04	2005–09	2010–14	2015–19
Grays/Chinook Rivers (late)	Coastal	-	-	-	0.37	0.27
Elochoman River (late)	Coastal	-	-	-	0.53	0.65
Clatskanie River (late)	Coastal	-	0.93	0.97	0.94	0.76
Mill/Abernathy/Germany Creeks (late)	Coastal	-	-	-	0.89	0.89
Scappoose River (late)	Coastal	-	0.94	0.99	1.00	0.99
Lower Cowlitz River (late)	Cascade	-	-	-	0.88	0.85
Coweeman River (late)	Cascade	-	-	-	0.91	0.89
North Fork Toutle River (early & late)	Cascade	-	-	-	0.70	0.56
South Fork Toutle River (early & late)	Cascade	-	-	-	0.84	0.79

Population[a]	MPG	1995–99	2000–04	2005–09	2010–14	2015–19
Upper Cowlitz/Cispus Rivers (early & late)	Cascade	0.73	0.13	0.26	0.20	0.23
Tilton River (early & late)	Cascade	0.64	0.07	0.29	0.38	0.48
Kalama River (late)	Cascade	-	-	-	0.07	0.27
North Fork Lewis River (early & late)	Cascade	-	-	-	0.60	0.22
East Fork Lewis River (early & late)	Cascade	-	-	-	0.87	0.68
Salmon Creek (late)	Cascade	-	-	-	0.98	0.94
Clackamas River (early & late)	Cascade	0.65	0.67	0.64	0.88	0.90
Sandy River (early & late)	Cascade	-	-	0.94	0.92	0.96
Washougal River (late)	Cascade	-	-	-	0.68	0.25
Hood River (early)	Gorge	-	0.40	0.58	0.25	0.48
Washington Upper Gorge Tributaries/White Salmon River (late)	Gorge	-	-	0.73	0.74	0.76

[a] Note that the Youngs Bay (Coastal), Big Creek (Coastal), Cispus (Cascade), and Lower Gorge (Gorge) populations are not included due to low abundances or lack of monitoring and available data, as discussed further in Ford (Ford 2022).

2.2.3.1.1.1.3. Summary

Overall abundance trends for the LCR Coho Salmon ESU are generally negative (Ford 2022). Natural spawner and total abundances have decreased in almost all populations (Figure 32), and Coastal and Gorge MPG populations are all at low levels, with significant numbers of hatchery-origin coho salmon on the spawning grounds (Table 44). Improvements in spatial structure and diversity have been slight, and overshadowed by declines in abundance and productivity (Ford 2022). In light of the poor ocean and freshwater conditions that occurred during much of this recent review period, it should be noted that some of the populations exhibited resilience and only experienced relatively small declines in abundance (Figure 32). Some populations were exhibiting positive productivity trends during the last year of review, representing the return of the progeny from the 2016 adult return (Ford 2022); (SWFSC 2022). For individual populations, the risk of extinction spans the full range, from “low” to “very high” (Ford 2022). Overall, the LCR Coho Salmon ESU remains at “moderate” risk (Ford 2022), and viability is largely unchanged from the prior status review (NWFSC 2015).

2.2.3.1.1.2. Limiting Factors

Understanding the limiting factors and threats that affect the LCR Coho Salmon ESU provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. Lower Columbia River coho salmon populations began to decline by the early 1900s because of habitat alterations and harvest rates that were unsustainable given these changing habitat conditions. There are many factors that affect the abundance, productivity, spatial structure, and diversity of the LCR Coho Salmon ESU. Factors that limit the ESU have been, and continue to be, hydropower development on the Columbia River and its tributaries, habitat degradation, hatchery operations, fishery management and harvest decisions, and ecological factors including predation and environmental variability. The ESU-level recovery plan consolidates the information regarding limiting factors and threats for the LCR Coho Salmon ESU available from various sources (NMFS 2013e).

The LCR recovery plan provides a detailed discussion of limiting factors and threats and describes strategies for addressing each of them. Chapter 4 (NMFS 2013e) of the recovery plan describes limiting factors on a regional scale and those factors apply to the four listed species from the LCR considered in the plan, including LCR coho salmon. Chapter 6 of the recovery plan discusses the limiting factors that pertain to the MPGs that compose the LCR Coho Salmon ESU. The discussion of limiting factors in Chapter 6 (NMFS 2013e) is organized to address the following:

- Tributary habitat,
- Estuary habitat,
- Hydropower,
- Hatcheries,
- Harvest, and
- Predation.

Chapter 4 (NMFS 2013e) includes additional details on large scale issues including the following:

- Ecological interactions,
- Climate change, and
- Human population growth.

Rather than repeating this extensive discussion from the roll-up recovery plan, these discussions in Chapters 4 and 6 are incorporated here by reference.

Harvest-related mortality is identified as a primary limiting factor for all natural populations within the ESU and occurs as a result of direct and incidental mortality of natural-origin fish in ocean fisheries, Columbia River recreational fisheries, and commercial gillnet fisheries. The LCR recovery plan envisions refinements in coho salmon harvest through (1) replacement or refinement of the existing harvest matrix to ensure that it adequately accounts for weaker components of the ESU, (2) continued use of mark-selective recreational fisheries, and (3) management of mainstem commercial fisheries to minimize impacts to natural-origin coho salmon (NMFS 2013e). The refinement of the harvest matrix ensured that harvest management is consistent with maintaining trajectories in populations where increasing natural production is beginning to be observed (e.g., the Clatskanie and Scappoose populations), with the assumption that additional refinements will be evaluated as natural production is documented in additional populations. Managing coho salmon harvest to minimize impacts to natural-origin fish has been complicated by uncertainties regarding annual natural-origin spawner abundance and actual harvest impacts on natural-origin fish (in both ocean and mainstem Columbia fisheries). The recovery plan notes these uncertainties and highlight the need for improved monitoring of harvest mortality and natural-origin spawner abundance.

Closely spaced releases of hatchery fish from all Columbia Basin hatcheries could lead to increased competition with natural-origin fish for food and habitat space in the estuary (NMFS 2013e). NMFS (2011b) and Lower Columbia Fish Recovery Board (LCFRB)(2010) identified quantifying levels of competition for food and space among hatchery and natural-origin juveniles in the estuary as a critical uncertainty. As stream-type fish, coho salmon spend less time in the Columbia River estuary and plume than do ocean-type salmon, such as fall Chinook, yet possible ecological interactions in this geographic area likely play a role. ODFW (2010) acknowledged that uncertainty but listed competition for food and space as a secondary limiting factor for juveniles of all populations. NMFS is working to better define and describe the scientific uncertainty associated with ecological interaction between hatchery-origin and natural-origin salmon and steelhead in freshwater, estuarine, and nearshore ocean habitats (NMFS 2013e).

As mentioned above, high proportions of hatchery-origin fish in spawning populations has been purposeful in some areas, e.g. for reintroduction purposes in the Upper Cowlitz and Lewis subbasins, and will continue, but the recent opinion on the majority of hatchery production affecting this ESU (NMFS 2017e) expects Federal funding guideline requirements to reduce limiting factors relative to hatchery effects over the course of the next decade.

2.2.4. Status of the Chum Salmon ESU

One chum salmon ESU was evaluated in this Opinion, the Columbia River Chum Salmon ESU. The recovery domain and population information for this ESU is detailed below in Table 45.

Table 45. Chum salmon ESA-listed salmon population considered in this Opinion.

Recovery Domain	ESU	MPGs	Populations
Willamette/Lower Columbia	Columbia River chum salmon	3	17
Total	1 ESU	3	17

Historically, chum salmon had the widest distribution of all Pacific salmon species, comprising up to 50% of annual biomass of the seven species, and may have spawned as far up the Columbia River drainage as the Walla Walla River (Nehlsen, Williams, and Lichatowich 1991). Chum salmon fry emerge from March through May (LCFRB 2010), typically at night (ODFW 2010), and are believed to migrate promptly downstream to the estuary for rearing. Chum salmon fry are capable of adapting to seawater soon after emergence from gravel (LCFRB 2010). Their small size at emigration is thought to make chum salmon more susceptible to predation mortality during this life stage (LCFRB 2010).

Given the minimal time juvenile chum salmon spend in their natural streams, the period of estuarine residency appears to be a critical phase in their life history and may play a major role in determining the size of returning adults (NMFS 2013f); (NMFS 2013e). Chum and ocean-type Chinook salmon usually spend more time in estuaries than do other anadromous salmonids—weeks or months, rather than days or weeks (NMFS 2013f); (NMFS 2013e). Shallow, protected habitats, such as salt marshes, tidal creeks, and intertidal flats serve as significant rearing areas for juvenile chum salmon during estuarine residency (LCFRB 2010).

Juvenile chum salmon rear in the Columbia River estuary from February through June before beginning long-distance ocean migrations (LCFRB 2010). Chum salmon remain in the North Pacific and Bering Sea for 2 to 6 years, with most adults returning to the Columbia River as 4-year-olds (ODFW 2010). All chum salmon die after spawning once.

2.2.4.1. Willamette/Lower Columbia Recovery Domain

2.2.4.1.1. Columbia River Chum Salmon ESU

On March 25, 1999, NMFS listed the Columbia River Chum Salmon ESU as a threatened species (64 FR 14508). The threatened status was most recently reaffirmed on April 14, 2014 (79 FR 20802). Critical habitat was designated on September 2, 2005 (70 FR 52746). In 2022, NMFS published its most recent 5-year review for Columbia River chum salmon (SWFSC 2022).

The ESU includes all naturally spawning populations of chum salmon in the Columbia River and its tributaries in Washington and Oregon, along with the hatchery chum salmon described in Table 46. This ESU is comprised of three MPGs and has 17 natural populations (Table 46). Chum salmon are primarily limited to the tributaries downstream of Bonneville Dam and the majority of the fish spawn in Washington tributaries of the Columbia River (Figure 34). Inside the geographic range of the ESU, three hatchery chum salmon programs are currently operational. Table 46 lists these hatchery programs, which are all included in the ESU (SWFSC 2022).

Columbia River chum salmon are classified as fall-run fish, entering freshwater from mid-October through November and spawning from early November to late December in the lower mainstems of tributaries and side channels. There is evidence that a summer-run chum salmon population returned historically to the Cowlitz River, and fish displaying this life history are occasionally observed there. The recovery scenario currently includes this as an identified population in the Cascade MPG (Table 46).

Table 46. Columbia River Chum Salmon ESU description and MPGs. The designations "(C)" and "(G)" identify Core and Genetic Legacy populations, respectively (McElhany et al. 2003); (Myers et al. 2006); (NMFS 2013e); (SWFSC 2022).

ESU Description	
Threatened	Listed under ESA in 1999; updated in 2014
3 MPGs	17 historical populations
MPG	***Populations***
Coast	Youngs Bay (C), Grays/Chinook (C,G), Big Creek (C), Elochoman/Skamokawa (C), Clatskanie, Mill/Abernathy/Germany Creeks, Scappoose
Cascade	Cowlitz-fall (C), Cowlitz-summer (C), Kalama, Lewis (C), Salmon Creek, Clackamas (C), Sandy, Washougal
Gorge	Lower Gorge (C,G), Upper Gorge[a]
Artificial production	
Hatchery programs included in ESU (3)	Grays River, Washougal Hatchery/Duncan Creek, Big Creek Hatchery
Hatchery programs not included in ESU (0)	N/A

[a] Includes White Salmon population.

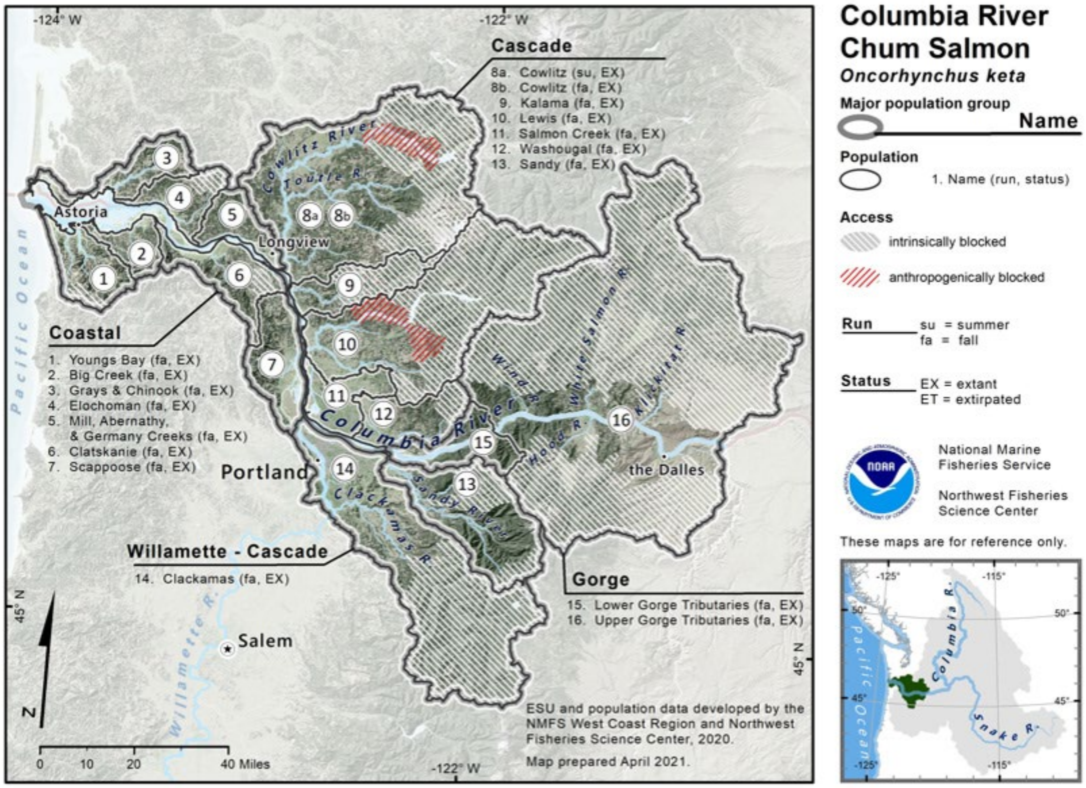


Figure 34. Map of the Columbia River chum salmon ESU's spawning and rearing areas, illustrating all 17 demographically independent populations and the three MPGs. Note that Population 8, Cowlitz River, contains two demographically independent populations, a fall and a summer run (Ford 2022).

2.2.4.1.1.1. Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the Columbia River Chum Salmon ESU, is at high risk and remains at threatened status. Target abundance that would be consistent with delisting criteria for each Columbia River chum salmon natural population is summarized in Table 47, along with the current 5-year mean abundance. Persistence probability is measured over a 100-year time period and ranges from very low (probability of less than 40%) to very high (probability of greater than 99%).

Table 47. Current five-year geometric mean of raw natural-origin spawner abundances and recovery targets for Lower Columbia River chum salmon demographically independent populations. Colors indicate the relative proportion of the recovery target currently obtained: red = <10%, orange = 10% > x < 50%, yellow = 50% > x < 100%, green = >100%. Numbers in parentheses represent total (hatchery and natural-origin) spawners (Ford 2022).

		Abundance	
Stratum	**Population**	**2015–19**	**Target**
Coast	Youngs Bay FA (OR)	n/a	<500
	Grays/Chinook River FA (WA)	10,027	1,600
	Big Creek FA (OR)	n/a	<500
	Elochoman/Skamokawa FA (WA)	n/a	1,300
	Clatskanie River FA (OR)	n/a	1,000
	Mill/Abernathy/Germany Creeks (WA)	n/a	1,300
	Scappoose Creek (OR)	n/a	1,000
Cascade	Cowlitz River SU (WA)	n/a	900
	Cowlitz River FA (WA)	n/a	900
	Kalama River FA (WA)	n/a	900
	Lewis River FA (WA)	n/a	1,300
	Salmon Creek FA (WA)	n/a	n/a
	Clackamas River FA (OR)	n/a	500
	Sandy River FA (OR)	n/a	1,000
	Washougal River (WA)	3,003	1,300
Gorge	Lower Gorge FA (WA & OR)	3,124	2,000
	Upper Gorge FA (WA & OR)	(85)	900

2.2.4.1.1.1.1. Abundance and Productivity

Over the last century, Columbia River chum salmon returns have collapsed from hundreds of thousands to just a few thousand per year (NMFS 2013e). Of the 17 natural populations that historically made up this ESU, 15 of them (six in Oregon and nine in Washington) are so depleted that either their baseline probability of persistence is very low, extirpated, or nearly so (Ford et al. 2011); (NMFS 2013e); (NWFSC 2015). The Grays River and Lower Gorge populations showed a sharp increase in 2002 for several years, but have since declined back to relatively low abundance levels in the range of variation observed over the last several decades.

It is notable that during this most recent review period, the three populations (Grays River, Washougal, and Lower Gorge demographically independent populations) improved markedly in abundance (Figure 35). Improvements in productivity were observed in almost every year during the 2015–19 interval (Ford 2022). This is somewhat surprising, given that the majority of chum salmon emigrate to the ocean as subyearlings after only a few weeks, and one would expect the poor ocean conditions to have a strong negative influence on the survival of juveniles (as with many of the other ESUs in this region). In contrast to these three demographically independent populations, the remaining populations in this ESU have not exhibited any detectable improvement in status (Ford 2022). Abundances for these populations are assumed to be at or near zero, and straying from nearby healthy populations does not seems sufficient to reestablish self-sustaining populations (Table 47 and Table 48). It may be that the chum salmon life-history strategy of emigrating post-emergence en masse (possibly as a predator swamping mechanism) requires a critical number of spawners to be effective (Ford 2022).

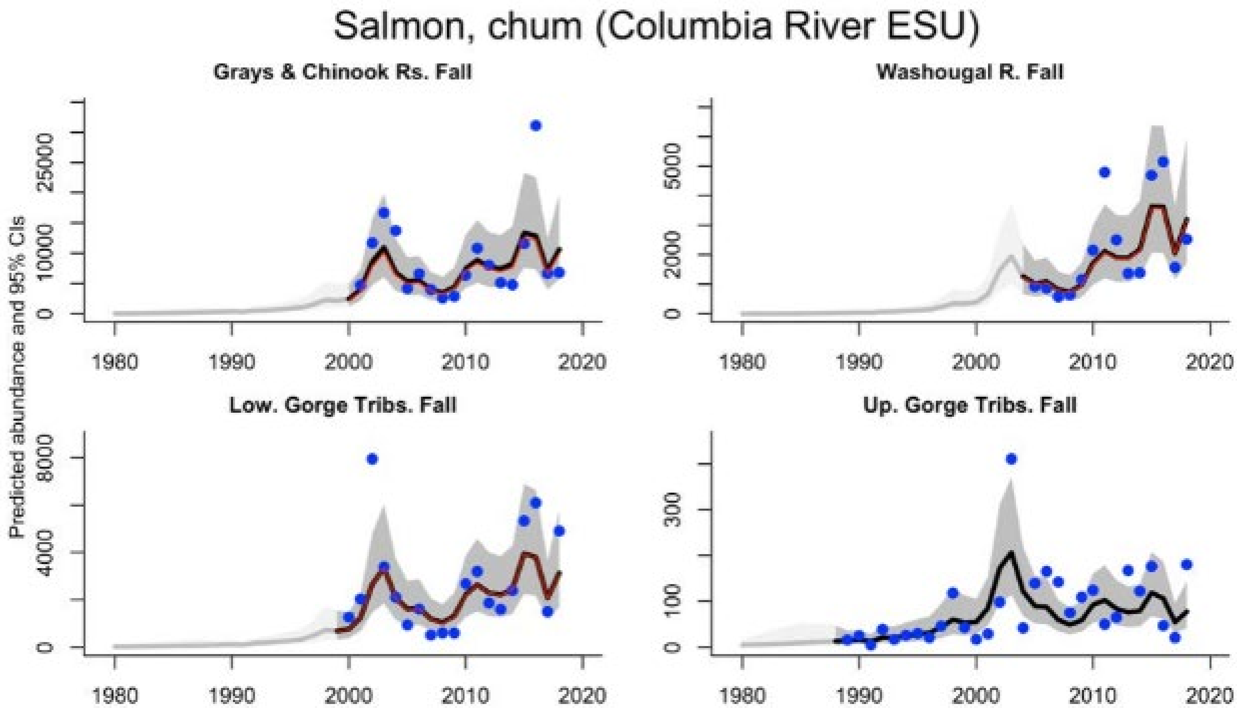


Figure 35. Smoothed trend in estimated total (thick black line, with 95% confidence interval in gray) and natural (thin red line) population spawning abundance.In portions of a time series where a population has no annual estimates but smoothed spawning abundance is estimated from correlations with other populations, the smoothed estimate is shown in light gray. Points show the annual raw spawning abundance estimates. For some trends, the smoothed estimate may be influenced by earlier data points not included in the plot. Lower Gorge Tributaries include mainstem Columbia River spawning aggregates (Ives Island, Horsetail Falls, etc.). Upper Gorge Tributaries is based on the Bonneville Dam count, although many chum salmon counted upstream are known to have fallen back and spawned below Bonneville Dam (Ford 2022).

Of the risk factors considered, freshwater habitat conditions may be negatively influencing spawning and early rearing success in some basins, and contributing to the overall low productivity of the ESU. Recent studies also suggest that a freshwater parasite, *Ceratonova shasta*, may be limiting the survival of juvenile chum salmon (WDFW and ODFW 2019). The prevalence of this parasite may increase with warmer water temperatures from flow modification or climatic change. Land development, especially in the low-gradient reaches that chum salmon prefer, will continue to be a threat to most chum populations due to projected increases in the population of the greater Vancouver–Portland area and the LCR overall (Metro 2014). The viability of this ESU is relatively unchanged since the prior review, and the improvements in some populations do not warrant a change in risk category, especially given the uncertainty regarding climatic effects in the near future. The LCR chum salmon ESU therefore remains at "moderate" risk of extinction, and the viability is largely unchanged from the prior review.

2.2.4.1.1.1.1.1. <u>Harvest</u>

Columbia River chum salmon were historically abundant and subject to substantial harvest until the 1950s (Johnson et al. 1997). In recent years, there has been no directed harvest of Columbia River chum salmon (NMFS 2018c). Data on the incidental harvest of chum salmon in LCR gillnet fisheries exist, but escapement data are inadequate to calculate exploitation rates. Incidental commercial landings have been approximately 100 fish per year since 1993 (except 275 fish in 2010), and all recreational fisheries have been closed since 1995 (Ford 2022). The incidental harvest rate on Columbia River chum salmon was estimated to be 0.3% in 2018 (ODFW and WDFW 2020). Overall, the exploitation rate has been estimated at below 1% for the last five years (Ford 2022).

2.2.4.1.1.1.2. Spatial Structure and Diversity

Chum salmon generally spawn in the mainstem Columbia River (in areas of groundwater seeps) and the lower reaches of both large and small tributaries, with the exception of the Cowlitz River (Myers et al. 2006). In contrast to other species, mainstem dams have less of an effect on chum salmon distribution; rather, it is smaller, stream-scale blockages that limit chum access to spawning habitat. Upland development can also affect the quality of spawning habitat by disrupting the groundwater upwelling that chum prefer. In addition, juvenile habitat has been curtailed through dikes and revetments that block access to riparian areas that are normally inundated in the spring. Loss of lower river and estuary habitat probably limits the ability of chum salmon to expand and recolonize historical habitat. Presently, detectable numbers of chum salmon persist in only four of the 17 demographically independent populations, a fraction of their historical range (Ford 2022).

2.2.4.1.1.1.2.1. <u>Hatcheries</u>

Hatchery managers have continued to implement and monitor changes in chum hatchery management since the 2016 5-year review (SWFSC 2022). All of the hatchery programs in this ESU use integrated stocks developed to supplement natural production. The goal of these programs for chum salmon is conservation and rebuilding population abundances throughout the ESU, including getting sufficient returns of chum salmon to the Big Creek hatchery. Given the low numbers of hatchery chum salmon released throughout the ESU (approximately 500,000;

Figure 36), the vast majority of spawning fish are of natural-origin (>90%; Table 48) (Ford 2022). Existing hatchery programs for chum salmon are important for the conservation and recovery of this ESU (NMFS 2017e). The most recent status review concluded that risk to this ESU from hatchery programs is low (SWFSC 2022).

Overall, the status of most chum salmon populations is unchanged from the baseline VSP scores estimated in the recovery plan. A total of three of 17 populations exceed the recovery goals established in the recovery plan (NMFS 2013e). The remaining populations have unknown abundances, although it is reasonable to assume that the abundances are very low and unlikely to be more than 10% of the established recovery goals (Ford 2022). Although the Big Creek demographically independent population is currently supported by a hatchery supplementation program, natural-origin returns have been very low (Ford 2022). Even with the improvements observed during the last five years, the majority of demographically independent populations in this ESU remain at a "very high" risk level (Ford 2022). With so many primary demographically independent populations at near-zero abundance, none of the MPGs could be considered viable (Ford 2022). The viability of this ESU is relatively unchanged since the NWFSC (2015) report, and the improvements in some populations do not warrant a change in the "moderate to high risk" category described, especially given the uncertainty regarding climatic effects in the near future (SWFSC 2022)[15].

Table 48. Five-year mean of fraction natural-origin spawner (sum of all estimates divided by the number of estimates) in Lower Columbia River chum salmon populations. Blanks (—) indicate that no estimate was available in that 5-year range (Ford 2022).

Population[a]	MPG	1996–2000	2001–05	2006–10	2011–15	2016–20
Grays/Chinook Rivers Fall	Coastal	—	0.92	0.95	0.93	0.95
Washougal River Fall	Cascade	—	0.98	0.97	—	0.99
Lower Gorge Tributaries Fall	Gorge	1	0.99	0.98	1.00	1.00
Upper Gorge Tributaries Fall	Gorge	—	—	—	—	—

[a] Note that the Youngs Bay (Coastal), Big Creek (Coastal), Cispus (Cascade), Elochoman/Skamokawa (Coastal), Clatskanie, Mill/Abernathy/Germany Creeks (Coastal), Scappoose (Coastal), Cowlitz-fall (Cascade), Cowlitz-summer (Cascade), Kalama (Cascade), Lewis (Cascade), Salmon Creek (Cascade), Clackamas (Cascade), and Sandy (Cascade) populations are not included due to low abundances or lack of monitoring and available data, as discussed further in Ford (Ford 2022)

[15] The NWFSC viability assessment identified risk category as "moderate" (Ford 2022).

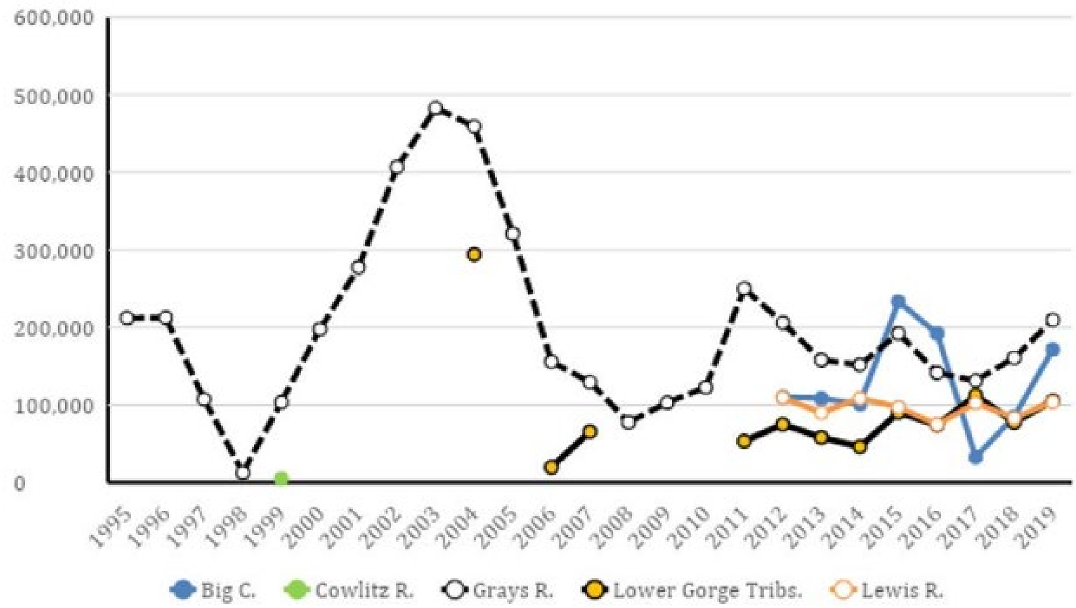


Figure 36. Releases of juvenile chum salmon into the Lower Columbia River. All releases were from sources originating from within the ESU. Data from the Regional Mark Information System (https://www.rmpc.org, April 2020). Figure reproduced from Ford (Ford 2022).

2.2.4.1.1.1.3. Summary

Overall, the status of most chum salmon populations is unchanged from the baseline VSP scores estimated in the recovery plan. A total of three of 17 populations exceed the recovery goals established in the recovery plan (NMFS 2013e). The remaining populations have unknown abundances, although it is reasonable to assume that the abundances are very low and unlikely to be more than 10% of the established recovery goals (Ford 2022). Although the Big Creek demographically independent population is currently supported by a hatchery supplementation program, natural-origin returns have been very low (Ford 2022). Even with the improvements observed during the last five years, the majority of demographically independent populations in this ESU remain at a "very high" risk level (Ford 2022). With so many primary demographically independent populations at near-zero abundance, none of the MPGs could be considered viable (Ford 2022). The viability of this ESU is relatively unchanged since the NWFSC (2015) report, and the improvements in some populations do not warrant a change in the "moderate to high risk" category described, especially given the uncertainty regarding climatic effects in the near future (SWFSC 2022)[16].

[16] The NWFSC viability assessment identified risk category as "moderate" (Ford 2022).

2.2.4.1.1.2. Limiting Factors

Understanding the limiting factors and threats that affect the Columbia River Chum Salmon ESU provides important information and perspective regarding the status of a species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. There are many factors that affect the abundance, productivity, spatial structure, and diversity of the Columbia River Chum Salmon ESU. Factors that limit the ESU have been, and continue to be, loss and degradation of spawning and rearing habitat including the estuary, impacts of mainstem hydropower dams on upstream access and downstream habitats, and the legacy effects of historical harvest; together, these factors have reduced the persistence probability of all populations (NMFS 2013e). Columbia River chum salmon were historically abundant and were subject to extensive harvest until the 1950s (Johnson et al. 1997); (NWFSC 2015). Other threats to the species include climate change impacts.

The recovery plan provides a detailed discussion of limiting factors and threats and describes strategies for addressing each of them. Chapter 4 of the recovery plan (NMFS 2013e) describes limiting factors on a regional scale and how they apply to the four listed species from the LCR considered in the plan, including the Columbia River Chum Salmon ESU (NMFS 2013e). Chapter 4 (NMFS 2013e) includes details on large scale issues including the following:

- Ecological interactions,
- Climate change, and
- Human population growth

Chapter 8 of the recovery plan discusses the limiting factors that pertain to Columbia River chum salmon natural populations specifically and the MPGs in which they reside. The discussion in Chapter 8 (NMFS 2013e) is organized to address the following:

- Tributary habitat,
- Estuary habitat,
- Hydropower,
- Hatcheries,
- Harvest, and
- Predation

Rather than repeating this extensive discussion from the recovery plan, the discussions in Chapter 4 and 8 are incorporated here by reference.

2.2.5. Status of the Sockeye Salmon ESU

Only one ESU of sockeye salmon was evaluated in this Opinion, the Snake River Sockeye Salmon ESU. The Snake River Sockeye Salmon ESU contains one MPG and one extant population and is contained within the Interior Columbia Recovery Domain. While there are very few sockeye salmon currently following an anadromous life cycle in the Snake River, the small remnant run of the historic population migrates 900 miles downstream from the Sawtooth Valley through the Salmon, Snake, and Columbia Rivers to the ocean (Figure 37). After one to three years in the ocean, they return to the Sawtooth Valley as adults, passing once again through these mainstem rivers and through eight major Federal dams, four on the Columbia River and four on the lower Snake River. Anadromous sockeye salmon returning to Redfish Lake in Idaho's Sawtooth Valley travel a greater distance from the sea, 900 miles, to a higher elevation (6,500 ft.) than any other sockeye salmon population. They are the southernmost population of sockeye salmon in the world (NMFS 2015e).

2.2.5.1. Interior Columbia Recovery Domain

2.2.5.1.1. Snake River Sockeye Salmon ESU

On November 20, 1991, NMFS listed the Snake River Sockeye Salmon ESU as an endangered species (56 FR 58619) under the ESA. This listing was affirmed in 2005 (70 FR 37160), and again on April 14, 2014 (79 FR 20802). Critical habitat was designated on December 28, 1993 (58 FR 68543). In 2022, NMFS published the most recent 5-year status review for Snake River sockeye salmon (NMFS 2022f). The ESU includes naturally spawned anadromous and residual sockeye salmon originating from the Snake River Basin in Idaho, as well as two artificially propagated sockeye salmon programs (Table 49).

Table 49. Snake River Sockeye Salmon ESU description and MPG (Ford 2022); (NMFS 2022f).

ESU Description	
Endangered	Listed under ESA in 1991; updated in 2005 and 2014
1 MPG	3-5 historical populations (2-4 extirpated)
MPG	***Population***
Sawtooth Valley	Redfish Lake
Artificial production	
Hatchery programs included in ESU (2)	Redfish Lake Captive Broodstock Program, Snake River Sockeye Salmon Hatchery Program
Hatchery programs not included in ESU (0)	Not applicable

The ICTRT treats Sawtooth Valley sockeye salmon as the single MPG within the Snake River Sockeye Salmon ESU. The MPG contains one extant population (Redfish Lake) and two to four historical populations (NMFS 2015e) (Figure 37). At the time of listing in 1991, the only confirmed extant population included in this ESU was the beach-spawning population of sockeye salmon from Redfish Lake, with about 10 fish returning per year (NMFS 2015e). Historical records indicate that sockeye salmon once occurred in several other lakes in the Stanley Basin, but no adults were observed in these lakes for many decades; once residual sockeye salmon were observed, their relationship to the Redfish Lake population was uncertain (McClure, Cooney, and ICTRT 2005). Since ESA-listing, progeny of the Redfish Lake sockeye salmon population have been outplanted to Pettit and Alturas lakes within the Sawtooth Valley for recolonization purposes (NMFS 2011f).

Lakes in the Stanley Basin and Sawtooth Valley are relatively small compared to the other lake systems that historically supported sockeye salmon production in the Columbia Basin. The average abundance targets recommended by the Snake River Recovery Team (Bevan et al. 1994) were incorporated as minimum abundance thresholds into a sockeye salmon viability curve. The viability curve was generated using historical age structure estimates from Redfish Lake sampling in the 1950s to the 1960s, and year-to-year variations in brood-year replacement rates generated from abundance series for Lake Wenatchee sockeye salmon. The minimum spawning abundance threshold is set at 1,000 for the Redfish and Alturas Lake populations (intermediate category for lake size), and at 500 for populations in the smallest historical size category for lakes (i.e., Alturas and Pettit Lakes). Because space in the lakes is limited, the available spawning capacity may also be limited based on available habitat. The ICTRT recommended that long-term recovery objectives should include restoring at least three of the lake populations in this ESU to viable or highly viable status.

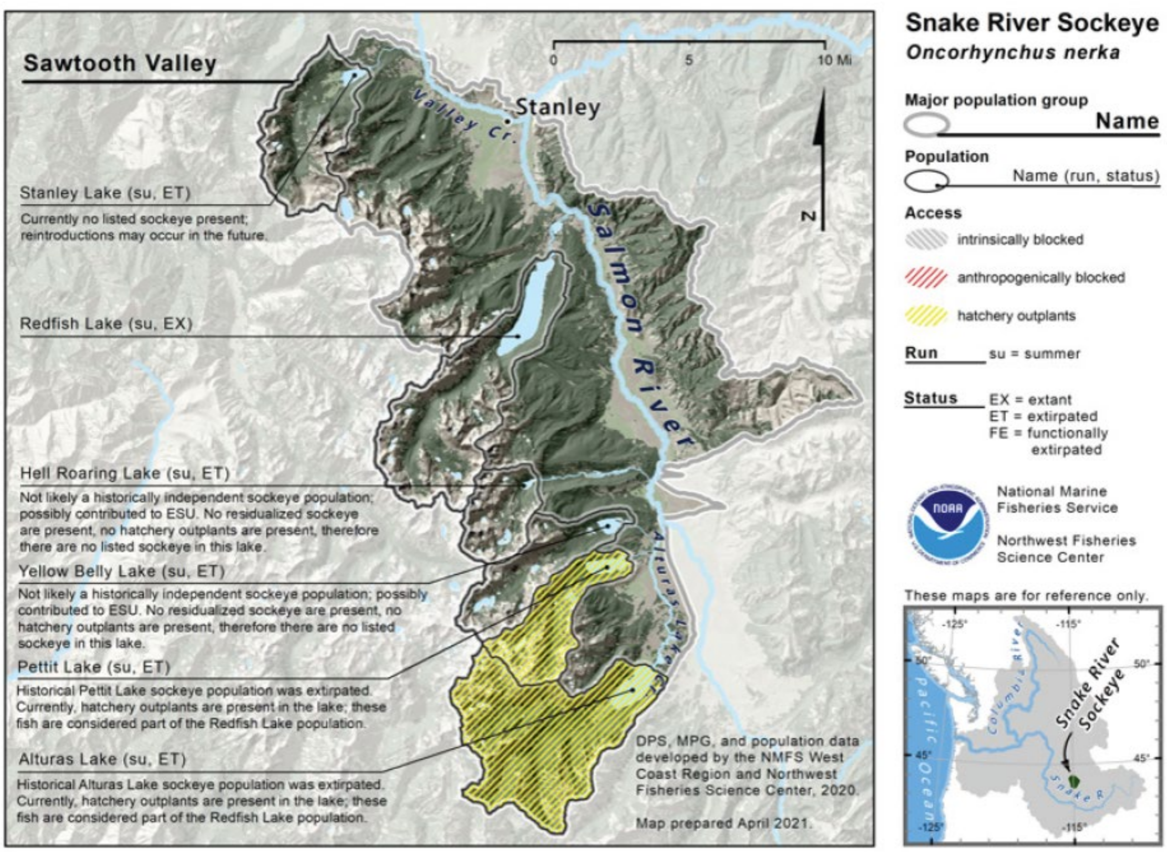


Figure 37. Map of the Snake River Sockeye Salmon ESU's spawning and rearing areas, illustrating populations and MPGs (Ford 2022).

2.2.5.1.1.1. Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the Snake River Sockeye Salmon ESU, is at high risk and remains at endangered status (Ford 2022).

2.2.5.1.1.1.1. Abundance and Productivity

Prior to the turn of the 20th century (ca. 1880), around 150,000 sockeye salmon ascended the Snake River to the Wallowa, Payette, and Salmon River basins to spawn in natural lakes Evermann, 1896, as cited in Chapman et al. (1990). The Wallowa River sockeye salmon run was considered extinct by 1905, the Payette River run was blocked by Black Canyon Dam on the Payette River in 1924, and anadromous Warm Lake sockeye salmon in the South Fork Salmon River basin may have been trapped in Warm Lake by a land upheaval in the early 20th century (ICTRT 2003). In the Sawtooth Valley, the Idaho Department of Fish and Game eradicated sockeye salmon from Yellowbelly, Pettit, and Stanley Lakes in favor of other species in the 1950s and 1960s, and irrigation diversions led to the extirpation of sockeye salmon in Alturas Lake in the early 1900s (ICTRT 2003), leaving only the Redfish Lake sockeye salmon population. From 1991 to 1998, a total of just 16 wild adult anadromous sockeye salmon returned to Redfish Lake. These 16 wild fish were incorporated into a captive broodstock program that began in 1992 and has since expanded. The program currently releases hundreds of thousands of juvenile fish each year in the Sawtooth Valley (Ford et al. 2011).

The increased abundance of hatchery reared Snake River sockeye salmon reduces the risk of extinction over the short-term, but levels of naturally produced sockeye salmon returns are variable and remain extremely low (Ford 2022). The ICTRT's viability target is at least 1,000 naturally produced spawners per year in each of Redfish and Alturas Lakes and at least 500 in Pettit Lake (ICBTRT 2007). The highest adult returns since the captive broodstock program began were in 2014, with a total of 1,579 counted in the Stanley Basin (Ford 2022). The general increases observed in the number of adult returns during 2008–2014 (Figure 41) were likely due to a number of factors, including increases in hatchery production and favorable marine conditions. The 5-year geometric mean of natural-origin adult returns was 137 for 2010–2014. Since then, natural-origin adult returns have declined (Figure 41) with a 2015–2019 5-year geometric mean of 16 (Ford 2022). Adult returns crashed in 2015 (Figure 38) due to a combination of low flows and warm water temperatures in the migration corridor. There was also high in-basin mortality of smolts released in 2015–2017 due to water chemistry shock between hatchery waters and the water of Redfish Lake (Ford 2022). Poor survival and growth in the ocean also play a role in low returns. The total number of returning adults documented in the Sawtooth Valley in 2020, 2021 and 2022 was 152, 55, and 749, respectively (Johnson, Plaster, and Powell 2021)[17].

[17] https://idfg.idaho.gov/press/july-sockeye-counts-lower-granite-dam-could-signal-larger-return-recent-years and https://idfg.idaho.gov/conservation/sockeye

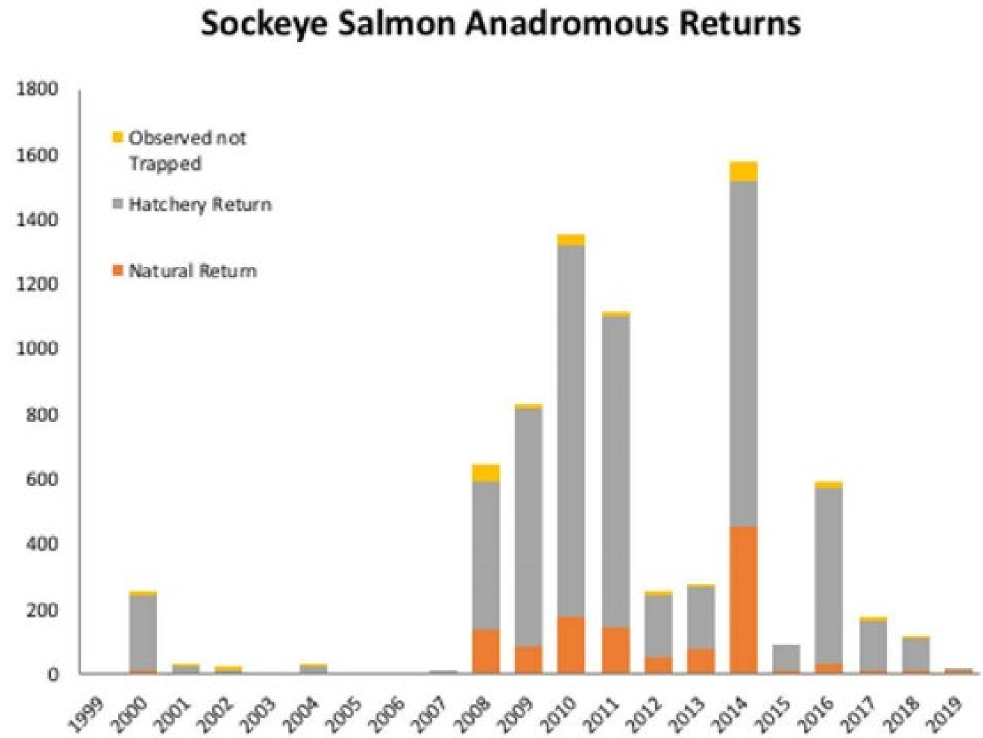


Figure 38. Snake River sockeye salmon anadromous returns, 1999–2019 (figure from Johnson et al. (2020).

2.2.5.1.1.1.1.1. <u>Harvest</u>

Ocean fisheries do not significantly impact Snake River sockeye salmon (Ford 2022). Within the mainstem Columbia River, treaty tribal net fisheries and non-tribal fisheries directed at Chinook salmon do incidentally take small numbers of sockeye salmon (Ford 2022). Most of the sockeye salmon harvested are from the UCR (Canada and Lake Wenatchee), but very small numbers of Snake River sockeye salmon are taken incidental to summer fisheries directed at Chinook salmon (Ford 2022). In the 1980s, fishery impact rates increased briefly due to directed sockeye salmon fisheries on large runs of UCR stocks (Figure 39).

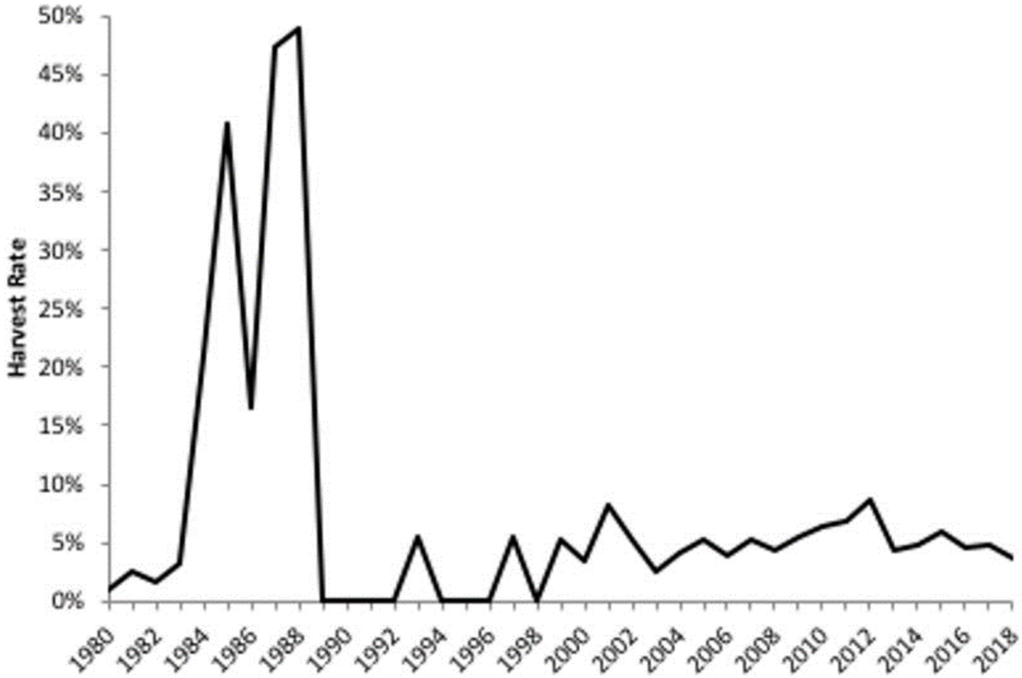


Figure 39. Exploitation rates on Snake River sockeye salmon. Figure reproduced from Ford (Ford 2022).

2.2.5.1.1.1.2. Spatial Structure and Diversity

There is evidence that the historical Snake River Sockeye Salmon ESU supported a range of life-history patterns, with spawning populations present in several of the small lakes in the Stanley Basin (NMFS 2015e). Historical production from Redfish Lake was likely associated with a lake shoal spawning life-history pattern, although there may have also been some level of spawning in Fishhook Creek (NMFS 2015e). Historical accounts indicate that Alturas Lake Creek supported an early timed riverine, and may have also contained lake shoal spawners (NMFS 2015e).

At present, anadromous returns are dominated by production from the captive spawning component. The ongoing reintroduction program is still in the phase of building sufficient returns to allow for large-scale reintroduction into Redfish Lake, the initial target for restoring natural production (NMFS 2015e). Initial releases of adult returns directly into Redfish Lake have been observed spawning in multiple locations along the lake shore, as well as in Fishhook Creek (NMFS 2015e). There is some evidence of very low levels of early timed returns in some recent years from outmigrating, naturally produced Alturas Lake smolts. At this stage of the recovery efforts, the ESU remains rated at "high risk" for both spatial structure and diversity.

2.2.5.1.1.1.2.1. Hatcheries

Currently, there are two ESA-listed sockeye salmon hatchery programs in the Snake River basin (Table 49). The hatchery programs' priorities are genetic conservation and building sufficient returns to support sustained outplanting (NMFS 2013d);(NMFS 2015e). While 318 returning anadromous adults have been released into Redfish and Pettit Lakes since the most recent 5-year review, the captive broodstock program provides the majority of the volitional spawners outplanted into Redfish and Pettit lakes.

The number of Snake River sockeye salmon outmigrants continued to increase through 2019 (Johnson, Plaster, et al. 2020). After a dip in survival was detected due to disparities in water hardness, stepwise acclimation from high to medium-hardness water and then from medium to low-hardness water was implemented (NMFS 2022f). Fish acclimated in this manner survived to Lower Granite Dam at a rate of 69 to 75%, while smolts directly released into Redfish Lake Creek survived at only 18% (Trushenski et al. 2019). In addition to poor transition survival, poor ocean conditions also contributed to low adult returns from these releases (Johnson, Kozfkay, et al. 2020).

In 2020, there were only 26 adult hatchery returns (NMFS 2022f) out of 785,000 hatchery smolt/presmolts released (Johnson et al. 2019). For the same brood year, natural-origin smolt-to-adult survival was higher with 34,009 emigrants producing 126 adult returns to the Sawtooth Valley. Despite improved survival of outmigrants, the cause of poor returns remains uncertain but may be tied to unintentional changes to smolt release size. This may suggest room for improvement with current hatchery practices and/or poor ocean conditions.

Natural-origin smolts survive at slightly lower rates than Sawtooth Fish Hatchery produced smolts when migrating from Redfish Lake to Lower Granite Dam (natural survival = 42% [2000–2018]; hatchery survival = 50% [2004–2015]) (Johnson, Plaster, et al. 2020). Differences in natural and hatchery smolt survival rates increase when measured at Bonneville Dam. For example, in 2019, natural smolt survival to Bonneville Dam's tailrace was about 16% while Sawtooth Hatchery smolt survival was 26% (Johnson, Plaster, et al. 2020). Despite these differences, natural origin smolts exhibit higher smolt-to-adult return survival rates than other life histories. When ocean conditions are considered good, contemporary (2010s) smolt-to-adult return survival estimates are similar to historically (1990s) observed smolt-to-adult return survival rates (Kozfkay et al. 2019).

2.2.5.1.1.1.3. Summary

In terms of natural production, the Snake River Sockeye Salmon ESU remains at "extremely high risk," although there has been substantial progress on the first phase of the proposed recovery approach—developing a hatchery-based program to amplify and conserve the stock to facilitate reintroductions (Ford 2022). Current climate change modeling supports the "extremely high risk" rating with the potential for extirpation in the near future (Crozier et al. 2020). The viability of the Snake River Sockeye Salmon ESU therefore has likely declined since the time of the prior review (NWFSC 2015), and the extinction risk category remains "high" (Ford 2022).

2.2.5.1.1.2. Limiting Factors

Understanding the limiting factors and threats that affect the Snake River Sockeye Salmon ESU provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. In the 1980s, fishery impact rates increased briefly due to directed sockeye salmon fisheries on large runs of UCR stocks. By the 1990s, very small numbers of this species remained in the Snake River Basin (Ford 2022).

There are many factors that affect the abundance, productivity, spatial structure, and diversity of the Snake River Sockeye Salmon ESU. Factors that limit the ESU have been, and continue to be the result of impaired mainstream and tributary passage, historical commercial fisheries, chemical treatment of Sawtooth Valley lakes in the 1950s and 1960s, poor ocean conditions, Snake and Columbia River hydropower system, and reduced tributary stream flows and high temperatures (NMFS 2015e). These combined factors reduced the number of sockeye salmon that make it back to spawning areas in the Sawtooth Valley to the single digits, and in some years, zero. The decline in abundance itself has become a major limiting factor, making the remaining population vulnerable to catastrophic loss and posing significant risks to genetic diversity (NMFS 2015e); (Ford 2022).

Today, some threats that contributed to the original listing of Snake River sockeye salmon now present little harm to the ESU, while others continue to threaten viability. Fisheries are now better regulated through ESA constraints and management agreements, significantly reducing harvest-related mortality. Potential habitat-related threats to the fish, especially in the Sawtooth Valley, pose limited concern since most passage barriers have been removed and much of the natal lake area and headwaters remain protected. Hatchery-related concerns have also been reduced through improved management actions (NMFS 2015e).

The recovery plan (NMFS 2015e) provides a detailed discussion in Chapters 5-7 of limiting factors and threats, and describes strategies and actions for addressing each of them. These limiting factors and threats include the following:

- Water quality (i.e. sedimentation and pollutants)
- Invasive species
- Blocked access to lakes
- Historical land use effects
- Current recreational use and development
- Irrigation water withdrawals
- FCRPS flow management
- Hydropower
- Fisheries
- Predation and disease
- Competition
- Climate change

Rather than repeating this extensive discussion from the recovery plan, the discussions in Chapters 5-7 are incorporated here by reference. Overall, the recovery strategy aims to reintroduce and support adaptation of naturally self-sustaining sockeye salmon populations in the Sawtooth Valley lakes. An important first step towards that objective has been the successful establishment of anadromous returns from natural-origin Redfish Lake resident stock gained through a captive broodstock program. The long-term strategy is for the naturally produced population to achieve escapement goals in a manner that is self-sustaining and without the reproductive contribution of hatchery spawners (NMFS 2015e).

In terms of natural production, the Snake River Sockeye Salmon ESU remains at extremely high risk although there has been substantial progress on the first phase of the proposed recovery approach – developing a hatchery-based program to amplify and conserve the stock to facilitate reintroductions. At this stage of the recovery program there is no basis for changing the ESU ratings assigned in prior reviews (Ford 2022).

2.2.6. Status of the Steelhead DPSs

Steelhead spawn in a wide range of conditions ranging from large streams and rivers to small streams and side channels (Myers et al. 2006). Steelhead are rainbow trout (*O. mykiss*) that migrate to and from the ocean (i.e., anadromous). Resident and anadromous life-history patterns are often represented in the same populations, with either life-history pattern yielding offspring of the opposite form. Steelhead are iteroparous, meaning they can spawn more than once. Repeat spawners are called “kelts” (NMFS 2013e).

Productive steelhead habitat is characterized by suitable gravel size, depth, and water velocity, and also by complexity that is primarily added in the form of large and small wood (Barnhart 1986). Steelhead may enter streams and arrive at spawning grounds weeks or even months before spawning and therefore are vulnerable to disturbance and predation. They need cover in the form of overhanging vegetation, undercut banks, submerged vegetation, submerged objects (e.g., logs, rocks), floating debris, deep water, turbulence, and turbidity (Geiger 1973). Their spawn timing must optimize avoiding risks from gravel-bed scour during high stream flows and increasing water temperatures that can become lethal to eggs. Spawning generally occurs earlier in areas of lower elevation, where water temperature is warmer, than in areas of higher elevation, with cooler water temperature.

Depending on water temperature, steelhead eggs may incubate for 35 to 50 days before hatching, and the alevins remain in the gravel 2 to 3 weeks thereafter, until the yolk-sac is absorbed. Generally, fry emergence occurs from March into July, with peak emergence time in April and May. Emergence timing is principally determined by the time of egg deposition and the water temperature during the incubation period. In the LCR, emergence timing differs slightly between winter and summer life-history types and among subbasins (NMFS 2013e). These differences may be a function of spawning location (and hence water temperature) or of genetic differences between life-history types.

Following emergence, fry usually move into shallow and slow-moving margins of the stream. As they grow, they inhabit areas with deeper water, with a wider range of velocities, and larger substrate, and they may move downstream to rear in large tributaries or mainstem rivers. Young steelhead typically rear in streams for some time before migrating to the ocean as smolts. Steelhead smolts generally migrate at ages ranging from 1 to 4 years with most smolting after 2 years in freshwater (Busby et al. 1996). Smoltification for steelhead has been described by Thorpe (Thorpe 1994) as a ‘‘developmental conflict’’ whereby juvenile steelhead are faced with three distinct possibilities every year: 1) undergo smoltification, followed by migration to the ocean; 2) begin maturation and attempt to spawn as a resident fish in the following winter (precocial residuals); and 3) remain in freshwater (natal streams, other tributaries, or the main channel of large rivers such as the Columbia River, etc.) and revisit these options in the following year (residuals, collectively). These possibilities represent a case of developmental plasticity where adoption of one of these three life-history strategies is initiated through the interplay of phenotypic expression with environmental and biological cues. In the LCR, outmigration of steelhead smolts (of both summer and winter life-history types) generally occurs from March to June, with peak migration usually in April or May (NMFS 2013e).

Both summer and winter steelhead occur in British Columbia, Washington and Oregon; Idaho only has summer steelhead; California is thought to have only winter steelhead (Busby et al. 1996). In the Pacific Northwest, summer steelhead enter freshwater between May and October, and winter steelhead enter freshwater between November and April (NMFS and ODFW 2011).

Sampling data suggest that juvenile steelhead migrate directly offshore during their first summer, rather than migrating nearer to the coast. Maturing Columbia River steelhead are found off the coast of Northern British Columbia and west into the North Pacific Ocean (Busby et al. 1996). Fin-mark and CWT data suggest that winter steelhead tend to migrate farther offshore but not as far north into the Gulf of Alaska as summer steelhead (Burgner et al. 1992). Most steelhead spend 2 years in the ocean (ranging from 1 to 4 years) before migrating back to their natal streams (Shapovalov and Taft 1954); (Narver 1969); (Ward and Slaney 1988). Once in the river, adult steelhead rarely eat and grow little, if at all. Unlike spring-run Chinook salmon, most steelhead do not move upstream quickly to tributary spawning streams.

Steelhead can residualize (i.e., lose the ability to smolt) in tributaries and never migrate to sea, thereby becoming resident rainbow trout. Conversely, progeny of resident rainbow trout can migrate to the sea and thereby become steelhead. Despite the apparent reproductive exchange between resident and anadromous *O. mykiss*, the two life forms remain separated physically, physiologically, ecologically, and behaviorally. Steelhead differ from resident rainbow trout physically in adult size and fecundity, physiologically by undergoing smoltification, ecologically in their preferred prey and principal predators, and behaviorally in their migratory strategy. Given these differences, NMFS believes that the anadromous steelhead populations are discrete from the resident rainbow trout populations (UCSRB 2007).

Steelhead species evaluated in this consultation include LCR steelhead, MCR steelhead, UCR steelhead, UWR steelhead, and Snake River Basin steelhead. Within these steelhead DPSs 72 demographically independent populations were identified (Table 50). These populations were further aggregated into strata or MPGs, groupings above the population level that are connected by some degree of migration, based on ecological subregions.

Table 50. Steelhead ESA-listed salmon populations considered in this Opinion.

Recovery Domain	DPS	MPGs	Populations
Willamette/Lower Columbia	Lower Columbia River steelhead	4	23
	Upper Willamette River steelhead	1	4
Interior Columbia	Middle Columbia River steelhead	4	17
	Upper Columbia River steelhead	3	4
	Snake River Basin steelhead	6	24
Totals	**Six DPSs**	**18**	**72**

2.2.6.1. Willamette/Lower Columbia Recovery Domain

2.2.6.1.1. Lower Columbia River Steelhead DPS

On March 19, 1998, NMFS listed the LCR Steelhead DPS as a threatened species (63 FR 13347). The threatened status was reaffirmed on January 5, 2006 (71 FR 834) and most recently on April 14, 2014 (79 FR 20802). Critical habitat for LCR steelhead was designated on September 2, 2005 (70 FR 52833). The most recent 5-year review for LCR steelhead was released in 2022 (SWFSC 2022). The DPS includes all naturally spawned anadromous steelhead populations below natural and manmade impassable barriers in streams and tributaries to the Columbia River between the Cowlitz and Wind Rivers, Washington (inclusive), and the Willamette and Hood Rivers, Oregon (inclusive), as well as multiple artificial propagation programs (Ford 2022); (SWFSC 2022).

Inside the geographic range of the DPS, 25 hatchery programs are currently operational, of which only 9 are considered part of the ESA-listed DPS description (Table 51). The LCR Steelhead DPS is composed of 23 historical populations, split by summer or winter life history, resulting in four MPGs (Table 51). There are six summer populations and seventeen winter populations (Table 51).

Lower Columbia River steelhead exhibit a complex life history (Figure 40, Table 52). Lower Columbia River basin populations include summer and winter steelhead (Ford 2022); (SWFSC 2022). The two life-history types differ in degree of sexual maturity at freshwater entry, spawning time, and frequency of repeat spawning (NMFS 2013e). Iteroparity (repeat spawning) rates for Columbia Basin steelhead have been reported as high as 2% to 6% for summer steelhead and 8% to 17% for winter steelhead (Leider, Chilcote, and Loch 1986); (Busby et al. 1996); (Hulett, Wagemann, and Leider 1996).

Historically, winter steelhead were likely excluded from Interior Columbia River subbasins by Celilo Falls. Winter steelhead favor lower elevation and coastal streams. Winter steelhead were historically present in all LCR subbasins and also return to other Columbia River tributaries as far upriver as Oregon’s Fifteenmile Creek.

Table 51. Lower Columbia River Steelhead DPS description and MPGs (Ford 2022); (SWFSC 2022). The designations "(C)" and "(G)" identify Core and Genetic Legacy populations, respectively (NMFS 2013e).

DPS Description	
Threatened	Listed under ESA in 1998; updated in 2014.
4 MPGs	23 historical populations
MPG	***Populations***
Cascade summer	Kalama (C), North Fork Lewis, East Fork Lewis (G), Washougal (C)
Gorge summer	Wind (C), Hood
Cascade winter	Lower Cowlitz, Upper Cowlitz (C, G), Cispus (C, G), Tilton, South Fork Toutle, North Fork Toutle (C), Coweeman, Kalama, North Fork Lewis (C), East Fork Lewis, Salmon Creek, Washougal, Clackamas (C), Sandy (C)
Gorge winter	Lower Gorge, Upper Gorge, Hood (C, G)
Artificial production	
Hatchery programs included in DPS (9)	Kalama River Wild Winter, Kalama River Wild Summer, Hood River Winter, Cowlitz Trout Hatchery Late Winter, Upper Cowlitz Wild Late, Tilton River Wild Late, Clackamas Hatchery Late Winter, Sandy Hatchery Late Winter, Lewis River Wild Late
Hatchery programs not included in ESU (16)	South Toutle Summer, Washougal Summer, Echo Net Pens Summer, Lewis Summer, Kalama River Skamania Summer, Kalama River Winter, Washougal Winter, Rock Creek Winter, Cowlitz River Summer, Coweeman Winter, Lewis River Winter, Klineline Winter, Eagle Creek National Fish Hatchery Winter, Eagle Creek National Fish Hatchery Early, Clackamas Summer, Sandy River Summer

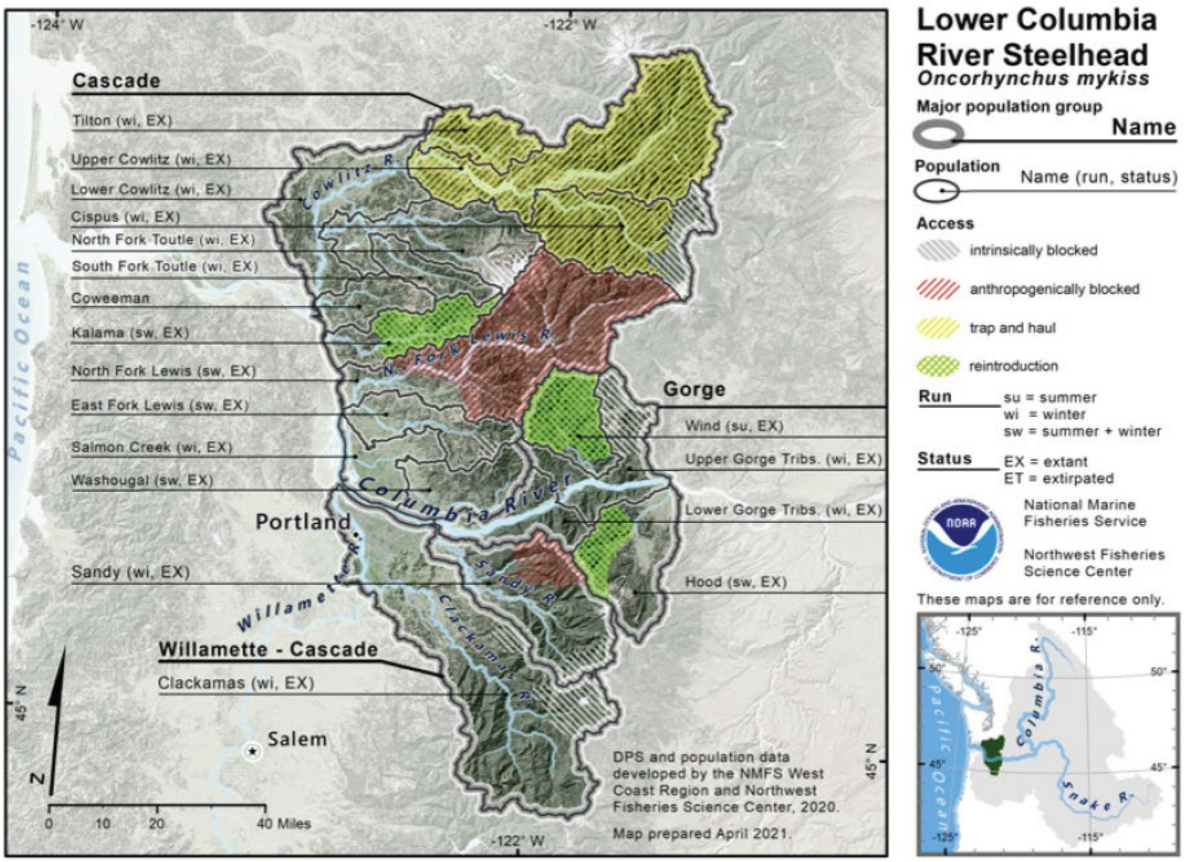


Figure 40. Map of 23 winter and summer-run steelhead demographically independent populations in the Lower Columbia River steelhead DPS. The DPS is separated into two MPGs: Cascade and Gorge. Areas that are accessible (green), accessible only via trap-and-haul programs (yellow), or blocked (cross-hatched), are indicated accordingly (Ford 2022).

Table 52. Life history and population characteristics of LCR steelhead.

Characteristic	Life-History Features	
	Summer	Winter
Number of extant populations	10	23
Life history type	Stream	Stream
River entry timing	May-November	November-April
Spawn timing	late February-May	late April-June
Spawning habitat type	Upper watersheds, streams	Rivers and tributaries
Emergence timing	March-July	March-July
Duration in freshwater	1-3 years (mostly 2)	1-3 years (mostly 2)
Rearing habitat	River and tributary main channels	River and tributary main channels
Estuarine use	Briefly in the spring, peak abundance in May	Briefly in the spring, peak abundance in May
Ocean migration	North to Canada and Alaska, and into the N Pacific	North to Canada and Alaska, and into the N Pacific
Age at return	3-5, occasionally 6 years	3-5, occasionally 6 years
Recent natural spawners	1,500	3,500
Recent hatchery adults	2,000	9,000

2.2.6.1.1.1. Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the LCR Steelhead DPS, is at moderate risk and remains at threatened status. Each natural population's baseline and target persistence probabilities are summarized in the section below, along with target abundance for each population that would be consistent with delisting. Persistence probability is measured over a 100-year time period and ranges from very low (probability < 40%) to very high (probability >99%).

2.2.6.1.1.1.1. Abundance and Productivity

The majority of winter-run steelhead demographically independent populations in this DPS continue to persist at low abundance levels (hundreds of fish), with the exception of the Clackamas and Sandy River populations, which have abundances in the low 1,000s (Figure 41, Table 53). Although the five-year geometric abundance means are near recovery plan goals for many populations (Table 53), the recent trends are negative (Ford 2022). Summer-run steelhead demographically independent populations were similarly stable, but also at low abundance levels (Ford 2022). Summer-run demographically independent populations in the Kalama, East Fork Lewis, and Washougal River demographically independent populations are near their recovery plan goals (Table 53); however, it is unclear how hatchery-origin fish contribute to this abundance. The decline in the Wind River summer-run demographically independent population is a source of concern, given that this population has been considered one of the healthiest of the summer runs (Ford 2022). It is not clear whether the declines observed represent a short-term oceanic cycle, longer-term climatic change, or other systematic issue. While other species in the Lower Columbia River steelhead DPS have a coastal-oriented distribution, steelhead are wide-ranging, and it is more difficult to predict the effects of changes in ocean productivity. Alternatively, most steelhead juveniles remain in freshwater for two years prior to emigration, making them more susceptible to climatic changes in temperature and precipitation (Ford 2022).

Spatial structure and abundances are limited due to migrational blockages in the Cowlitz and Lewis River basins (Ford 2022). The efficiency of adult passage and juvenile collection programs remain an issue. Recent studies indicate that there have been improvements in juvenile collection efficiency in the Cowlitz River, but these have not been reflected yet in adult abundance (Ford 2022).

The juvenile collection facilities at North Fork Dam in the Clackamas River appear to be successful enough to support increases in abundance. It is not possible to determine the risk status of this DPS given the uncertainty in abundance estimates for nearly half of the demographically independent populations (Ford 2022). Additionally, nearly all of the demographically independent populations for which there are abundance data exhibited negative abundance trends in 2018 and 2019 (Figure 41).

2.2.6.1.1.1.1.1. Harvest

Steelhead from this DPS are incidentally intercepted in mainstem treaty, and non-treaty commercial and recreational fisheries targeting non-listed hatchery and naturally produced Chinook salmon, and non-listed steelhead (Ford 2022). Mark-selective net fisheries in the mainstem Columbia River can result in post-release mortality rates of 10% to over 30%, although there is considerable disagreement on the overall rate (SWFSC 2022). Recreational fisheries targeting marked hatchery-origin steelhead encounter natural-origin fish at a relatively high rate, but hooking mortalities are generally lower than those in the net fisheries (SWFSC 2022). Estimated mortality for naturally produced winter-run steelhead has averaged 0.3% (Ford 2022). The current *U.S. v. Oregon* Management Agreement (2018–2027) has, on average, maintained reduced harvest impacts for LCR steelhead fisheries with 2018 harvest rates for winter-run steelhead in mainstem fisheries at 0.3% (NMFS 2018c), and with harvest rates for unclipped summer-run steelhead of 0.5% in fisheries below Bonneville Dam and 0.01% in the Bonneville Pool (Ford 2022).

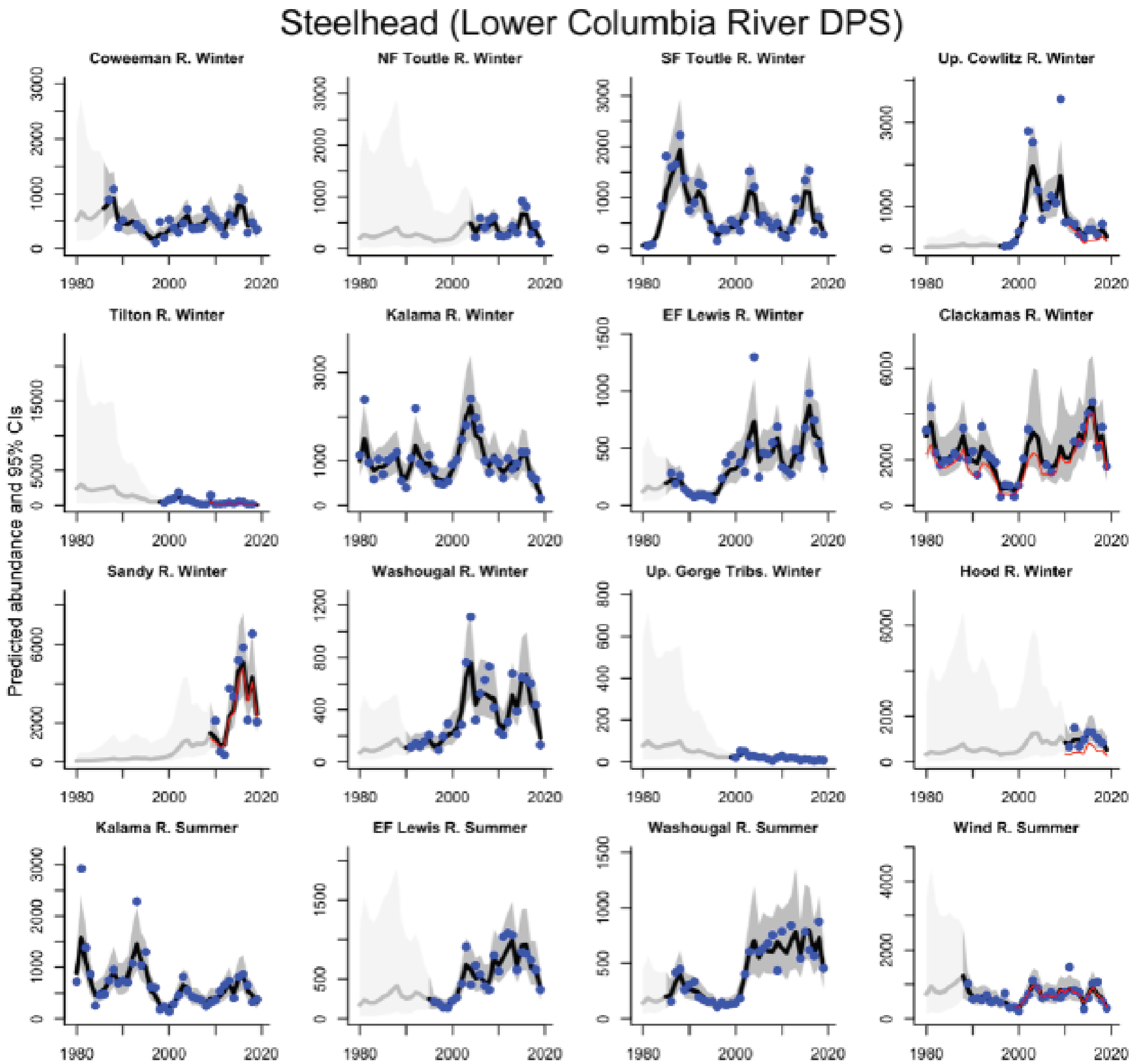


Figure 41. Smoothed trend in estimated total (thick black line, with 95% confidence interval in gray) and natural (thin red line) population spawning abundance. In portions of a time series where a population has no annual estimates but smoothed spawning abundance is estimated from correlations with other populations the smoothed estimate is shown in light gray. Points show the annual raw spawning abundance estimates. For some trends the smoothed estimate may be influenced by earlier data points not included in the plot (Ford 2022).

Table 53. Current 5-year geometric mean of raw natural-origin spawner abundances and recovery targets for Lower Columbia River steelhead demographically independent populations. Colors indicate the relative proportion of the recovery target currently obtained: red = <10%, orange = 10% > x < 50%, yellow = 50% > x < 100%, green = >100%. Numbers in parentheses represent total (hatchery and natural-origin) spawners; * = high uncertainty about whether they are meeting their recovery targets (Ford 2022). W and Su indicate winter and summer populations.

		Abundance	
Stratum	**Population**	**2015–19**	**Target**
Cascade	Coweeman River (WA) W	(528)*	500
	North Fork Toutle River (WA) W	(409)*	600
	South Fork Toutle River (WA) W	(660)*	600
	Upper Cowlitz River (WA) W	199	500
	Lower Cowlitz River (WA) W	n/a	400
	Cispus River (WA) W	n/a	500
	Tilton River (WA) W	241	200
	Kalama River (WA) W	(618)*	600
	North Fork Lewis River (WA) W	n/a	400
	East Fork Lewis River (WA) W	(613)*	500
	Salmon Cr (WA) W	n/a	n/a
	Clackamas River (OR) W	2,819	10,671
	Sandy River (OR) W	3,615	1,519
	Washougal River (WA) W	(427)*	350
	Kalama River (WA) Su	(560)*	500
	North Fork Lewis River (WA) Su	n/a	500
	East Fork Lewis River (WA) Su	(650)*	500
	Washougal River (WA) Su	(644)*	500
Gorge	Upper Gorge (Wind R) (WA) W	(9)	n/a
	Lower Gorge (WA & OR) W	n/a	300
	Hood River (OR) W	650	2,079
	Wind River (WA) Su	627	1,000
	Hood River (OR) Su	n/a	2,008

2.2.6.1.1.1.2. Spatial Structure and Diversity

There have been a number of large-scale efforts to improve accessibility (one of the primary metrics for spatial structure) in this DPS. This includes providing access to the upper Cowlitz River basin (Upper Cowlitz, Cispus, and Tilton Rivers) beginning in 1996 with the initiation of juvenile collection at Cowlitz Falls Dam (Ford 2022) and structural and operational changes at the Cowlitz Falls Dam, most recently in 2017, to improve collection efficiency (Ford 2022). The collection of steelhead kelts remains another area where further improvement is needed, with trap-and-haul operations occurring on the Lewis River since 2012 for winter-run steelhead, reestablishing access to historically occupied habitat above Swift Dam (RKM 77.1). Environmental variability may make it difficult to assess the effects of changes in spatial structure, except through longer-term datasets (Ford 2022). These changes include the removal of Marmot Dam in 2007 and the Little Sandy River diversion dam in 2008, and Hemlock Dam on Trout Creek (Wind River) in 2009. Additionally, beginning in 2010, unmarked steelhead have been passed above the hatchery weir on Cedar Creek, a tributary to the Sandy River. Powerdale Dam was removed in 2010, and while this dam previously provided for fish passage, removal of the dam is thought to eliminate passage delays and injuries. Finally, there has been a trap-and-haul operation at the sediment retention structure on the North Fork Toutle River since 1989. Transportation above the sediment retention structure is limited to two small tributaries, and only a small proportion of the upper basin is utilized (Ford 2022). In addition, there have been numerous recovery actions throughout the DPS to remove or improve the thousands of culverts and other small-scale passage barriers (Ford 2022).

2.2.6.1.1.1.2.1. Hatcheries

Total steelhead hatchery releases in the LCR steelhead DPS have decreased slightly since the 2015 viability review (NWFSC 2015), declining from an average annual release (summer- and winter-run) of 3 million smolts annually to 2.75 million (Ford 2022). Some populations continue to have relatively high fractions of hatchery-origin spawners while others have relatively few (Table 54), though data for many populations is not available. Washington Department of Fish and Wildlife (WDFW) is currently developing a new methodology to assess the hatchery contribution to naturally spawning steelhead. In addition, the North Fork Toutle River, East Fork Lewis River, and Wind River have been established by WDFW as natural gene banks. Where hatcheries maintain multiple stocks of steelhead, there continues to be some risk of hybridization between different run times or native and out-of-DPS stocks (Ford 2022).

Hatchery managers have continued to implement and monitor changes in LCR steelhead hatchery management since the 2016 5-year review (SWFSC 2022). One of the major changes in hatchery operations was the elimination of the out-of-DPS steelhead broodstock programs in the Kalama River (Ford 2022). Previously, out-of-DPS releases were terminated in the Cowlitz and East Fork Lewis Rivers (NWFSC 2015). Out-of-DPS releases continue in the Clackamas River, Sandy River, South Fork Toutle River, and Washougal River with the release of Skamania Hatchery summer-run steelhead (Ford 2022).

Table 54. Five-year mean of fraction natural Lower Columbia River steelhead spawners (sum of all estimates divided by the number of estimates), 1995–2019. Blanks (—) indicate that no estimate was available in that 5-year range (Ford 2022).

Population[a]	MPG	1995–99	2000–04	2005–09	2010–14	2015–19
Upper Cowlitz River (winter)	Cascade	—	—	—	0.70	0.49
Tilton River (winter)	Cascade	—	—	—	1.00	0.79
Clackamas River (winter)	Cascade	0.67	0.76	0.75	0.96	0.92
Sandy River (winter)	Cascade	—	—	—	0.92	0.94
Hood River (winter)	Gorge	—	—	—	0.37	0.61
Wind River (summer)	Gorge	—	—	—	—	—

[a] Note that the Kalama (Cascade Summer), North Fork Lewis (Cascade Summer), East Fork Lewis (Cascade Summer), Washougal (Cascade Summer), Hood (Gorge Summer), Lower Cowlitz (Cascade Winter), Cispus (Cascade Winter), South Fork Toutle (Cascade Winter), North Fork Toutle (Cascade Winter), Coweeman (Cascade Winter), Kalama (Cascade Winter), North Fork Lewis (Cascade Winter), East Fork Lewis (Cascade Winter), Salmon Creek (Cascade Winter), Washougal (Cascade Winter), Sandy (Cascade Winter), Lower Gorge (Gorge Winter), and Upper Gorge (Gorge Winter) populations are not included due to low abundances or lack of monitoring and available data, as discussed further in (Ford 2022).

2.2.6.1.1.1.3. Summary

Although a number of demographically independent populations exhibited increases in their five-year geometric means, others still remain depressed, and neither the winter- nor summer-run MPGs are near viability in the Gorge (Ford 2022). There have been improvements in diversity through hatchery reform, especially the elimination of non-native Chambers Creek winter-run broodstock and some Skamania Hatchery-origin broodstock (Ford 2022). Population-specific data on hatchery contribution to the naturally spawning populations is not available for most demographically independent populations, and diversity criteria cannot be properly evaluated without them (Ford 2022). Spatial structure remains a concern, especially for those populations that rely on adult trap-and-haul programs and juvenile downstream passage structures for sustainability. Overall, the LCR steelhead DPS is therefore considered to be at “moderate” risk (Ford 2022), and the viability is largely unchanged from the prior review (NWFSC 2015).

2.2.6.1.1.2. Limiting Factors

Understanding the limiting factors and threats that affect the LCR Steelhead DPS provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. There are many factors that affect the abundance, productivity, spatial structure, and diversity of the LCR Steelhead DPS. Factors that limit the DPS have been, and continue to be, hydropower development on the Columbia River and its tributaries, habitat degradation, hatchery effects, fishery management and harvest decisions, and ecological factors including predation and environmental variability. The recovery plan consolidates the information regarding limiting factors and threats for the LCR Steelhead DPS available from various sources (NMFS 2013e).

The recovery plan provides a detailed discussion of limiting factors and threats and describes strategies for addressing each of them. Chapter 4 of the plan describes limiting factors on a regional scale and how they apply to the four listed species from the LCR considered in the plan. Chapter 9 of the plan discusses the limiting factors that pertain specifically to LCR steelhead with details that apply to the winter and summer populations and MPGs in which they reside. The discussion of limiting factors in Chapter 9 is organized to address the following:

- Tributary habitat,
- Estuary habitat,
- Hydropower,
- Hatcheries,
- Harvest, and
- Predation.
- Chapter 4 includes additional details on large scale issues including:
- Ecological interactions,
- Climate change, and
- Human population growth.

Rather than repeating this extensive discussion from the recovery plan, these discussions in Chapters 4 and 9 are incorporated here by reference. However, summarizing the recovery plan's discussion of the threat hatchery induced selection poses to LCR steelhead indicates population-level effects of hatchery fish interbreeding with natural-origin fish was a primary limiting factor that we expect to reduce greatly in the near future by NMFS adopting and WDFW implementing terms and conditions from its opinion evaluating Mitchell Act funding criteria (NMFS 2017e) which terminated out-of-DPS releases of hatchery steelhead inside this DPS's geographic range. While the low to very low baseline persistence probabilities of most LCR steelhead populations reflect low productivity, abundance is improving, and it's likely that genetic and life-history diversity have been reduced as a result of pervasive hatchery effects and population bottlenecks (NMFS 2013e), but this will be alleviated by switching to hatchery broodstocks whose genetic origins are from those in the LCR (NMFS 2017e).

2.2.2.1.2 Upper Willamette River Steelhead DPS

On March 25, 1999, NMFS listed the UWR Steelhead DPS as a threatened species (64 FR 14517). The threatened status was reaffirmed in 2006 and most recently on April 14, 2014 (79 FR 20802). Critical habitat for the DPS was designated on September 2, 2005 (70 FR 52848). NMFS' most recent five-year review for UWR Steelhead was completed in 2024 (NMFS 2024b). The NWFSC finalized its updated biological viability assessment for Northwest Pacific salmon and steelhead listed under the ESA in January 2022 (Ford 2022).

The UWR Steelhead DPS includes all naturally spawned anadromous winter-run steelhead originating below natural and manmade impassable barriers in the Willamette River, Oregon, and its tributaries upstream from Willamette Falls to the Calapooia River (Ford 2022). One MPG, composed of four historical populations, comprises the UWR Steelhead DPS (Figure 48). Inside the geographic range of the DPS, 1 hatchery program is currently operational, though it is not included in the DPS (Table 55)(Ford 2022); (NMFS 2024b). Hatchery summer-run steelhead also occur in the Willamette River Basin but are an out-of-basin stock that is not included as part of this DPS (Ford 2022). As explained above NMFS (NMFS 2005d), genetic resources can be housed in a hatchery program but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS see NMFS (NMFS 2005d).

Table 55. Upper Willamette River Steelhead DPS description and MPGs. The designations "(C)" and "(G)" identify core and genetic legacy populations, respectively (McElhany et al. 2003); (Jones 2015); (NWFSC 2015); (Ford 2022); (NMFS 2024b).

DPS Description	
Threatened	Listed under ESA as threatened in 1999; updated in 2014.
1 MPG	4 historical populations
MPG	***Populations***
Willamette	South Santiam River (C,G), North Santiam River (C,G), Molalla River, Calapooia River
Artificial production	
Hatchery programs included in DPS (0)	n/a
Hatchery programs not included in DPS (1)	Upper Willamette summer (in South Santiam River, North Santiam, McKenzie, MF Willamette)

Before the construction of a fish ladder at Willamette Falls in the early 1900s, flow conditions allowed steelhead to ascend Willamette Falls only during the late winter and spring. Presently, the majority of the UWR winter steelhead run return to freshwater from January through April, pass Willamette Falls from mid-February to mid-May, and spawn from March through June (with peak spawning in late April and early May). Upper Willamette River steelhead currently exhibit a stream-type life-history with individuals exhibiting yearling life-history strategy. Juvenile steelhead rear in headwater tributaries and upper portions of the subbasins from one to four years (average of two years), then as smoltification occurs in April through May, they migrate downstream through the mainstem Willamette and Columbia River estuaries and into the ocean. The downstream migration speed depends on factors including river flow, temperature, turbidity, and others, with the quickest migration occurring with high river flows. Upper Willamette River steelhead can forage in the ocean for one to two years (average of two years) and during this time period, are thought to migrate north to waters off Canada and Alaska and into the North Pacific including the Alaska Gyre (Myers et al. 2006); (ODFW and NMFS 2011).

This species may spawn more than once; however, the frequency of repeat spawning is relatively low. The repeat spawners are typically females that spend more than one year post spawning in the ocean and spawn again the following spring (ODFW and NMFS 2011).

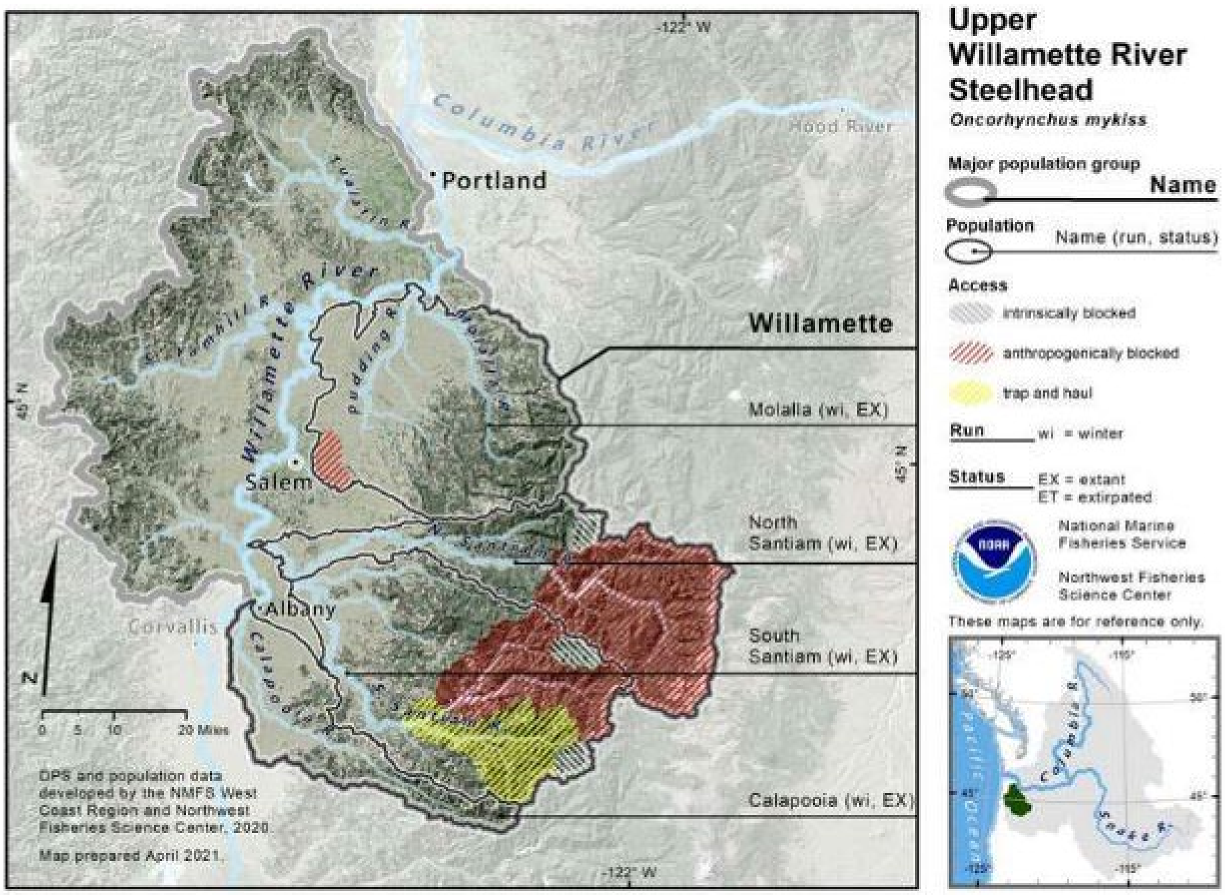


Figure 42. Map of the four demographically independent populations in the Upper Willamette River steelhead DPS (Ford 2022).

2.2.2.1.2.1 Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the UWR Steelhead DPS, is at moderate risk and remains at threatened status. The most recent viability status update (Ford 2022) determined that there has been no change in the biological risk category since the prior reviews of these populations (NWFSC 2015). There is still uncertainty in the underlying causes of the long-term declines in spawner abundances that these populations have experienced. Although the recent magnitude of these declines is relatively moderate, continued declines would be a cause for concern (Ford 2022).

2.2.2.1.2.2 Abundance and Productivity

Abundance and life history data for steelhead in the UWR steelhead DPS are very limited. Consistent redd counts are available for some index reaches, primarily in Thomas and Crabtree Creeks, but these do not provide population-level indicators of abundance (Ford 2022). Specific research projects have been undertaken to estimate steelhead spawning abundance and distribution (Mapes, Sharpe, and Friesen 2017), but only in specific basins and for a limited number of years (Ford 2022). Adult counts were also available from observations at Willamette Falls, Bennett Dam, the Minto Dam fish facility (North Santiam River), and Foster Dam (South Santiam River). While steelhead counts at Willamette Falls provide a DPS-wide estimate of abundance, there is some uncertainty in distinguishing native late-winter steelhead from non-native early-winter steelhead and unmarked non-native summer steelhead (Johnson et al. 2018); (Weigel et al. 2019). Counts of steelhead in eastside tributaries provide more population-specific information on abundance (Ford 2022). Winter steelhead counts at Willamette Falls provide a complete count of fish returning to the DPS (Ford 2022).

Populations in this DPS have experienced long-term declines in spawner abundance (Figure 43, Table 56). The underlying cause(s) of these declines is not well understood. Returning adult winter steelhead do not experience the same deleterious water temperatures as the spring-run Chinook salmon, and prespawn mortalities are not likely to be significant (Ford 2022). Although the recent magnitude of these declines is relatively moderate, continued declines would be a cause for concern. Improvements to Bennett Dam fish passage and operational temperature control at Detroit Dam may be providing some stability in abundance in the North Santiam River demographically independent population (Ford 2022). It is unclear if sufficient high-quality habitat is available below Detroit Dam to support the population reaching its VSP recovery goal (Table 57), or if some form of access to the upper watershed is necessary to sustain a "recovered" population (Ford 2022). Similarly, the South Santiam River 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 the Middle Santiam River) and/or improved juvenile downstream passage at Foster Dam (Ford 2022).

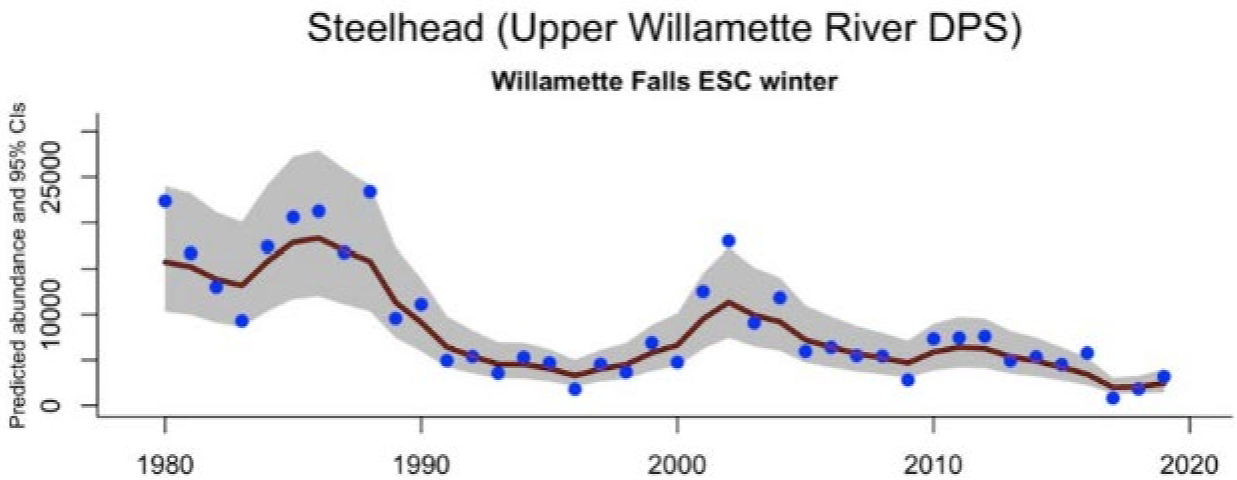


Figure 43. Smoothed trend in estimated total (thick black line, with 95% confidence interval in gray) and natural (thin red line) population spawning abundance. In portions of a time series where a population has no annual estimates but smoothed spawning abundance is estimated from correlations with other populations, the smoothed estimate is shown in light gray. Points show the annual raw spawning abundance estimates. For some trends, the smoothed estimate may be influenced by earlier data points not included in the plot (Ford 2022).

Table 56. Five-year geometric mean of raw natural spawner counts for the Upper Willamette River steelhead DPS. Willamette Falls counts represent counts of prespawning winter steelhead, and include an unknown number of non-native early-winter-run steelhead. Population estimates (1990–2009) were calculated using proportional assignment of Willamette Falls counts. In parentheses, 5-year geometric mean of raw total spawner counts is shown. A value only in parentheses means that a total spawner count was available but no or only one estimate of wild spawners available. The geometric mean was computed as the product of counts raised to the power 1 over the number of counts available (2 to 5). A minimum of 2 values were used to compute the geometric mean. Percent change between the 2 most recent 5-year periods is shown on the far right (Ford 2022).

Population	MPG	1990–1994	1995–1999	2000–2004	2005–2009	2010–2014	2015–2019	% change
Willamette Falls W	Cascade	(5,619)	(3,961)	(10,293)	(5,028)	(6,431)	(2,628)	(–59)
Calapooia River W	Cascade	149 (149)	219 (219)	406 (406)	214 (214)	—	—	—
Molalla River W	Cascade	1,182 (1,462)	726 (798)	1,924 (1,924)	1,357 (1,357)	—	—	—
North Santiam River W	Cascade	2,495 (2,928)	1,953 (2,388)	3,333 (3,423)	2,500 (2,500)	—	—	—
South Santiam River W	Cascade	1,940 (1,940)	1,277 (1,277)	2,440 (2,440)	1,594 (1,594)	—	—	—

2.2.2.1.2.2.2.1 Harvest

There is no consumptive fishery for winter steelhead in the UWR (Ford 2022). Winter-run steelhead in the Columbia River fishery are intercepted at a low rate, 0.2% (ODFW and WDFW 2020); (Ford 2022). Similarly, due to differences in return timing between native winter-run steelhead, introduced hatchery summer-run steelhead, and hatchery spring-run Chinook salmon, the encounter rates for winter-run fish in the Willamette River recreational fishery are thought to be low (Ford 2022). Tribal fisheries occurring above Bonneville Dam have not been shown to impact UWR steelhead (Ford 2022).

2.2.2.1.2.2.2.2 Spatial Structure and Diversity

The exclusion of steelhead from headwater reaches in the North and South Santiam Rivers continues to be the primary spatial structure concern (Ford 2022). Although the historical distribution of steelhead is not precisely known, indications are that the majority of steelhead and salmon spawning occurred above the current site of Detroit Dam in the North Santiam River (Mattson 1948); (Ford 2022). Similarly, in the South Santiam River, while steelhead have access to habitat above Foster Dam, the Middle Santiam River is blocked by Green Peter Dam. Conditions in the South Santiam River above Foster Reservoir may be limiting, due to high (>20°C) summer prespawning holding temperatures, and poor incubation and rearing habitat conditions (the river is prone to scour during flood episodes) (Ford 2022). Alternatively, historical habitat (Quartzville Creek and the Middle Santiam River) above Green Peter Dam may provide better spawning and rearing habitat than the upper South Santiam River (Ford 2022). Efforts to provide passage for steelhead in the North Santiam River are still at the planning stage, and little effort has been allocated to providing passage at Green Peter Dam. Foster Dam provides volitional downstream passage, but juvenile and kelt survivals need to improve further to meet passage criteria. Smaller-scale upstream and downstream passage issues exist throughout the DPS, related in part to water withdrawal structures. While some of these have been addressed, others remain (Ford 2022).

2.2.2.1.2.2.2.3 Hatcheries

Winter-run steelhead hatchery programs were terminated in the late 1990s (Ford 2022). Currently, the only steelhead programs in the UWR release Skamania Hatchery-origin summer-run steelhead. Annual total releases for the entire UWR DPS (including the McKenzie and Middle Fork Willamette Rivers) have decreased slightly, to 500,000 (2015–19; Figure 44). Still, the legacy of previous hatchery-origin releases persists in the UWR.

A recent genetic study by Johnson et al. (2021) evaluated the level of colonization by non-native stocks and introgression between non-native summer-run steelhead and non-native early-winter-run steelhead with native late-winter-run steelhead. This work identified westside tributaries as being largely occupied by non-native early-winter-run steelhead originating from releases by Big Creek Hatchery (LCR, Southwest Washington Steelhead DPS) beginning in the 1920s. With the exception of the lower North Santiam River, native late-winter steelhead are still predominant in eastside tributaries that drain the Cascades north of the McKenzie River (Ford 2022). Areas above dams in the North and South Santiam Rivers and in the Calapooia River appear to have little influence from non-native introductions. Below dams in the North Santiam River, pure non-native summer-run and a non-native Big Creek winter-run steelhead were detected, as were hybrids between non-native and native steelhead (Ford 2022). Below dams of the South Santiam River, introgression from introduced steelhead was higher than in the North Santiam. In the Molalla River, the predominant genotype was native winter-run steelhead (40%), but a substantial number of hybrids between the native and non-native steelhead were detected. The presence of pure and hybrid summer-run steelhead in the Molalla River is surprising, because summer run steelhead have not been released in this basin since 1998 (Ford 2022). The establishment of feral non-native summer and winter runs of steelhead poses a genetic risk to the native populations (Ford 2022). In addition, the presence of hatchery-reared and feral hatchery-origin fish may affect the growth and survival of juvenile late-winter steelhead (Ford 2022).

While the diversity goals are partially achieved through the closure of winter-run steelhead hatchery programs in the UWR, 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 (Ford 2022). Overall, none of the populations in the DPS are meeting their recovery goals (Table 57).

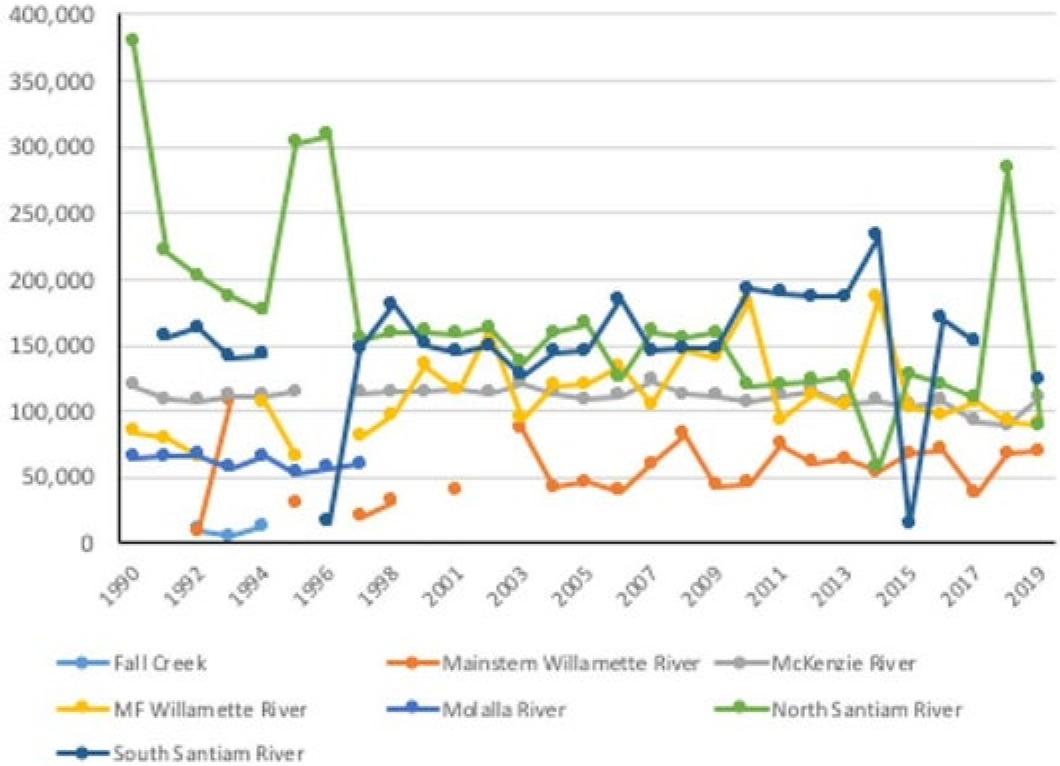


Figure 44. Annual releases of hatchery-origin (Skamania stock) summer-run steelhead into Willamette River tributaries, by sub-basin. Releases of fish <2.5 g are not included. All releases are considered to be out-of-DPS in origin. Data from the Regional Mark Information System (https://www.rmpc.org, April 2020)(Figure reproduced from Ford (Ford 2022)).

Table 57. Current 5-year geometric mean of raw natural-origin abundances and recovery scenario targets presented in the recovery plan (ODFW and NMFS 2011) for Upper Willamette River steelhead demographically independent populations. Willamette Falls count includes non-native early-winter-run steelhead, and therefore represents an upper limit to total abundance. No tributary abundance estimates are available and the approximate total DPS abundance is represented by the Willamette Falls count. This total abundance is compared to the sum of the individual demographically independent population targets. Colors indicate the relative proportion of the recovery target currently obtained: red = <10%, orange = 10% > x < 50%, yellow = 50% > x < 100%, green = >100% (Ford 2022).

Abundance			
MPG	**Population**	**2015–19**	**Target**
Cascade	Willamette Falls Winter Count	2,628	n/a
	Molalla River Winter	n/a	3,000
	North Santiam River Winter	n/a	8,358
	South Santiam River Winter	n/a	3,913
	Calapooia River Winter	n/a	498
	Total:	2,628	15,769

2.2.2.1.2.2.2.4 Summary

Overall, the UWR steelhead DPS continued to decline in abundance (Table 56, Figure 43). 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 (Ford 2022). Uncertainty in adult counts at Willamette Falls are a concern, given that the counts represent an upper bound on DPS abundance. Radio-tagging studies suggest that a considerable proportion of "winter" steelhead ascending Willamette Falls do not enter the tributaries that are considered part of this DPS; these fish may be non-native early-winter steelhead that appear to have colonized the western tributaries, misidentified summer steelhead, late-winter steelhead that have colonized tributaries not historically part of the DPS, or hybrids between native and non-native steelhead (Ford 2022).

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 (Ford 2022). Efforts to provide juvenile downstream passage at Detroit Dam are well behind the proscribed timetable (NMFS 2008e), and passage at Green Peter Dam has not yet entered the planning stage. Much of the accessible habitat in the Molalla, Calapooia, and the lower reaches of the North and South Santiam Rivers is degraded and under continued development pressure (Ford 2022). Although habitat restoration efforts are underway, the time scale for restoring functional habitat is considerable. While the viability of the DPS appears to be declining, the recent uptick in abundance may provide a short-term demographic buffer (Ford 2022). Furthermore, increased monitoring is necessary to provide quantitative verification of sustainability for most of the populations. In the absence of substantial changes in accessibility to high-quality habitat, the DPS will remain at "moderate-to-high" risk (Ford 2022). Overall, the UWR Steelhead DPS is therefore at "moderate-to-high" risk, with a declining viability trend (Ford 2022).

2.2.2.1.2.3 Limiting Factors

Understanding the limiting factors and threats that affect the UWR Steelhead DPS provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting the species is to ensure that the underlying limiting factors and threats have been addressed. The populations in this DPS have experienced long-term declines in spawner abundances, but the underlying cause(s) of these declines is not well understood (Ford 2022). There are many factors that affect the abundance, productivity, spatial structure, and diversity of the UWR Steelhead DPS. Factors that limit the DPS have been, and continue to be, loss and degradation of spawning and rearing habitat, impacts of mainstem hydropower dams on upstream access and downstream habitats, and the legacy effects of historical harvest; together, these factors have reduced the abundance, productivity, spatial structure, and diversity of the populations in this DPS (Ford 2022).

The recovery plan (ODFW and NMFS 2011) provides a detailed discussion of limiting factors and threats and describes strategies for addressing each of them. Chapter 5 of the recovery plan describes the limiting factors on a regional scale and how those factors affect the populations of the UWR Steelhead DPS (ODFW and NMFS 2011). Chapter 7 of the recovery plan addresses the recovery strategy and actions for the entire DPS. The recovery plan addresses the topics of:

- Flood control/hydropower management,
- Land management,
- Harvest-related effects,
- Hatchery-related effects,
- Habitat access,
- Impaired productivity and diversity,
- Effects of predation, competition, and disease,
- Impaired growth and survival,
- Physical habitat quality, and
- Water quality.

Rather than repeating this extensive discussion from the recovery plan, is the discussion in Chapters 5 and 7 are incorporated here by reference.

In summary, the new information in the 2022 viability assessment (Ford 2022) does not indicate a change in the biological risk category of this DPS since the previous review (NWFSC 2015). Although direct biological performance measures for this DPS indicate some progress to date toward meeting its recovery criteria, there is no new information to indicate that its extinction risk has been reduced significantly. The DPS continues to demonstrate a stable overall low abundance pattern. More definitive genetic monitoring of steelhead ascending Willamette Falls in tandem with radio tagging work needs to be undertaken to estimate the total abundance of this DPS (NMFS 2011f); (NWFSC 2015); (Ford 2022).

The release of non-native summer steelhead continues to be a concern. Genetic analysis suggests that there is some level of introgression among native late-winter steelhead and summer steelhead (Friesen and Ward 1999). Accessibility to historical spawning habitat is still limited, especially in the North Santiam River. Much of the accessible habitat in the Molalla River, Calapooia River, 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 (NWFSC 2015); (Ford 2022).

2.2.6.2. Interior Columbia Recovery Domain

2.2.6.2.1. Middle Columbia River Steelhead DPS

On March 25, 1999, NMFS listed the MCR Steelhead DPS as a threatened species (64 FR 14517). The threatened status was reaffirmed in 2006 and most recently on April 14, 2014 (79 FR 20802). Critical habitat for the MCR steelhead was designated on September 2, 2005 (70 FR 52808). The most recent 5-year review for MCR steelhead was released in 2022 (NMFS 2022c).

The MCR Steelhead DPS includes naturally spawned anadromous O. mykiss originating from below natural and manmade impassable barriers from the Columbia River and its tributaries upstream of the Wind River (Washington) and Hood River (Oregon) to and including the Yakima River, excluding the UCR tributaries (upstream of Priest Rapids Dam) and the Snake River. Four MPGs, composed of 19 historical populations (2 extirpated), comprise the MCR Steelhead DPS (Figure 45). Inside the geographic range of the DPS, six hatchery steelhead programs are currently operational. Four of these artificial programs are included in the DPS (Table 58). As explained by NMFS (2005d), genetic resources can be housed in a hatchery program, but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS see NMFS (2005d).

Table 58. Middle Columbia River Steelhead DPS description and MPGs (Ford 2022); (NMFS 2022c). Winter steelhead populations are denoted by an asterisk.

DPS Description	
Threatened	Listed under ESA as threatened in 1999; updated in 2014.
4 MPGs	19 historical populations (2 extirpated, 17 extant)
MPG	***Populations***
Cascades Eastern Slope Tributaries	Deschutes River Eastside, Deschutes River Westside, Fifteenmile Creek*, Klickitat River*, Rock Creek*

DPS Description	
John Day River	John Day River Lower Mainstem Tributaries, John Day River Upper Mainstem Tributaries, Middle Fork John Day River, North Fork John Day River, South Fork John Day River
Yakima River	Naches River, Satus Creek, Toppenish Creek, Yakima River Upstream Mainstem
Umatilla/Walla Walla Rivers	Touchet River, Umatilla River, Walla Walla River
Artificial production	
Hatchery programs included in DPS (4)	Touchet River Endemic summer, Yakima River Kelt Reconditioning summer (in Satus Creek, Toppenish Creek, Naches River, and Upper Yakima River), Umatilla River summer, Deschutes River summer
Hatchery programs not included in DPS (2)	Walla Walla River Release summer, Skamania Stock Release summer

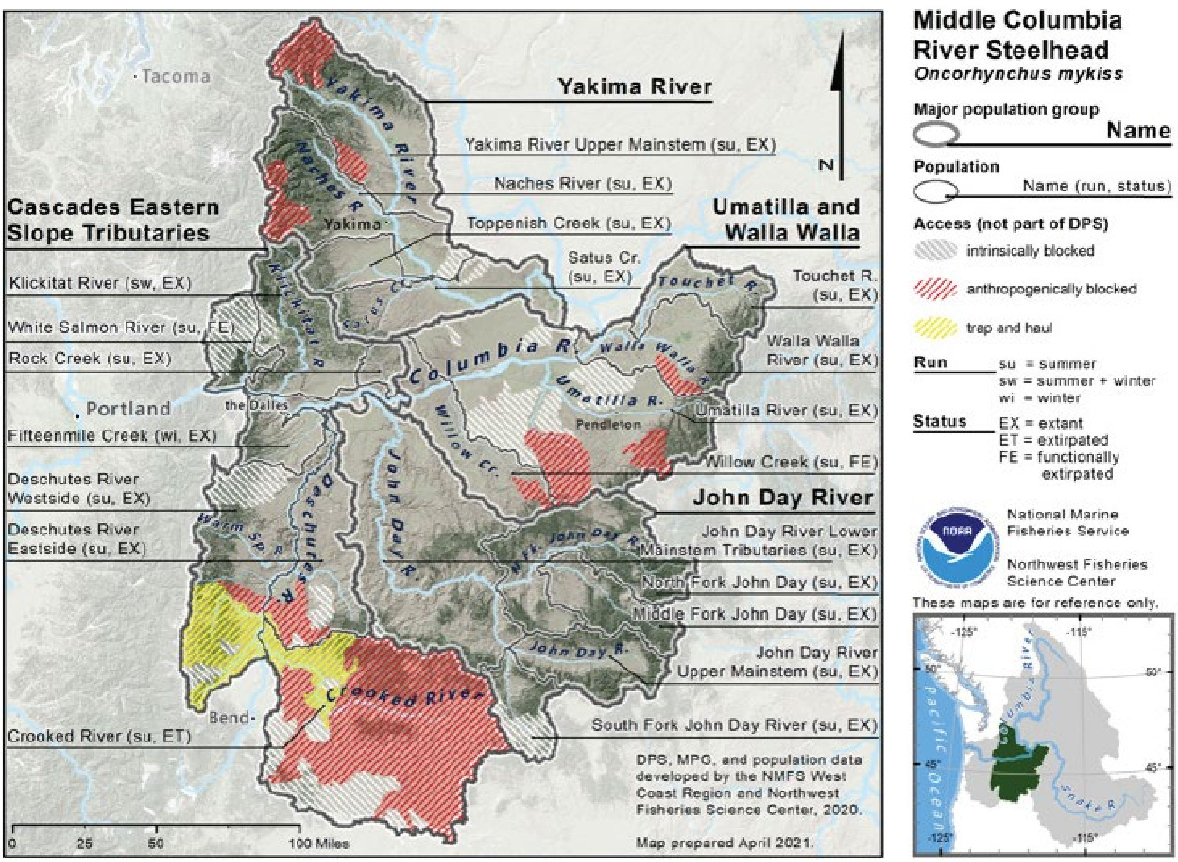


Figure 45. Map of the Middle Columbia River steelhead DPS's spawning and rearing areas, illustrating populations and MPGs (Ford 2022).

Steelhead exhibit more complex life history traits than other Pacific salmonid species as discussed in previous steelhead specific DPS sections above. While MCR steelhead share these general life history traits, it is worth noting they typically reside in marine waters for two to three years before returning to their natal stream to spawn at four or five years of age (NMFS and ODFW 2011).

The MCR Steelhead DPS includes the only populations of inland winter steelhead in the Columbia River (those populations in the LCR Steelhead DPS and UWR Steelhead DPS that are classified as “winter” are geographically close enough to the Pacific Ocean so as not to be considered inland steelhead). Variations in the migration timing exist between populations.

Most fish in this DPS smolt at two years and spend one to two years in salt water before re-entering freshwater, where they may remain up to a year before spawning (Howell et al. 1985); (Murtagh et al. 1992). Age-2-ocean steelhead dominate the steelhead run in the Klickitat River, whereas most other rivers with summer steelhead produce about equal numbers of age 1- and 2-ocean fish. Juvenile life stages (i.e., eggs, alevins, fry, and parr) inhabit freshwater/riverine areas throughout the range of the DPS. Parr usually undergo a smolt transformation as 2-year-olds, at which time they migrate to the ocean. A non-anadromous form of O. mykiss (i.e., rainbow or redband trout) co-occurs with the DPS, which only consists of the anadromous form and its residuals, and juvenile life stages of the two forms can be very difficult to differentiate. In addition, hatchery steelhead are also distributed throughout the range of this DPS (NMFS and ODFW 2011).

2.2.6.2.1.1. Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the MCR Steelhead DPS, is at moderate risk and remains at threatened status. The most recent viability assessment (Ford 2022) used updated abundance and hatchery contribution estimates provided by regional fishery managers to inform the analysis on this DPS. However, this DPS has been noted as difficult to evaluate in several of the reviews for reasons such as: the wide variation in abundance for individual natural populations across the DPS, chronically high levels of hatchery strays into the Deschutes River, and a lack of consistent information on annual spawning escapements in some tributaries (Ford 2022).

Many steelhead populations along the West Coast can co-occur with conspecific populations of resident rainbow trout. Previous status reviews (Ford et al. 2011) have recognized that there may be situations where reproductive contributions from resident rainbow trout could mitigate short-term extinction risk for some steelhead DPS populations (Good, Waples, and Adams 2005). In the MCR Steelhead DPS, a study in the Deschutes River Basin found no evidence of a significant contribution from the very abundant resident form to anadromous returns (Zimmerman and Reeves 2000). A study of natural-origin steelhead kelts in the Yakima Basin, comparing chemical patterns in otoliths (i.e., inner ear bones) with water chemistry sampling, found evidence for variable maternal resident contribution rates to anadromous returns, with a high degree of variation among natal areas and across years (Courter et al. 2013); (NWFSC 2015).

2.2.6.2.1.1.1. Abundance and Productivity

Abundance data series are available for all five extant populations in the Cascades Eastern Slope Tributaries MPG (Ford 2022). Spawner abundance estimates for the most recent five years decreased relative to the prior review for all five populations (Figure 46). The 15-year trend in natural-origin spawners was strongly negative for the Deschutes River Eastside population, and essentially zero for the Fifteenmile Creek and Deschutes River Westside runs (Figure 46). Preliminary estimates of escapements into Rock Creek were recently developed, and a high proportion of the observed steelhead in that system were out-of-basin strays (Ford 2022).

Total escapement and natural-origin escapements declined relative to the prior five-year review (NWFSC 2015) for all five of the John Day MPG populations (Ford 2022). Only two of the five populations in this group had a positive 15-year trend in natural-origin abundance (Figure 52), driven largely by peak returns in the early 2000s, despite the strong declines over the most recent five-year period (Figure 46).

Five-year geometric mean natural-origin and total abundance (Figure 46) estimates for each of the four populations in the Yakima MPG also decreased sharply relative to the previous review (NWFSC 2015). All four populations in this group have exhibited increases since the early 1990s, with similar peak return years as other DPS populations, but, given recent declines, the 15-year trend for all populations was essentially zero (Figure 46).

Total spawning escapements have decreased in the most recent brood cycle for all three populations in the Umatilla/Walla Walla MPG as well (Figure 46). The 15-year trend in natural-origin abundance was positive for the Umatilla River population and slightly negative for Touchet River (Figure 46), though the trends are shallow (Ford 2022). Population productivity was cyclical, with most populations following a similar pattern of growth and decline (Ford 2022).

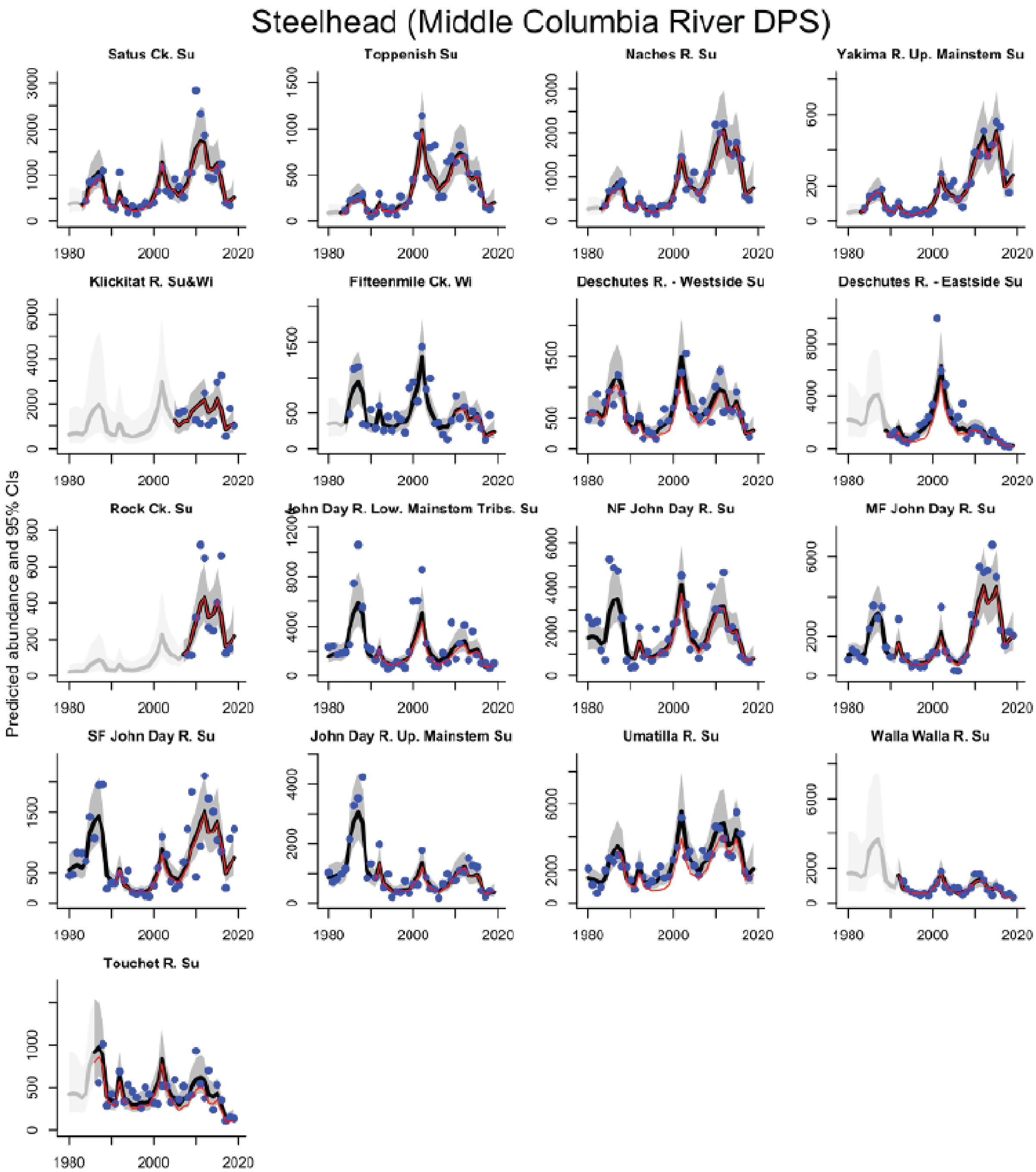


Figure 46. Smoothed trend in estimated total (thick black line, with 95% confidence interval in gray) and natural (thin red line) population spawning abundance. In portions of a time series where a population has no annual estimates but smoothed spawning abundance is estimated from correlations with other populations, the smoothed estimate is shown in light gray. Points show the annual raw spawning abundance estimates. For some trends, the smoothed estimate may be influenced by earlier data points not included in the plot (Ford 2022).

Table 59. Summary of Middle Columbia River steelhead DPS viability relative to the ICTRT viability criteria, grouped by MPG. Natural spawning = most-recent 10-yr geometric mean (range). ICTRT productivity = 20-yr geometric mean for parent escapements below 75% of population threshold. Current A/P estimates are geometric means. Range in annual abundance, standard error, and number of qualifying estimates for productivities in parentheses (Ford 2022).

Abundance/productivity (A/P) metrics					Spatial structure/diversity (SS/D) metrics			
Population	**ICTRT threshold**	**Natural spawning**	**ICTRT productivity**	**Integrated A/P risk**	**Natural processes**	**Diversity risk**	**Integrated SS/D risk**	**Overall risk rating**
Klickitat River	1,000	1,462 (SD 919)	1.07 (0.12 8/20)	Moderate	Low	Moderate	Moderate	Maintained
Fifteenmile Creek	500	378 (SD 170)	2.12 (0.19 8/20)	Moderate	Very Low	Low	Low	Maintained
Deschutes River Westside	1,500 (1,000)	538 (SD 306)	1.10 (0.15 18/20)	High	Low	Moderate	Moderate	High
Deschutes River Eastside	1,000	604 (SD 453)	1.75 (0.29 7/20)	Moderate	Low	Moderate	Moderate	Maintained
Rock Creek	500	298 (SD 232)	—	High	Moderate	Moderate	Moderate	High
Crooked River (extirpated)	2,000	—	—	—	—	—	—	Extirpated
White Salmon River (extirpated)	500	—	—	—	—	—	—	Extirpated (recolonizing)
John Day River Lower Mainstem Tributaries	2,250	1,424 (SD 1,026)	2.72 (0.19 12/20)	Moderate	Very Low	Moderate	Moderate	Maintained
North Fork John Day River	1,000	1,852 (SD 1,343)	3.31 (0.16 2/20)	Very Low	Very Low	Low	Low	Highly Viable
Middle Fork John Day River	1,000	3,371 (SD 1,811)	4.49 (0.27 8/20)	Very Low	Low	Moderate	Moderate	Viable
South Fork John Day River	500	943 (SD 552)	2.45 (0.29 10/20)	Very-Low	Very Low	Moderate	Moderate	Viable
John Day River Upper Mainstem	1,000	738 (SD 418)	1.56 (0.16 14/20)	Moderate	Very Low	Moderate	Moderate	Maintained
Satus Creek	1,000 (500)	1,064 (SD 777)	1.92 (0.30 3/20)	Low	Low	Moderate	Moderate	Viable

Abundance/productivity (A/P) metrics					Spatial structure/diversity (SS/D) metrics			
Population	**ICTRT threshold**	**Natural spawning**	**ICTRT productivity**	**Integrated A/P risk**	**Natural processes**	**Diversity risk**	**Integrated SS/D risk**	**Overall risk rating**
Toppenish Creek	500	407 (SD 231)	3.35 (0.23 9/20)	Moderate	Low	Moderate	Moderate	Maintained
Naches River	1,500	1,340 (SD 601)	2.00 (0.23 6/20)	Moderate	Low	Moderate	Moderate	Maintained
Yakima River Upper Mainstem	1,500	346 (SD 129)	1.73 (0.15 20/20)	Moderate	Moderate	High	High	High
Umatilla River	1,500	2,747 (SD 1,108)	0.98 (0.27 6/20)	Moderate	Moderate	Moderate	Moderate	Maintained
Walla Walla River	1,000	713 (SD 511)	1.79 (0.18 8/20)	Moderate	Moderate	Moderate	Moderate	Maintained
Touchet River	1,000	253 (SD 222)	0.91 (0.09 19/20)	High	Low	Moderate	Moderate	High

2.2.6.2.1.1.1.1. Harvest

Encounters of steelhead in the ocean fisheries are rare and incidental impacts to steelhead in ocean fisheries targeting other species are inconsequential to very rare (PFMC 2023d). The majority of harvest related impacts on MCR steelhead occurs in the mainstem Columbia River. Fisheries that impact MCR steelhead are subject to fisheries management provisions of the U.S. v. Oregon Management Agreement. A new 10-year agreement (2018–2027) was adopted since the 2016 5-year review (NMFS 2016b) and limits on incidental harvest rates for MCR steelhead have remained the same (NMFS 2018c). Pursuant to the Agreement, non-treaty fisheries (Figure 47) are managed subject to limits on the winter and summer components of the MCR steelhead DPS of 2% and 4%, respectively (NMFS 2018c). Over the past six years (run year 2014 through 2019), harvest rates of MCR steelhead have remained relatively constant. In non-treaty fisheries (Figure 53), harvest rates on the winter and summer components of the DPS have averaged 0.4% and 1.8%, respectively (NMFS 2022c). There are no specific limits for impacts in treaty fisheries for MCR steelhead, but harvest rates have remained the same since the 2016 5-year review (NMFS 2016b) and have not changed under the 2018 Management Agreement (NMFS 2018c).

2.2.6.2.1.1.1.2. Spatial Structure and Diversity

Updated information on spawner and juvenile rearing distribution does not support a change in status due to spatial structure improvements for MCR Steelhead DPS populations, though the newly re-established run in the White Salmon River and the developing time series of population data from the Klickitat River and Rock Creek do warrant consideration in the DPS recovery plan (Ford 2022). Viability indicators for within-population diversity have changed for some populations since the previous viability review (NWFSC 2015), although in most cases the changes have not been sufficient to shift composite risk ratings for a particular population (Ford 2022).

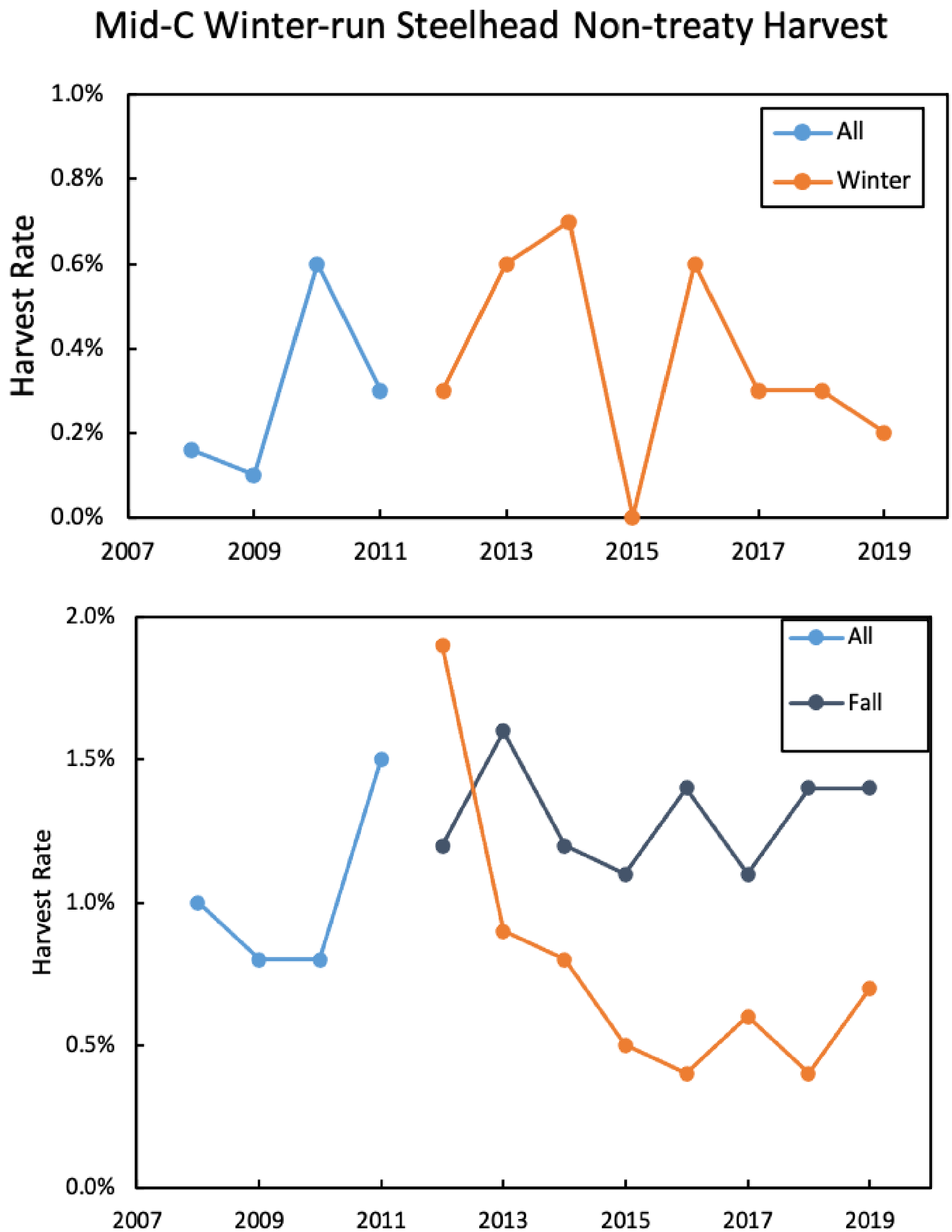


Figure 47. Non-treaty harvest impacts on natural winter- (upper panel) and summer-run (lower panel) steelhead from the Middle Columbia River steelhead DPS. As of 2012, harvest management reporting is broken into two periods, FA and W/SP/SU, where previously reporting was done by full calendar year (Figure reproduced from Ford (2022)).

2.2.6.2.1.1.1.3. Hatcheries

The proportions of hatchery-origin returns in natural spawning areas varies between the MPGs within the MCR Steelhead DPS (Table 60), with low proportions observed in the Yakima and John Day River MPGs, and larger proportions in the Umatilla/Walla Walla and Cascades Eastside Slope Tributaries MPGs (Ford 2022). The management of the fish being propagated at the various programs has changed recently to focus production on individual populations using only fish from within that population (NMFS 2007d); (NMFS 2008h); (NMFS 2017e); (NMFS 2018c); (NMFS 2019a).

Out-of-DPS hatchery strays may pose a risk to some Oregon MCR steelhead populations, particularly the Eastside and Westside Deschutes and John Day populations (NMFS 2022c). NMFS's 2016 5-year review (NMFS 2016b) noted a decrease in the proportion of strays in the John Day River basin and identified a need for additional information to assess the effects of hatchery strays on natural production in the Deschutes River and John Day River systems (NMFS 2016b).

Genetic sampling has documented that the Rock Creek steelhead population is highly introgressed with the Snake River Basin steelhead DPS (85% of adult PIT-tag detections with known juvenile origin were of Snake River origin) (NMFS 2022c). With additional data, it should become apparent if steelhead in Rock Creek are a viable naturalized subpopulation or are sustained by an annual influx of stray steelhead originating from the Snake River (NWFSC 2015). Snake River steelhead transport rates have decreased as a result of earlier migrations and higher spill, and transported Snake River steelhead are known to stray at higher rates than fish that migrated in-river as juveniles (NMFS 2022c).

Hatchery programs operated in middle Columbia tributaries – including the Umatilla, Walla Walla, and Westside Deschutes River subbasins – also create some risks due to ecological interactions and genetic introgression (NMFS 2022c). For hatchery programs that incorporate sufficient natural-origin adults into the broodstock or were derived from the endemic population, NMFS has determined that fish produced therein have not changed substantially or displayed a level of genetic divergence from the local population that is greater than the divergence among closely related natural populations within the DPS (85 FR 81822). The Umatilla River summer steelhead and the Touchet River endemic summer steelhead (Walla Walla Basin) programs currently incorporate natural-origin adults into the broodstock (NMFS 2019c), and the Round Butte Hatchery summer steelhead program (Deschutes River) is proposing to incorporate natural-origin adults into the broodstock (NMFS 2022c).

Table 60. Five-year mean of fraction natural spawners (sum of all estimates divided by the number of estimates). Blanks mean no estimate available in that 5-year range (Ford 2022).

Population	MPG	1995–99	2000–04	2005–09	2010–14	2015–19
Klickitat River	Cascades Eastern Slope Tributaries	—	—	1.00	1.00	1.00
Fifteenmile Creek	Cascades Eastern Slope Tributaries	—	—	—	0.96	0.96
Deschutes River Westside	Cascades Eastern Slope Tributaries	0.67	0.78	0.83	0.94	0.96
Deschutes River Eastside	Cascades Eastern Slope Tributaries	0.51	0.79	0.84	0.86	0.86
Rock Creek	Cascades Eastern Slope Tributaries	—	—	1.00	1.00	1.00
John Day River Lower Mainstem Tributaries	John Day River	0.95	0.86	0.74	0.88	0.97
North Fork John Day River	John Day River	0.95	0.89	0.92	0.98	1.00
Middle Fork John Day River	John Day River	0.95	0.89	0.92	0.98	1.00
South Fork John Day River	John Day River	0.95	0.89	0.92	0.98	1.00
John Day River Upper Mainstem	John Day River	0.95	0.89	0.92	0.98	1.00
Satus Creek	Yakima River	0.89	0.98	0.97	0.98	1.00
Toppenish Creek	Yakima River	0.88	0.98	0.97	0.98	0.99
Naches River	Yakima River	0.89	0.98	0.97	0.98	1.00
Yakima River Upper Mainstem	Yakima River	0.98	0.97	0.99	0.95	0.99
Umatilla River	Umatilla/Walla Walla	0.56	0.71	0.77	0.84	0.85
Walla Walla River	Umatilla/Walla Walla	0.99	0.96	0.97	0.98	0.87
Touchet River	Umatilla/Walla Walla	0.87	0.92	0.76	0.79	0.76

2.2.6.2.1.1.1.4. Summary

The MCR Steelhead DPS does not currently meet the viability criteria described in the MCR Steelhead Recovery Plan (NMFS 2009a); (NMFS 2022c). In addition, several of the factors cited by the 2005 Biological Review Team (Good, Waples, and Adams 2005) remain as concerns or key uncertainties. While recent (5-year) returns are declining across all populations (Figure 46), the declines are from relatively high returns in the previous 5–10-year interval, so the longer-term risk metrics that are meant to buffer against short-period changes in abundance and productivity remain unchanged (Ford 2022). Natural-origin spawning estimates are highly variable relative to minimum abundance thresholds across the populations in the DPS (Ford 2022). Two of the four MPGs in this DPS include at least one population rated at "low" or "very low" risk for abundance and productivity, while the other two MPGs remain in the "moderate" to "high" risk range (Table 59). Updated information indicates that stray levels into the John Day

River populations have decreased in recent years (Ford 2022). Out-of-basin hatchery stray proportions, although reduced, remain high in spawning reaches within the Deschutes River basin and the Umatilla, Walla Walla, and Touchet River populations (Table 60). Overall, the MCR Steelhead DPS remains at “moderate” risk of extinction (Ford 2022), with viability unchanged from the prior review (NWFSC 2015).

2.2.6.2.1.2. Limiting Factors

Understanding the limiting factors and threats that affect the MCR Steelhead DPS provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting the species is to ensure that the underlying limiting factors and threats have been addressed. There are many factors that affect the abundance, productivity, spatial structure, and diversity of the MCR Steelhead DPS. Factors that limit the DPS have been, and continue to be, loss and degradation of spawning and rearing habitat, impacts of mainstem hydropower dams on upstream access and downstream habitats, and the legacy effects of historical harvest; together, these factors have reduced the viability of natural population in the MCR Steelhead DPS. Historically, extensive beaver activity, dynamic patterns of channel migration in floodplains, human settlement and activities, and loss of rearing habitat quality and floodplain channel connectivity in the lower reaches of major tributaries, all impacted the MCR Steelhead DPS populations (Ford 2022).

The recovery plan (NMFS 2009a) summarizes information from four regional management unit plans covering the range of tributary habitats associated with the DPS in Washington and Oregon. Each of the management unit plans are incorporated as appendices to the recovery plan, along with modules for the mainstem Columbia hydropower system and the estuary, where conditions affect the survival of steelhead production from all of the tributary populations comprising the DPS. The recovery objectives defined in the recovery plan are all based on the biological viability criteria developed by the ICTRT (NMFS and ODFW 2011).
The recovery plan also provides a detailed discussion of limiting factors and threats and describes strategies for addressing each of them. Chapter 6 of the recovery plan describes the limiting factors on a regional scale and how they affect the populations in the MCR Steelhead DPS (NMFS 2009a). Chapter 7 of the recovery plan addresses the recovery strategy for the entire DPS and more specific plans for individual MPGs within the DPS (NMFS 2009a). The recovery plan addresses the topics of:

- Tributary habitat conditions,
- Columbia River mainstem conditions,
- Impaired fish passage,
- Water temperature and thermal refuges,
- Hatchery-related adverse effects,
- Predation, competition, and disease,
- Degradation of estuarine and nearshore marine habitat, and
- Climate change

Rather than repeating this extensive discussion from the recovery plan, the discussions in Chapters 6 and 8 are incorporated here by reference.

Overall, the MCR Steelhead DPS is not currently meeting the viability criteria (adopted from the ICTRT) in the Mid-Columbia Steelhead Recovery Plan (NMFS 2009a). In addition, several factors cited by the 2005 Biological Review Team remain as concerns or key uncertainties (Good, Waples, and Adams 2005). The population level viability ratings remained largely unchanged from the prior review (NWFSC 2015) for each MPG within the DPS (Ford 2022).

2.2.6.2.2. Upper Columbia River Steelhead DPS

On August 18, 1997, NMFS listed the UCR Steelhead DPS as an endangered species (62 FR 43937). The UCR steelhead was then listed as a threatened species as of January 5, 2006 (71 FR 834). This DPS was re-classified as endangered on January 13, 2007 (74 FR 42605). However, the status was changed to threatened again in 2009 (74 FR 42605) and was reaffirmed on April 14, 2014 (79 FR 20802). Critical habitat for the UCR Steelhead DPS was designated on September 2, 2005 (70 FR 52630). The most recent five-year review for UCR Steelhead was released in 2022 (NMFS 2022h).

The UCR Steelhead DPS includes all naturally spawned anadromous *O. mykiss* (steelhead) populations below natural and manmade impassable barriers in streams in the Columbia River Basin upstream from the Yakima River, Washington, to the U.S.-Canada border, as well as six artificial propagation programs (Table 61, Figure 48) (Ford 2022); (NMFS 2022h).

As with other Steelhead DPSs, NMFS has defined the UCR Steelhead DPS to include only the anadromous members of this species (70 FR 67130). The UCR Steelhead DPS is composed of one extant MPG with four extant populations (Table 61 and Figure 48).

The life-history pattern of steelhead in the UCR Basin is complex (Chapman et al. 1994). UCR steelhead exhibit a stream-type life with individuals exhibiting a yearling life history strategy (NMFS 2016k). Adults return to the Columbia River in the late summer and early fall. A portion of the returning run overwinters in the mainstem Columbia River reservoirs, passing into tributaries to spawn in April and May of the following year. Spawning occurs in the late spring of the year following entry into the Columbia River. Steelhead in the Upper Columbia Basin have a relatively high fecundity, averaging between 5,300 and 6,000 eggs (Chapman et al. 1994) ; (UCSRB 2007).

Table 61. Upper Columbia River Steelhead DPS description and MPGs (Ford 2022); (NMFS 2022h).

DPS Description	
Threatened	Listed under ESA as endangered in 1997 and 2007; reviewed and listed as threatened in 2006 and 2009, and updated in 2014.
3 MPGs	11 historical populations, 4 extant
MPG	***Populations***
North Cascades	Wenatchee River, Entiat River, Crab Creek (functionally extirpated), Methow River, Okanogan River
Upper Columbia River above Chief Joseph Dam (extirpated)	Sanpoil River, Kettle River, Pend Oreille, Kootenay River
Spokane River (extirpated)	Spokane River, Hangman Creek
Artificial production	
Hatchery programs included in DPS (5)	Wenatchee River Program, Wells Complex Hatchery Program (Methow River), Winthrop National Fish Hatchery Program, Ringold Hatchery Program, Okanogan River Program
Hatchery programs not included in DPS (1)	Wells Hatchery Complex summer (Columbia River)

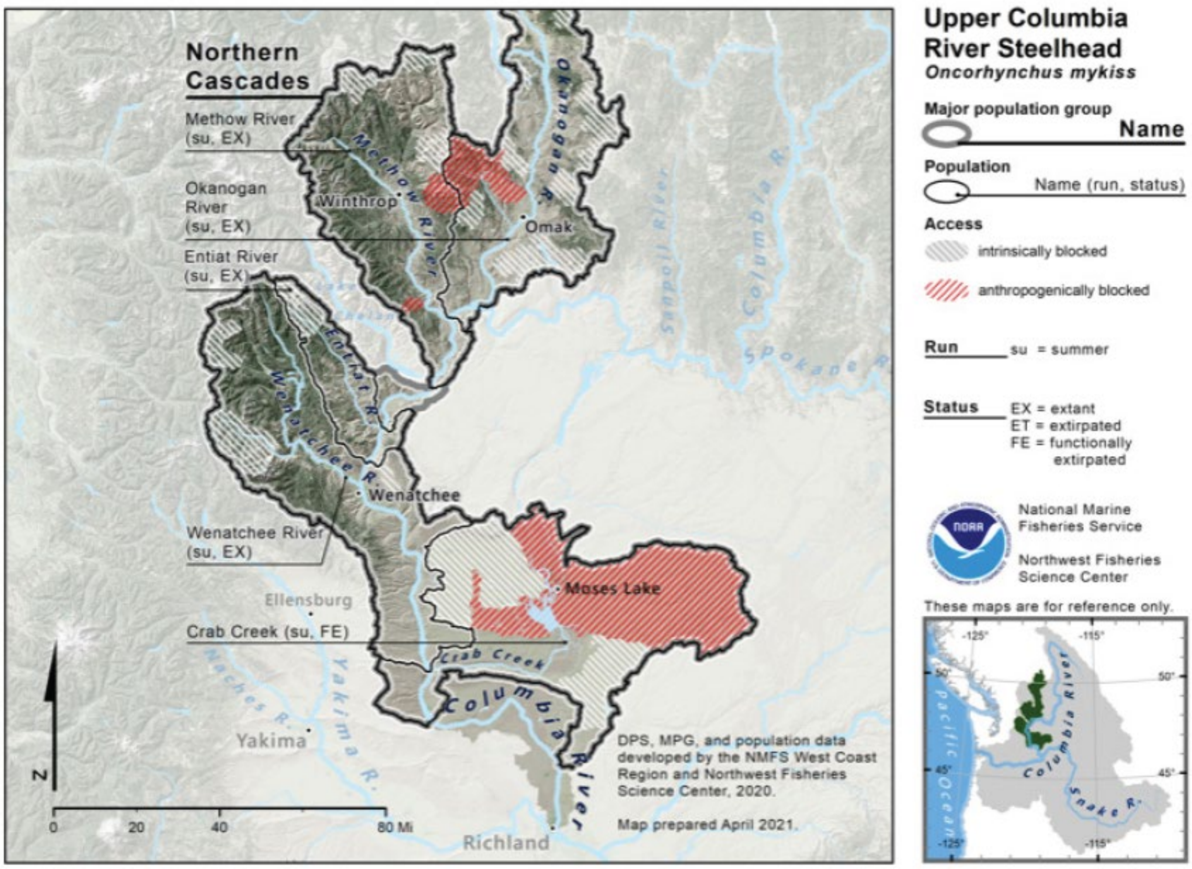


Figure 48. Map of the Upper Columbia River Steelhead DPS's spawning and rearing areas, illustrating natural populations and MPGs (Ford 2022).

2.2.6.2.2.1. Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the UCR Steelhead DPS, is at high risk and remains at threatened status. The most recent viability assessment (Ford 2022) used updated data series on spawner abundance, age structure, and hatchery-to-wild spawner proportions to generate current assessments of abundance and productivity at the population level. Evaluations were done using both a set of metrics corresponding to those used in the prior reviews as well as a set corresponding to the specific viability criteria based on the ICTRT recommendations for this DPS (Ford 2022).

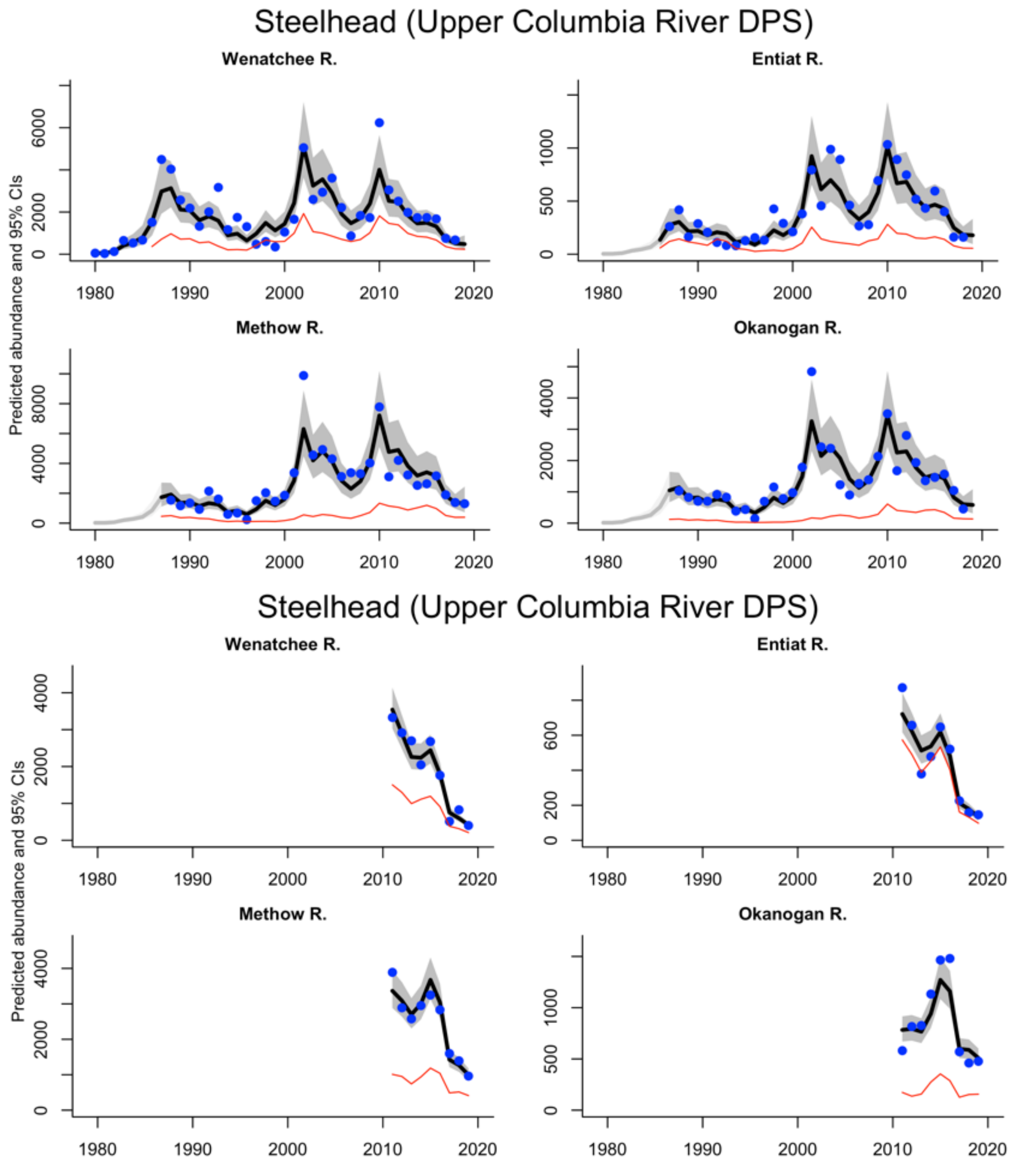


Figure 49. Smoothed trend in estimated total (thick black line, with 95% confidence interval in gray) and natural (thin red line) population spawning abundance. In portions of a time series where a population has no annual estimates but smoothed spawning abundance is estimated from correlations with other populations, the smoothed estimate is shown in light gray. Points show the annual raw spawning abundance estimates. For some trends, the smoothed estimate may be influenced by earlier data points not included in the plot. Upper panel is the traditionally generated spawner abundance time series for each population. Lower panel is population estimates based on PIT-tag detections within each population watershed relative to tagging the aggregate Upper Columbia River run at large (Ford 2022).

2.2.6.2.2.1.1. Abundance and Productivity

All four populations in the UCR Steelhead DPS remain at high overall risk (NMFS 2022h). Natural origin abundance has decreased over the levels reported in the prior review for all populations in this DPS, in many cases sharply (Figure 49). The abundance data for the entire DPS show a downward trend over the last 5 years, with the recent 5-year abundance levels for all four populations declining by an average of 48% (Figure 49). The consistent and sharp declines for all populations in the DPS are concerning. Relatively low ocean survivals in recent years were a major factor in recent abundance patterns.

Spatial structure ratings remain unchanged from the prior review and continue to be rated at low risk for the Wenatchee and Methow populations, moderate risk for the Entiat population, and high risk for the Okanogan population (Table 62). The overall diversity ratings remain unchanged at high risk (Table 62). The high-risk ratings for diversity are largely driven by high levels of hatchery spawners within natural spawning areas and lack of genetic diversity among the populations (NMFS 2022h). Under the current recovery plan, habitat protection and restoration actions are being implemented that are directed at key limiting factors.

Table 62. Upper Columbia River Steelhead DPS: North Cascades MPG population risk ratings integrated across the four VSP parameters. Viability key: Dark Green = highly viable; Green = viable; Orange = maintained; and Red = high risk (does not meet viability criteria) (From NMFS (NMFS 2022h), adapted using data from Ford (2022)).

		Risk Rating for Spatial Structure/Diversity			
Risk Rating for Abundance/ Productivity		Very Low	Low	Moderate	High
	Very Low (<1%)	Highly Viable	Highly Viable	Viable	Maintained
	Low (1–5%)	Viable	Viable	Viable	Maintained
	Moderate (6–25%)	Maintained	Maintained	Maintained	High Risk *Wenatchee*
	High (>25%)	High Risk	High Risk	High Risk	High Risk *Entiat Methow Okanogan*

Given the high degree of year-to-year variability in life stage survivals and the time lags resulting from the 5-year life cycle of the populations, it is not possible to detect incremental gains from habitat actions implemented to date in population level measures of adult abundance or productivity. Based on the information available for this review, the risk category for the UCR steelhead remains unchanged from the prior review (Ford 2022). Although, the recent decline of population abundances is concerning, each population remains well above the abundance levels of when they were listed. All four populations remain at high risk (Table 62).

2.2.6.2.2.1.1.1. Harvest

Steelhead encounters in the ocean are rare and incidental impacts to steelhead in ocean fisheries targeting other species are inconsequential (low hundreds of fish each year) to very rare (NMFS 2022h). The majority of harvest on UCR steelhead occurs in the mainstem Columbia River (NMFS 2022h). Non-treaty fisheries in the Columbia River are limited to an incidental take of 2% during the combined winter, spring, summer period 2% during the fall management period (NMFS 2018c). Overall, impacts on UCR steelhead have remained the same or declined since the last 5-year review. Impacts in non-treaty fisheries have averaged 0.57% and 1.28% for the winter/spring/summer and fall management periods, respectively during the years 2014-2019 (Figure 56). There are no specific limits for impacts in treaty fisheries for UCR steelhead but harvest rates have remained the same since the 2016 5-year review and have not changed under the 2018 Management Agreement (NMFS 2018c).

Steelhead were historically taken in tribal and non-tribal gillnet fisheries, and in recreational fisheries in the mainstem Columbia River and in tributaries (Ford 2022). In the 1970s, retention of steelhead in non-treaty commercial fisheries was prohibited, and in the mid-1980s, tributary recreational fisheries in Washington adopted mark-selective regulations (Ford 2022). There is incidental mortality associated with mark-selective recreational fisheries. Sport fisheries targeting hatchery-run steelhead occur in the mainstem Columbia River and in several UCR tributaries (Ford 2022). In recent years, UCR exploitation rates have been stable at around 1.5% (Figure 50). As of 2012, rates are estimated over two management intervals per year, Fall and Winter/Spring/Summer (Figure 50).

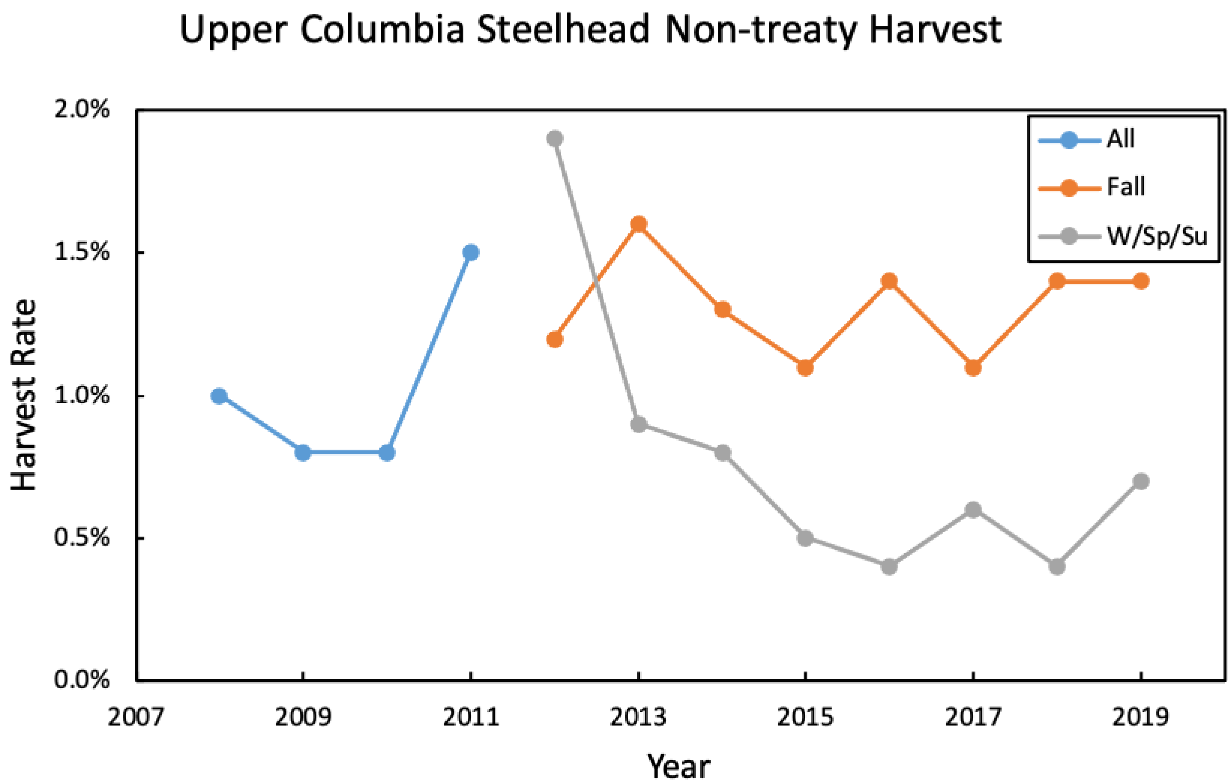


Figure 50. Harvest rates for non-treaty Upper Columbia River steelhead. As of 2012, reporting is generated across two management periods, Fall (orange line) and Winter/Spring/Summer (gray line). Prior to 2012, harvest rate reporting was across all of the calendar year (Figure from Ford (2022)).

2.2.6.2.2.1.2. Spatial Structure and Diversity

With the exception of the Okanogan population, the UCR steelhead populations were rated as low-risk for spatial structure (Ford 2022). The high-risk ratings for diversity are largely driven by high levels of hatchery spawners within natural spawning areas, and lack of genetic diversity among the populations (Ford 2022). The basic major life-history patterns (summer A-run type, tributary and mainstem spawning/rearing patterns, and the presence of resident populations and subpopulations) appear to be present. All of the populations were rated at high risk for current genetic characteristics by the ICTRT (Ford 2022). Genetics samples taken in the 1980s indicate little differentiation within populations in the UCR Steelhead DPS (Ford 2022). More recent studies within the Wenatchee River basin have found differences between samples from the Peshastin River, believed to be relatively isolated from hatchery spawning, and those from other reaches in the basin (Ford 2022). This suggests that there may have been a higher level of within- and among-population diversity prior to the advent of major hatchery releases (Seamons et al. 2012). Genetic studies are underway based on sampling in the Wenatchee River, as well as other

UCR steelhead DPS tributaries, and should allow for future analyses of current genetic structure and any impacts of changing hatchery release practices.

2.2.6.2.2.1.2.1. Hatcheries

The effects of hatchery fish on the status of an ESU or DPS depends upon which of the four key attributes – abundance, productivity, spatial structure, and diversity – are currently limiting the ESU/DPS, and how the hatchery fish within the ESU/DPS affect each of the attributes (70 FR 37204). 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 may pose risks to natural productivity and diversity. The magnitude and type of the risk depends on the status of affected populations and on specific practices in the hatchery program (NMFS 2022h).

The proportions of hatchery-origin returns in natural spawning areas remain high across the DPS, especially in the Methow and Okanogan river populations (Table 63), but the management of the fish being propagated at the various programs has changed recently to focus production on individual populations using only fish from within that population (NMFS 2022h). Given the recent changes in hatchery practices in the Wenatchee River and the potential for reduced hatchery contributions or increased spatial separation of hatchery- vs. natural-origin spawners, it is possible that genetic composition could trend toward patterns consistent with strong natural selection influences in the future (Ford 2022). Ongoing genetic sampling and analysis could provide information in the future to determine if the diversity risk is abating. The proportions of hatchery-origin returns in natural spawning areas remain high across the DPS, especially in the Methow and Okanogan River populations (Ford 2022).

Table 63. Five-year mean of fraction natural-origin spawners (sum of all estimates divided by the number of estimates) (table from Ford (2022)).

Population	1995–99	2000–04	2005–09	2010–14	2015–19
Wenatchee River	0.41	0.34	0.38	0.56	0.50
Entiat River	0.21	0.24	0.24	0.30	0.33
Methow River	0.13	0.11	0.15	0.24	0.31
Okanogan River	0.05	0.06	0.14	0.21	0.24

2.2.6.2.2.1.3. Summary

The most recent estimates (five-year geometric mean) of total and natural-origin spawner abundance have declined since the NWFSC (2015) viability assessment, largely erasing gains observed over the past two decades for all four populations (Figure 49, Table 63). Recent declines are persistent and large enough to result in small, but negative 15-year trends in abundance for all four populations (Figure 49). The abundance and productivity viability rating for the Wenatchee River exceeds the minimum threshold for 5% extinction risk (Ford 2022). The overall UCR Steelhead DPS viability remains largely unchanged from the prior review (NWFSC 2015), and the DPS is at high risk driven by low abundance and productivity relative to viability objectives and diversity concerns (Ford 2022).

2.2.6.2.2.2. Limiting Factors

Understanding the limiting factors and threats that affect the UCR Steelhead DPS provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting the species is to ensure that the underlying limiting factors and threats have been addressed. It is unlikely that the aboriginal fishing (pre-1930s) was responsible for steelhead declines in the Columbia River (UCSRB 2007). Their artisanal fishing methods were incapable of harvesting UCR steelhead at rates that approached or exceeded optimal maximum sustainable yield, probably 69% for steelhead, as estimated in Chapman (Chapman 1986); (UCSRB 2007). Instead, commercial fishing had a significant effect on the abundance of steelhead in the Columbia River. An intense industrial fishery in the LCR, employing traps, beach seines, gillnets, and fish wheels, developed in the latter half of the 1800s. Intensive harvest not only affected abundance and productivity of fish stocks, but probably also the diversity of populations (UCSRB 2007).

There are many factors that affect the abundance, productivity, spatial structure, and diversity of the UCR Steelhead DPS. Factors that limit the DPS have been, and continue to be, hydropower effects, agricultural effects, and habitat degradation; together these factors have affected the populations of this DPS (UCSRB 2007).

The Upper Columbia Recovery Plan (UCSRB 2007) provides a detailed discussion of limiting factors and threats and describes strategies for addressing each of them (Chapters 4, 5, and 8).

Some of the main limiting factors are listed below:

- Mainstem Columbia River hydropower-related adverse effects,
- 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, and
- Harvest-related effects

The plan indicates that the highest priority for protecting biological productivity of UCR salmonids should be to allow unrestricted stream channel migration, complexity and floodplain function. The principal means to meet this objective is to protect riparian habitat in category 1 and 2 sub-watersheds. The highest priority for increasing biological productivity is to restore the complexity of the stream channel and floodplain. Rather than repeating this extensive discussion from the recovery plan, the discussions in Chapters 4, 5, and 8 are incorporated here by reference.

Although all of the natural populations in the DPS remain at high risk and the DPS remains to be listed as threatened, ongoing genetic sampling and analysis could provide information in the future to determine if the diversity risk is abating. The proportions of hatchery-origin returns in natural spawning areas remain high across the DPS, especially in the Methow and Okanogan River populations (Table 63). The improvements in natural returns in recent years largely reflect several years of relatively good natural survival in the ocean and tributary habitats. Tributary habitat actions called for in the Upper Columbia Salmon Recovery Plan are anticipated to be implemented over the next 25 years, and the benefits of some of those actions will require some time to be realized (Ford 2022).

2.2.6.2.3. Snake River Basin Steelhead DPS

On August 18, 1997, NMFS listed the Snake River Basin Steelhead DPS as a threatened species (62 FR 43937). The threatened status was reaffirmed in 2006 and most recently on April 14, 2014 (79 FR 20802). Critical habitat for the DPS was designated on September 2, 2005 (70 FR 52769). The most recent 5-year status review for Snake River Basin steelhead was released in 2022 (NMFS 2022c).

The Snake River Basin Steelhead DPS includes all naturally spawned anadromous O. mykiss originating below natural and manmade impassable barriers in streams in the Snake River Basin of southeast Washington, northeast Oregon, and Idaho (Figure 51) (Ford 2022). Twenty-seven historical populations within six MPGs comprise the Snake River Basin Steelhead DPS. Inside the geographic range of the DPS, 13 hatchery steelhead programs are currently operational. Six of these artificial programs are included in the DPS (Table 64) (NMFS 2022c). Genetic resources can be housed in a hatchery program but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS see NMFS (NMFS 2005d).

This DPS consists of A-Index steelhead, which primarily return to spawning areas beginning in the summer, and B-Index steelhead, which exhibit a larger body size and begin their migration in the fall (NMFS 2011f).

Table 64. Snake River Basin Steelhead DPS description and MPGs (Ford 2022); (NMFS 2022c).

DPS Description	
Threatened	Listed under ESA as threatened in 1997; updated in 2014.
6 MPGs	27 historical populations (3 extirpated), 24 extant
MPG	***Populations***
Grande Ronde	Joseph Creek, Upper Mainstem, Lower Mainstem, Wallowa River
Imnaha River	Imnaha River
Clearwater	Lower Mainstem River, North Fork Clearwater (extirpated), Lolo Creek, Lochsa River, Selway River, South Fork Clearwater
Salmon River	Little Salmon/Rapid, Chamberlain Creek, Secesh River, South Fork Salmon, Panther Creek, Lower MF, Upper MF, North Fork, Lemhi River, Pahsimeroi River, East Fork Salmon, Upper Mainstem
Lower Snake	Tucannon River, Asotin Creek
Hells Canyon Tributaries	No associated independent populations
Artificial production	
Hatchery programs included in DPS (6)	Tucannon River summer, Little Sheep Creek summer, East Fork Salmon River Natural A, Dworshak National Fish Hatchery B, South Fork Clearwater (Clearwater Hatchery) B, Salmon River B
Hatchery programs not included in DPS (7)	Lyons Ferry National Fish Hatchery summer, Wallowa Hatchery summer, Hells Canyon A, Pahsimeroi Hatchery A, Upper Salmon River A, Streamside Incubator Project A, Little Salmon River A

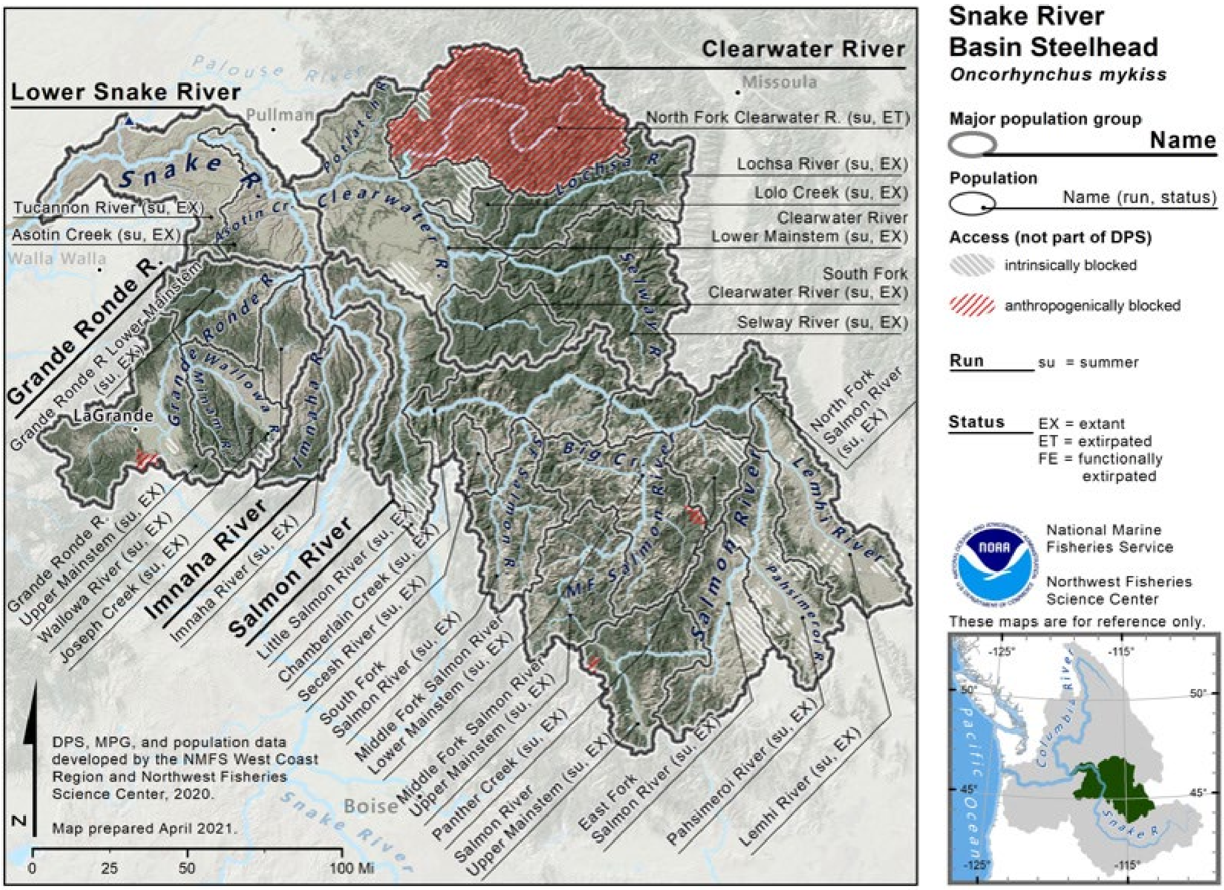


Figure 51. Snake River Basin steelhead DPS spawning and rearing areas, illustrating populations and MPGs (Ford 2022).

As mentioned above, Snake River Basin steelhead exhibit two distinct morphological forms, identified as “A-Index” and “B-Index” fish, which are distinguished by differences in body size, run timing, and length of ocean residence. B-Index fish predominantly reside in the ocean for 2 years, while A-Index steelhead typically reside in the ocean for 1-year (Copeland et al. 2017). As a result of different ocean residence times, B-Index steelhead are generally larger than A-Index fish. The smaller size of A-Index adults allows them to spawn in smaller headwater streams and tributaries. The differences in the two fish stocks represent an important component of phenotypic and genetic diversity of the Snake River Basin Steelhead DPS through the asynchronous timing of ocean residence, segregation of spawning in larger and smaller streams, and possible differences in the habitats of the fish in the ocean (NMFS 2012d).

2.2.6.2.3.1. Abundance, Productivity, Spatial Structure, and Diversity

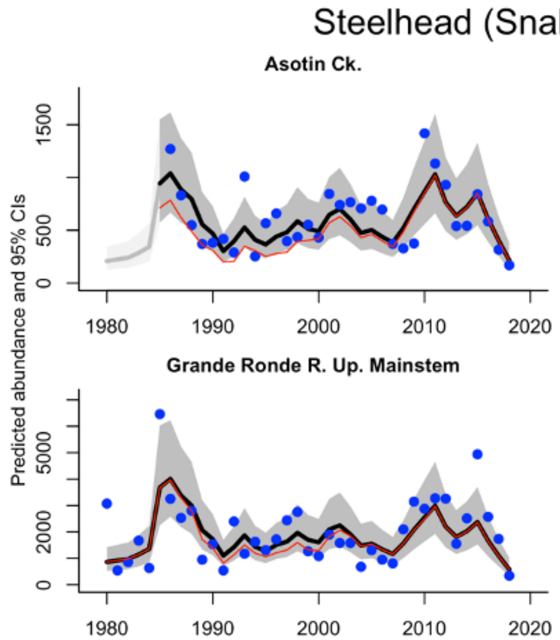
Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the Snake River Basin Steelhead DPS, ranges from moderate to high risk and remains at threatened status. The viability assessment (Ford 2022) used new data to inform the analysis on this DPS. Additionally, ODFW has continued to refine sampling methods for various survey types, which has also led to more accurate data available for use. However, a great deal of uncertainty remains regarding the relative proportion of hatchery-origin fish in natural spawning areas near major hatchery release sites. Because of this, it is difficult to estimate changes in the DPS viability (Ford 2022).

2.2.6.2.3.1.1. Abundance and Productivity

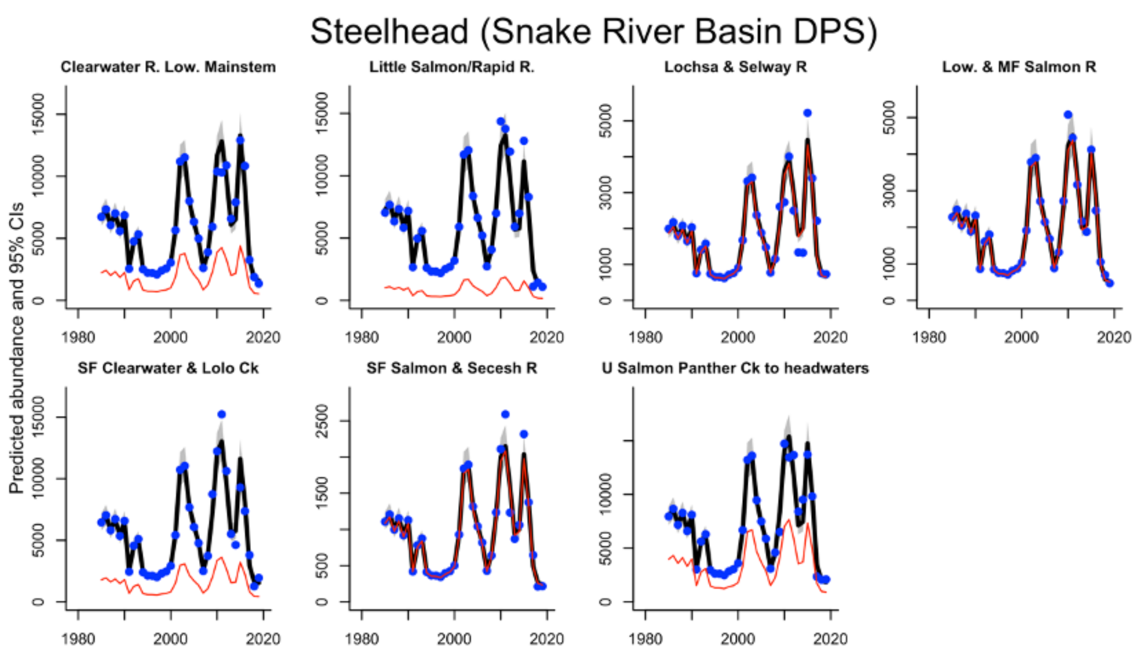
Based on the updated viability information available for this review, none of the five MPGs meet the viability criteria set forth in the 2017 recovery plan, and the viability of many individual populations remains uncertain (Ford 2022); (NMFS 2022c). Of particular note, the updated, population-level abundance estimates have made very clear the recent (last 5 years) sharp declines (Figure 52) that are extremely worrisome, were they to continue (Ford 2022); (NMFS 2022c). The most recent 5-year metric indicates that each population has decreased by about 50% (Figure 52). The viability metrics used in these analyses (standardized Pacific Northwest-wide and ICTRT) are intentionally based on long-time periods (10 to 20-year geometric means) to buffer against the rapid swings in abundance that salmon and steelhead populations are known to exhibit (Ford 2022).

Based on 20-year geometric means, productivity for all populations remains above replacement (Ford 2022); (NMFS 2022c). Cyclical spawner-to-spawner ratios, which reflect combined impacts of habitat, climate, and density dependence, have been strongly below replacement since 2010. Productivity is also expected to decline in the coming years due to recent declines in abundance (Ford 2022); (NMFS 2022c).

a)


Steelhead (Snake River Basin DPS)
Asotin Ck.
Joseph Ck.
Grande Ronde R. Up. Mainstem
Predicted abundance and 95% CIs

b)


Steelhead (Snake River Basin DPS)
Clearwater R. Low. Mainstem
Little Salmon/Rapid R.
Lochsa & Selway R
Low. & MF Salmon R
SF Clearwater & Lolo Ck
SF Salmon & Secesh R
U Salmon Panther Ck to headwaters
Predicted abundance and 95% CIs

c)

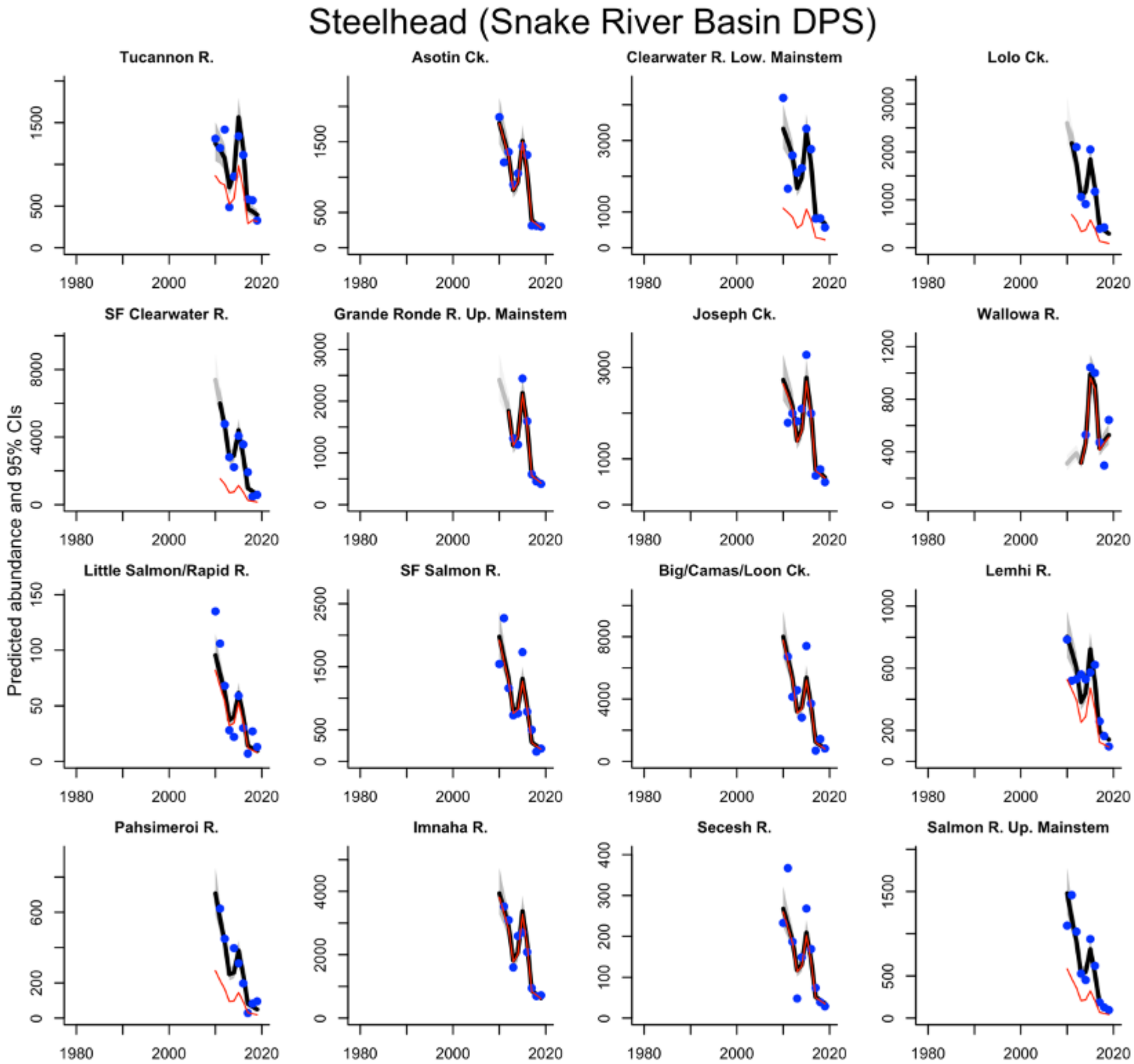


Figure 52. Smoothed trend in estimated total (thick black line, with 95% confidence interval in gray) and natural (thin red line) population spawning abundance. In portions of a time series where a population has no annual estimates but smoothed spawning abundance is estimated from correlations with other populations, the smoothed estimate is shown in light gray. Points show the annual raw spawning abundance estimates. For some trends, the smoothed estimate may be influenced by earlier data points not included in the plot (Ford 2022). a) Long-term dataset from weir and redd surveys. b) Super-population groups from Genetic Stock Identification (GSI)-based run partitioning of the run-at-large over Lower Granite Dam. c) PIT-tag-based population estimation method based on mixture model and tag detection network across the DPS.

2.2.6.2.3.1.1.1. Harvest

Systematic improvements in fisheries management since the 2016 5-year review (NMFS 2016d) include implementation of a new *U.S. v. Oregon* Management Agreement for the years 2018–2027, which replaces the previous 10-year agreement (NMFS 2018c). This new agreement maintains the limits and reductions in harvest impacts for the listed ESUs/DPSs that were secured in previous agreements (NMFS 2018c).

Steelhead encounters in the ocean are rare and incidental impacts to steelhead in ocean fisheries targeting other species are inconsequential (low hundreds of fish each year) to very rare (PFMC 2023b). The majority of harvest-related impacts on Snake River Basin steelhead occurs in the mainstem Columbia River (NMFS 2022c). Overall, impacts on Snake River Basin steelhead have declined since the 2016 5-year review (NMFS 2016d). Impacts in treaty fisheries have declined from 13.8% in 2016 5-year review period (NMFS 2016d) to an average of 8.7% during years 2014–2019 (NMFS 2022c). Impacts in non-treaty fisheries have averaged 0.58, 1.28, 0.08, and 1.52% for A-Run winter/spring/summer, A-Run fall, B-Run winter/spring/summer, and B-run fall, respectively during the years 2014–2019 (NMFS 2022c). Harvest rates have decreased since the 2016 5-year review (NMFS 2016d). Impacts in treaty and non-treaty fisheries are limited by the 2018–2027 *U.S. v. Oregon* Management Agreement (NMFS 2018c). Therefore, harvest continues to pose a moderate risk to Snake River Basin steelhead (NMFS 2022c).

2.2.6.2.3.1.2. Spatial Structure and Diversity

Spatial structure risk ratings for all of the Snake River Basin steelhead populations were low or very low risk (Table 65) given the evidence of broad distribution of natural production within populations (NMFS 2022d). The exception was Panther Creek, which was given a high-risk rating for spatial structure (Table 65) based on the lack of spawning in the upper sections (NMFS 2022d). Based on extensive survey information from the Salmon River and Clearwater River MPGs, the spatial structure ratings for Snake River Basin steelhead populations were maintained at the levels assigned in the original ICTRT assessment (NMFS 2022d). Diversity risk ratings were low to moderate and nearly unchanged from the previous 5-year review period (Table 65).

2.2.6.2.3.1.2.1. Hatcheries

Currently, there are 13 steelhead hatchery programs in the Snake River basin (6 of which are included in the Snake River Basin DPS; Table 64), plus one kelt reconditioning program (NMFS 2022d). The hatchery programs that are considered to be part of the DPS are: Tucannon River, Salmon River B-run, South Fork Clearwater (Clearwater Hatchery) B-run, Dworshak National Fish Hatchery, East Fork Salmon River, and Little Sheep Creek/Imnaha River Hatchery (Table 64).

Table 65. Summary of viability relative to the ICTRT viability criteria, grouped by MPG. Natural spawning = most-recent 10-yr geometric mean (range). ICTRT productivity = 20-yr geometric mean for parent escapements below 75% of population threshold. Current A/P estimates are geometric means. Range in annual abundance, standard error, and number of qualifying estimates for productivities in parentheses. Populations with no abundance and productivity data are given a default "high" A/P risk rating (Ford 2022).

	Abundance/productivity (A/P) metrics				Spatial structure/diversity (SS/D) metrics			
Population	ICTRT threshold	Natural spawning	ICTRT productivity	Integrated A/P risk	Natural processes	Diversity risk	Integrated SS/D risk	Overall risk rating
Tucannon River	1,000	n/a	n/a	High	Low	Moderate	Moderate	High
Lower Snake R. (Tucannon R. and Asotin Crk.)[a]	1,500	750 (SD 751)	2.52 (0.21, 12/20)	Moderate	Low	Moderate	Moderate	Maintained
Asotin Creek	500	574 (SD 389)	1.63 (0.41, 3/20)	Low	Low	Moderate	Moderate	Viable
Lower Grande Ronde River	1,000	n/a	n/a	High	Low	Moderate	Moderate	High
Joseph Creek	500	2,327 (SD 1,291)	1.21 (0.14, 0/20)	Low	Very Low	Low	Low	Viable
Grande Ronde River Upper Mainstem	1,500	2,192 (SD 1,227)	2.01 (0.35, 6/20)	Very Low	Very Low	Moderate	Moderate	Viable
Wallowa River	1,000	n/a	n/a	High	Very Low	Low	Low	High
Imnaha River	1,000	1,811 (SD 1,151)	2.36 (0.21, 9/20)	Very Low	Very Low	Moderate	Moderate	Viable
Clearwater River Lower Mainstem	1,500	2,026 (SD 1,382)	2.32 (0.18, 9/20)	Very Low	Very Low	Low	Low	Highly Viable
South Fork Clearwater River	1,000	1,564 (SD 1,275)	2.80 (0.23, 8/20)	Very Low	Low	Moderate	Moderate	Viable
Lolo Creek	500	1,946 (SD 1,426)	1.82 (0.19, 15/20)	Moderate	Low	Moderate	Moderate	Maintained
Selway River	1,000			Moderate	Very Low	Low	Low	Maintained
Lochsa River	1,000			Moderate	Very Low	Low	Low	Maintained
Little Salmon River	500	750 (SD 751)	2.53 (0.21, 12/20)	Very Low	Low	Moderate	Moderate	Viable
South Fork Salmon River	1,000	919 (SD 816)	1.85 (0.19, 15/20)	Moderate	Very Low	Low	Low	Maintained
Secesh River	500			Moderate	Low	Low	Low	Maintained
Chamberlain Creek	500			Moderate	Low	Low	Low	Maintained

Population	Abundance/productivity (A/P) metrics			Integrated A/P risk	Spatial structure/diversity (SS/D) metrics			Overall risk rating
	ICTRT threshold	Natural spawning	ICTRT productivity		Natural processes	Diversity risk	Integrated SS/D risk	
Lower Middle Fork Salmon River	1,000	1,937 (SD 1,566)	2.47 (0.15, 10/20)	Moderate	Very Low	Low	Low	Maintained
Upper Middle Fork Salmon River	1,000			Moderate	Very Low	Low	Low	Maintained
Panther Creek	500	3,502 (SD 2,562)	1.88 (0.17, 16/20)	Moderate	High	Moderate	High	High
North Fork Salmon River	500			Moderate	Low	Moderate	Moderate	Maintained
Lemhi River	1,000			Moderate	Low	Moderate	Moderate	Maintained
Pahsimeroi River	1,000			Moderate	Moderate	Moderate	Moderate	Maintained
East Fork Salmon River	1,000			Moderate	Very Low	Moderate	Moderate	Maintained
Salmon River Upper Mainstem	1,000			Moderate	Very Low	Moderate	Moderate	Maintained

[a] Note that the Lower Snake River MPG is discussed as a whole in this table as population-level abundance datasets are not available for the entirety of either of the two populations in this MPG; however, a data series for a large subarea within the Asotin Creek population is available (Ford 2022).

Several uncertainties exist regarding the effects of hatchery programs on natural-origin Snake River Basin steelhead populations. One of the main areas of uncertainty is the relative proportion (Table 66) and distribution of hatchery-origin spawners in natural spawning areas at the population level, particularly for Snake River Basin steelhead (Ford 2022). Because of this lack of information, the diversity status of most of the populations in the DPS remains uncertain (NMFS 2022d). Information is needed to determine where and to what extent unaccounted for hatchery steelhead are interacting with ESA-listed populations, particularly in Idaho (Ford 2022). Co-managers have continued to install PIT tag arrays throughout the Snake River basin that are likely to provide new information on population abundance and productivity, and hatchery fish proportions and distribution throughout the Snake River basin (NMFS 2022d).

2.2.6.2.3.1.3. Summary

Population abundance declines since the 2016 5-year review (NMFS 2016d) are sharp and are expected to negatively affect productivity in the coming years corresponding with these declines (NMFS 2022d). These declines in abundance, according to short-term metrics, are of greater concern if they continue through the next 5-year review period (NMFS 2022d). However, spatial structure risk is very low as Snake River Basin steelhead are widely distributed throughout their accessible range, and the species exhibits resilience to rapid changes in abundance (NMFS 2022d). Overall, the information analyzed for the 2022 viability assessment (Ford 2022) does not indicate a change in the biological risk status of the DPS, which remains in the moderate extinction risk category (NMFS 2022d).

2.2.6.2.3.2. Limiting Factors

Understanding the limiting factors and threats that affect the Snake River Basin Steelhead DPS provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting the species is to ensure that the underlying limiting factors and threats have been addressed.

There are many factors that affect the abundance, productivity, spatial structure, and diversity of the Snake River Basin Steelhead DPS. Factors that limit the DPS have been, and continue to be, hydropower projects, predation, harvest, hatchery effects, tributary habitat, and ocean conditions; together these factors have affected the natural populations of this DPS (NMFS 2017g). Specifically, limiting factors also include the following:

- Mainstem Columbia River hydropower-related adverse effects,
- Impaired tributary fish passage,
- Degraded, including degradation in floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream flow, and water quality as a result of cumulative impacts of agriculture, forestry, and development,
- Impaired water quality and increased water temperature,
- Related harvest effects, particularly for B-Index steelhead,

- Predation, and
- Genetic diversity effects from out-of-population hatchery releases

All five MPGs are currently not meeting the specific viability objectives in the Snake River Recovery Plan (NMFS 2017g), and the status of many individual populations remain uncertain. The additional monitoring programs instituted in the early 2000s to gain better information on natural-origin abundance and related factors have significantly improved the ability to assess status at a more detailed level. The new information has resulted in an updated view of the relative abundance of natural-origin spawners and life history diversity across the populations in the DPS. The more specific information on the distribution of natural returns among stock groups and populations indicates that differences in abundance/productivity status among populations may be more related to geography or elevation rather than the morphological forms (i.e., A-Index versus B-Index). A great deal of uncertainty still remains regarding the relative proportion of hatchery-origin fish in natural spawning areas near major hatchery release sites within individual populations. Overall, the information analyzed for the 2022 status review does not indicate a change in biological risk status (Ford 2022).

Table 66. Five-year mean of fraction natural natural-origin spawners (sum of all estimates divided by the number of estimates). Blanks mean no estimate available in that 5-year range. Upper rows: long-term dataset from weir and redd surveys. Middle rows (shaded): super-population groups from GSI-based run partitioning of the run-at-large over Lower Granite Dam. Lower rows: PIT-tag-based population estimation method based on mixture model and tag detection network across the DPS (Ford 2022).

Population	MPG	1995–99	2000–04	2005–09	2010–14	2015–19
Asotin Creek	Lower Snake River	0.65	0.90	0.92	0.99	1.00
Joseph Creek	Grande Ronde River	1.00	1.00	1.00	0.98	0.97
Grande Ronde River Upper Mainstem	Grande Ronde River	0.80	0.91	1.00	0.99	0.99
Clearwater River Lower Mainstem	Clearwater River	0.33	0.33	0.33	0.33	0.33
Lochsa and Selway Rivers	Clearwater River	0.97	0.97	0.97	0.97	0.97
South Fork Clearwater River and Lolo Creek	Clearwater River	0.28	0.28	0.28	0.28	0.28
Little Salmon/Rapid River	Salmon River	0.14	0.14	0.14	0.14	0.14
South Fork Salmon and Secesh Rivers	Salmon River	0.80	0.91	1.00	0.99	0.99
Lower and Middle Fork Salmon River	Salmon River	0.97	0.97	0.97	0.97	0.97
Upper Salmon River and Panther Creek to headwaters	Salmon River	0.50	0.50	0.50	0.50	0.50
Tucannon River	Lower Snake River	—	—	—	0.69	0.68
Asotin Creek	Lower Snake River	—	—	—	0.99	1.00
Clearwater River Lower Mainstem	Clearwater River	—	—	—	0.33	0.33
Lolo Creek	Clearwater River	—	—	—	0.32	0.32
South Fork Clearwater River	Clearwater River	—	—	—	0.26	0.26

Population	MPG	1995–99	2000–04	2005–09	2010–14	2015–19
Grande Ronde River Upper Mainstem	Grande Ronde River	—	—	—	1.00	0.99
Joseph Creek	Grande Ronde River	—	—	—	0.97	0.97
Wallowa River	Grande Ronde River	—	—	—	0.97	0.97
Imnaha River	Imnaha River	—	—	—	0.97	0.97
Little Salmon/Rapid River	Salmon River	—	—	—	0.86	0.86
South Fork Salmon River	Salmon River	—	—	—	0.97	0.97
Big/Camas/Loon Creeks	Salmon River	—	—	—	0.97	0.97
Lemhi River (SU)	Salmon River	—	—	—	0.66	0.66
Pahsimeroi River	Salmon River	—	—	—	0.38	0.38
Secesh River	Salmon River	—	—	—	0.97	0.97
Upper Salmon River	Salmon River	—	—	—	0.40	0.40

2.2.7. Status of Eulachon (Southern DPS)

On March 18, 2010, NMFS listed the southern DPS of Pacific eulachon (*Thaleichthys pacificus*) as a threatened species (NMFS 2017c). Eulachon are endemic to the northeastern Pacific Ocean; they range from northern California to southwest and south-central Alaska and into the southeastern Bering Sea (Figure 53). 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.

2.2.7.1. Eulachon Life History

Adult eulachon spawning typically occurs in the lower reaches of larger rivers fed by snowmelt, and takes place over sand, coarse gravel, or mineral grains. Eulachon eggs attach to small sediment particles (sand and mineral grains); eggs incubate and develop while being actively carried downstream by river currents. Eggs hatch in 30 to 40 days depending on water temperatures. Newly hatched larvae are transparent and are transported downstream by spring freshets, and are dispersed by estuarine, tidal, and ocean currents into the estuary-nearshore environment. However, larval eulachon may remain in low salinity, surface waters of estuaries for several weeks or longer before entering the ocean (Kitada, Hayash, and Kishino 2000). Once larval eulachon enter the ocean they eventually move from shallow nearshore areas to deeper areas over the continental shelf, typically in waters 66 to 292 feet deep (Kitada, Hayash, and Kishino 2000), and sometimes as deep as 597 feet (Barraclough 1964). Eulachon typically spend 2–5 years in saltwater before returning to freshwater to spawn from late winter through spring, spending 95 to 98 percent of their lives at sea (Kitada, Hayash, and Kishino 2000).

Annual eulachon run size estimates (spawning stock biomass estimations) are provided for the years 2000 through 2023 for the Columbia River subpopulation and 1995 through 2023 for the Fraser River subpopulation, Figure 54 and Figure 55, to support our impact analysis on the subpopulation and species scales. Run size estimates are not available for the Klamath subpopulation and the British Columbia subpopulation.

Table 67 provides a summary of listing and recovery plan information, status and major threats for the eulachon. Table 68 provides a summary of eulachon migration, spawning, egg emergence, and larval drift for the Columbia River subpopulation, and Table 69 provides a summary of documented river-entry and spawn-timing for eulachon.

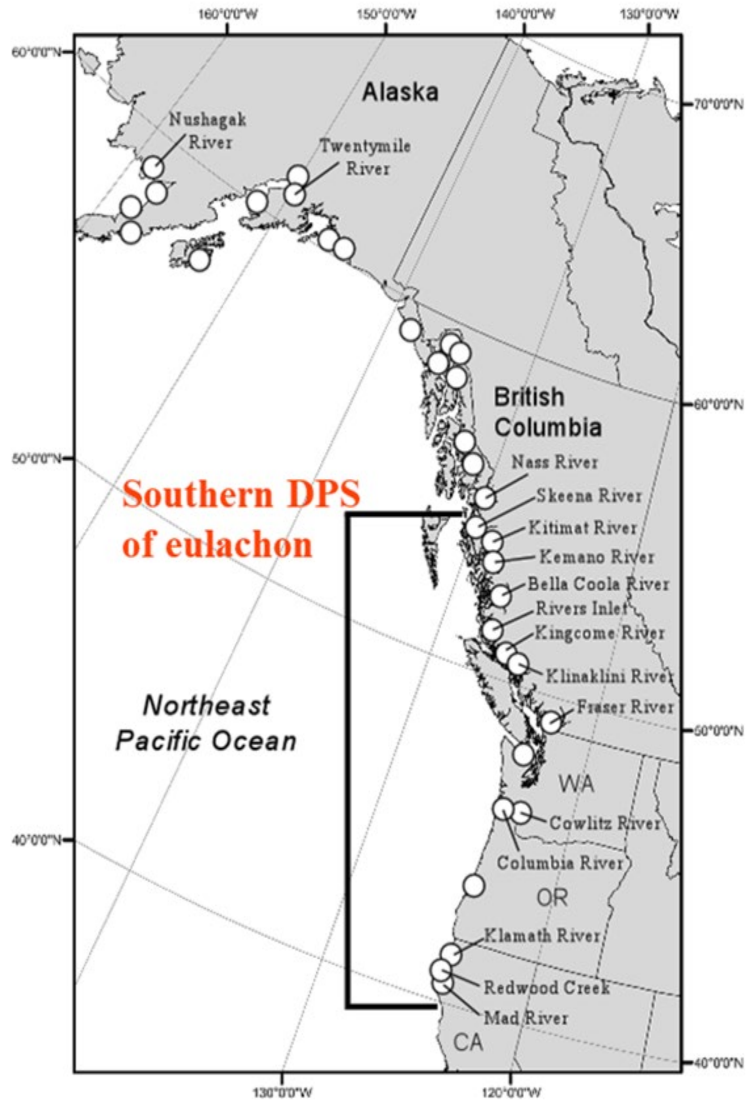


Figure 53. Distribution of the southern district population segment of eulachon

Table 67. Listing classification and date, recovery plan reference, most recent status review, status summary, and limiting factors for eulachon.

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Major Threats
Southern DPS of eulachon	Threatened 3/18/10	NMFS (NMFS 2017c)	NMFS (NMFS 2022a)	Eulachon are endemic to the northeastern Pacific Ocean; they range from northern California to southwest and south-central Alaska and into the southeastern Bering Sea. The southern DPS of eulachon is comprised of fish that spawn in rivers south of the Nass River in British Columbia to, and including, the Mad River in California. In the most recent status review (NMFS 2022o), none of the eulachon mean sustainable stock biomass (SSB) estimates for the years 2016 – 2021 met the HIGH demographic recovery criteria for either the Columbia River subpopulation or the Fraser River subpopulation. For the Columbia River subpopulation, the LOW demographic recovery criterion was met in 2020, and for the Fraser River subpopulation, the LOW demographic recovery criterion was met in 2018 and 2020. In 2022 and 2023, none of the eulachon mean SSB estimates met the HIGH demographic recovery criteria for either the Columbia River subpopulation or the Fraser River subpopulation; however, for the Columbia River subpopulation the LOW demographic recovery criteria was met in both years. For the Fraser River subpopulation, the LOW demographic was not met in either 2022 and 2023. And, for the years 2016 through 2023, the eulachon presence, spatial distribution, and frequency of occurrence recovery criterion was met in several, but not all, representative watersheds.	● Climate change impacts on ocean and freshwater habitat ● Bycatch in offshore shrimp trawl fisheries ● Changes in downstream flow-timing and intensity due to dams and water diversions ● Predation

Table 68. Eulachon migration/spawning/egg emergence and larval drift for the Columbia River subpopulation. Dark grey cells indicate peak activity level and light grey cells indicate non-peak activity level.

Life Stage	Approximate River Miles	River System	Jan	Feb	Ma r	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Migration[1]	0–146	Columbia												
Adult Migration[2]	0–146	Columbia												
Adult Migration[2]		Grays												
Adult Migration[2]		Cowlitz												
Adult Migration[2]		Kalama												
Adult Migration[2]		Lewis												
Adult Migration[2]		Sandy												
Spawning[2]	30–146	Columbia												
Spawning[2]	30–146	Columbia												
Spawning[2]		Grays												
Spawning[3]	30–73	Columbia												
Spawning[2]		Cowlitz												
Spawning[2]		Kalama												
Spawning[2]		Lewis												
Spawning[2]		Sandy												
Eggs/Larval emergence-drift[1,2]	Plume–146	Columbia												
Eggs/Larval emergence-drift[2]	Plume–146	Columbia												
Eggs/Larval emergence-drift[2]	Plume–23	Grays												
Eggs/Larval emergence-drift[3]	Plume–146	Columbia												
Eggs/Larval emergence-drift[2]	Plume–68	Cowlitz												
Eggs/Larval emergence-drift[2]	Plume–73	Kalama												
Eggs/Larval emergence-drift[2]	Plume–85	Lewis												
Eggs/Larval emergence-drift[2]	Plume–121	Sandy												

[1](LCFRB 2004)
[2] Table A-9 in (Drake et al. 2010)
[3] (Romano, Howell, and Rien 2002)

Table 69. Range (gray shading) and peak (black shading) timing of documented river-entry and/or spawn-timing for eulachon.

Basin	Source[a]	December	January	February	March	April	May	June
Oregon								
Tenmile Creek	5							
Columbia Basin								
Columbia River	8							
Cowlitz River	8							
Sandy River	5							
Washington								
Elwha River	1							
British Columbia								
Fraser River	3,9							
Kemano River	6							
Bella Coola River	10							
Kitimat River	2,7							
Skeena River	11							
Nass River	4							

a; 1- (Shaffer et al. 2007) ; 2- (Pedersen, Orr, and Hay 1995) ; 3- (Ricker, Manzer, and Neave 1954) ; (Hart and McHugh 1944); 4- (Langer, Shepherd, and Vroom 1977) ; 5- (WDFW and ODFW 2001) as cited in (Moody 2008); 6- Lewis et al. (2002) as cited in Moody (2008); 7- Kelson (1996) as cited in (Moody 2008) ; 8- (WDFW and ODFW 2001) ;9- (Hart 1943) 10- (Moody 2008); 11- (Lewis 1997) .

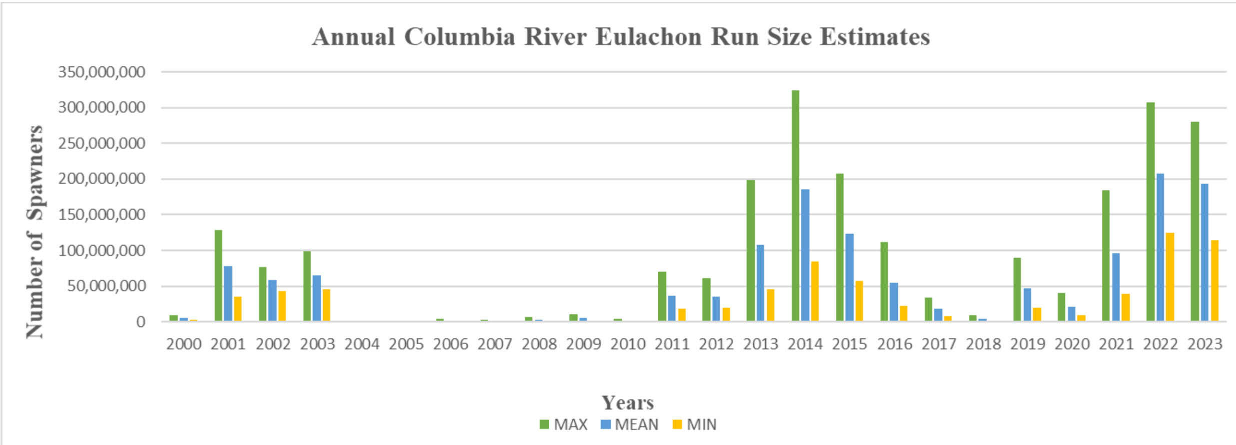


Figure 54. Columbia River subpopulation run size estimations for the years 2000 through 2023.

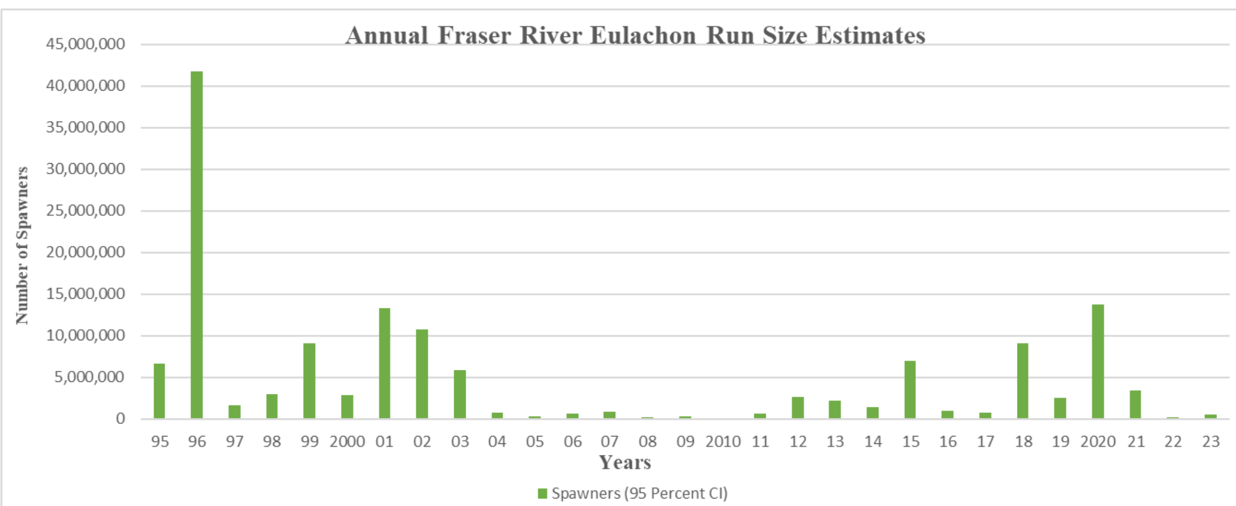


Figure 55. Fraser River subpopulation run size estimations for the years 1995 through 2023.

2.2.8. Status of Salmon and Steelhead Critical Habitat

This section of the Opinion examines the range-wide status of designated critical habitat for the affected species (Sections 2.2.2 through 2.2.6). NMFS has reviewed the status of critical habitat affected by the proposed action. Critical habitat is designated within the Action Area (defined in Section 2.3) for the majority of species affected by the Proposed Action. These critical habitat designations are described further below. No critical habitat exists within the Action Area for the California Coastal Chinook Salmon ESU or the Central Valley Spring-run Chinook Salmon ESU. We review the status of designated critical habitat affected by the Proposed Action by examining the condition and trends of essential physical and biological features throughout the range of the Action Area. Examining these physical and biological features is important because these features support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration and foraging) and are essential to the conservation of the listed species.

For salmon and steelhead, NMFS categorized watersheds as high, medium, or low in terms of the conservation value that the watersheds provide to each listed species they support[18] within designated critical habitat at the scale of the fifth-field hydrologic unit code (HUC5). To determine the conservation value of each watershed to species viability, NMFS's critical habitat analytical review teams (CHARTs) evaluated the quantity and quality of habitat features (i.e., spawning gravels, wood and water condition, side channels), the relationship of the specific geographic area being examined compared to other areas within the species' range, and the significance to the species of the population occupying that area (NMFS 2005a). Thus, even a location that has poor quality of habitat could be ranked with a high conservation value if it were essential because of factors such as limited availability (e.g., one of a very few spawning areas), a unique contribution to the population it served (e.g., for a population at the extreme end of geographic distribution), or the fact that it serves another important role besides providing habitat (e.g., obligate area for migration to upstream spawning areas).

This section examines relevant critical habitat conditions for the affected anadromous species discussed in the previous section. The analysis is grouped by the similarity of essential physical and biological features for each species and the overlapping critical habitat areas.

NMFS determines the range-wide status of critical habitat by examining the condition of its PBF (also called PCEs, or primary constituent elements, in some designations) that were identified when critical habitat was designated. These features are essential to the conservation of the listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration and foraging). The species in Table 1 have overlapping

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

ranges, similar life history characteristics, and, therefore, many of the same PBFs. These PBFs include sites essential to support one or more life stages (spawning, rearing, and/or migration) and contain the physical and biological features essential to the conservation of each species. For example, important features include spawning gravels, forage species, cover in the form of submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks and migration corridors free of artificial obstruction with sufficient water quantity and quality.

The complex life cycle of many salmonids gives rise to complex habitat needs, particularly when the salmonids are in freshwater. For each species, the gravel they utilize for spawning must be a certain size and largely free of fine sediments to allow successful incubation of the eggs and later emergence or escape from the gravel as alevins. Eggs also require cool, clean, and well-oxygenated waters for proper development. Juveniles need abundant food sources, including insects, crustaceans, and other small fish. They need in-stream places to hide from predators (mostly birds and larger fish), such as under logs, root wads, and boulders, as well as beneath overhanging vegetation. They also need refuge from periodic high flows in side channels and off-channel areas and from warm summer water temperatures in cold water springs and deep pools. Returning adults generally do not feed in freshwater, but instead, rely on limited energy stored to migrate, mature, and spawn. Like juveniles, the returning adults also require cool water that is free of contaminants and migratory corridors with adequate passage conditions (timing, water quality/quantity) to allow access to the various habitats required to complete their life cycle (NMFS 2005c).

The watersheds within the Action Area (as described in Section 2.3) have been designated as essential for spawning, rearing, juvenile migration, and adult migration for many of the listed species in Table 13. Specific major factors affecting PBFs and habitat related limiting factors within the Action Area are described for each species in Sections 2.2.2 through 2.2.6. However, across the entire Action Area, widespread development and other land use activities have disrupted watershed processes (e.g., erosion and sediment transport, storage and routing of water, plant growth and successional processes, input of nutrients and thermal energy, nutrient cycling in the aquatic food web, etc.), reduced water quality, and diminished habitat quantity, quality, and complexity in many of the subbasins. Past and/or current land use or water management activities have adversely affected the quality and quantity of stream and side channel areas (e.g., areas where fish can seek refuge from high flows), riparian conditions, floodplain function, sediment conditions, and water quality and quantity; as a result, the important watershed processes and functions that once created healthy ecosystems for salmon and steelhead production have been weakened.

Within estuaries, essential PBFs have been defined as “areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation” (NMFS 2008b).

The conservation role of salmon and steelhead critical habitat is to provide PCEs that support populations that can contribute to conservation of ESUs and DPSs. NMFS's critical habitat designations for salmon have noted that the conservation value of critical habitat also considers "(1) the importance of the populations associated with a site to the ESU conservation, and (2) the contribution of that site to the conservation of the population either through demonstrated or potential productivity of the area." (68 FR 55926, September 29, 2003). This means that, in some cases, having a small area within the total area of designated critical habitat with impaired habitat features could result in a significant impact on conservation value of the entire designated area, when that particular habitat location serves an especially important role to the population and the species' recovery needs (e.g., unique genetic or life history diversity, critical spatial structure). In other words, because the conservation value of habitat indicates that its supporting important viability parameters of populations, conservation values themselves therefore may be considered impaired (NMFS 2016k).

2.2.8.1. Puget Sound Recovery Domain

Critical habitat has been designated in Puget Sound for Puget Sound Chinook salmon, Puget Sound steelhead, and Hood Canal Summer-run chum salmon. Major tributary river basins in the Puget Sound basin include the Nooksack, Samish, Skagit, Sauk, Stillaguamish, Snohomish, Lake Washington, Cedar, Sammamish, Green, Duwamish, Puyallup, White, Carbon, Nisqually, Deschutes, Skokomish, Duckabush, Dosewallips, Big Quilcene, Elwha, and Dungeness rivers and Soos Creek.

Critical habitat for Puget Sound Chinook salmon was designated on September 2, 2005 (70 FR 52630). Critical habitat includes 1,683 miles of streams, 41 square miles of lakes, and 2,182 miles of nearshore marine habitat in Puget Sound. 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.

Critical habitat for Hood Canal Summer-run chum salmon was designated on September 2, 2005 (70 FR 52630). Critical habitat includes 79 miles of rivers and 377 miles of nearshore marine habitat in Hood Canal. Most freshwater rivers in Hood Canal Summer-run chum salmon designated critical habitat are in fair to poor condition. Many nearshore areas are degraded, but some areas, including Port Gamble Bay, Port Ludlow, and Kilisut Harbor, remain in good condition (Garono and Robinson 2002); (Daubenberger et al. 2017).

Critical habitat for Puget Sound steelhead was designated on February 24, 2016 (81 FR 9252). Critical habitat 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. Critical habitat for Puget Sound steelhead includes freshwater spawning sites, freshwater rearing sites, and freshwater migration corridors.

Critical habitat is designated for Puget Sound Chinook salmon and Hood Canal Summer-run chum in estuarine and nearshore areas. Designated critical habitat for Puget Sound steelhead does not include nearshore areas, as this species does not make extensive use of these areas during the juvenile life stage.

Landslides can occur naturally in steep, forested lands, but inappropriate land use practices likely have accelerated their frequency and the amount of sediment delivered to streams. Fine sediment from unpaved roads has also contributed to stream sedimentation. Unpaved roads are widespread on forested lands in the Puget Sound basin, and to a lesser extent, in rural residential areas. Historical logging removed most of the riparian trees near stream channels. Subsequent agricultural and urban conversion permanently altered riparian vegetation in the river valleys, leaving either no trees, or a thin band of trees. The riparian zones along many agricultural areas are now dominated by alder, invasive canary grass and blackberries, and provide substantially reduced stream shade and large wood recruitment (SSDC 2007).

Diking, agriculture, revetments, railroads and roads in lower stream reaches have caused significant loss of secondary channels in major valley floodplains in this region. Confined main channels create high-energy peak flows that remove smaller substrate particles and large wood. The loss of side-channels, oxbow lakes, and backwater habitats has resulted in a significant loss of juvenile salmonid rearing and refuge habitat. When the water level of Lake Washington was lowered 9 feet in the 1910s, thousands of acres of wetlands along the shoreline of Lake Washington, Lake Sammamish and the Sammamish River corridor were drained and converted to agricultural and urban uses. Wetlands play an important role in hydrologic processes, as they store water that ameliorates high and low flows. The interchange of surface and groundwater in complex stream and wetland systems helps to moderate stream temperatures. Forest wetlands are estimated to have diminished by one-third in Washington State (FEMAT 1993); (Spence et al. 1996); (SSDC 2007).

Loss of riparian habitat, elevated water temperatures, elevated levels of nutrients, increased nitrogen and phosphorus, and higher levels of turbidity, presumably from urban and highway runoff, wastewater treatment, failing septic systems, and agriculture or livestock impacts, have been documented in many Puget Sound tributaries (SSDC 2007).

Peak stream flows have increased over time due to paving (roads and parking areas), reduced percolation through surface soils on residential and agricultural lands, simplified and extended drainage networks, loss of wetlands, and rain-on-snow events in higher elevation clear cuts (SSDC 2007). In urbanized Puget Sound, there is a strong association between land use and land cover attributes and rates of coho spawner mortality likely due to runoff containing contaminants emitted from motor vehicles (Feist, Anderson, and Miyamoto 1996). Recent studies have shown that coho salmon show high rates of pre-spawning mortality when exposed to chemicals that leach from tires (McIntyre et al. 2015). Researchers have recently identified a tire rubber antioxidant as the cause (Tian et al. 2021). Although Chinook salmon did not experience the same level of mortality, tire leachate is still a concern for all salmonids. Traffic residue also contains many unregulated toxic chemicals such as pharmaceuticals, polycyclic aromatic hydrocarbons (PAHs), fire retardants, and emissions that have been linked to deformities, injury and/or death of salmonids and other fish (Trudeau 2017); (Young 2018).

Dams constructed for hydropower generation, irrigation, or flood control have substantially affected Puget Sound salmon and steelhead populations in a number of river systems. The construction and operation of dams have blocked access to spawning and rearing habitat, changed flow patterns, resulted in elevated temperatures and stranding of juvenile migrants, and degraded downstream spawning and rearing habitat by reducing recruitment of spawning gravel and large wood to downstream areas (SSDC 2007). These actions tend to promote downstream channel incision and simplification (Kondolf 1997), limiting fish habitat. Water withdrawals reduce available fish habitat and alter sediment transport. Hydropower projects often change flow rates, stranding and killing fish, and reducing aquatic invertebrate (food source) productivity (Hunter 1992). In some instances, such as in the Elwha River, dams have been removed as part of restoration efforts.

Juvenile mortality occurs in unscreened or inadequately screened diversions. Water diversion ditches resemble side channels in which juvenile salmonids normally find refuge. When diversion headgates are shut, access back to the main channel is cut off and the channel goes dry. Mortality can also occur with inadequately screened diversions from impingement on the screen, or mutilation in pumps where gaps or oversized screen openings allow juveniles to get into the system. Blockages by dams, water diversions, and shifts in flow regime due to hydroelectric development and flood control projects are major habitat problems in many Puget Sound tributary basins (SSDC 2007).

The nearshore marine habitat has been extensively altered and armored by industrial and residential development near the mouths of many of Puget Sound’s tributaries. A railroad runs along large portions of the eastern shoreline of Puget Sound, eliminating natural cover along the shore and natural recruitment of beach sand (SSDC 2007).

Degradation of the near-shore environment has occurred in the southeastern areas of Hood Canal in recent years, resulting in late summer marine oxygen depletion and significant fish kills. Circulation of marine waters is naturally limited, and partially driven by freshwater runoff, which is often low in the late summer. However, human development has increased nutrient loads from failing septic systems along the shoreline, and from use of nitrate and phosphate fertilizers on lawns and farms. Shoreline residential development is widespread and dense in many places. The combination of highways and dense residential development has degraded certain physical and chemical characteristics of the near-shore environment (HCCC (Hood Canal Coordinating Council) 2005); (SSDC 2007).

NMFS has completed several section 7 consultations on large-scale habitat projects affecting listed species in Puget Sound. Among these are the Washington State Forest Practices Habitat Conservation Plan (NMFS 2006a), and consultations on Washington State Water Quality Standards (NMFS 2008c), the National Flood Plain Insurance Program (NMFS 2008d), the Washington State Department of Transportation Preservation, Improvement and Maintenance

Activities (NMFS 2013b), and the Elwha River Fish Restoration Plan (Ward et al. 2008); (NMFS 2014a); (NMFS 2019e); (NMFS 2020d).

In 2012, the Puget Sound Action Plan was developed with several federal agencies (e.g., Environmental Protection Agency (EPA), NOAA Fisheries, the United States Army Corps of Engineers (USACE), Natural Resources Conservation Service, United States Geological Survey, Federal Emergency Management Agency, and USFWS). The most recent version of the Puget Sound Federal Task Force Action Plan (for years 2022-2026) was released in May 2022[19]. The purpose of the Puget Sound Federal Task Force Action Plan is to contribute toward realizing a shared vision of a healthy and sustainable Puget Sound ecosystem by leveraging Federal programs across agencies and coordinating diverse programs on a specific suite of priorities.

In the 2019, Puget Sound steelhead recovery plan identified approximately 8,000 culverts that block steelhead habitat in Puget Sound (NMFS 2019g), with the plans to address these blockages being extended over many years. Smaller scale improvements in habitat, restoration of riparian habitat and reconnecting side- or off-channel habitats, will allow better access to habitat types and niche diversification.

While there have been some significant improvements in restoring access, it is recognized that land development, loss of riparian and forest habitat, loss of wetlands, demands on water allocation all continue to degrade the quantity and quality of available fish habitat (Ford 2022).

In summary, even with restoration success, like dam removal and blocked culverts being addressed, critical habitat for salmon and steelhead throughout the Puget Sound basin continues to be degraded by numerous management activities, including: hydropower development, loss of mature riparian forests, increased sediment inputs, removal of large wood, intense urbanization, agriculture, alteration of floodplain and stream morphology (i.e., channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, dredging, armoring of shorelines, marina and port development, road and railroad construction and maintenance, logging, and mining. Changes in habitat quantity, availability, and diversity, and flow, temperature, sediment load and channel instability are common limiting factors in areas of critical habitat. As mentioned above, development of shoreline and estuary areas of Puget Sound is expected to continue to adversely impact the quality of marine habitat for Puget Sound salmonids. As noted throughout this Opinion, future effects of climate change on habitat quality throughout Puget Sound are expected to be negative.

The Puget Sound recovery domain CHART for Puget Sound Chinook salmon and Hood Canal Summer-run chum salmon (NMFS 2005c) determined that only a few watersheds with PCEs for Chinook salmon in the Whidbey Basin (Skagit River/Gorge Lake, Cascade River, Upper Sauk River, and the Tye and Beckler rivers) are in good-to-excellent condition with no potential for improvement. Most HUC5 watersheds are in fair-to-poor or fair-to-good condition. However, most of these watersheds have some or a high potential for improvement.

[19] https://www.epa.gov/system/files/documents/2022-06/puget-sound-federal-task-force-action-plan-2022-2026.pdf

2.2.8.1.1. Willamette/Lower Columbia Recovery Domain

NMFS has designated critical habitat in the Willamette/Lower Columbia recovery domain for the UWR Chinook Salmon ESU, LCR Chinook Salmon ESU, LCR Coho Salmon ESU, LCR Steelhead DPS, UWR Steelhead DPS, and the Columbia River Chum Salmon ESU. This recovery domain is described in Section 2.2.2.2.

Critical habitat for UWR Chinook salmon was designated on September 2, 2005 (70 FR 52629). Critical habitat encompasses 60 watersheds within the range of this ESU as well as the lower Willamette/Columbia River rearing/migration corridor, occurring in both Oregon and Washington (70 FR 52629). This includes 1,472 miles of stream habitat and 18 square miles of lake habitat. Nineteen watersheds received a low rating, 18 received a medium rating, and 23 received a high rating of conservation value to the ESU (NMFS 2005c). The lower Willamette/ Columbia River rearing/migration corridor downstream of the spawning range is also considered to have a high conservation value and is the only habitat designated in four of the high value watersheds.

Critical habitat for LCR Chinook salmon was designated on September 2, 2005 (70 FR 52706). Critical habitat includes 1,311 miles of stream habitat and 33 square miles of lake habitat. There are 48 watersheds within the range of this ESU. Four watersheds received a low rating, 13 received a medium rating, and 31 received a high rating of conservation value to the ESU (NMFS 2005c). The LCR rearing/migration corridor downstream of the spawning range is considered to have a high conservation value and is the only habitat area designated in one of the high value watersheds.

Critical habitat was originally proposed for LCR coho salmon on January 14, 2013 and was finalized on February 24, 2016 (81 FR 9251). Critical habitat includes 2,300 miles of streams and lakes. There are 55 watersheds within the range of this ESU. Three watersheds received a low conservation value rating, 18 received a medium rating, and 34 received a high rating (NMFS 2015a). The LCR rearing/migration corridor downstream of the spawning range is considered to have a high conservation value.

Critical habitat for LCR steelhead was designated on September 2, 2005 (70 FR 52833). Critical habitat includes 2,324 miles of stream habitat and 27 square miles of lake habitat. There are 32 watersheds within the range of this DPS. Two watersheds received a low rating, 11 received a medium rating, and 29 received a high rating of conservation value to the DPS (NMFS 2005c). The LCR rearing/migration corridor downstream of the spawning range is considered to have a high conservation value and is the only habitat area designated in one of the high value watersheds.

Critical habitat for the UWR Steelhead DPS was designated on September 2, 2005 (70 FR 52848). Critical habitat includes 1,276 miles of stream habitat and 2 square miles of lake habitat. There are 38 watersheds within the range of this DPS. Seventeen watersheds received a low rating, 6 received a medium rating, and 15 received a high rating of conservation value to the DPS (NMFS 2005c). The lower Willamette/Columbia River rearing/migration corridor downstream of the spawning range is also considered to have a high conservation value and is the only habitat area designated in four of the high value watersheds.

Critical habitat was designated for Columbia River Chum Salmon ESU on September 2, 2005 (70 FR 52746). Critical habitat includes 708 miles of stream habitat. There are 20 watersheds within the range of this ESU. Three watersheds received a medium rating and 17 received a high rating of conservation value to the ESU (NMFS 2005c). The LCR rearing/migration corridor downstream of the spawning range is considered to have a high conservation value and is the only habitat area designated in one of the high value watersheds.

In addition to the Willamette River and Columbia River mainstems, important tributaries to the Willamette/Lower Columbia are also described in Section 2.3 for both Oregon and Washington. Most watersheds have some or a high potential for improvement and the only watersheds in good to excellent condition with no potential for improvement are the watersheds in the upper McKenzie River and its tributaries (NMFS 2016k).

Land management activities have severely degraded stream habitat conditions in the Willamette River mainstem above Willamette Falls and in associated subbasins. In the Willamette River mainstem and lower subbasin mainstem reaches, high density urban development and widespread agricultural effects have reduced aquatic and riparian habitat quality and complexity, and altered sediment composition and water quality and/or quantity, and watershed processes. The Willamette River, once a highly braided river system, has been dramatically simplified through channelization, dredging, and other activities that have reduced rearing habitat by as much as 75% since before modern development began. In addition, the construction of 37 dams in the basin blocked access to more than 435 miles of stream and river habitat, including much of the best spawning habitat in the basin. The dams alter the temperature regime of the Willamette River and its tributaries, affecting the timing and development of naturally-spawned eggs and fry. Logging, agriculture, urbanization, and gravel mining in the Cascade and Coast Ranges have contributed to increased erosion and sediment loads throughout the Willamette/Lower Columbia domain (NMFS 2016k).

On the mainstem of the Columbia River, hydropower projects, including the FCRPS, have significantly degraded salmon and steelhead habitats. The series of dams and reservoirs that make up the FCRPS block an estimated 12 million cubic yards of debris and sediment that would otherwise naturally flow down the Columbia River and replenish shorelines along the Washington and Oregon coasts. The Columbia River estuary has lost a significant amount of the tidal marsh and tidal swamp habitats that are critical to juvenile salmon and steelhead, particularly small or ocean-type species, as a result of the FCRPS modifications to these mainstem river processes. Furthermore, habitat and food-web changes within the estuary, and other factors affecting salmon population structure and life histories, have altered the estuary's capacity to support juvenile salmon (NMFS 2016k).

2.2.8.1.2. Interior Columbia Recovery Domain

Critical habitat has been designated in the Interior Columbia recovery domain, which includes the Snake River Basin, for the Snake River Spring/summer-run Chinook Salmon ESU, Snake River Fall-run Chinook Salmon ESU, UCR Spring-run Chinook Salmon ESU, Snake River Sockeye Salmon ESU, MCR Steelhead DPS, UCR Steelhead DPS, and Snake River Basin Steelhead DPS (Table 13).

Critical habitat for Snake River spring/summer-run Chinook salmon was originally designated on December 28, 1993 (58 FR 68543) but updated most recently on October 25, 1999 (65 FR 57399). The designated habitat for Snake River spring/summer-run chinook salmon 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 Snake River spring/summer chinook salmon (except reaches above impassable natural falls and Hells Canyon Dam).

Critical habitat was designated for Snake River fall-run Chinook salmon on December 28, 1993 (58 FR 68543). The designated habitat for Snake River fall-run chinook salmon consists of river reaches of the Columbia, Snake, and Salmon rivers, and all tributaries of the Snake and Salmon rivers presently or historically accessible to Snake River fall-run chinook salmon (except reaches above impassable natural falls, and Dworshak and Hells Canyon Dams).

Critical habitat for the UCR spring-run Chinook salmon was designated on September 2, 2005 (70 FR 2732). Critical habitat includes 974 miles of stream habitat and 4 square miles of lake habitat. There are 31 watersheds within the range of this ESU. Five watersheds received a medium rating and 26 received a high rating of conservation value to the ESU (NMFS 2005c). The Columbia River rearing/migration corridor downstream of the spawning range is considered to have a high conservation value and is the only habitat area designated in 15 of the high value watersheds identified.

Critical habitat was designated for Snake River sockeye salmon on December 28, 1993 (58 FR 68543). The designated habitat for Snake River sockeye salmon 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).

Critical habitat for the MCR Steelhead DPS was designated on September 2, 2005 (70 FR 52808). Critical habitat includes 5,815 miles of stream habitat. There are 114 watersheds within the range of this DPS. Nine watersheds received a low rating, 24 received a medium rating, and 81 received a high rating of conservation value to the DPS (NMFS 2005c). The LCR rearing/migration corridor downstream of the spawning range is considered to have a high conservation value and is the only habitat area designated in three of the high value watersheds identified above.

Critical habitat for the UCR Steelhead DPS was designated on September 2, 2005 (70 FR 52630). Critical habitat includes 1,262 miles of stream habitat and 7 square miles of lake habitat.

There are 42 watersheds within the range of this DPS. Three watersheds received a low rating, 8 received a medium rating, and 31 received a high rating of conservation value to the DPS (NMFS 2005c). The Columbia River rearing/migration corridor downstream of the spawning range is considered to have a high conservation value and is the only habitat area designated in 11 of the high value watersheds identified.

Critical habitat for the Snake River Basin Steelhead DPS was designated on September 2, 2005 (70 FR 52769). Critical habitat includes 8,049 miles of stream habitat and 4 square miles of lake habitat. There are 289 watersheds within the range of this DPS. Fourteen watersheds received a low rating, 44 received a medium rating, and 231 received a high rating of conservation value to the DPS (NMFS 2005c). The lower Snake/ Columbia River rearing/migration corridor downstream of the spawning range is considered to have a high conservation value and is the only habitat area designated in 15 of the high value watersheds identified above.

In Washington, the Upper Methow, Lost, White, and Chiwawa watersheds are in good-to-excellent condition with no potential for improvement. In Oregon, only the Lower Deschutes, Minam, Wenaha, Upper and Lower Imnaha rivers HUC5 watersheds are in good-to-excellent condition with no potential for improvement. In Idaho, some watersheds with PCEs for steelhead (Upper Middle Salmon, Upper Salmon/Pahsimeroi, MF Salmon, Little Salmon, Selway, and Lochsa Rivers) are in good-to-excellent condition with no potential for improvement. Additionally, several Lower Snake River watersheds in the Hells Canyon area, straddling Oregon and Idaho, are in good-to-excellent condition with no potential for improvement (NMFS 2016k).

Habitat quality in tributary streams in the Interior Columbia recovery domain varies from excellent in wilderness and road-less areas to poor in areas subject to heavy agricultural and urban development. Critical habitat throughout much of the Interior Columbia recovery domain has been degraded by intense agriculture, alteration of stream morphology (i.e., through channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining, and urbanization. Reduced summer stream flows, impaired water quality, and reduction of habitat complexity are common problems for critical habitat in developed areas, including those within the Interior Columbia River recovery domain (NMFS 2016k).

Habitat quality of migratory corridors in this area have been severely affected by the development and operation of the FCRPS dams and reservoirs in the mainstem Columbia River, Bureau of Reclamation (BOR) tributary projects, and privately-owned dams in the Snake River and UCR basins. Hydroelectric development has modified natural flow regimes of the rivers, resulting in higher water temperatures, changes in fish community structure that lead to increased rates of piscivorous and avian predation on juvenile salmon and steelhead, and delayed migration for both adult and juvenile salmonids. Physical features of dams, such as turbines, also kill out-migrating fish. In-river survival is inversely related to the number of hydropower projects encountered by emigrating juveniles. Additionally, development and operation of extensive irrigation systems and dams for water withdrawal and storage in tributaries have altered hydrological cycles (NMFS 2016k).

Many stream reaches designated as critical habitat are listed on Oregon, Washington, and Idaho's Clean Water Act Section 303(d) list for water temperature. Many areas that were historically suitable rearing and spawning habitat are now unsuitable due to high summer stream temperatures. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water for agricultural or municipal use all contribute to elevated stream temperatures. Furthermore, contaminants, such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste, are common in some areas of critical habitat (NMFS 2016k). They can negatively impact critical habitat and the organisms associated with these areas.

2.2.8.2. Estuaries

Critical habitat has been designated in the estuary of the Columbia River for every species included in the Willamette/Lower Columbia and Interior Columbia Recovery Domains. This area is described in Section 2.2.2.3. Historically, the downstream half of the Columbia River estuary was a dynamic environment with multiple channels, extensive wetlands, sandbars, and shallow areas. The mouth of the Columbia River was about four miles wide. Winter and spring floods, low flows in late summer, large woody debris floating downstream, and a shallow bar at the mouth of the Columbia River maintained a dynamic environment. Today, navigation channels have been dredged, deepened and maintained, jetties and pile-dike fields have been constructed to stabilize and concentrate flow in navigation channels, marsh and riparian habitats have been filled and diked, and causeways have been constructed across waterways. These actions have decreased the width of the mouth of the Columbia River to two miles and increased the depth of the Columbia River channel at the bar from less than 20 to more than 55 feet (NMFS 2008j).

Over time, more than 50% of the original marshes and spruce swamps in the estuary have been converted to industrial, transportation, recreational, agricultural, or urban uses. More than 3,000 acres of intertidal marsh and spruce swamps have been converted to other uses since 1948. Many wetlands along the shore in the upper reaches of the estuary have been converted to industrial and agricultural lands after levees and dikes were constructed. Furthermore, water storage and release patterns from reservoirs upstream of the estuary have changed the seasonal pattern and volume of discharge. The peaks of spring/summer floods have been reduced, and the amount of water discharged during winter has increased (NMFS 2008j).

In addition, model studies indicate that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of suspended particulate matter to the lower river and estuary by about 40% (as measured at Vancouver, Washington) and have reduced fine sediment transport by 50% or more. The significance of these changes for anadromous species under NMFS's jurisdiction in this area is unclear, although estuarine habitat is likely to provide ecosystem services (e.g., food and refuge from predators) to subyearling migrants that reside in estuaries for up to two months or more (NMFS 2008j).

NMFS (NMFS 2005c) identified the PCEs for Columbia basin salmonids in estuaries as follows:

- Estuarine areas free of obstruction with water quality, quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater;
- Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and
- Juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.

These features are essential to conservation because, without them, juvenile salmonids cannot reach the ocean in a timely manner and use the variety of habitats that allow them to avoid predators, compete successfully, and complete the behavioral and physiological changes needed for life in the ocean. Similarly, these features are essential to the conservation of adult salmonids because these features in the estuary provide a final source of abundant forage that will provide the energy stores needed to make the physiological transition to fresh water, migrate upstream, avoid predators, and develop to maturity upon reaching spawning areas (NMFS 2008h).

2.2.9. Climate Change Effects on Salmon and Steelhead

This section starts with a general discussion regarding vulnerability of salmonids to climate change and temperature increase (Section 2.2.9.1), then proceeds with discussions specific to freshwater (Section 2.2.9.2), estuarine (Section 2.2.9.3), and oceanic (Section 2.2.9.4) habitats. It concludes with a discussion on uncertainty in climate predictions (Section 2.2.9.5).

2.2.9.1. General Vulnerability of Salmonids to Climate Change

Climate change is negatively affecting ESA-listed salmon and steelhead habitat and populations across the Pacific Northwest. These effects are expected to continue and intensify in the coming decades. Climate and climate-related elements of freshwater and marine aquatic habitats in the Puget Sound and Columbia River basin regions have been changing for several decades. Average annual Pacific Northwest air temperatures have increased by approximately 1ºC since 1900, or about 50% more than the global average over the same period (USGCRP 2023). Climate change is expected to continue for many decades into the future, with substantial negative implications to freshwater and marine habitats and the species that currently inhabit these waters. For the Pacific Northwest, recent climate models project a warming of 1.9–3.5 ºC by the 2050s relative to the period 1950–1999 based on low to high greenhouse gas emissions scenarios (Climate Impacts Group. 2021). By the 2080s, a warming of 2.6–5.6 ºC is projected. The recently-published Fifth National Climate Assessment (USGCRP 2023) provides a detailed overview of the concomitant effects to such environmental conditions as snowpack, streamflow, extreme temperature and precipitation events, drought recurrence and severity, regional sea surface temperatures, and ocean acidification, among others. Changes to these are expected to negatively affect ESA-listed salmon, their habitat, and the food webs upon which they depend.

Climate change has broad and substantial negative implications for salmonids and salmonid habitat in the Pacific Northwest (e.g., (Climate Impacts Group 2004); (Beechie et al. 2006); (Zabel et al. 2006); (Battin et al. 2007); (ISAB 2007); (Mantua, Tohver, and Hamlet 2010); (Wade et al. 2013); (Tohver, Hamlet, and Lee 2014); (Mauger et al. 2015); (Crozier et al. 2019);

(Crozier et al. 2021); (Crozier and Siegel 2023); (McClure et al. 2023). Higher summer water temperatures, lower summer–early fall stream and river flows, increased magnitude of winter peak flows and flooding, and changes to hydrologic regime are expected to have considerable negative effects to salmonid populations in rivers and streams across both regions. Related long-term negative effects include but are not limited to the following: depletion of cool water habitat and refugia; detrimental alterations to adult and juvenile migration patterns; increased egg and fry mortality from increased flooding and sediment loads; increased competition among species; greater vulnerability to predators; and, increased disease susceptibility. Climate change is also expected to detrimentally affect marine habitats and salmonid survival through warmer water temperatures, loss of coastal and estuary habitat from sea level rise, ocean acidification, and changes in water quality and freshwater inputs. As a result, the distribution and productivity of salmonid populations in the Pacific Northwest are expected to be negatively affected by climate change.

Crozier et al. (2019) performed a detailed climate change vulnerability assessment of all ESA-listed Pacific salmon ESUs and steelhead DPSs. Their assessment was based on the following three components of vulnerability: 1) biological sensitivity (a function of individual species characteristics); 2) climate exposure (a function of geographical location and projected future climate conditions); and, 3) adaptive capacity, which describes the ability of an ESU or DPS to adapt to rapidly changing environmental conditions. Most ESUs and DPSs considered in this Opinion were determined to have high vulnerability to climate change (Figure 56). The rest were determined to have either moderate or very high vulnerability.

Habitat preservation and restoration actions can help mitigate the adverse impacts of climate change on salmonids (e.g., (Battin et al. 2007); (ISAB 2007); (Beechie et al. 2013); (Crozier 2019). For example, restoring connections to historical floodplains, off-channel freshwater habitats, and currently-blocked estuarine areas would increase rearing area, provide refugia, and increase floodwater storage. Protecting and restoring riparian buffers would ameliorate stream temperature increases, reduce sediment inputs, and minimize erosion. Purchasing or applying easements to lands that provide important cold water or refuge habitat would also be beneficial. Harvest and hatchery actions can respond to changing conditions associated with climate change by incorporating greater uncertainty in assumptions about environmental conditions, and conservative assumptions about salmon survival, in setting management and program objectives and in determining rearing and release strategies (Beer and Anderson 2013); (Crozier et al. 2019).

Like most fishes, salmon are poikilotherms (cold-blooded animals). Therefore, increasing temperatures in all habitats can have pronounced effects on their physiology, growth, and development rates (see review by Whitney et al. (Whitney et al. 2016)). Higher ambient air temperatures will likely cause water temperatures to rise (ISAB 2007). In the northeast Pacific Ocean, sea surface temperatures from 2013-2020 were exceptionally high and coincided with widespread declines and low abundances for many west coast salmon and steelhead populations (SWFSC 2022). Increases in water temperatures beyond their thermal optima will likely be detrimental through a variety of processes including: increased metabolic rates (and therefore food demand), decreased disease resistance, increased physiological stress, and reduced reproductive success. As trends progress toward warmer oceans and streams, more extreme winter flood events, summer low flows, loss of snowpack in the mountains, and ocean acidification, salmon face increasing challenges (Ford 2022). All of these processes are likely to reduce survival (Beechie et al. 2013); (Wainwright and Weitkamp 2013); (Whitney et al. 2016). As examples of this, high mortality rates for adult sockeye salmon in the Columbia River have been attributed to higher water temperatures and likewise in the Fraser River, as increasing temperatures during adult upstream migration are expected to result in increased mortality of sockeye salmon adults by 9 to 16% by century's end (Martins et al. 2011). Juvenile parr-to-smolt survival of Snake River Chinook salmon are predicted to decrease by 31–47% due to increased summer temperatures (Crozier et al. 2008).

Salmonids require cold water for spawning and incubation. Increased temperatures at ranges well below thermal optima (i.e., when the water is cold) can increase growth and development rates. Examples of this include accelerated emergence timing during egg incubation stages, or increased growth rates during fry stages (Crozier, Zabel, and Hamlet 2008); (Martins et al. 2011). Temperature is also an important behavioral cue for migration (Sykes, Johnson, and Shrimpton 2009), and elevated temperatures may result in earlier-than-normal migration timing. While there are situations or stocks where this acceleration in processes or behaviors is beneficial, there are also others where it is detrimental (Martins et al. 2012); (Whitney et al. 2016).

Figure 56. Vulnerability of salmon ESUs and steelhead DPSs to climate change, including those considered in this Opinion, as determined by Crozier et al. (2019). Box colors show final vulnerability rank for each ESU and DPS as a product of sensitivity and exposure scores: red indicates very high vulnerability, orange high, yellow moderate, and green low. From Crozier et al. (2019).

Very High			Central California Coast Coho*** Sacramento River winter-run Chinook Central Valley spring-run Chinook Central Valley fall/late fall-run Chinook Upper Willamette River Chinook Snake River Sockeye	
High			*Southern Oregon/Northern California Coast Coho**** *Mid-Columbia River spring-run Chinook**** Upper Columbia River spring-run Chinook California Coastal Chinook Puget Sound Chinook Snake River Basin Steelhead Southern California Coast Steelhead Middle Columbia River Steelhead Upper Columbia River Steelhead Puget Sound Coho Puget Sound Steelhead Snake River fall-run Chinook	Snake River spring/summer-run Chinook

			Hood Canal summer-run Chum Upper Willamette River Steelhead Lower Columbia River Coho Oregon Coast Coho	
Moderate		Puget Sound Chum Columbia River Chum	*Central California Coast Steelhead* South Central California Coast Steelhead Northern California Steelhead Central Valley Steelhead Lower Columbia River Steelhead Lower Columbia River Chinook Lake Ozette Sockeye	
Low		Puget Sound Pink		

As climate change progresses and stream temperatures warm, thermal refugia will be essential to persistence of many salmonid populations. Thermal refugia are important for providing salmonids with patches of suitable habitat while allowing them to undertake migrations through or to make foraging forays into areas with greater than optimal temperatures. To avoid waters above summer maximum temperatures, juvenile rearing may be increasingly found only in the confluence of colder tributaries or other areas of cold water refugia (Mantua, Tohver, and Hamlet 2009).

2.2.9.2. Climate Change in Freshwater

As described previously, climate change is predicted to increase the intensity of storms, reduce winter snow pack at low and middle elevations, and increase snowpack at high elevations in northern areas. Middle and lower elevation streams will have larger fall/winter flood events and lower late summer flows, while higher elevations may have higher minimum flows. How these changes will affect freshwater ecosystems largely depends on their specific characteristics and location, which vary at fine spatial scales (Crozier et al. 2008); (Martins et al. 2012). For example, within a relatively small geographic area (Salmon River Basin, Idaho), survival of some Chinook salmon populations was shown to be determined largely by temperature, while others were determined by flow (Crozier and Zabel 2006). Certain salmon populations inhabiting regions that are already near or exceeding thermal maxima will be most affected by further increases in temperature and perhaps the rate of the increases while the effects of altered flow are less clear and likely to be basin-specific (Crozier et al. 2008); (Wade et al. 2013). However, river flow is already becoming more variable in many rivers, and is believed to negatively affect anadromous fish survival more than other environmental parameters (Bond et al. 2015). It is likely this increasingly variable flow is detrimental to multiple salmon and steelhead populations, and likely multiple other freshwater fish species in the Columbia River Basin as well.

Stream ecosystems will likely change in response to climate change in ways that are difficult to predict (Lynch et al. 2016). Changes in stream temperature and flow regimes will likely lead to shifts in the distributions of native species and provide "invasion opportunities" for exotic species. This will result in novel species interactions including predator-prey dynamics, where juvenile native species may be either predators or prey (Lynch et al. 2016); (Rehage and Blanchard 2016). How juvenile native species will fare as part of "hybrid food webs," which are constructed from natives, native invaders, and exotic species, is difficult to predict (Naiman et al. 2012).

2.2.9.3. Climate Change in Estuaries

In estuarine environments, the two big concerns associated with climate change are rates of sea level rise and temperature warming (Wainwright and Weitkamp 2013); (Limburg et al. 2016). Estuaries will be affected directly by sea-level rise: as sea level rises, terrestrial habitats will be flooded and tidal wetlands will be submerged (Kirwan et al. 2010); (Wainwright and Weitkamp 2013); (Limburg et al. 2016). The net effect on wetland habitats depends on whether rates of sea-level rise are sufficiently slow that the rates of marsh plant growth and sedimentation can compensate (Kirwan et al. 2010).

Due to subsidence, sea level rise will affect some areas more than others, with the largest effects expected for the lowlands, like southern Vancouver Island and central Washington coastal areas (Verdonck 2006); (Lemmen et al. 2016). The widespread presence of dikes in Pacific Northwest estuaries will restrict upward estuary expansion as sea levels rise, likely resulting in a near-term loss of wetland habitats for salmon (Wainwright and Weitkamp 2013). Sea level rise will also result in greater intrusion of marine water into estuaries, resulting in an overall increase in salinity, which will also contribute to changes in estuarine floral and faunal communities (Kennedy 1990). While not all anadromous fish species are generally highly reliant on estuaries for rearing, extended estuarine use may be important in some populations (Jones et al. 2014), especially if stream habitats are degraded and become less productive.

2.2.9.4. Climate Change in the Ocean

In marine waters, increasing temperatures are associated with observed and predicted poleward range expansions of fish and invertebrates in both the Atlantic and Pacific oceans (Lucey and Nye 2010); (Asch 2015); (Cheung et al. 2015). Rapid poleward species shifts in distribution in response to anomalously warm ocean temperatures have been well documented in recent years, confirming this expectation at short time scales. Range extensions were documented in many species from southern California to Alaska during unusually warm water associated with "The Blob" in 2014 and 2015 (Bond et al. 2015); (Di Lorenzo and Mantua 2016), and past strong El Niño events (Pearcy 2002); (Fisher, Peterson, and Rykaczewski 2015). Overall, the marine heat wave from 2014 to 2016 had the most drastic impact on marine ecosystems in 2015, with lingering effects into 2016 and 2017. Conditions had somewhat returned to "normal" in 2018, but another marine heat wave in 2019 again set off a series of marine ecosystem changes across the North Pacific. One reason for lingering effects of ecosystem response is due to biological lags. These lags result from species impacts at larval or juvenile stages, which are typically most sensitive to extreme temperatures or changes in food supply. It is only once these species grow to adult size or recruit into fisheries that the impact of the heat wave is apparent (Ford 2022).

Exotic species benefit from these extreme conditions as they increase their distributions. Green crab (*Carcinus maenas*) recruitment increased in Washington and Oregon waters during winters with warm surface waters, including 2014 (Yamada, Peterson, and Kosro 2015). Similarly, Humboldt squid (*Dosidicus gigas*) dramatically expanded their range during warm years from 2004–2009 (Litz et al. 2011). The frequency of extreme conditions, such as those associated with El Niño events or "blobs" are predicted to increase in the future (Di Lorenzo and Mantua 2016). This is likely to occur to some degree over the next ten years, but at a similar rate as the last ten years.
As with changes to stream ecosystems, expected changes to marine ecosystems due to increased temperature, altered productivity, or acidification, will have large ecological implications through mismatches of co-evolved species and unpredictable trophic effects (Cheung et al. 2015); (Rehage and Blanchard 2016). These effects will certainly occur, but predicting the composition or outcomes of future trophic interactions is not possible with the tools available at this time.

Pacific Northwest anadromous fish inhabit as many as three marine ecosystems during their ocean residence period: the Salish Sea, the California Current, and the Gulf of Alaska (Brodeur 1992); (Weitkamp and Neely 2002); (Morris et al. 2007). The response of these ecosystems to climate change is expected to differ, although there is considerable uncertainty in all predictions. It is also unclear whether overall marine survival of anadromous fish in a given year depends on conditions experienced in one versus multiple marine ecosystems. Several are important to Columbia River basin and Puget Sound species, including the California Current and Gulf of Alaska.

In marine habitat, scientists are not certain of all the factors impacting salmon and steelhead survival, but several ocean basin-scale and regional-scale events are linked with fluctuations in salmon and steelhead health and abundance, such as the Oceanic Niño Index (ONI), the Pacific Decadal Oscillation (PDO), and deep-water salinity and temperature (Ford 2022). The NWFSC's Annual Salmon Forecast[20] provides annual summaries of these ocean indicators and additional indicators based on large-scale physical, regional-scale physical, and local-scale biological data that occur in the year of ocean entry for salmon smolts (Ford 2022). In general, years that are favorable for salmonid survival are characterized by physical conditions that include cold water along the U.S. West Coast before or after outmigration, no El Niño events at the equator, cold and salty water locally, and an early onset of upwelling. Climate change plays a part in salmon and steelhead mortality but more studies are needed.

Wind-driven upwelling is responsible for the extremely high productivity in the California Current ecosystem (Bograd et al. 2009); (Peterson et al. 2014). Minor changes to the timing, intensity, or duration of upwelling, or the depth of water column stratification, can have dramatic effects on the productivity of the ecosystem (Black et al. 2014); (Black et al. 2014). Current projections for changes to upwelling are mixed: some climate models show upwelling unchanged, but others predict that upwelling will be delayed in spring, and more intense during

[20] https://www.fisheries.noaa.gov/west-coast/science-data/ocean-ecosystem-indicators-pacific-salmon-marine-survival-northern

summer (Rykaczewski et al. 2015). Should the timing and intensity of upwelling change in the future, it may result in a mismatch between the onset of spring ecosystem productivity and the timing of salmon entering the ocean, and a shift towards food webs with a strong sub-tropical component (Bakun et al. 2015). This may result in changes to distribution and availability of salmon prey in the California region (Brady et al. 2017).

Columbia River and Puget Sound anadromous fish also use coastal areas of British Columbia and Alaska, and mid-ocean marine habitats in the Gulf of Alaska, although their fine-scale distribution and marine ecology during this period are poorly understood (Morris et al. 2007); (Pearcy and McKinnell 2007). Increases in temperature in Alaskan marine waters have generally been associated with increases in productivity and salmon survival (Mantua et al. 1997); (Martins et al. 2012), thought to result from temperatures that have been below thermal optima (Gargett 1997). Warm ocean temperatures in the Gulf of Alaska are also associated with intensified downwelling and increased coastal stratification, which may result in increased food availability to juvenile salmon along the coast (Hollowed et al. 2009); (Martins et al. 2012). Predicted increases in freshwater discharge in British Columbia and Alaska may influence coastal current patterns (Foreman et al. 2014), but the effects on coastal ecosystems are poorly understood.

In addition to becoming warmer, the world's oceans are becoming more acidic as increased atmospheric carbon dioxide (CO_2) is absorbed by water. The North Pacific is already acidic compared to other oceans, making it particularly susceptible to further increases in acidification (Lemmen et al. 2016). Laboratory and field studies of ocean acidification show it has the greatest effects on invertebrates with calcium-carbonate shells and relatively little direct influence on finfish (see reviews by Haigh et al. (2015) and Mathis et al. (2015). Consequently, the largest impact of ocean acidification on salmon will likely be its influence on marine food webs, especially its effects on lower trophic levels, which are largely composed of invertebrates (Haigh et al. 2015); (Mathis et al. 2015).

A primarily positive or slightly negative pattern in the PDO was in place from 2014 through 2019, though since 2019 the pattern has been primarily negative[21]. The NWFSC's most recent 2022 summary of ocean ecosystem indicators[22] reported 2022 was a mix of good and bad ocean conditions for juvenile salmon in the Northern California Current. The PDO turned negative (cool phase) in January 2020 and has remained negative through 2022 with some of the lowest (coldest) values in the 25-year time series occurring in 2021 and 2022. The ONI also signaled cold ocean conditions. The ONI turned negative in May 2020 and has remained negative throughout 2022 with La Niña conditions (values less than or equal to -0.5 °C) for the last 15 consecutive three-month periods (August 2021 to October 2022). The National Weather Service Climate Prediction Center predicted ONI to remain negative throughout the winter and transition to El Niño Southern Oscillation (ENSO)-neutral conditions in February–April 2023. Despite the lackluster upwelling, the northern copepod biomass anomalies and copepod species richness showed signs of cool conditions in the spring and early summer. Still, the anomalies of northern

[21] https://www.ncei.noaa.gov/access/monitoring/pdo/
[22] https://www.fisheries.noaa.gov/west-coast/science-data/2022-summary-ocean-ecosystem-indicators

copepods turned weakly negative by mid-summer, resulting in average biomass anomalies for the May–September period. Weakly positive temperature anomalies occurred in June 2022, following weak upwelling conditions. Strongly positive temperature anomalies followed in July through September. Cool and neutral temperature anomalies returned in September, the remainder of fall was punctuated by strong positive anomalies. The existing regional climate cycles will interact with global climate changes in unknown and unpredictable ways.

2.2.9.5. Uncertainty in Climate Predictions

There is considerable uncertainty in the predicted effects of climate change on the globe as a whole, and on Pacific Northwest in particular and there is also the question of indirect effects of climate change and whether human "climate refugees" will move into the range of salmon and steelhead, increasing stresses on their respective habitats (Dalton, Mote, and [Eds.] 2013); (Poesch et al. 2016).

Many of the effects of climate change (e.g., increased temperature, altered flow, coastal productivity, etc.) will have direct impacts on the food webs that species examined in this analysis rely on in freshwater, estuarine, and marine habitats to grow and survive. Such ecological effects are extremely difficult to predict even in fairly simple systems, and minor differences in life history characteristics among stocks of salmon may lead to large differences in their response (e.g., (Crozier et al. 2008); (Martins et al. 2011); (Martins et al. 2012). This means it is likely that there will be "winners and losers" meaning some salmon populations may enjoy different degrees or levels of benefit from climate change while others will suffer varying levels of harm.

Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of each individual population and on the level and rate of change. They should be able to adapt to some changes, but others are beyond their adaptive capacity (Crozier et al. 2008); (Waples, Beechie, and Pess 2009). With their complex life cycles, it is also unclear how conditions experienced in one life stage are carried over to subsequent life stages, including changes to the timing of migration between habitats. Systems already stressed due to human disturbance are less resilient to predicted changes than those that are less stressed, leading to additional uncertainty in predictions (Bottom et al. 2011); (Naiman et al. 2012); (Beaudreau and Whitney 2016).

Climate change is expected to impact anadromous fish, (e.g., salmon, steelhead, and green sturgeon), during all stages of their complex life cycle. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater and changes to food webs in freshwater, estuarine and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty.

2.3. Action Area

"Action area" means all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR 402.02). The extent of the Action Area for this consultation is defined largely in terms of areas where juvenile, subadult, and adult hatchery-origin salmon and steelhead propagated and released from hatcheries that are a consequence of NMFS's administration of Mitchell Act hatchery funding may occur are known or likely to occur and where such hatchery-origin fish may affect the listed species considered in this Opinion. This Action Area remains largely the same as the 2017 Mitchell Act Opinion for all species. This Action Area includes rivers, streams, and hatchery facilities where hatchery-origin salmon and steelhead occur or are anticipated to occur in the Columbia River Basin, including within the Snake River and all other tributaries of the Columbia River in the United States (U.S.). This Action Area also includes the Columbia River estuary[23], plume[24], and the Pacific Ocean on the continental shelf between Yakutat Bay, Alaska and Heceta Head, Oregon, where the hatchery-origin fish are expected to occur.

The freshwater component of the Action Area comprises two salmon recovery domains (the Willamette/Lower Columbia and the Interior Columbia (IC)) as established by NMFS under its ESA recovery planning responsibilities (Figure 57). The Action Area contains seven ecological provinces and more than 37 subbasins (i.e., tributaries to the Columbia or Snake Rivers) (NMFS 2014b).

[23] The estuary is broadly defined to include the entire continuum where tidal forces and river flows interact, regardless of the extent of saltwater intrusion. This geographic scope encompasses areas from Bonneville Dam (River Mile [RM] 146; River Kilometer [RKm] 235) to the mouth of the Columbia River. The scope includes the lower portion of the Willamette River (from Willamette Falls, at RM 26.6 [RKm 42.6], to the Willamette River's confluence with the Columbia River), along with the tidally influenced portions of other tributaries below Bonneville Dam. This region is that of which experiences ocean tides, extending up the Columbia River to Bonneville Dam and up the Willamette River to Willamette Falls (south of Portland at Oregon City, Oregon) from the mouth of the Columbia River.

[24] The plume is generally defined by a reduced-salinity contour of approximately 31 parts per thousand near the ocean surface. The plume varies seasonally with discharge, prevailing near-shore winds, and ocean currents. For purposes of this Opinion, the plume is considered to be off the immediate coast of both Oregon and Washington and to extend outward to the continental shelf. This definition is consistent with the Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead (Appendix D in (NMFS 2013d).

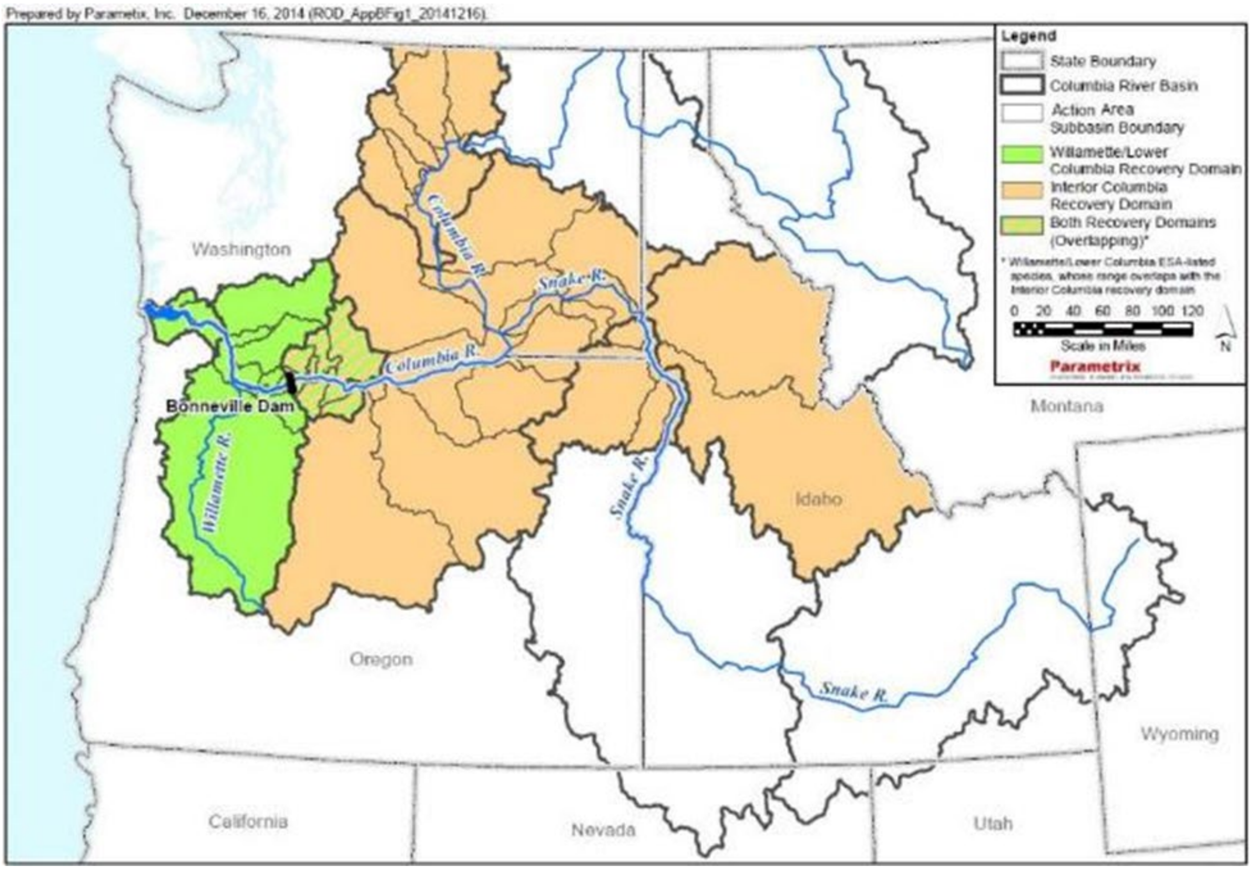


Figure 57. Action Area inside the Columbia River Basin (NMFS 2014b).

The Willamette/Lower Columbia Recovery Domain includes the Willamette River Basin and all Columbia River tributaries from the mouth of the Columbia River to the confluence of Hood River in Oregon and the confluence of White Salmon River in Washington. This domain contains four ESA-listed ESUs of salmon and two ESA-listed DPSs of steelhead: LCR Chinook Salmon ESU, CR Chum Salmon ESU, UWR Chinook Salmon ESU, LCR Coho Salmon ESU, LCR Steelhead DPS, and UWR Steelhead DPS.

The IC Recovery Domain covers all of the Columbia River Basin accessible to anadromous salmon and steelhead above Bonneville Dam. The IC Recovery Domain contains four ESA-listed ESUs of salmon and three ESA-listed DPSs of steelhead: Snake River Sockeye Salmon ESU, Snake River Spring/Summer-run Chinook Salmon ESU, Snake River Fall-run Chinook Salmon ESU, UCR Spring-run Chinook Salmon ESU, Snake River Steelhead DPS, MCR Steelhead DPS, and UCR Steelhead DPS.

Each recovery domain consists of several ecological provinces, as identified by the NPCC (see www.nwcouncil.org for more information). Ecological provinces encompass subbasins with similar climates and geography (NMFS 2014b). This Action Area encompasses only 7 of the 11 Columbia River Basin ecological provinces because anadromous salmon and steelhead do not currently have access to the other 4 ecological provinces (the Middle Snake, Upper Snake, Intermountain, and Mountain Columbia Ecological Provinces). A sample of the location of these respective domains and associated subbasins are captured in Table 70.

The hatchery facilities and programs that are proposed to receive Mitchell Act funding are located in three regions: the LCR, MCR, and Snake River (Figure 58). Some of the facilities in the LCR are displayed in Figure 59, additional facilities in the LCR, Bonneville, and Columbia River Gorge area are displayed in Figure 60, those in the MCR are displayed in Figure 61, and those in the Snake River are in Figure 62.

In the Pacific Ocean, the extent of the Action Area is defined in terms of the effects of the Proposed Action on listed salmon and steelhead. In delimiting this part of the Action Area, we considered both: 1) the oceanic range and distribution of hatchery-origin Chinook, coho, and chum salmon and steelhead trout from the Columbia River basin; and, 2) the potential effects to ESA-listed fish within this range. Broadly speaking, there are two primary parts of the ocean to consider in terms of delineating the Action Area: the continental shelf and the open ocean. The extent to which all Pacific salmon species and steelhead trout migrate across the open ocean is unclear, but they must transit and/or reside on the continental shelf for a period of time if they do end up utilizing the open ocean. Open ocean ranges and distributions at the scale of populations, let alone ESUs and DPSs, are unknown (Beamish 2018b). Thus, we do not know the spatiotemporal scale at which hatchery salmon or steelhead may overlap with ESA-listed salmon or steelhead in the open ocean given the vast area over which these species may range. Though research is limited, we found no evidence of either inter- or intra-specific ecological effects in the open ocean to any listed salmon or steelhead species from hatchery-origin Chinook, chum, or coho salmon, or steelhead trout originating from the continental United States. For these reasons, the open ocean is not included in the Action Area.

Table 70. **Action Area by recovery domain, ecological province (with subbasin examples).**

Recovery Domain	Ecological Province	Subbasin[1]
Willamette/ Lower Columbia	Columbia Estuary	Grays River (WA)
		Elochoman River (WA)
		Youngs Bay (OR)
		Klaskanine River (OR)
	Lower Columbia	Cowlitz River (WA)
		North Fork Toutle River (WA)
		South Fork Toutle River (WA)
		Coweeman River (WA)
		Kalama River (WA)
		Lewis River (WA)

Recovery Domain	**Ecological Province**	**Subbasin**[1]
		Salmon Creek (WA)
		Washougal River (WA)
		Willamette River (OR)
		Sandy River (OR)
Overlap of Willamette/ Lower Columbia and Interior Columbia[2]	Columbia Gorge	Wind River (WA)
		Little White Salmon River (WA)
		Klickitat River (WA)
		Hood River (OR)
		Fifteen Mile Creek (OR)
Interior Columbia	Columbia Plateau	Yakima River (WA)
		Walla Walla River (WA/OR)
		Umatilla River (OR)
		Lower Middle Columbia River (WA/OR)
		Lower Snake River (WA)
	Columbia Cascade	Wenatchee River (WA)
		Entiat River (WA)
		Methow River (WA)
		Okanogan River (WA/BC)
		Upper Middle Columbia River (WA)
	Blue Mountain	Asotin Creek (WA)
		Grande Ronde River (WA/OR)
		Imnaha River (OR)
		Snake Hell's Canyon (OR/ID)
	Mountain Snake	Clearwater River (ID)
		Salmon River (ID)

[1] Not all subbasins are included in this table, instead these were chosen simply to represent the geographic range that the Action Area encompasses given these subbasins are thought to be more commonly known.

[2] The Willamette/Lower Columbia Recovery Domain and the IC Recovery Domain overlap within the Columbia Gorge Ecological Province (see Figure 57).

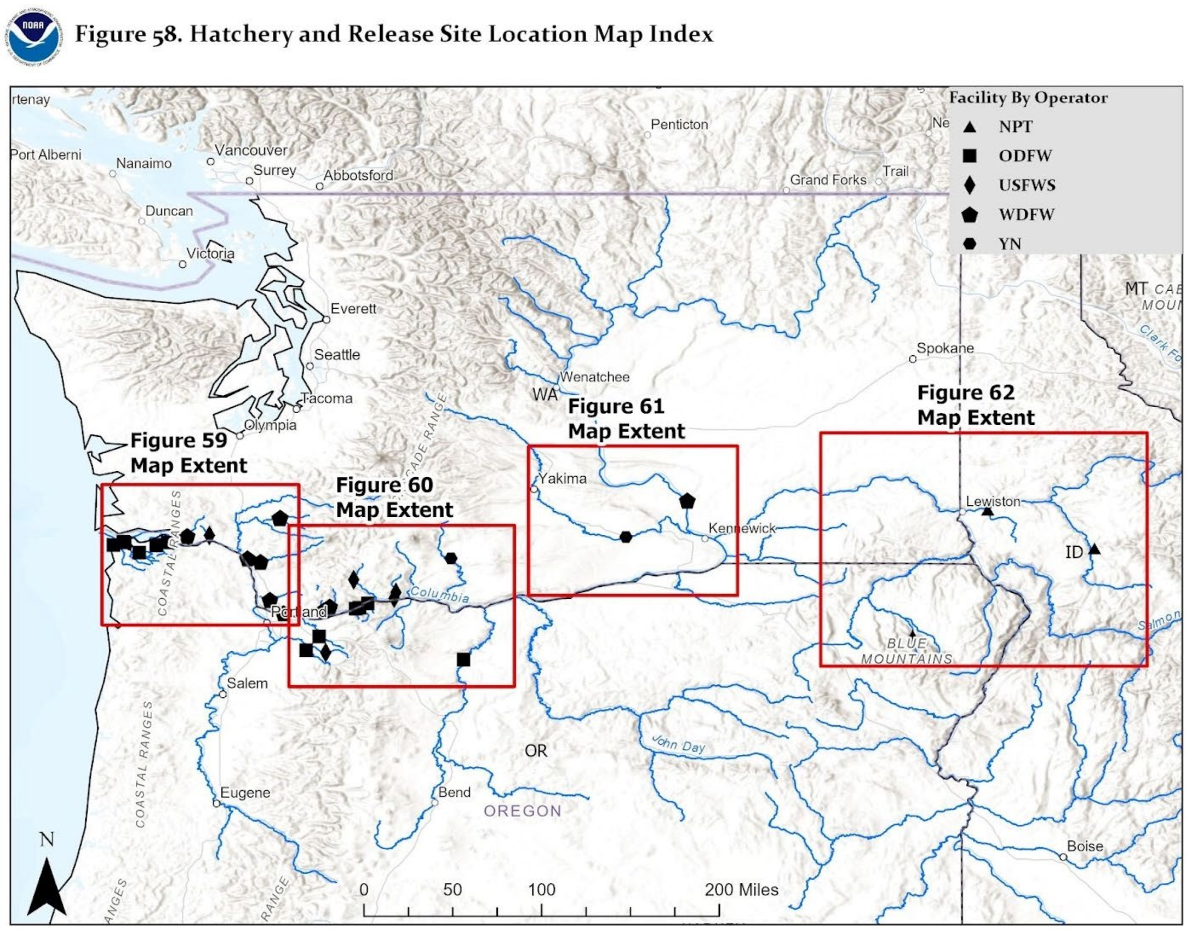


Figure 58. General hatchery facility and release site locations within the Action Area with sub-figure areas identified.

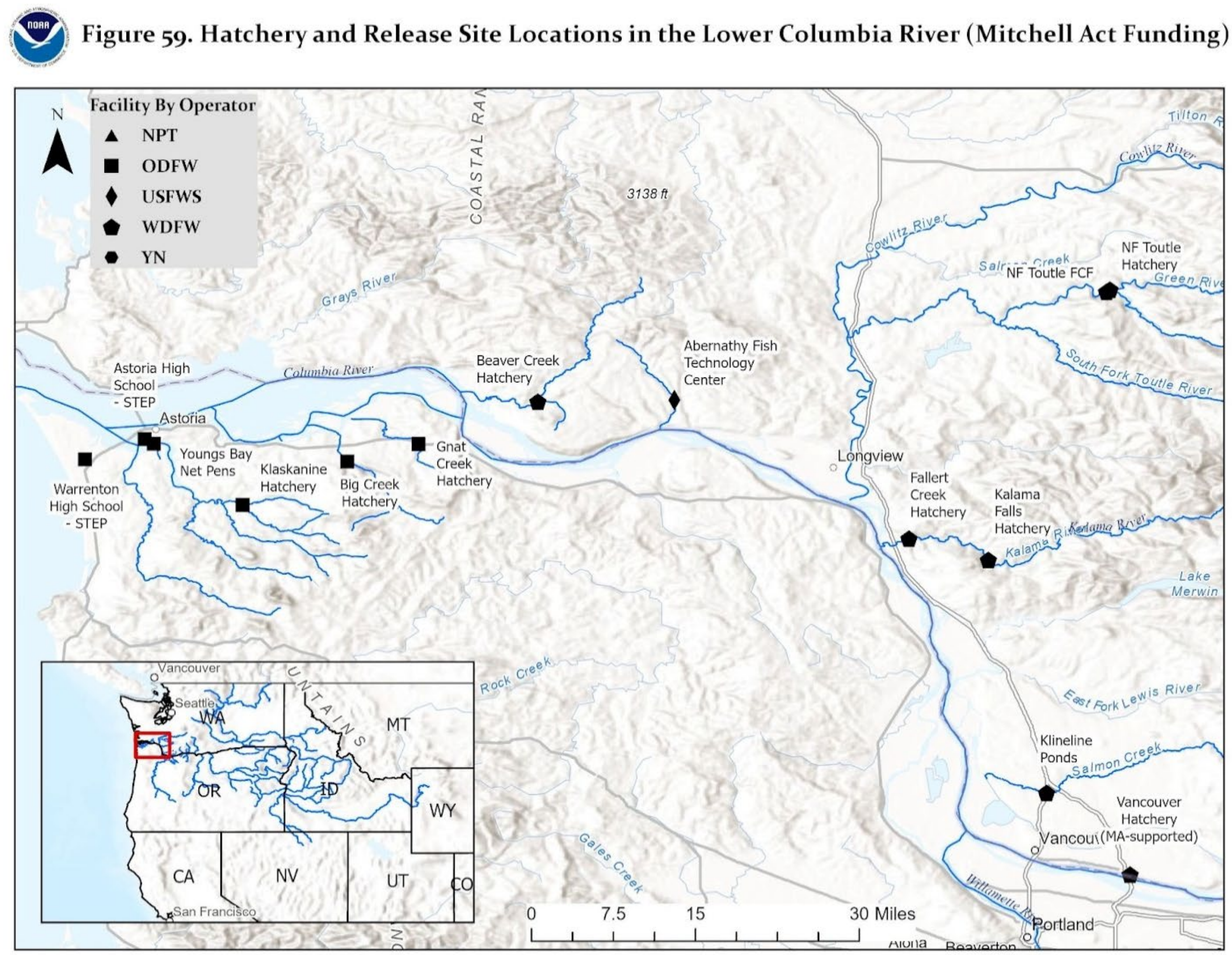


Figure 59. Hatchery and release site locations in the Lower Columbia River (Mitchell Act Funding).

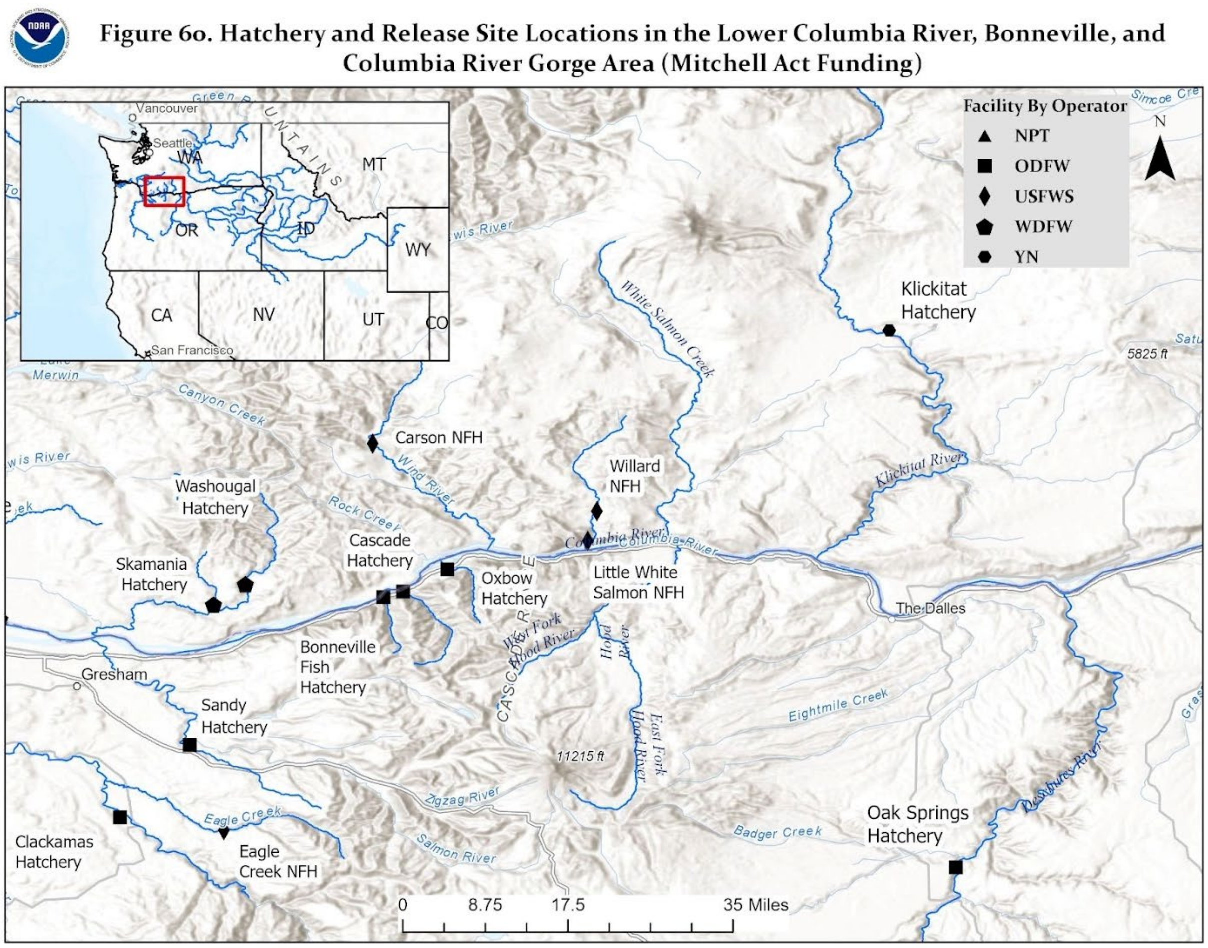


Figure 60. Hatchery and release site locations in the Lower Columbia River within the Bonneville, and Columbia River Gorge Area (Mitchell Act Funding).

Figure 61. Hatchery and Release Site Locations in the Middle Columbia River (Mitchell Act Funding)

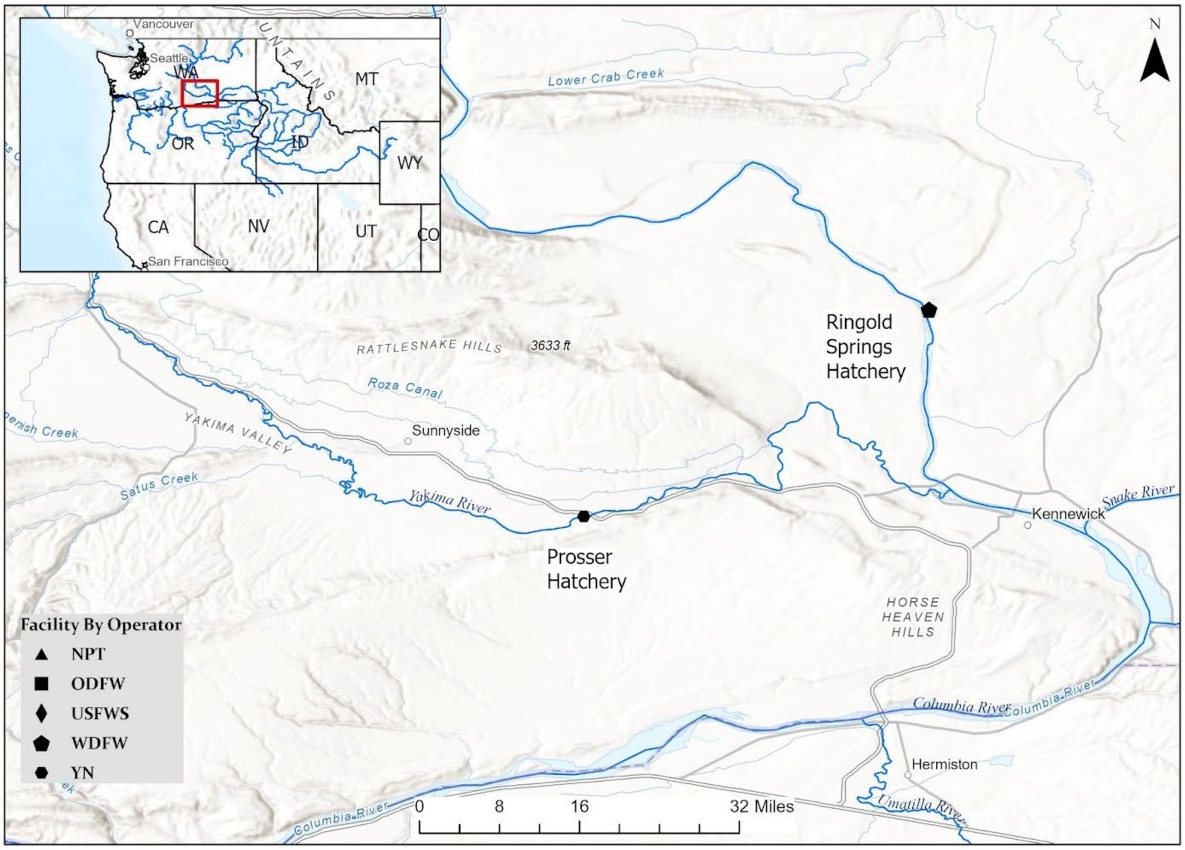


Figure 61. Hatchery and release site locations in the Middle Columbia River (Mitchell Act Funding).

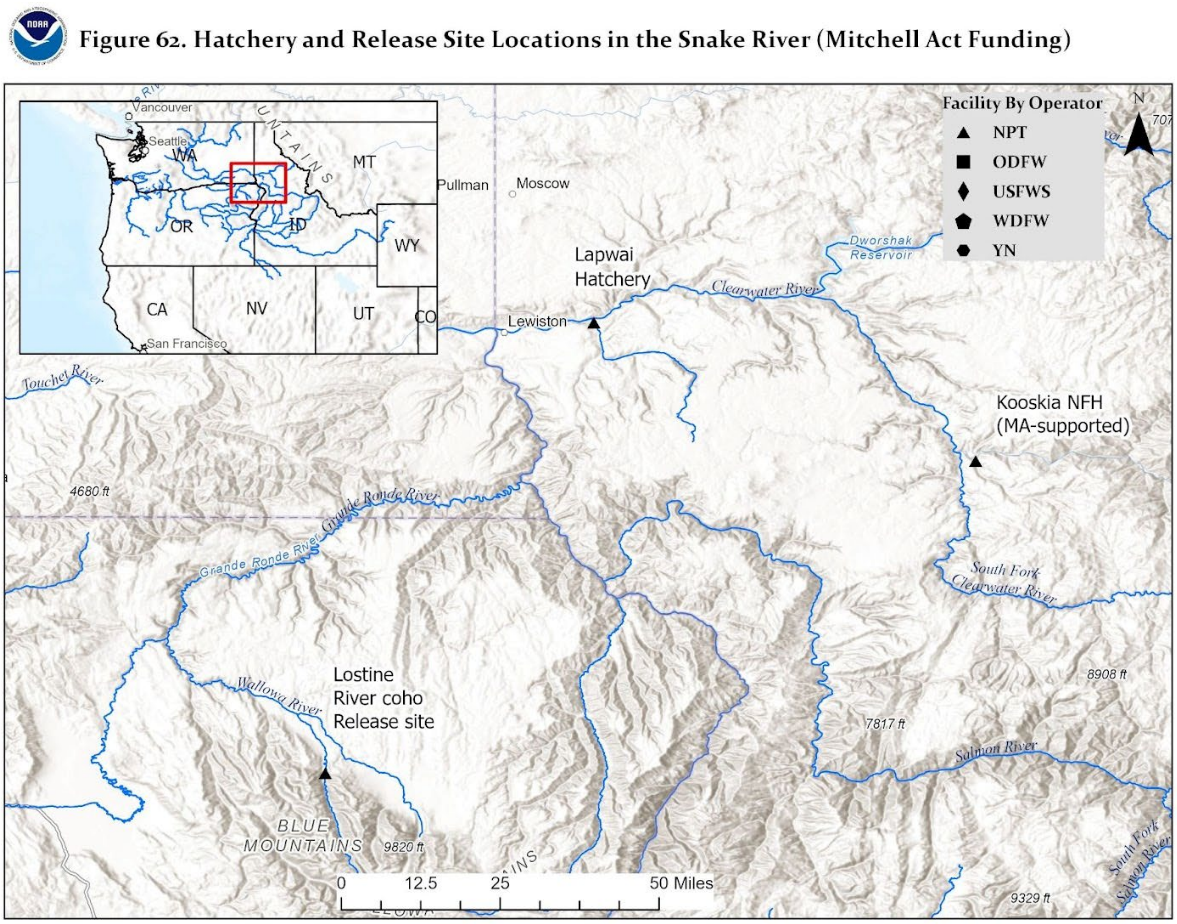


Figure 62. Hatchery and release site locations in the Snake River (Mitchell Act Funding).

Ecological interactions from hatchery-origin fish of the species included in the Proposed Action are more likely on the continental shelf, where juveniles of most species (all except steelhead trout) rear for at least several months. Along the North American continental shelf, there is some limited, and in some cases equivocal, evidence of competition and negative density-dependent interactions occurring within some groups or populations of Chinook (Riddell et al. 2018), coho (Beamish 2018b), and chum (Anderson et al. 2021) salmon. Hatchery-origin salmon may contribute to density-dependent effects in areas where hatchery fish occur in relatively high abundances and densities. However, available data are insufficient to be able to predict precisely where such areas may occur, other than that they may occur at some level within certain broad geographic regions. On the continental shelf, juvenile hatchery-origin Chinook (Fisher et al. 2014); (Riddell et al. 2018), coho (Morris et al. 2007); (Fisher et al. 2014); (Beacham et al. 2016), and chum (Fisher et al. 2007);(Beamish 2018b).; (Urawa et al. 2018); (Anderson et al. 2021) salmon from the Proposed Action will primarily occur from Heceta Head, Oregon in the south to Yakutat Bay, Alaska in the north, where they may interact with ESA-listed salmonids. Therefore, we include these areas in the Action Area (Figure 57).

We considered whether continental shelf areas to the south of Heceta Head, Oregon should be included in the Action Area (Figure 63). Several studies have found Columbia River Basin-origin juvenile Chinook salmon, including hatchery-origin fish, in southern Oregon and northern California continental shelf waters by early summer (June–July) (Brodeur et al. 2004); (Fisher et al. 2014); (Hassrick et al. 2016). In addition, modeling based on CWT recoveries (Shelton 2024b); (Shelton 2024c); (Shelton et al. 2019) indicates that a small proportion (2.3%) of Chinook salmon from the Proposed Action may occur south of Heceta Head, Oregon as subadults and adults. Our analysis found that relatively high abundances and densities of hatchery-origin fish may contribute to ecological interactions with natural-origin fish in continental shelf areas. Because of the very small abundance of hatchery-origin fish from the Proposed Action expected to move south of Heceta Head, Oregon, and very small contribution to overall Chinook salmon abundance (< 1%) in these areas, we did not include this area in the Action Area.

The Action Area as described above encompasses a portion of the endangered Southern Resident killer whale (SRKW) coastal range from the Oregon Coast north of Heceta Head to Vancouver Island, British Columbia where SRKW could overlap with the range of Chinook salmon produced at hatchery programs proposed for funding under the Mitchell Act. Thus, SRKW, would be expected to experience some effects of the Proposed Action in marine waters of the Action Area.

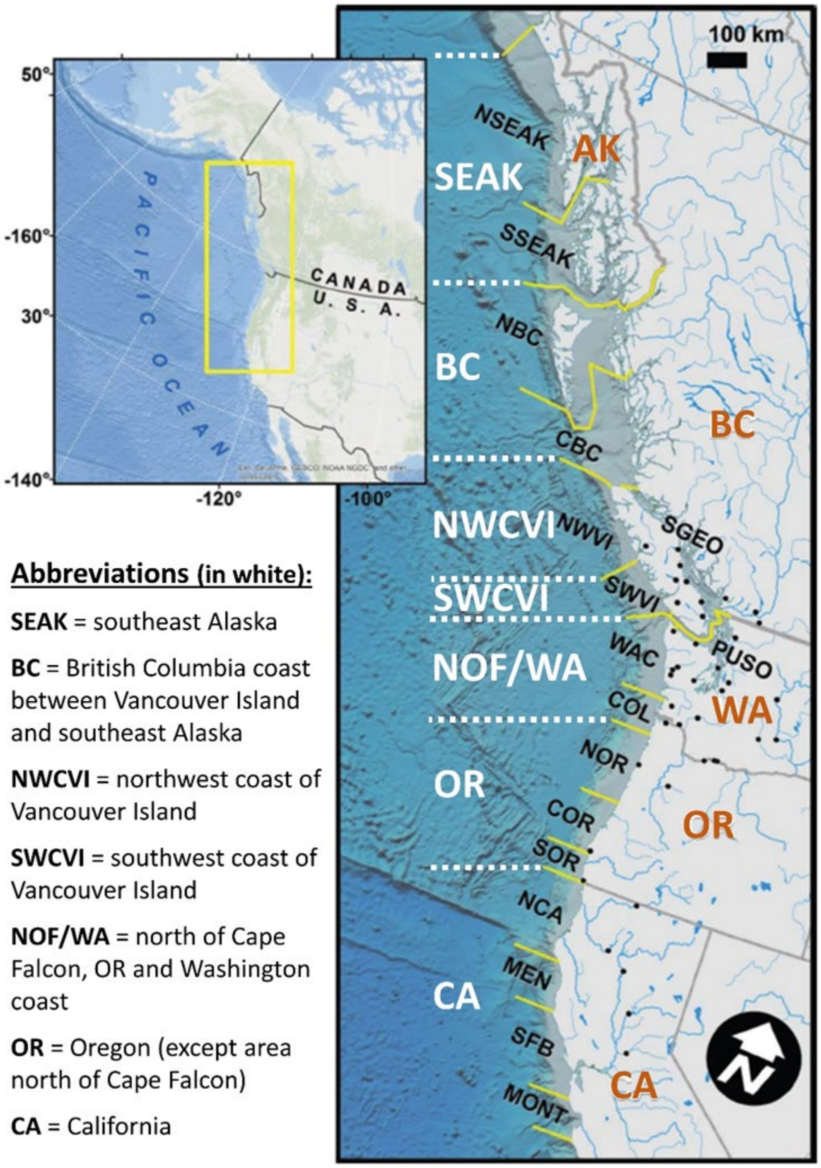


Figure 63. Areas of the Pacific Ocean along the North American continental shelf commonly used for managing fisheries and describing ocean distribution of Pacific salmon (black text and yellow lines). Coarser-scale segmentation (white text and lines) are used for some purposes within this Opinion. The oceanic portion of this Opinion's Action Area includes waters overlying the continental shelf in the following areas: NOR part of OR, NOF/WA, SWCVI, NWCVI, BC, SEAK. Figure adapted from (Shelton et al. 2019).

For eulachon, the Action Area includes all rivers and streams that are accessible to eulachon in the Columbia River Basin. The LCR mainstem provides spawning and incubation sites for eulachon, and a large migratory corridor to spawning areas in the tributaries. Prior to the construction of Bonneville Dam, eulachon ascended the Columbia River as far as Hood River, Oregon. Now, eulachon are only located below Bonneville Dam. Major tributaries that currently support spawning runs include the Grays, Skamokawa, Elochoman, Kalama, Lewis, and Sandy Rivers. The Action Area for eulachon also includes marine waters of the Salish Sea, and the coastal estuaries in Washington State to Cape Falcon, Oregon where hatchery salmon and steelhead may interact with eulachon. In the Pacific Ocean, the extent of the Action Area includes coastal marine waters from the Dixon Entrance in the north to Cape Falcon, Oregon in the south.

2.4. Environmental Baseline

The "environmental baseline" refers to the condition of the ESA-listed species or its designated critical habitat in the Action Area, without the consequences to the listed species or designated critical habitat caused by the Proposed Action. The environmental baseline includes the past and present impacts of all federal, state, or private actions and other human activities in the Action Area, the anticipated impacts of all proposed federal projects in the Action Area that have already undergone formal or early section 7 consultations, and the impact of State or private actions which are contemporaneous with the consultation in process. The impacts to listed species or designated critical habitat from federal agency activities or existing federal agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

2.4.1. Salmon and Steelhead

The environmental baseline for listed salmon and steelhead and their designated critical habitat across the Action Area can be described along the following five dimensions: hydropower, habitat, hatcheries, harvest, and climate change. In general, a wide array of human activities is responsible for the current condition of ESA-listed salmon and steelhead and critical habitat PBFs in the Action Area. It is difficult to overstate how much the quantity and quality of salmonid habitat has been diminished throughout the Columbia River Basin over the last 150 years. Habitat destruction, surface water management (damming, water withdrawal, flow modification), logging, urbanization, pollution, competition with and predation by non-native introduced species, fishing pressure, and genetic and ecological effects from hatchery production have influenced the condition of salmon and steelhead in the Action Area (NRC 1996). Many of these stressors are persistent, though some improvements have been made over the past several decades. These are also described below.

2.4.1.1. Dams and Hydropower

Salmon and steelhead from the following Recovery Domains are expected to occur within the portion of the Action Area affected by dams and hydropower:

- Willamette/Lower Columbia
- Interior Columbia

The general effects of mainstem and tributary dams on salmonid habitat and designated critical habitat include the following:

- Inundation and loss of historical spawning sites and rearing areas (critical habitat PBFs 1 and 2: conditions supporting spawning; physical habitat conditions, cover, and side channels);
- Lost access to historical spawning areas upstream from dams built without fish passage facilities (critical habitat PBF 3: safe passage in migration corridors);
- Juvenile and adult passage survival at dams with passage facilities (critical habitat PBF 3: safe passage in migration corridors);
- Water quantity (i.e., flow) and seasonal timing of water delivery (critical habitat PBFs 2, 3, and 4: water quantity and velocity; cover/shelter; food/prey; riparian vegetation; safe passage in migration corridors; floodplain connectivity and space in rearing areas, including the estuarine floodplain);
- Temperature, both in the reaches below the large mainstem storage projects and in rearing areas and migration corridors (critical habitat PBFs 2 and 3: water quality; safe passage in the migration corridor);
- Sediment transport and turbidity in rearing areas and migration corridors (critical habitat PBFs 2 and 3: water quality; safe passage in the migration corridor);
- Total dissolved gas (TDG) in rearing areas and migration corridors (critical habitat PBFs 2 and 3: water quality; safe passage in the migration corridor);
- Food webs, including both predators and prey (critical habitat PBFs 2 and 3: food/prey; safe passage in migration corridors).

The Columbia River Basin has more than 450 dams, which are managed for hydropower, flood control, water supply, and other uses. The total water storage in the Columbia River system is 55 million acre-feet, of which 42 million acre-feet are available for coordinated water management (e.g., power production, flood control, water supply, fish operations) (BPA, USBR, and USACE 2001). Flow management operations at large storage reservoirs in the interior of the Columbia River Basin (e.g., Grand Coulee, Dworshak) affect habitat in the LCR mainstem and estuary, and the volume of the Columbia River plume.

The Columbia River System (CRS; formerly the Federal Columbia River Power System, or FCRPS) is a series of 14 multipurpose, hydroelectric facilities on the mainstem Columbia, Snake, and Clearwater (tributary to Snake River) Rivers, constructed and operated by the USACE and the BOR. Eight dams are on the mainstem lower Snake and Columbia Rivers. These are all operated as run-of-river projects. The other six dams are in upstream areas and are operated as storage projects. The BPA markets and transmits the power produced at CRS dams. NMFS has been consulting on the effects of the CRS since the first salmonid species in the basin was listed under the ESA in 1992 (Snake River sockeye salmon). Most recently, NMFS completed a biological opinion in 2020 (NMFS 2020c) for the continued operations and maintenance of the hydropower system. The Proposed Action included salmon conservation measures, including additional spill to improve passage conditions for juvenile salmon, as well as other measures including but not limited to conservation-oriented structural modifications, predator management, and estuary restoration.

In addition, NMFS has completed consultation with the Federal Energy Regulatory Commission (FERC) on effects of the run-of-river hydroelectric projects in the middle reach of the Columbia

River (upstream of the confluence with the Snake River), which are operated by three public utility districts (PUDs). These include the following: Douglas PUD's Wells Hydroelectric Project at Columbia RM 515 (NMFS 2003c); Chelan PUD's Rocky Reach Hydroelectric Project at Columbia RM 453 (NMFS 2003b); and, Grant PUD's Priest Rapids Hydroelectric Project at Columbia RM 379 (NMFS 2008d). In general, passage effects of these PUD projects are similar to those described below for the eight mainstem CRS run-of-river dams in the lower Snake and Columbia Rivers. NMFS has also completed consultation on effects of the Willamette Project, a series of 13 USACE high-head storage dams within the Willamette River basin (NMFS 2008i).

As discussed in more detail below, dams and their associated reservoirs present fish-passage obstacles, causing passage delays and varying rates of injury and mortality. The altered habitats in project reservoirs reduce smolt migration rates and create more favorable habitat conditions for fish predators. These effects have been the subject of the ESA section 7 opinions cited above for the Columbia River PUD dams, the Willamette Project dams, and a series of opinions for the CRS projects.

The Columbia River hydropower system can affect migrating salmon and steelhead by delaying downstream juvenile passage and increasing direct and indirect mortality of juvenile migrants. The hydropower projects have converted much of the once free-flowing migratory river corridor into a stair-step series of slower pools (though juveniles do feed and rear in the reservoirs). Construction of the mainstem dams increased the time it took for smolts to migrate through the lower Snake and Columbia Rivers with migration delays most pronounced in low flow years (Bilby et al. 2005). The addition of surface spillway weirs at CRS dams and increased levels of spill during the last fifteen years has reduced delay for yearling fish, particularly for steelhead (Smith 2014). Though migration times have been reduced, delays likely continue to impact smolts by: (1) increasing their exposure to predation, disease, and thermal stress in the reservoirs; (2) disrupting their arrival time in the estuary; (3) depleting their energy reserves; and, (4) for steelhead, substantial delay has been shown to cause residualism (a loss of migratory behavior).

Juvenile salmon and steelhead can be killed while migrating through the dams, both directly through collisions with structures and abrupt pressure changes during passage through turbines and spillways, and indirectly, through non-fatal injury and disorientation that leave fish more susceptible to predation and disease, resulting in delayed, or latent, mortality. Actions over the last 20 years have improved passage conditions for all listed Columbia River salmon and steelhead species. By 2009, each of the eight mainstem lower Snake and LCR dams was equipped with a surface passage structure (spill bay weirs, powerhouse corner collectors, or modified ice and trash sluiceways) to improve passage of smolts, which primarily migrate in the upper 20 feet of the water column in the lower Snake and Columbia Rivers. Other improvements included the relocation of juvenile bypass system outfalls to avoid areas where predators collect, changes to spill operations, installation of avian wires to reduce juvenile losses to avian predators, and structures that reduce dissolved gas concentrations that might otherwise limit spill operations. Nevertheless, while these and other changes have improved smolt survival in recent years, dam passage impacts remain. The degree to which mortality in the estuary and ocean is caused by the prior experience of juveniles passing through the FCRPS (i.e., delayed or latent mortality) is unknown, and hypotheses regarding the magnitude of this effect vary greatly (ISAB 2007); (ISAB 2012).

Adult migration is likely less affected by the dams and reservoirs than juvenile migration. Adult salmonids can pass each of the eight mainstem dams in the lower Snake and Columbia Rivers volitionally at fish ladders, which in general are highly effective. Except during recent years with high summer water temperatures, the migration rates of adults through the mainstem CRS projects is similar to that before the dams were built (Ferguson et al. 2005). Any delay that adults experience as they search for and navigate through fish ladder entrances is balanced by the faster rate of migration through the lower velocity reservoir environments. The dams have altered the thermal regime of mainstem areas, likely to the benefit of species that migrate from spring through mid-summer (i.e., spring and summer Chinook salmon; early migrating sockeye salmon and steelhead). However, late summer and fall migrating fish—such as sockeye salmon and steelhead—are exposed to elevated temperatures compared to the predevelopment period. Upriver stocks experience a loss of about 7–11% moving through the system of mainstem dams and reservoirs. Sources of this loss include the following: 1) stresses that occur during upstream migration that are influenced by temperature, spill, and a variety of other factors; 2) straying; 3) illegal harvest; 4) indirect effects of harvest such as injury and delayed mortality from contact with fishing gear; and, 5) injuries sustained during predation attempts by predators such as pinnipeds.

In the Willamette River basin, 13 federal and several other non-federal dams that operate for flood control and hydropower have the following effects to salmon and steelhead and their habitat (NMFS 2008i); (ODFW and NMFS 2011): 1) blocked or impaired fish passage for adults and juveniles; 2) loss of some riverine habitat (and associated functional connectivity) due to reservoirs; 3) reduction in instream flow volume due to water withdrawals; 4) lack of sediment transport and role in habitat function; 5) altered physical habitat structure; and, 6) altered water temperature and flow regimes.

Within the Willamette River basin, the largest flood control/hydropower complex is the Willamette Project, managed principally as a flood control system by the USACE. The most recent biological opinion for the Willamette Project (NMFS 2008i), and supporting references within, provides an extensive review of the multiple impacts this project has on UWR Chinook salmon and steelhead populations and habitats within subbasins, but also as they contribute to habitat quality impacts in the Willamette River mainstem. Within the Willamette subbasins where these projects are located, the flood control structures block or delay adult fish passage to major portions of the historical holding and spawning habitat for UWR Chinook salmon (North Santiam, South Santiam, McKenzie and Middle Fork Willamette subbasins), and for UWR steelhead in the North Santiam and South Santiam basins. In addition, most Willamette Project dams have limited facilities or operational provisions for safely passing juvenile Chinook salmon and steelhead downstream of the facilities. Past operations and current configurations of the Willamette Project have impacted several salmonid life stages, through impacts on water flows, water temperatures, total dissolved gas (TDG), sediment transport, and channel structure.

In addition to the Federally owned and operated flood control/hydropower facilities in the Willamette River basin, other subbasin facilities such as the Portland General Electric complex in the Clackamas River basin, the Eugene Water and Electric Board Carmen Smith complex (and associated structures) in the McKenzie River basin, and municipal flow control facilities contribute to the flood control/hydropower limiting factors and threats to salmon and steelhead in the Willamette River watershed. Improvements for anadromous fish at these facilities are negotiated and formalized under processes and subsequent relicensing under the FERC.

2.4.1.2. Habitat

2.4.1.2.1. Freshwater (exclusive of Columbia River and Snake River mainstems)

Salmon and steelhead from the following Recovery Domains are expected to occur within the freshwater portion of the Action Area (exclusive of Columbia River and Snake River mainstems):

- Willamette/Lower Columbia
- Interior Columbia

The environmental baseline for listed salmon and steelhead in these Recovery Domains is broadly similar in regard to habitat conditions and conditions of their designated critical habitat. In general, salmonid habitat is substantially altered and diminished in quantity and quality throughout the Columbia River Basin and Puget Sound freshwater areas. Watershed processes that create and sustain abundant, high-quality habitat have also been substantially impaired. The history and nature of these many and varied alterations, and their effects on salmon and steelhead, are well-documented and described on a broad scale in such documents as NRC (1996). Collectively, these altered, diminished, and impaired conditions and processes are a primary factor that both: 1) contributed to the decline and ESA listing of the ESUs and DPSs considered in this Opinion; and, 2) continue to limit their productivity and recovery.

Baseline freshwater habitat conditions are described in detail in the documents cited in the following paragraphs. To summarize, many stream and riparian areas have been degraded by the effects of land and water use, including urbanization, road construction, forest management, agriculture, mining, transportation, and water development. Some streams have suffered little disturbance and maintain good habitat quality but are subject to the risk of new development in the floodplain. Other streams with high habitat quality are on Federal lands and are not subject to industrial, commercial, or residential development. Development activities have contributed to a myriad of interrelated factors causing the decline of species considered in this Opinion. Among the most important of these are changes in stream channel morphology; reduced instream roughness and cover; loss and degradation of off-channel areas, refugia, estuarine rearing habitats, riparian areas, spawning areas, and wetlands; degradation of water quality (e.g., temperature, sediment, dissolved oxygen, contaminants); and blocked fish passage. In addition to habitat loss, development has modified fluvial processes like channel migration, which has ecological consequences. The loss of mature riparian forests have reduced riparian functions and aquatic habitat quality due to decreases in habitat complexity (e.g., overhang banks, large wood), bank stability (i.e., increased erosion), shading (i.e., increased temperature), and prey sources.

Dams constructed throughout the region have had additional effects, which are detailed in Subsection 2.4.1.1.

Anadromous fish species have been greatly affected by land conversion due to urban and agricultural development. Dikes and levees constructed to protect infrastructure and agriculture have isolated floodplains from their river channels and restricted fish access. Development (e.g., urbanization, roads, agriculture) and their associated actions (e.g., shipping, dredging, roads, water withdrawals) have reduced and degraded anadromous fish habitat in numerous ways, including but not limited to the following:

- filling floodplains and wetlands,
- straightening and armoring rivers,
- reducing available in- and off-channel habitat,
- simplifying remaining habitat,
- restricting lateral channel movement,
- accelerating flow velocities,
- increasing erosion,
- decreasing cover,
- reducing prey sources,
- modifying stormwater runoff pathways,
- reducing groundwater infiltration,
- modifying subsurface flows,
- increasing flood elevations,
- contributing contaminants,
- increasing water temperatures,
- degrading water quality,
- reducing water quantity,
- removing riparian vegetation,
- modifying floodplain forest development, and
- reducing quantity and quality of in-channel shade and wood.

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

Significant efforts to protect and restore habitat and habitat-forming processes by Federal, state, local, and tribal entities across the Action Area have been ongoing for decades. These are summarized in NMFS 5-year status review documents (e.g., (NMFS 2016k); (NMFS 2016d); (NMFS 2022o); (NMFS 2022n); (NMFS 2022k); (NMFS 2022m); (NMFS 2022f); (NMFS 2022i); (NMFS 2022a), incorporated here by reference. These efforts have been substantial and are expected to benefit the survival and productivity of the targeted populations. However, overall habitat improvement has been relatively modest compared to the extensive, persistent, and widespread nature of the loss and degradation. To date, habitat restoration efforts in the Pacific Northwest, much of which has occurred since initial ESA-listings in the mid-1990s, have not led to long-term population viability improvements necessary to achieve recovery targets (e.g., (Bilby et al. 2022); (Bilby et al. 2023); (Jaeger and Scheuerell 2023). Instead, it is generally expected to take up to five decades to demonstrate increases in viability resulting from habitat improvements. Ongoing habitat protection and restoration efforts are expected to continue to make incremental improvements at the scale of the Action Area and ESUs and DPSs, while increasing human population and climate change are expected to exert negative pressures on habitat conditions across the region.

In the Columbia River Basin, specific baseline habitat conditions for each salmon ESU and steelhead DPS are thoroughly described in NMFS (2020c), NMFS (2008i), and ODFW and NMFS (2011), all of which are incorporated here by reference. The baseline habitat conditions described in these documents have not substantively changed since they were issued. The Proposed Action of the 2020 biological opinion on the Continued Operation and Maintenance of the Columbia River System (NMFS 2020c) includes habitat mitigation intended to improve habitat conditions in tributaries and the estuary. Other recent and ongoing Federal, state, tribal, and private efforts to conserve and improve habitat conditions at the scale of each ESU and DPS are described in the most recent NMFS 5-year status review documents (NMFS 2016k); (NMFS 2022o); (NMFS 2022n); (NMFS 2022k); (NMFS 2022m); (NMFS 2022f); (NMFS 2022i); (NMFS 2022a), incorporated here by reference.

NMFS has completed several ESA section 7 consultations on large scale projects affecting listed species in the Puget Sound and the Columbia River basins. Among these are the Washington State Forest Practices Habitat Conservation Plan (NMFS 2006a), and consultations on Washington State Water Quality Standards (NMFS 2008b), Washington State Department of Transportation Preservation, Improvement, and Maintenance Activities (NMFS 2013b), and the National Flood Insurance Program (NMFS 2008c); (NMFS 2016i). These documents considered the effects of Proposed Actions that would occur during the next 50 years on the ESA-listed salmon and steelhead species in the Puget Sound basin. Information on the status of these species, the environmental baseline, and the effects of the Proposed Actions are reviewed in detail. The environmental baselines in these documents consider the effects from timber, agriculture and irrigation practices, urbanization, and hatcheries, and tributary habitat, estuary, and large scale environmental variation. These biological opinions and Habitat Conservation Plans, in addition to the information mentioned above, provide a current and comprehensive overview of baseline habitat conditions in Puget Sound and are incorporated here by reference.

2.4.1.2.2. Columbia River and Snake River mainstems to Bonneville Dam

Salmon and steelhead from the following Recovery Domains are expected to occur within the Columbia River and Snake River mainstems upriver from Bonneville Dam:

- Interior Columbia

Mainstem habitat in the Columbia River and the lower Snake River has been substantially altered by basinwide water management operations, the construction and operation of mainstem hydroelectric projects, the growth of native avian and pinniped predator populations, the introduction of non-native species (e.g., smallmouth bass, walleye, channel catfish, and invertebrates), and other human practices that have degraded water quality and habitat. Effects of dams on habitat are summarized below and discussed in more detail in Section 2.4.1.1. The environmental baseline incorporates, by reference, the environmental baseline and the relevant actions and their effects that are the subject of the recent biological opinion on federal Columbia and Snake River dams and their operations (NMFS 2020c).

On the mainstem of the Columbia and Snake rivers, water storage projects—including the CRS and reservoirs in Canada operated under the Columbia River Treaty—and related flow regulation for flood control, hydropower, and consumptive (agricultural and municipal) uses have altered the quantity and timing of flows and have significantly degraded salmon and steelhead habitats (Bottom et al. 2005); (Fresh et al. 2005); (NMFS 2013c). Reduced spring and summer flows have increased travel times during outmigration for upper basin salmonids and, combined with the construction of dikes and levees, have reduced access to high-quality estuarine habitats from May through July. NMFS and the CRS action agencies have attempted to manage Columbia and Snake River water resources to more closely approximate the shape of the natural hydrograph in order to enhance flows and water quality and to improve juvenile and adult fish survival. The action agencies attempt to maintain seasonal flows above threshold objectives given the amount of runoff expected in a given year. Achieving these seasonal flow objectives provides multiple benefits for smolts in the migration corridor, estuary, and plume. Higher spring flow helps reduce fish travel time, increases juvenile access to shallow water habitat along the river banks, increases the flux of invertebrate prey to shoreline habitat, increases turbidity (which can reduce predation on juvenile migrants), and increases the size of the Columbia River plume, which is a key transition corridor for smolts to the nearshore ocean environment. Conversely, when seasonal flow objectives are not met, juvenile survival may be reduced via these same pathways of ecological effects. From 1998 to 2019, spring flow objectives were met in 48% and 81% of years at Lower Granite and McNary Dams, respectively. Summer objectives were met in only 18% and 14% of years at Lower Granite and McNary Dams, respectively.

The BOR operates 23 irrigation projects in the Columbia River Basin, reducing the annual runoff volume at Bonneville Dam by about 5.5 million acre feet. These depletions occur primarily during the spring and summer as the reservoirs are refilled and as water is diverted for irrigation purposes. Spring flow reductions have both beneficial and adverse effects on fish survival. During above average water years, flow reduction during reservoir refill reduces involuntary spills, which are known to cause undesirable TDG conditions in the migratory corridor. However, this beneficial effect is small because the amount of flow attenuation provided is generally too small to greatly affect involuntary spill events below Hells Canyon and Chief Joseph Dams. Flow depletions associated with the BOR's projects contribute to juvenile migration delay and decrease juvenile migrant survival. In addition to these mainstem flow effects, several of the projects below Hells Canyon and Chief Joseph Dams affect listed salmonids in the tributary streams where these dams are located or where irrigation return flows occur.

Water quality in mainstem areas is impaired. Common toxic contaminants include polychlorinated biphenols (PCBs), PAHs, polychlorinated diphenyl ethers (PBDEs), dichlorodiphenyltrichloroethane (DDT) and other legacy pesticides, current use of pesticides, pharmaceuticals and personal care products, and trace elements (LCREP 2007); (Herger, Edmond, and Hayslip 2017). Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute municipal and industrial waste discharges to the LCR. Common water-quality issues with urban development and residential septic systems include warmer water temperatures, lowered dissolved oxygen, increased nutrient loading, increased fecal coliform bacteria, and increased chemicals associated with pesticides and urban runoff (LCREP 2007). Mining areas scattered around the basin deliver high background concentrations of metals into nearby waterbodies. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river. Concentrations of copper are present at levels that could interfere with crucial salmon behaviors. Under these environmental conditions, fish in the Action Area are stressed. While the magnitude of effects to juvenile or adult salmon and steelhead is unclear, stress is likely to lead to reductions in biological reserves, altered biological processes, increased disease susceptibility, and altered performance of individual fish (e.g., growth, osmoregulation, and survival). Effects can be direct or indirect and lethal or, more likely, sublethal. The interaction of co-occurring stressors may have a greater impact on salmon than if they occur in isolation (Dietrich et al. 2014). Together, these contaminants are likely affecting the productivity and abundance of Columbia River Basin salmon and steelhead, especially during the rearing and juvenile migration life stages.

Water temperatures in the Columbia and Snake rivers are a concern for salmon and steelhead. Both rivers are included on the Clean Water Act §303(d) list of impaired waters established by the relevant states because of temperature standard exceedances. Temperature conditions in the basin are affected by many factors, including the following: 1) natural variation in weather and river flow; 2) the presence and operation of the dam and reservoir system, which create large reservoir surface areas and slower river velocities contributing to warmer late summer/fall water temperatures; 3) increased temperatures of tributaries due to water withdrawn for irrigated agriculture, and due to grazing and logging; 4) point source thermal discharges from cities and industries; and, 5) climate change.

In general, the mainstem dams have the following effects on water temperature: 1) maximum summer water temperature is slightly reduced; 2) water temperature variability is decreased; and, 3) water temperatures stay cooler longer into the spring and warmer later into the fall, a phenomenon termed thermal inertia. These hydrosystem effects (which stem from both upstream storage projects and run-of-river mainstem projects) continue downstream and, along with tributaries, influence temperature conditions in the LCR. At a broad scale, water temperature affects salmonid distribution, behavior, and physiology (Groot and Margolis 1991). At a finer scale, temperature influences migration swim speed of salmonids (Salinger and Anderson 2006), timing of river entry (Bennett and Peery 2003), susceptibility to disease and predation (Groot and Margolis 1991), and survival at temperature extremes.

Since the mid-1990s, water releases from Dworshak Dam (North Fork Clearwater River, Snake River basin) during the summer have been managed to reduce temperatures and enhance flows in the lower Snake River such that temperatures at the tailrace of Lower Granite Dam do not exceed 68°F (20°C). This action reduces temperatures through the downstream mainstem reaches of the Snake River basin, but has little to no discernible effect on temperature in the Columbia River downstream of the Snake River confluence. Despite this flow augmentation, temperature criterion exceedances occur frequently in downstream reaches of the Snake River from mid-July to mid-September (EPA 2021). The thermal inertia of large upper basin storage projects has largely reduced the risk that salmon and steelhead will encounter elevated temperatures in the middle and LCR during spring, although summer-migrating fish and, in low flow years, late-spring migrants may encounter elevated water temperatures due to the hydrosystem. For example, adult UCR spring-run Chinook salmon migrating at the end of their respective runs (June–July) and adult MCR steelhead migrating in the late summer may be at elevated risk.

In August 2021, EPA issued a total maximum daily load (TMDL) for addressing exceedances of various state and tribal criteria for temperature in the Columbia River and lower Snake River. As part of the 2015 biological opinion on EPA's approval of water-quality standards, including temperature (NMFS 2015d), EPA committed to work with Federal, state, and tribal agencies to identify and protect thermal refugia and thermal diversity in the LCR and its tributaries. These areas of cold water refugia are important to summer migrating salmonids.

Historically, TDG supersaturation was a major contributor to juvenile salmon mortality in that it induces gas bubble trauma (GBT). However, infrastructure modifications (e.g., "flip lips") and state regulatory requirements for monitoring TDG levels and GBT prevalence, and for limiting spill when thresholds are exceeded, have curtailed this problem. Under recent operations (2008 to 2019), exposure to elevated TDG levels exceeding state standards was restricted to involuntary spill, most often between mid-May and mid-June. Thus, this condition affects primarily yearling spring Chinook salmon smolts and adults more than other fish. Monitoring data from 1998 to 2022 indicate that TDG did not increase instantaneous mortality rates for juvenile yearling Chinook in the CRS (DeHart et al. 2023).

The series of dams and reservoirs in the CRS has blocked natural sediment transport. Total sediment discharge into the estuary and Columbia River plume is only one-third of 19-century levels (Simenstad, Fresh, and Salo 1982); (Sherwood et al. 1990); (Simenstad, Small, and McIntire 1990); (Weitkamp 1994); (NRC 1996); (NMFS 2008h). Bottom et al. Bottom et al. (2005) estimated that, together, hydrosystem operations and reduced river flows caused by climate change have decreased the delivery of sediment to the lower river and estuary by more than 50% (as measured at Vancouver, Washington). The overall reduction in sediment, combined with bank armoring and in-water structures that focus flow in the navigation channel, has reduced the availability of shallow water habitat along the margins of the river.

Industrial harbor and port development is a significant influence on the lower Snake River and LCR (Bottom et al. 2005); (Beamer et al. 2005); (NMFS 2013c). Since 1878, the USACE has dredged 100 miles of river channel within the mainstem Columbia River, its estuary, and the Willamette River as a navigation channel. Originally dredged to a 20-foot minimum depth, the Federal navigation channel of the LCR is now maintained at a depth of 43 feet and a width of

600 feet. The dredging, along with diking, draining and fill material placed in wetlands and shallow habitat, disconnects the river from its floodplain, resulting in the loss of shallow-water rearing habitat and the ecosystem functions that floodplains provide (e.g., supply of prey, refuge from high flows, temperature refugia) (Bottom et al. 2005).

The introduction of exotic species has altered the ecosystem through competition, predation, disease, parasitism, and alterations in the food web (NPCC); (Sytsma et al. 2004). One study indicated that numbers of one of these introduced species, the American shad, exceeded 4 million annually (NPCC 2004), for example. Planktivorous shad exert tremendous pressure on the estuarine food web because of the sheer weight of their biomass and energetic requirements. Some evidence suggests they reduce the abundance and size of *Daphnia* in the mainstem reservoirs, reducing this food resource for subyearling fall-run Chinook salmon. However, Haskell et al. Haskell, Beauchamp, and Bollens (2017) found that juvenile shad were eaten by subyearling Chinook salmon in John Day Reservoir, especially in late July and early August when *Daphnia* populations diminish, so there is uncertainty regarding their net effect on the growth and survival of listed salmonids.

2.4.1.2.3. Columbia River estuary

Salmon and steelhead from the following Recovery Domains are expected to occur within the Columbia River estuary, which includes all areas from Bonneville Dam to the river's mouth at the Pacific Ocean:

- Willamette/Lower Columbia
- Interior Columbia

The Columbia River estuary provides important rearing and/or migratory habitat for ESA-listed juvenile salmonids. Since the late 1800s, 68–74% of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, bank hardening, flow regulation, and other modifications (Kukulka and Jay 2003); (Bottom et al. 2005); (Marcoe and Pilson 2017); (Brophy et al. 2019). Disconnection of tidal wetlands and floodplains has reduced the production of wetland macrodetritus supporting salmonid food webs (Simenstad, Small, and McIntire 1990); (Maier and Simenstad 2009), both in shallow water and for larger juveniles migrating in the mainstem.

Restoration actions in the estuary, such as those highlighted in the recent 5-year reviews (NMFS 2022n); (NMFS 2022j); (NMFS 2022k); (NMFS 2022m); (NMFS 2022i), have improved access and connectivity to floodplain habitat. From 2007 through 2019, action agencies implemented 64 projects, including breaching or lowering dikes and levees, and removing or upgrading tide-gates. Combined, these projects reconnected over 6,100 acres of historical tidal floodplain habitat to the mainstem and another 2,000 acres of floodplain lakes. This represents more than a 2.5% net increase in the connectivity index for these important floodplain habitats that either are used extensively by some species and life history stages of listed salmonids (e.g., subyearling Chinook salmon). These habitats also produce and export large amounts of prey—particularly chironomid insects—to the migratory corridor where it is accessible to other species and life history stages of listed salmonids (e.g., steelhead, yearling Chinook salmon). In addition to this extensive reconnection effort, about 2,500 acres of currently functioning floodplain habitat have been acquired for conservation.

Floodplain habitat restoration can affect the performance of juvenile salmonids whether they move onto the floodplain or stay in the mainstem. Wetland food production supports foraging and growth within the wetland (Johnson, Fresh, and Sather 2018), but these prey items (primarily chironomid insects and corophiid amphipods) (PNNL and NMFS 2018); (PNNL and NMFS 2020) are also exported to the mainstem and off-channel habitats behind islands and other landforms, where they become available to salmon and steelhead migrating in these locations (Roegner and Johnson 2023). Thus, while some species and life history stages typically do not enter tidal wetland channels, they still derive benefits from these habitats. Improved opportunities for feeding on prey that drift into the mainstem are likely to contribute to survival at ocean entry. Blood serum levels of insulin-like growth factor-1 (IGF-1) for yearling steelhead and spring and summer Chinook salmon collected in the estuary were higher than are typically found in hatchery fish before release, suggesting that prey quality and quantity in the estuary were sufficient for growth (PNNL and NMFS 2020); (Weitkamp et al. 2022). However, variation in IGF-1 levels was substantial (two to three times higher in some individuals than in others) (Weitkamp et al. 2022), both within and between genetic stocks, indicating differences in feeding and migration patterns. Continuing to grow during estuary transit may be part of a strategy to escape predation during the ocean life stage through larger body size.

Past and continuing releases of toxic contaminants from both estuarine and upstream sources have degraded habitat quality and the food web in the estuary (Fresh et al. 2005); (LCREP 2007). Historically, levels of contaminants in the Columbia River were low, except for some metals and naturally occurring substances (Fresh et al. 2005). Today, levels in the estuary are much higher, as it receives contaminants from more than 1,000 point sources that discharge into basin waterways and numerous non-point sources of runoff (Fuhrer et al. 1996). With Portland and other cities on its banks, the Columbia River below Bonneville Dam is the most urbanized section of the river. Sediments in the river at Portland are contaminated with various toxic compounds, including metals, PAHs, PCBs, chlorinated pesticides, and dioxin (EPA 2017). Contaminants have been detected in aquatic insects, resident fish species, salmonids, river mammals, and osprey, indicating that contaminants are widespread throughout the estuarine food web (e.g., (Fuhrer et al. 1996); (Tetra Tech 1996); (Johnson, Ylitalo, Arkoosh, et al. 2007); (Johnson, Ylitalo, Sloan, et al. 2007); (LCREP 2007); (Herger, Edmond, and Hayslip 2017). The diversity of toxic contaminants present can induce a variety of effects to individual animals and the ecosystem as a whole, though more research is needed on contaminant uptake and impacts to different populations and life-history types of listed salmonids.

2.4.1.2.4. Pacific Ocean

Salmon and steelhead from the following Recovery Domains are expected to occur within the oceanic portion of the Action Area:

- Willamette/LCR: all salmon ESUs and steelhead DPSs
- Interior Columbia River: all salmon ESUs and steelhead DPSs

- Puget Sound Chinook salmon
- North Central California Coast: California Coastal Chinook Salmon
- Central Valley: Central Valley Spring-Run Chinook Salmon

In the oceanic portion of the Action Area, salmonid growth and survival is influenced by a variety of interrelated local physical (temperature, upwelling, currents) and biological (primary productivity, abundance of predators, prey, and competitors) variables. These local variables are driven by larger-scale processes that operate on longer time scales, such as the Pacific Decadal Oscillation (PDO), the North Pacific Gyre Oscillation (NPGO), and the ENSO. These variables and processes combine each year to result in conditions that may be unfavorable, intermediate, or favorable for salmon growth and survival (Beamish et al. 2018). See, for example, NMFS's Ocean Ecosystem Indicators of Pacific Salmon Marine Survival in the Northern California Current.[25]

In the southern part of the Action Area (west coast of Vancouver Island and south), herring, anchovy, and sardine dominate the surface-oriented fish community (Fisher et al. 2007). These species may compete with juvenile salmonids during their early marine residence (Brodeur et al. 2007), but provide a forage resource as the salmon grow larger, particularly for more piscivorous species such as Chinook and coho salmon (e.g., (Daly, Brodeur, and Weitkamp 2009). In these southern areas, juvenile salmon make up a small proportion (about 2–13%) of the surface-oriented fish community. This contrasts with northern areas, where juvenile salmon are most abundant, particularly pink, chum, and sockeye salmon, and to a lesser extent coho salmon (Fisher et al. 2007); (Orsi et al. 2011); (Orsi et al. 2012); (Fergusson, Sturdevant, and Orsi 2013); (Fisher et al. 2014); (Orsi and Fergusson 2015); (Orsi and Fergusson 2016); (Fergusson et al. 2018). In these more northern areas, juvenile salmon comprise about 35–83% of the surface-oriented fish community.

In the ocean, ESA-listed salmonids are affected by climate change (described in subsection 2.4.1.5, Climate Change) and by fish harvest activities (described in subsection 2.4.1.4, Harvest). ESA-listed salmonids have also been affected by marine mammal protection (e.g., the 1972 Marine Mammal Protection Act [MMPA]and 1973 ESA in the United States; the 1970 Fisheries Act and 2002 Species at Risk Act in Canada). As a result, populations of several marine mammal species have increased throughout the Action Area, leading, for example, to a substantial increase in predation on Chinook salmon (Chasco et al. 2017); (Couture, Christensen, and Walters 2024) and possibly also contributing to the observed decline in body size of Chinook salmon (Ohlberger et al. 2018); (Ohlberger et al. 2019). Chasco et al. (2017) found that predation on Chinook salmon from killer whales and three species of pinnipeds—California sea lions *(Zalophus californianus)*, Steller sea lions *(Eumetopias jubatus)*, and harbor seals *(Phoca vitulina)*—increased substantially from 1975 to 2015 along the North American continental shelf. The number of individual Chinook salmon consumed increased by a factor of 6.3 (from 5 to 31.5 million fish) and the biomass consumed increased by a factor of 2.5 (from 6,100 to 15,200 metric tons). Chinook salmon populations from the Columbia River and Puget Sound

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[25] https://www.fisheries.noaa.gov/west-coast/science-data/ocean-ecosystem-indicators-pacific-salmon-marine-survival-northern

made up about two-thirds of consumed fish and biomass. The abundance of pinnipeds has increased considerably in the Pacific Northwest since the MMPA was enacted in 1972 (Carretta, Greenman, et al. 2023). In addition, the abundance of Northern Resident Killer Whales—whose range overlaps the primary ocean distribution of Columbia River Chinook salmon stocks—has doubled since 1980 (Towers et al. 2020). Ohlberger et al. (2019) attributed range-wide declines in Chinook salmon size and age at maturity to increasing resident killer whale abundance.

Ohlberger et al. (2019) indicated that other apex marine predators such as salmon sharks (*Lamna ditropis*) may compound effects of marine mammal predation. Though salmon sharks have not been well studied, there is evidence that salmon shark abundances have increased in some areas of the northeast Pacific Ocean (Okey, Wright, and Brubaker 2007). Salmon sharks may consume large numbers of Chinook salmon (Manishin et al. 2019); (Seitz et al. 2019) and may have a substantial influence on Chinook salmon abundance and age structure (Manishin et al. 2021). A large summer-time aggregation of salmon sharks has been documented in British Columbia’s Queen Charlotte Sound (Williams et al. 2010). The Queen Charlotte Sound and nearby areas are known to be used by Chinook salmon from Puget Sound and the Columbia River Basin during the summer ((Shelton et al. 2019); (Shelton et al. 2021)).

2.4.1.3. Predation

Salmon and steelhead from the following Recovery Domains are expected to be affected by predation in freshwater and/or marine parts of the Action Area:

- Willamette/Lower Columbia (freshwater and marine, except Puget Sound)
- Interior Columbia (freshwater and marine, except Puget Sound)

A variety of avian and fish predators consume juvenile listed salmon and steelhead on their migration from rearing areas to the ocean. Pinnipeds eat adults from the ocean through lower river reaches. High predation rates have been observed for some predators on some species at certain times and places.

As noted above, dams and reservoirs throughout the Columbia River Basin block sediment transport. As a result, total sediment discharge into the river’s estuary and plume is about one-third of 19th-century levels (Bottom et al. 2005). Reduced sediment discharge to the lower river, especially during spring, contributes to reduced turbidity, which may make juvenile outmigrants more vulnerable to visual predators like piscivorous birds and some piscivorous fishes.

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, have a significant impact on the survival of juvenile listed salmonids in the Columbia River (Roby, Evans, and Collis 2021). For example, Caspian terns *(Hydroprogne caspia)* on Rice Island, an artificial dredged-material disposal island in the Columbia River estuary, consumed 5–15% of all salmonid smolts reaching the estuary in 1997 and 1998 (Angliss and DeMaster 2003). In 1999, this tern colony was moved 13 miles closer to the ocean to East Sand Island where their diet could diversify to include marine forage fish, resulting in a 59% reduction in salmonid smolt consumption from

2001 to 2015. Similarly, double-crested cormorants (*Phalacrocorax auritus*) in the Columbia River estuary consumed 1.8–7.5% of all outmigrating juvenile listed salmonids from 2003 to 2014 except for those from two ESUs. Predation on the Lower Columbia Chinook Salmon ESU was very high at 25.5% during this period. Avian predation also occurs at mainstem dams, though management measures required by the 2008 CRS biological opinion (NMFS 2008h) help minimize predation at these areas. Smolts migrating through the interior Columbia River plateau have been vulnerable to predation by terns nesting in colonies on islands in McNary Reservoir, in the Hanford Reach, and in Potholes Reservoir. Management efforts are ongoing to reduce salmonid consumption by terns and cormorants in the Columbia River estuary and throughout the basin. The extent to which management measures and subsequent predation reduction affects adult returns is uncertain.

The native northern pikeminnow (*Ptychocheilus oregonensis*) is a significant predator of juvenile salmonids in the Columbia and Snake Rivers followed by non-native smallmouth bass and walleye (reviewed in (Friesen and Ward 1999); (Beauchamp and Duffy 2011); (ISAB 2015). Northern pikeminnow consumed about 8% of outmigrating juvenile salmonids annually before the start of the Northern Pikeminnow Management Program (NPMP) in 1990. This program typically reduces predation by around 30% (Winther, Waltz, and Martin 2023). Combined, the NPMP's Sport Reward Fishery and Dam Angling Programs remove about 100,000 to 200,000 piscivorous pikeminnow per year (Winther, Waltz, and Martin 2023). Relatively small numbers of Chinook, coho, and sockeye salmon and steelhead trout are incidentally caught by anglers while participating in these programs (e.g., (Williams, Winther, and Storch 2016); (Williams, Winther, and Barr 2017); (Williams et al. 2018); (Williams et al. 2019); (Winther et al. 2020); (Winther et al. 2021); (Winther, Waltz, and Martin 2022); (Winther, Waltz, and Martin 2023). Regarding smallmouth bass and walleye, ODFW, which manages these two non-native predator species, have taken actions such as removing bag limits to help reduce predation pressure on juvenile salmonids. These programs for removing pikeminnow, smallmouth bass, and walleye are expected to incrementally improve juvenile salmonid survival during their migration to the ocean.

The abundance of pinnipeds—which prey on juvenile and/or adult salmonids—has increased considerably in the Pacific Northwest since the MMPA was enacted in 1972 (Carretta, Oleson, et al. 2023). California sea lions *(Zalophus californianus)*, Steller sea lions *(Eumetopias jubatus)*, and harbor seals *(Phoca vitulina)* all consume salmonids from the mouth of the Columbia River and its tributaries up to the tailrace of Bonneville Dam. Rub et al. (2019) found that non-harvest mortality of adult spring Chinook salmon through the estuary was 20–44% annually from 2010 to 2015, and presented evidence that much of this was attributable to pinniped predation. Hydroelectric dams can delay upstream fish passage and congregate fish searching for ladder entrances (Kareiva, Marvier, and McClure 2000); (Quiñones et al. 2015). Such delays and spatial constrictions can make fish vulnerable to predation by pinnipeds (Naughton et al. 2011); (Stansell et al. 2014). Pinniped abundance in the Bonneville Dam tailrace generally increased from 2002 to a peak in 2015, but has declined since then to pre-2010 levels (Tidwell, Braun, and van der Leeuw 2023). From 2018 to 2022, pinnipeds in the 1.25-mile reach below the dam have annually consumed 7.2–8.7% of the steelhead run, 2.5–3.3% of the spring Chinook salmon run, and 2.5–3.3% of all adult salmonids combined. Sea lion excluder gates are designed to reduce predation vulnerability and are installed at all eight ladder entrances at Bonneville Dam. From 2008 to 2019, NMFS permitted pinniped hazing and lethal removal of California sea lions in certain areas of the LCR basin to help reduce predation. These approvals were expanded in August 2020 to include lethal removal of Steller sea lions. The authorization allows for removal of up to 540 California sea lions and 176 Steller sea lions through August 2025.

There is evidence that marine mammal predation on Chinook salmon has also increased in marine waters outside of Puget Sound and the Columbia River estuary. Chasco et al. (2017) found that marine mammal predation on Chinook salmon increased substantially from 1975 to 2015. The number of individual Chinook salmon consumed increased by a factor of 6.3 (from 5 to 31.5 million fish) and the biomass consumed increased by a factor of 2.5 (from 6,100 to 15,200 metric tons). Stocks from the Columbia River and Puget Sound made up about two-thirds of consumed fish and biomass. As mentioned above, substantial marine mammal predation occurs within Puget Sound and the Columbia River estuary. However, Chasco et al. (2017) provided evidence that a sizeable proportion of increased consumption occurs in marine waters outside of these areas, likely due in part to increased killer whale abundance. Abundance of Northern Resident Killer Whales—whose range overlaps with the primary ocean distribution of Puget Sound and Columbia River Chinook salmon stocks—has doubled since 1980 (Towers et al. 2020). Further, Ohlberger et al. (2019) attributed range-wide declines in Chinook salmon size and age at maturity to increasing resident killer whale abundance.

Ohlberger et al. (2019) indicated that other apex marine predators such as salmon sharks (*Lamna ditropis*) may compound effects of killer whale predation. Though salmon sharks have not been well studied, there is evidence that salmon shark abundances have increased in some areas of the northeast Pacific Ocean (Okey, Wright, and Brubaker 2007). Salmon sharks may consume large numbers of Chinook salmon (Manishin et al. 2019); (Seitz et al. 2019) and may have a substantial influence on Chinook salmon abundance and age structure (Manishin et al. 2021). A large summer-time aggregation of salmon sharks has been documented in British Columbia's Queen Charlotte Sound (Williams et al. 2010). The Queen Charlotte Sound and nearby areas are known to be used by Chinook salmon from Puget Sound and the Columbia River basin during the summer (Shelton et al. 2019); (Shelton et al. 2021).

2.4.1.4. Hatchery

This Section includes the effects of hatchery operations in the Columbia River Basin, for the operation of hatcheries prior to this consultation, as well as the continued operation of hatchery programs that have already undergone a separate ESA Section 7 consultation. The effects of future operations of hatchery programs with expired ESA Section 7 consultation and those programs yet to undergo ESA Section 7 consultation cannot be included in the environmental baseline, except when effects are ongoing (e.g., returning adults from past hatchery releases for programs with expired ESA permits).

A more detailed description of the specific effects of hatchery programs NMFS analyzes can be found in Section 2.5.1, Factors Analyzed when Assessing Hatchery Programs, and Appendix C, *Effects of Hatchery Programs on Salmon and Steelhead Populations: Reference Document for NMFS ESA Hatchery Consultations* (Revised May 2023). For example, these include competition with natural-origin fish for spawning sites and food, outbreeding depression, and hatchery-influenced selection. Because most programs are ongoing, the effects of each are reflected in the most recent status of the species, which NMFS re-evaluated in 2022 (NWFSC 2015) and were summarized in Section 2.2.1 of this Opinion. We also incorporate some analysis of baseline effects of the hatchery programs included in our Proposed Action when necessary to evaluate effects of the programs into the future (i.e., past pHOS values, past broodstocking practices). The information below provides context on the number, size, and purpose of hatchery programs throughout the Columbia River Basin.

2.4.1.4.1. History and Evolution of Hatcheries in the Columbia River Basin

The history and evolution of hatcheries are important factors in analyzing their past and present effects. From their origin more than 100 years ago, hatchery programs have been tasked to compensate for factors that limit anadromous salmonid viability. The first hatcheries, beginning in the late 19th century, provided fish to supplement harvest levels, as human development and harvest impacted naturally produced salmon and steelhead populations. As development of the Columbia River Basin proceeded (e.g., dam construction as part of the FCRPS between 1939 and 1975), hatcheries were used to mitigate for lost salmon and steelhead harvest attributable to reduced salmon and steelhead survival and habitat degradation. Since that time, most hatchery programs have been tasked to maintain fishable returns of adult salmon and steelhead, usually for cultural, social, recreational, or economic purposes, as the capacity of natural habitat to produce salmon and steelhead has been reduced.

A new role for hatcheries emerged during the 1980s and 1990s after naturally produced salmon and steelhead populations declined to unprecedented low levels. Genetic resources that represent the ecological and genetic diversity of a species can reside in fish spawned in a hatchery, as well as in fish that spawn in the wild (Hard et al. 1992); (NMFS 2008a); (Jones 2015). Hatchery programs have been used as a tool to conserve the genetic resources of depressed natural populations and to reduce extinction risk, at least in the short-term (e.g., Snake River sockeye salmon). Such hatchery programs are designed to preserve the salmonid genetic resources until the factors limiting salmon and steelhead viability are addressed. In this role, hatchery programs reduce the risk of extinction (NMFS 2005a); (Ford et al. 2011). Hatchery programs that only conserve genetic resources, however, "do not substantially reduce the extinction risk of the ESU in the foreseeable future" or long-term (NMFS 2005a). Furthermore, hatchery programs that conserve vital genetic resources are not without risk to the natural salmonid populations because the manner in which these programs are implemented can affect the genetic structure and evolutionary trajectory of the target population (i.e., natural population that the hatchery program aims to conserve) by reducing genetic and phenotypic variability and patterns of local adaptation (HSRG 2014); (NMFS 2014b).

Hatchery actions designed to benefit salmon and steelhead viability sometimes produce only limited positive results. One potential reason for this is that other factors (i.e., limiting factors and threats) can offset or out-weigh the benefits from hatchery actions. Hatchery programs can serve an important conservation role when habitat conditions in freshwater depress juvenile survival or when access to spawning and rearing habitat is blocked. Under circumstances like these, and in the short-term, the demographic risks of extinction of such populations likely exceed genetic and ecological risks to natural-origin fish that would result from supplementing the natural population through hatchery actions. Benefits like this should be considered *transitory*, or short-term, and these benefits alone may not result in survival rate changes necessary to meet recovery plan abundance and productivity viability criteria, depending on the circumstances. These hatchery programs are intended to help "to preserve remaining genetic diversity, and likely have prevented the loss of several populations" (NMFS 2005a); (Ford et al. 2011). However, until the other factors limiting salmon and steelhead productivity are addressed, the full benefit (i.e., potential contributions to increased viability) of hatchery actions designed to benefit salmon and steelhead viability may not be realized. Therefore, fixing the ecological and other factors limiting viability is the key to long-term viability. "The fitness of the naturally spawning population, its productivity, and the numbers of adult salmon returning to the watershed, ultimately must depend on the natural habitat, not on the output of the hatchery" (HSRG 2004). Salmon and steelhead populations that rely on hatchery production are not viable (McElhany et al. 2000); (NMFS 2013d), and increased dependence on hatchery intervention results in decreasing benefits and increasing risks (ICTRT 2005); (NMFS 2014e).

Population viability and reductions in threats are key measures for salmon and steelhead recovery (NMFS 2013d). Beside their role in conserving genetic resources, hatchery programs also are a tool that can be used to help improve viability (i.e., supplementation of natural population abundance through hatchery production). In general, these hatchery programs increase the number and spatial distribution of naturally spawning fish by increasing the natural production with returning hatchery adults. These programs alone are not, however, a proven technology for achieving sustained increases in adult production (ISAB 2003), and the long-term benefits and risks of hatchery supplementation remain uncertain (Christie et al. 2014). The LCR in particular is currently very dependent on hatchery production, with concurrent risks. In particular, many listed natural Chinook and coho salmon have high percentages of hatchery-origin fish on the spawning grounds. In addition, the hatchery fish released in some cases originate from non-local sources, creating an added risk to diversity. Examples are long-time use of a steelhead stock that originated in Puget Sound and more recently a Chinook salmon stock that originated in the Rogue River.

Regarding hatchery consultations in the Action Area, NMFS describes the progression of consultations that have been performed in Section 0, Consultation History. Here, we incorporate those biological opinions by reference and update the environmental baseline with the contemporary effects that result from those consultations' analyses and conclusions.

2.4.1.4.2. Current Hatchery Production in the Columbia River Basin

There are more than 163 salmon and steelhead hatchery programs in the Columbia River Basin that released 140 million fish in 2024, according to the *U.S. v. Oregon* Production Advisory

Committee (PAC). These hatchery programs are operated by federal and state agencies, tribes, and private entities (see Figure 64 and Figure 65).

Currently, these Columbia River Basin hatchery facilities support approximately 152 individual hatchery programs (Table 71). Many of the hatchery facilities support one or more hatchery programs, and funding for these facilities can come from multiple entities, including NMFS (through the Mitchell Act) and other Federal agencies. Hatchery facilities funded under the Lower Snake River Compensation Program are also supported by Federal funds. These hatchery facilities were built to mitigate the effect of Federal dams on the lower Snake River (USACE 1975). The BOR funds hatchery production to mitigate the effects of the Grand Coulee Dam. The USACE funds substantial hatchery production as mitigation for dams in the mainstem Columbia River and Snake River. Furthermore, the NPCC Columbia River Basin Fish and Wildlife Program allocates BPA funding to finance artificial production programs authorized by the Northwest Power Planning and Conservation Act of 1980 (PL 96-501, December 5, 1980). Other hatchery facilities in the Columbia River Basin are funded by private power companies or PUDs and do not receive Federal funds.

The total number of hatchery facilities and hatchery programs normally remains fairly constant, but individual programs can change from year to year depending on environmental conditions, broodstock collection, juvenile survival, fisheries management changes, ESA concerns, and funding. For example, the spring Chinook salmon hatchery program at Entiat National Fish Hatchery (NFH) was terminated in 2007 because of ESA concerns over the effects of the program on the conservation of UCR spring Chinook salmon, and the tule fall Chinook salmon program at the Little White Salmon NFH was terminated in 2013 due to management and funding source changes. More recently, ODFW decided to discontinue its Select Area Brights (SABs) fall Chinook salmon program, following a final release of juveniles in 2024, citing concerns with diminishing fisheries benefits (Clements, ODFW, pers. comm). This out-of-basin stock is also known to interbreed with and pose genetic risk to ESA-listed LCR fall Chinook salmon (Roegner et al. 2011). Even when a hatchery program is terminated, the effects of that program on listed species can continue for a number of years depending on the species released. In the case of SABs Chinook salmon, hatchery-origin juveniles released in 2024 are expected to return as late as 2027, as 4-year-old adults.

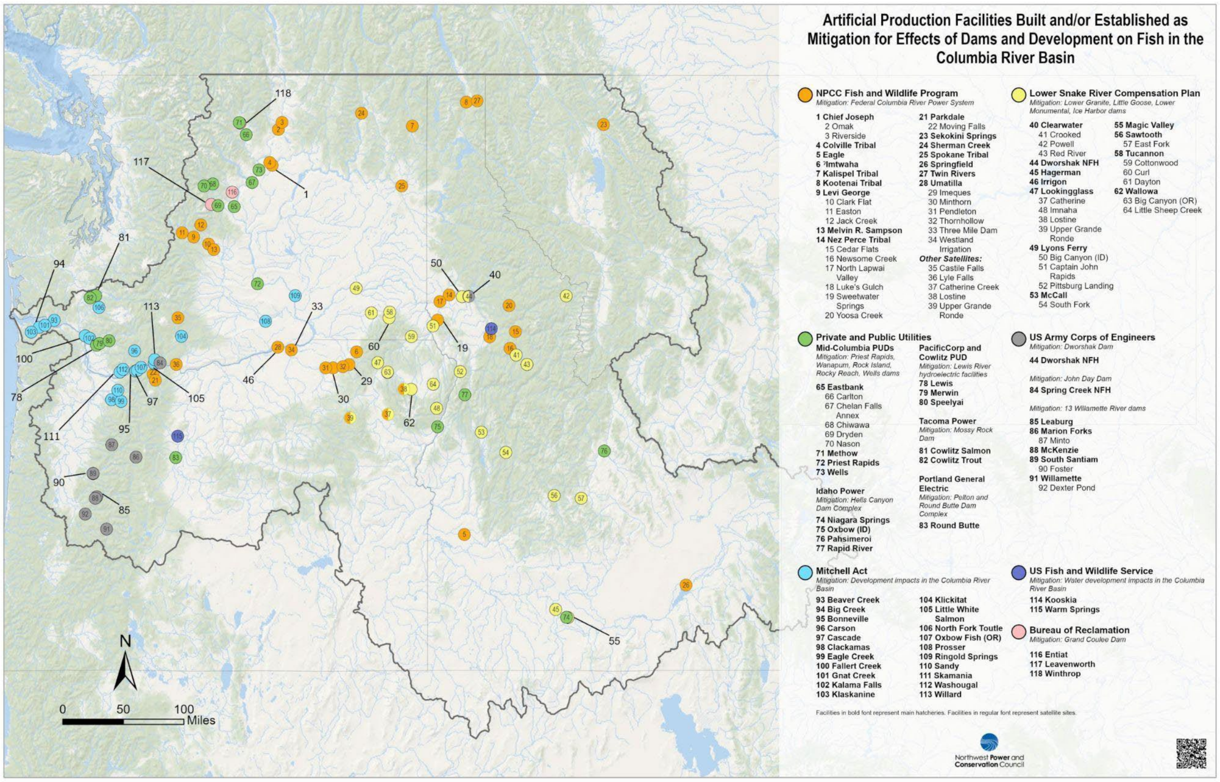

Figure 64. Mitigation hatchery facilities in the Columbia River Basin (NWPCC).

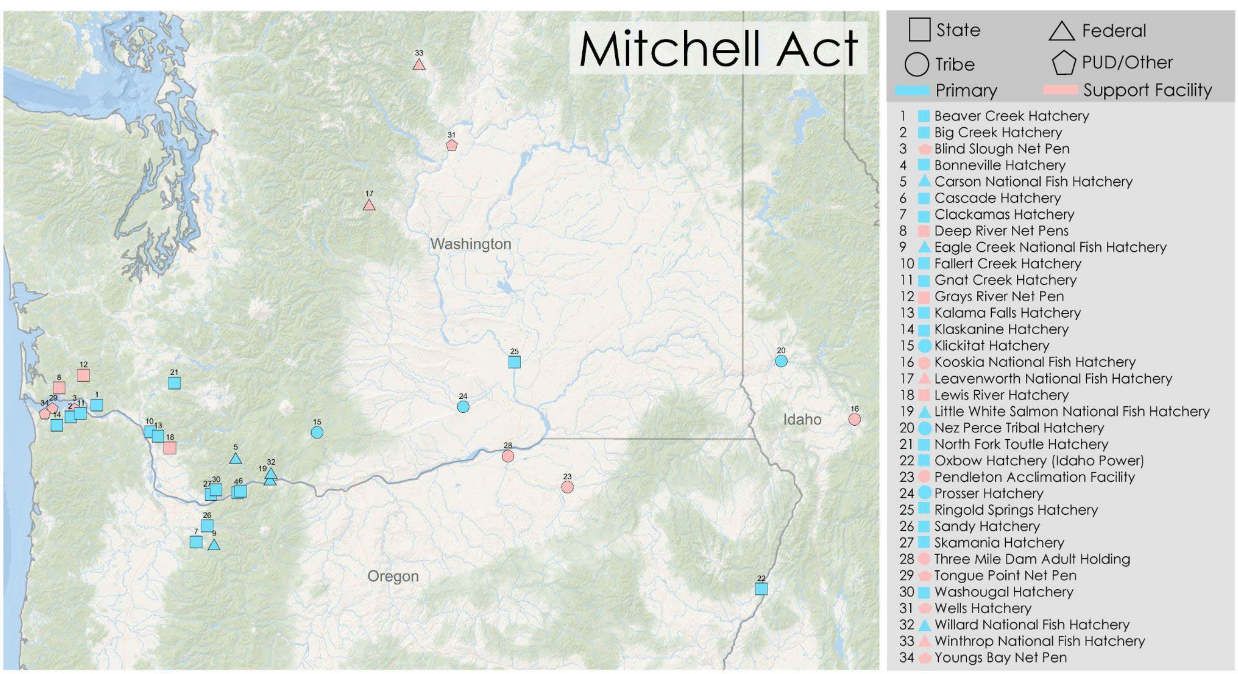

Figure 65. Hatchery facilities funded by Mitchell Act (NWPCC).

Survival from release at the hatchery facility to the ocean is highly variable, depending on the species, size at release, timing of release, release location, distance traveled within the tributaries, number of dams encountered, whether the fish are collected and transported downstream, and in-river environmental conditions. All of these factors affect the survival of hatchery-origin juveniles. For example, Faulkner et al. (2015), using the mean migrant survival estimate for the 2002-2014 outmigration years, estimated that the survival of hatchery-origin spring-run Chinook salmon juveniles from release in the upper Snake River Basin to Lower Granite Dam was 64.2%. That is, out of all of the hatchery-origin spring-run Chinook yearlings released into the Snake River, less than two-thirds reached the first dam. Similarly, Neeley (2012) estimated juvenile survival from the acclimation and release locations in the Yakima River basin to McNary Dam (distances ranging from 90 to 229 river miles) for spring-run Chinook salmon, coho salmon, summer-run Chinook salmon, and fall-run Chinook salmon has been less than 30% over that distance. Estimates of juvenile survival from acclimation and release locations in the Umatilla River basin to Three Mile Dam (at approximately RM 4 of the Umatilla River) have averaged less than 50% in recent years, and survival to John Day Dam (a distance of 77 miles) has averaged less than 40% (Clarke et al. 2014). Faulkner et al. (2015), when estimating the number of juvenile fish that could be encountered at each of the mainstem dams, assumed that there is approximately a 10% loss for each dam that the juvenile salmon and steelhead must cross. Applying this information, less than one-half of the annual release of over 88 million above Bonneville Dam would survive to below Bonneville Dam.

This Opinion includes, in the baseline, the effects of hatchery operations in the Columbia River Basin. These effects constitute factors that may increase risk to the recovery of the ESA-listed ESUs and DPSs, which result from the operation of hatcheries prior to this consultation, as well as the continued operation of hatcheries into the future for those hatchery programs that have already undergone a separate ESA Section 7 consultation as listed in Table 71 below. The effects of future operations of those hatchery programs yet to undergo ESA Section 7 consultation (Table 71) cannot be included in the environmental baseline, but the effects of these programs on ESA-listed species will be considered under Cumulative Effects. In some instances, effects are ongoing (e.g., returning adults from past hatchery releases for programs with expired ESA permits) and are included in the analysis, even for those future operations that are excluded from the baseline.

Table 71. Columbia River Basin hatchery releases by region, program, species, run, release goal, and applicants/operators (URB – Upriver Bright[26]; RSI – remote site incubators[27]).

[26] URB stocks are derived from fall Chinook stocks that spawned above Celilo Falls. They are not considered a part of listed ESUs in the LCR and they have a later return time compared to tules. URB stocks are primarily wild fish destined for the Hanford Reach section of the Columbia River. Smaller URB components are destined for the Deschutes, Snake, and Yakima rivers {TAC, 2008 #7080} .

[27] RSIs are portable incubation units. They can be made from a variety of materials (e.g., wood, plastic, and metal) and attempt to minimize natural mortality of incubating salmonid eggs. By providing a vessel that is directly located

Region	Program	Species	Run	Release Goal	Funding Entity, Operators
Columbia River Bain Hatchery Programs Evaluated in this Opinion					
Lower Col	Beaver Creek Summer Steelhead	Steelhead	Summer	30,000	NMFS/WDFW
Lower Col	Beaver Creek Winter Steelhead	Steelhead	Winter	130,000	NMFS/WDFW
Lower Col	Beaver Creek (Elochoman) Coho	Coho	Fall	225,000	NMFS/WDFW
Lower Col	South Toutle Summer Steelhead	Steelhead	Summer	25,000	NMFS/WDFW
Lower Col	Coweeman Winter Steelhead	Steelhead	Winter	12,000	NMFS/WDFW
Lower Col	Klineline Winter Steelhead (Salmon Cr)	Steelhead	Winter	40,000	NMFS/WDFW
Lower Col	Washougal Summer Steelhead	Steelhead	Summer	70,000	NMFS/WDFW
Lower Col	Washougal Winter Steelhead	Steelhead	Winter	60,000	NMFS/WDFW
Lower Col	Rock Creek Winter Steelhead	Steelhead	Winter	20,000	NMFS/WDFW
Lower Col	Kalama Spring Chinook	Chinook	Spring	750,000	NMFS/WDFW
Lower Col	Bonneville Coho	Coho	Fall	250,000	NMFS/ODFW
Lower Col	Bonneville Tule Fall Chinook	Chinook	Fall	6,000,000	NMFS/ODFW
Lower Col	Big Creek tule Chinook	Chinook	Fall	1,400,000	NMFS/ODFW
Lower Col	Big Creek coho	Coho	Fall	735,000	NMFS/ODFW
Lower Col	Big Creek chum	Chum	Fall	1,690,000	NMFS/ODFW
Lower Col	Big Creek Winter Steelhead (combined with Gnat Creek and Klaskanine)	Steelhead	Winter	147,000	NMFS/ODFW
Lower Col	Youngs Bay (Klaskanine) Fall Chinook	Chinook	Fall	2,300,000	NMFS/ODFW
Lower Col	Astoria High School STEP Coho	Coho	Fall	4,000	NMFS/ODFW
Lower Col	Astoria High School STEP Tule FC	Chinook	Fall	25,000	NMFS/ODFW
Lower Col	Warrenton High School STEP Coho	Coho	Fall	5,000	NMFS/ODFW
Lower Col	Warrenton High School STEP Tule FC	Chinook	Fall	16,500	NMFS/ODFW
Lower Col	Clackamas Summer Steelhead	Steelhead	Summer	175,000	NMFS/ODFW

next to a spawning site, but diverts water flow to a chamber (generally a 50 gallon sized barrel) where salmon eggs are housed, incubating eggs are protected from predators and silt suffocation. This increases their survival rate to fry stage, at which point they exit the RSI through a downstream tube, which returns the diverted stream flow back to the natural spawning channel.

Region	Program	Species	Run	Release Goal	Funding Entity, Operators
Lower Col	Clackamas Winter Steelhead	Steelhead	Winter	265,000	NMFS/ODFW
Lower Col	Clackamas Spring Chinook	Chinook	Spring	1,100,000	NMFS/ODFW/PGE/USFWS
Lower Col	North Toutle Fall Chinook	Chinook	Fall	1,100,000	NMFS/WDFW
Lower Col	North Toutle Coho	Coho	Fall	90,000	NMFS/WDFW
Lower Col	Kalama Fall Chinook	Chinook	Fall	2,000,000	NMFS/WDFW
Lower Col	Kalama coho- Type N	Coho	Fall	300,000	NMFS/WDFW
Lower Col	Kalama Summer Steelhead (integrated)	Steelhead	Summer	90,000	NMFS/WDFW
Lower Col	Kalama Winter Steelhead (integrated)	Steelhead	Winter	45,000	NMFS/WDFW
Lower Col	Kalama Winter Steelhead (segregated)	Steelhead	Winter	90,000	NMFS/WDFW
Lower Col	Washougal Fall Chinook	Chinook	Fall	1,200,000	NMFS/WDFW
Lower Col	Washougal coho	Coho	Fall	108,000	NMFS/WDFW
Lower Col	Carson NFH Spring Chinook	Chinook	Spring	1,520,000	NMFS/USFWS
Lower Col	Little White Salmon NFH Spring Chinook	Chinook	Spring	1,800,000	NMFS/USFWS
Lower Col	Willard National Fish Hatchery URB Chinook	Chinook	Fall	2,000,000	NMFS/USFWS
Lower Col	Eagle Creek NFH Coho	Coho	Fall	350,000	NMFS/USFWS
Lower Col	Abernathy (at Elochoman and Beaver Creek) Tule Conservation Program	Chinook	Fall	113,000	NMFS/WDFW
Lower Col	Clatskanie River Tule Fall Chinook Supplementation Program	Chinook	Fall	210,000	NMFS/ODFW
Lower Col	Sandy River Spring Chinook	Chinook	Spring	300,000	NMFS/ODFW
Lower Col	Sandy River Winter Steelhead	Steelhead	Winter	170,000	NMFS/ODFW
Lower Col	Sandy River Summer Steelhead	Steelhead	Summer	80,000	NMFS/ODFW
Lower Col	Sandy River Coho	Coho	Fall	300,000	NMFS/ODFW
Mid Col	Klickitat Coho	Coho	Fall	3,500,000	NMFS/Yakama Nation/WDFW
Mid Col	Klickitat URB Chinook	Chinook	Fall (URB)	4,000,000	NMFS/Yakama Nation
Mid Col	Klickitat Spring Chinook	Chinook	Spring	600,000	NMFS/Yakama Nation
Mid Col	Klickitat Skamania Summer Steelhead	Steelhead	Summer	90,000	NMFS/Yakama Nation/WDFW
Upper Col	Ringold Spring coho	Coho	Fall	108,000	NMFS/WDFW
Upper Col	Ringold Summer Steelhead	Steelhead	Summer	180,000	NMFS/WDFW
Snake	Lostine River coho	Coho	Fall	550,000	NMFS/BPA/NPT

Region	Program	Species	Run	Release Goal	Funding Entity, Operators
Snake	Clearwater coho restoration	Coho	Fall	500,000	NMFS/BPA/NPT
Columbia River Basin Hatchery Programs that currently have ESA authorization.					
Lower Col	SAFE Spring Chinook	Chinook	Spring	1,700,000	BPA/ODFW/CCF
Lower Col	SAFE Coho (Youngs Bay, Tongue Point, Blind Slough, SF Klaskanine)	Coho	Fall	2,565,000	BPA/ODFW/CCF
Lower Col	Little White Salmon NFH URB Chinook	Chinook	Fall (URB)	4,500,000	USFWS/COE
Lower Col	Spring Creek NFH Tule Chinook	Chinook	Fall	10,500,000	USFWS/COE
Lower Col	Hood River Spring Chinook	Chinook	Spring	150,000	BPA/Warm Springs Tribe
Lower Col	Hood River Winter Steelhead	Steelhead	Winter	50,000	BPA/Warm Springs Tribe/ODFW
Mid Col	Walla Walla Spring Chinook	Chinook	Spring	250,000	BPA/CTUIR
Mid Col	Yakima River (Prosser coho/Eagle Creek Stock)	Coho	Fall	500,000	NMFS/Yakama Nation
Mid Col	Yakima River Summer/fall Chinook (Prosser Release)	Chinook	Fall (URB)	1,700,000	NMFS/Yakama Nation
Mid Col	Yakima River Summer/fall Chinook	Chinook	Fall (URB) (Summer/ Fall)	1,000,000	BPA/Yakama Nation
Mid Col	Walla Walla/Lyons Ferry steelhead	Steelhead	Summer	100,000	USFWS/WDFW
Mid Col	Umatilla Spring Chinook	Chinook	Spring	810,000	BPA/CTUIR/ODFW
Mid Col	Umatilla Fall Chinook	Chinook	Fall (URB)	1,200,000	BPA/CTUIR/ODFW/COE
Mid Col	Umatilla Steelhead	Steelhead	Summer	150,000	BPA/ODFW/CTUIR
Mid Col	Umatilla coho	Coho	Fall	550,000	NMFS/BPA/ODFW/CTUIR
Mid Col	Touchet (integrated) Steelhead	Steelhead	Summer	50,000	USFWS/WDFW
Mid Col	Round Butte Spring Chinook	Chinook	Spring	240,000	ODFW/PGE
Mid Col	Round Butte Steelhead	Steelhead	Summer	1,092,000	ODFW/PGE
Snake	Lyons Ferry/FCAP/IPC Fall Chinook	Chinook	Snake (Fall)	4,100,000	BPA/USFWS/NPT/WDFW/IDFG/IPC
Snake	Nez Perce Fall Chinook	Chinook	Snake (Fall)	1,400,000	BPA/NPT
Snake	Snake River Sockeye	Sockeye	Fall	1,000,000	BPA/IDFG
Snake	Imnaha Spring Chinook	Chinook	Spring	490,000	USFWS/ODFW/BIA

Region	Program	Species	Run	Release Goal	Funding Entity, Operators
Snake	Wallowa/Lostine Spring Chinook	Chinook	Spring	250,000	USFWS/ODFW/ BIA
Snake	Catherine Creek Spring Chinook	Chinook	Spring	150,000	USFWS/ODFW/ BIA
Snake	Upper Grande Ronde Spring Chinook	Chinook	Spring	250,000	USFWS/ODFW/ BIA/CTUIR
Snake	Lookingglass Spring Chinook	Chinook	Spring	250,000	USFWS/ODFW/ BIA
Snake	Tucannon Spring Chinook	Chinook	Spring	225,000	USFWS/WDFW/ BIA
Snake	Clearwater NFH Summer Chinook	Chinook	Summer	600,000	IDFG
Snake	Clearwater NFH Spring Chinook	Chinook	Spring	3,400,000	IDFG
Snake	Rapid River Spring Chinook	Chinook	Spring	2,500,000	IDFG/IPC
Snake	Hells Canyon Spring Chinook	Chinook	Spring	350,000	IDFG/IPC
Snake	Sawtooth Spring Chinook	Chinook	Spring	1,600,000	IDFG
Snake	Pahsimeroi Summer Chinook	Chinook	Summer	1,000,000	IDFG
Snake	SF Salmon Spring Chinook	Chinook	Summer	1,000,000	IDFG
Snake	SF Clearwater B Steelhead	Steelhead	Summer	843,000	IDFG
Snake	Upper Salmon A Steelhead	Steelhead	Summer	279,000	IDFG/IPC
Snake	Pahsimeroi A Steelhead	Steelhead	Summer	800,000	IDFG
Snake	Upper Salmon B Steelhead	Steelhead	Summer	372,000	IDFG
Snake	Sawtooth A Steelhead	Steelhead	Summer	1,500,000	IDFG
Snake	EF Salmon Steelhead	Steelhead	Summer	60,000	IDFG
Snake	Little Salmon Steelhead	Steelhead	Summer	636,000	IDFG/IPC
Snake	Hells Canyon Steelhead	Steelhead	Summer	550,000	IDFG/IPC
Snake	Dworshak B Steelhead	Steelhead	Summer	2,100,000	USFWS/COE
Snake	Kooskia Spring Chinook	Chinook	Spring	650,000	BPA/USFWS
Snake	NPTH Spring Chinook	Chinook	Spring	400,000	BPA/NPT
Snake	Dworshak NFH Spring Chinook	Chinook	Spring	1,650,000	USFWS/COE
Snake	Yankee Fork Spring Chinook	Chinook	Spring	600,000	BPA/ShoBan Tribe
Snake	Panther Creek Spring Chinook	Chinook	Spring	400,000	BPA/ShoBan Tribe
Snake	South Fork Chinook Eggbox Project	Chinook	Summer	RSI	BPA/ShoBan Tribe
Snake	Upper Salmon Steelhead (boxes)	Steelhead	Summer	RSI	BPA/ ShoBan Tribe (LSRCP)
Snake	Yankee Fork B Steelhead	Steelhead	Summer	524,000	BPA/ ShoBan Tribe (LSRCP)
Snake	Johnson Creek Spring Chinook	Chinook	Summer	150,000	BPA

Region	Program	Species	Run	Release Goal	Funding Entity, Operators
Snake	Little Sheep Steelhead	Steelhead	Summer	215,000	USFWS/ODFW
Snake	Grande Ronde Basin Summer Steelhead	Steelhead	Summer	900,000	USFWS/ODFW
Snake	Upper Tucannon Steelhead (endemic)	Steelhead	Summer	150,000	USFWS/WDFW
Snake	Lyons Ferry Steelhead Wallowa Stock	Steelhead	Summer	360,000	USFWS/WDFW
Upper Col	Methow & Wenatchee Coho	Coho	Fall	700,000	BPA/Yakama Nation
Upper Col	Nason Creek Spring Chinook	Chinook	Spring	223,670	Grant PUD/WDFW
Upper Col	Chiwawa Spring Chinook	Chinook	Spring	144,000	Chelan PUD/WDFW
Upper Col	Wenatchee Steelhead	Steelhead	Summer	25,000	Chelan PUD/WDFW
Upper Col	Chief Joseph Summer Chinook	Chinook	Summer	2,000,000	BPA/Coville Tribe
Upper Col	Chief Joseph Spring Chinook (Carson)	Chinook	Spring	700,000	BPA/Coville Tribe
Upper Col	Chief Joseph Spring Chinook (Composite)	Chinook	Spring	200,000	USFWS/Coville Tribe
Upper Col	Entiat Summer Chinook	Chinook	Summer	400,000	USFWS/BOR
Upper Col	Twisp River Acclimation	Chinook	Spring	30,000	Douglas PUD/WDFW
Upper Col	Leavenworth NFH Spring Chinook	Chinook	Spring	1,200,000	USFWS/BOR
Upper Col	Winthrop NFH Spring Chinook	Chinook	Spring	400,000	USFWS/BOR
Upper Col	Winthrop NFH Steelhead	Steelhead	Summer	200,000	USFWS/BOR
Upper Col	Methow/Wells Steelhead	Steelhead	Summer	260,000	Douglas PUD/WDFW
Upper Col	Methow Spring Chinook	Chinook	Spring	163,249	Douglas PUD/Grant PUD/WDFW
Upper Col	Methow Spring Chinook-Chelan	Chinook	Spring	60,516	Chelan PUD/WDFW
Upper Col	Okanogan Steelhead	Steelhead	Summer	100,000	Grant PUD/Coville Tribe
Upper Col	Skaha Lake Sockeye	Sockeye	Fall	2,000,000	Chelan/Grant PUD/ONA
Upper Col	Priest Rapids Fall Chinook	Chinook	Fall (URB)	7,300,000	Grant PUD/COE/WDFW
Upper Col	Ringold Springs Fall Chinook	Chinook	Fall (URB)	3,500,000	COE/WDFW
Upper Col	Wenatchee Summer Chinook	Chinook	Summer	500,000	Chelan PUD/WDFW

Region	Program	Species	Run	Release Goal	Funding Entity, Operators
Upper Col	Chelan Falls Summer Chinook	Chinook	Summer	576,000	Chelan PUD/WDFW
Upper Col	Wells Summer Chinook	Chinook	Summer	804,000	Douglas PUD/WDFW
Upper Col	Methow Summer Chinook	Chinook	Summer	200,000	Douglas PUD/WDFW
Willamette	Molalla River Spring Chinook	Chinook	Spring	100,000	COE/ODFW
Willamette	McKenzie River Spring Chinook	Chinook	Spring	610,000	COE/ODFW
Willamette	North Santiam Spring Chinook	Chinook	Spring	710,000	COE/ODFW
Willamette	South Santiam Spring Chinook	Chinook	Spring	1,100,000	COE/ODFW
Willamette	Middle Fork Willamette Spring Chinook	Chinook	Spring	1,700,000	COE/ODFW
Willamette	South Santiam Summer Steelhead	Steelhead	Summer	600,000	COE/ODFW
Columbia River Basin Hatchery Programs that have not completed ESA consultation.					
Lower Col	Grays River Chum Salmon	Chum	Fall	250,000	BPA/WDFW
Lower Col	Salmon Creek Type-N Coho	Coho	Fall	60,000	WDFW/Clark PUD
Lower Col	Lewis River Spring Chinook	Chinook	Spring	1,350,000	WDFW/ Pacificorp
Lower Col	Lewis River Late Winter Steelhead	Steelhead	Winter	50,000	WDFW/ Pacificorp
Lower Col	Lewis River Type-N Coho Salmon	Coho	Fall	900,000	WDFW/ Pacificorp
Lower Col	Lewis River Type-S Coho Salmon	Coho	Fall	1,100,000	WDFW/ Pacificorp
Lower Col	Lewis River Early Winter Steelhead	Steelhead	Winter	100,000	WDFW/ Pacificorp
Lower Col	Lewis River Summer Steelhead	Steelhead	Summer	235,000	WDFW/ Pacificorp
Lower Col	Lewis River Chum Salmon	Chum	Fall	100,000	WDFW/ Pacificorp
Lower Col	Lewis River Co-op	Coho	Fall	RSI	WDFW/NGOs
Lower Col	Duncan Creek/Washougal Chum	Chum	Fall	400,000	BPA/WDFW
Lower Col	Cowlitz Spring Chinook	Chinook	Spring	1,038,529	WDFW/Tacoma Power
Lower Col	Cowlitz Fall Chinook	Chinook	Fall	2,400,000	WDFW/Tacoma Power
Lower Col	Cowlitz Coho Salmon	Coho	Fall	2,178,000	WDFW/Tacoma Power
Lower Col	Cowlitz Late Winter Steelhead	Steelhead	Winter	645,000	WDFW/Tacoma Power
Lower Col	Cowlitz Summer Steelhead	Steelhead	Summer	626,000	WDFW/Tacoma Power

Region	Program	Species	Run	Release Goal	Funding Entity, Operators
			Total	**133,618,464**	

2.4.1.4.3 Updates on Mitchell Act Hatchery Programs Since the 2017 Opinion

Facility operations funded by the Mitchell Act were evaluated in the 2017 Mitchell Act Opinion and are included in the environmental baseline for this Opinion, as illustrated in Table 75. Under the 2017 Mitchell Act Opinion, NMFS identified Mitchell Act funded hatchery facility infrastructure that needed upgrading specific to the NMFS screening and fish passage criteria[28] (NMFS 2011a)(see Table 72). The 2017 Mitchell Act Opinion and ITS required the operators of these facilities to develop plans to address the upgrade needs identified in that opinion, including a timeframe for the completion of the upgrades and a plan to secure funding for these activities, through the Mitchell Act or other sources. Table 72 below delineates the hatchery facilities identified as needing improvement in the 2017 Mitchell Act Opinion, and provides information on the expected timeline for improvements in 2017, as well as available updates on the status of those improvements. Additionally, the Factor 5 analysis in this Opinion (Section 2.5.2.5) serves to build off of the information in Table 72 to analyze any remaining needs for facility improvements at Mitchell Act funded hatchery facilities in the Columbia River Basin.

Table 72. Hatchery facilities identified as needing improvement in the 2017 Mitchell Act Opinion, with information on the expected timeline for improvements in 2017 and updates on the current status of those improvements.

Hatchery Facility	Improvement Identified As Needed in 2017	Current Status
Grays River Hatchery	Primary intake does not meet criteria and dewaters section of stream between intake and hatchery outfall. Update: Facility closed in 2020	NA
Fallert Creek Hatchery	Fallert Creek intake was lost in the 2016 flood and needs to be updated to meet current criteria and to provide passage for NOR adults. Mainstem Kalama River pump screens have been updated but may not meet 2011 criteria. Update: Awaiting state legislative funding	Incomplete
Clackamas Hatchery	Mainstem Clackamas River intake does not meet criteria. New intake in River Mill Dam reservoir needed and expected to be completed in 2017 Update: Completed 2018	Complete

[28] Mitchell Act-funded facilities were evaluated under the 2011 fish passage and screening criteria. Since the 2017 consultation, NMFS has released an updated version of the fish passage and screening criteria in 2022 that incorporates climate change directives, but the screening and fish passage criteria related to hatchery facilities infrastructure remains unchanged from the 2011 criteria.

Hatchery Facility	Improvement Identified As Needed in 2017	Current Status
Klaskanine Hatchery	Mainstem Intake #1 does not meet current criteria. Provide adult passage at Intakes #2 and #3. Update: Awaiting state legislative funding	Incomplete
NF Toutle Hatchery	Surface intake needs improvement. Feasibility study completed in 2012, awaiting funding. Update: Awaiting state legislative funding	Incomplete
Beaver Creek Hatchery	Elochoman River intake being upgraded. Expected to be completed in 2017. Update: Completed 2018	Complete
Kalama Falls Hatchery	Intake screens updated in 2006; but may not meet 2011 criteria. Considered a low priority. Update: Awaiting state legislative funding	Incomplete
Washougal Hatchery	Intake screens do not meet current criteria. Update: Funding secured. Work expected to begin in 2025.	Incomplete
Klickitat Hatchery	Surface intake structure does not meet current criteria. Under negotiations on remodel of intake. Update: Funding secured. Work expected to begin in 2025.	Incomplete

The 2017 Mitchell Act Opinion and ITS included additional terms and conditions designed to minimize adverse impacts to natural-origin salmon and steelhead from hatchery production, including the use of weirs in certain locations throughout the basin.

A weir is one type of adult management tool that is deployed to block upstream passage. The purpose of the weirs under the 2017 Proposed Action was to remove returning hatchery-origin adult fall Chinook and coho salmon encountered in order to more effectively remove spawning hatchery fish from naturally spawning populations. If properly implemented, NMFS expected the use of the weirs in strategic watersheds to reduce pHOS to levels that would allow resource managers to assess the collective demographic vitality of these small populations. This was intended to provide direction for future resource management adaptability (NMFS 2017a).

In late 2022, NMFS was alerted to the fact that WDFW may not have completed its required actions for Phase 2 of the Proposed Action in the 2017 Mitchell Act Opinion. Specifically, WDFW had not implemented weirs in 11 locations in LCR tributaries, as required under the opinion. These weirs were designed to control the straying of hatchery-origin adult salmon (particularly Chinook and coho) to the spawning grounds occupied by natural-origin fish. From January through July 2023, NMFS engaged in discussions with WDFW as to whether the weirs could be correctly implemented or whether an alternate strategy could be deployed immediately to reach the same result in controlling hatchery adults. However, the issue was not resolved. Accordingly, NMFS contacted WDFW by letter to inform them that the lack of weirs in the LCR constituted a significant enough change to the 2017 Proposed Action that it was necessary to reinitiate consultation. On August 7, 2023, NMFS informed WDFW by letter that WDFW's actions had triggered reinitiation of consultation on the 2017 Mitchell Act Opinion under our ESA implementing regulations at 50 CFR § 402.16.

WDFW's failure to implement all weirs required under the 2017 Mitchell Act Opinion resulted in adverse effects to natural-origin fish – in the form of pHOS levels in certain streams in the Columbia River Basin being higher than they would have been if the 2017 opinion's Proposed Action and ITS had been fully implemented. These increased pHOS levels are now part of this Opinion's environmental baseline, and the analysis in this Opinion takes into account all past actions, including WDFW's inadequate weir installation.

To help mitigate these past impacts, this Opinion's Proposed Action (Section 1.3) incorporates measures that better isolate "segregated" hatchery programs and better integrate "integrated" hatchery programs, following the original intent of the Proposed Action evaluated in the 2017 Mitchell Act Opinion and the Preferred Alternative in the Mitchell Act FEIS (NMFS 2014g). Specifically, the HOF includes measures that build and ultimately improve upon the Proposed Action in the 2017 Mitchell Act Opinion, including measures that terminate or relocate certain programs to reduce interactions between natural- and hatchery-origin salmon and steelhead; maintain existing and/or implement new weirs to reduce hatchery- and natural-origin interactions; initiate conservation hatchery programs for Chinook salmon; and accelerate the reintroduction of Coho salmon and initiate reintroduction of spring and fall Chinook salmon in certain river reaches. All of these actions are designed to mitigate the adverse impacts of Mitchell Act funded programs on natural-origin salmon and steelhead in the Columbia River Basin and to provide conservation benefits to the ESA-listed species evaluated in this Opinion. As such, these measures are intended to improve the environmental baseline for listed fish.

2.4.1.5 Harvest

The following Sections describe the past and ongoing effects of harvest on the ESUs and DPSs that are the subject of this consultation.

2.4.1.5.3 Salmon-directed Fisheries

Fisheries targeting salmon occur throughout the Action Area and are managed by different entities under different regulatory regimes. Fisheries throughout the Action Area are managed consistent with the PST between the U.S. and Canada, and are also managed under domestic laws such as the MSA, the ESA, and the law concerning tribal fishing rights.

The PST includes management regimes for fisheries affecting various salmon species and geographic areas. In the U.S., the PST is implemented under the Pacific Salmon Treaty Act of 1985 (16 USC 3631, et seq.). The management regimes, described in Chapters to an Annex to the PST, are renegotiated periodically. In 2018, U.S. and Canadian representatives reached agreement to amend versions of five expiring Chapters of Annex IV (Turner and Reid 2018); both countries have since executed this agreement. Management must be carried out in a manner consistent with the provisions of the new regimes for their duration, unless otherwise modified by a new agreement between the U.S. and Canada. Consistency with the new regimes means that both countries will regulate their domestic fisheries so as not to exceed the catch or mortality levels specified in the regimes. The U.S. fisheries that are managed consistent with the provisions of the PST, include salmon fisheries in Southeast Alaska (SEAK), the Washington and Oregon coasts, the Puget Sound and freshwater rivers flowing into it, and the Columbia River. It is important to note that there is no provision in the PST that requires harvest to occur at a particular level; either Party may harvest at levels less than the upper limits allowed in the regimes. This point is especially relevant as some U.S. fisheries, particularly the southern area fisheries, which are routinely constrained by U.S. domestic regulations and fishery management plans to a greater degree than required by the bilateral agreement (i.e., due to more stringent ESU-specific constraints necessitated by the ESA).

2.4.1.5.4 Management under the PST

The effects of past salmon fisheries include reducing the abundance of the targeted salmon. Beginning in 1999, NMFS consulted on the effects of fisheries managed under each 10-year agreement. In our 1999 biological opinion (NMFS 1999b), NMFS considered the effects on listed species resulting from SEAK fisheries managed under the new regime for the 1999 summer and 1999/2000 winter seasons. NMFS subsequently completed consultation on the full scope of the 1999 PST Agreement on November 18, 1999 (NMFS 1999b). Once the ESA and funding contingencies were satisfied, the 1999 PST Agreement was finalized by the governments and provided the basis for managing the affected fisheries in the U.S. and Canada during the ten-year term of the 1999 PST Agreement. Subsequently, in 2008 NMFS considered effects on listed species resulting from fisheries managed based on a newly negotiated regime described in the 2009 PST Agreement (NMFS 2008f).

The PST Agreement was most recently revised in 2019. The 2019–2028 PST agreement includes reductions in allowable harvest levels for all Chinook fisheries within its scope, and refines the management of sockeye, pink, chum, and coho salmon caught in the covered areas. The agreement includes reductions in the allowable annual catch of Chinook salmon in the SEAK and Canadian West Coast of Vancouver Island and Northern British Columbia fisheries by up to 7.5 and 12.5%, respectively, compared to the previous agreement (2008–2019). The level of reduction depends on the Chinook abundance in a particular year. This comes on top of the reductions of 15 and 30% for those same fisheries that occurred as a result of the prior 10-year agreement (2009 through 2018). Overall, harvest rates on Chinook salmon stocks caught in southern British Columbia and U.S. salmon fisheries are reduced by up to 15% from the previous agreement (2009 through 2018). Beginning in January 2020, this resulted in an increased proportion of abundances of Chinook salmon migrating to waters more southerly in the U.S. Pacific Coast Region portion of the EEZ than under prior PST agreements. Although provisions of the updated agreement are complex, they were specifically designed to reduce fishery impacts in all fisheries to respond to conservation concerns for a number of U.S. and Canadian stocks.

2.4.1.5.5 Southeast Alaska salmon fisheries

Salmon fisheries in SEAK are managed by the State of Alaska under authority delegated by NMFS and the North Pacific Fishery Management Council (NPFMC) consistent with the MSA. Fisheries in SEAK impacting Chinook salmon are managed as AABM fisheries consistent with the PST Agreement. An AABM fishery is an abundance-based regime that constrains catch or total mortality to a numerical limit computed from either a pre-season forecast or an in-season estimate of abundance, from which a harvest rate index can be calculated, expressed as a proportion of the 1979 to 1982 base period. In other words, the salmon fisheries in SEAK are managed to stay within an annual catch level that is determined based on the annual estimated abundance of all of the Chinook salmon stocks present in SEAK. Often these fisheries are managed to stay within the annual catch level but are not managed to account for the abundance of the individual stocks in the fishery. In its 2019 biological opinion on domestic actions related to the 2019–2028 PST agreement (NMFS 2019f), NMFS assumed that the State of Alaska would manage its SEAK salmon fisheries consistent with the provisions of that agreement. NMFS determined that ESA-listed coho, chum, sockeye salmon and steelhead are not likely to be adversely affected by SEAK Chinook salmon fisheries due to their range and life histories, and the nature of the fisheries themselves (NMFS 2019f).

2.4.1.5.6 Canadian salmon fisheries

NMFS does not have detailed information on the implementation of salmon fisheries in Canadian waters; however, a general description of what is known about likely interception of ESA-listed species in Canadian salmon fisheries is described here. In salmon fishery consultations, particularly those on the SEAK fishery prior to the 1999 PST agreement, NMFS generally tried to anticipate the effect of Canadian fisheries on the species status. Based on past PST agreement performance, NMFS has been able to rely on those to project Canadian fishing levels in its biological opinions. In order to describe fishery performance under past agreements and account for changing ocean conditions, NMFS has recently used the 1999 to 2018 timeframe to characterize and present Canadian harvest-related impacts that are part of the environmental baseline. As described in (NMFS 2019f), Canadian fisheries were managed subject to provisions of the 1999 PST agreement from 1999 to 2008, and subject to the 2009 PST agreement from 2009 to 2018. Management provisions that applied to Canadian fisheries under those agreements are described in their respective biological opinions (NMFS 1999b); (NMFS 2008f).

As discussed above, Chapter 3 of Annex IV of the PST describes a comprehensive and coordinated Chinook fishery management program that uses an abundance-based framework to manage all Chinook fisheries that are subject to Chapter 3. Harvest regimes are based on annual indices of abundance that are responsive to changes in production, that take into account all fishery induced mortalities, and that are designed to meet maximum sustainable yield (MSY) or other agreed biologically-based numeric escapement or exploitation rate objectives (NMFS 2024e). The harvest regime in this management program includes an AABM.

Additionally, the PST agreement limits the impact of Canadian and U.S. fisheries on natural coho salmon stocks originating in southern British Columbia, Puget Sound, and along the northern and central Washington coast (NMFS 2008f). The agreement also limits the impact of U.S. and Canadian fisheries on the subject coho salmon stocks to specified exploitation rate limits that vary as a function of the annual status forecast of those runs. ESA-listed coho salmon are distributed off the U.S. West Coast and rarely migrate as far north as Canada. As a consequence, harvest impacts on ESA-listed coho salmon in Canadian fisheries are quite low (NMFS 2008f).

The nearest marine area fisheries targeting chum salmon that might affect the Columbia River Chum Salmon ESU occur in terminal areas near Vancouver Island and in the Strait of Juan de Fuca. Chum salmon fisheries in Canada occur inside Barkley Sound, on the west coast of Vancouver Island, and near Nitnat on the south coast of the island. These are terminal fisheries directed at local stocks with little or no impact to stocks from outside areas. Commercial fisheries also occur in the western and eastern parts of the Strait of Juan de Fuca directed at chum salmon returning to Puget Sound and the Fraser River at the end of their spawning migration. Chum salmon stocks from the Washington coast are present in low abundance in these fisheries, but there are no reports of chum salmon from the Columbia River or their nearest neighbor on the northern Oregon coast. ESA-listed Hood Canal summer-run chum salmon are rarely caught in ocean fisheries (NMFS 2008f). The PST agreement contains requirements for Canadian fishermen to release chum salmon caught in purse seine gear when Hood Canal summer-run chum salmon are thought to be present (NMFS 2008f). In addition, Canadian coho salmon fisheries that historically occurred through the latter part of September, and likely intercepted some late returning Hood Canal summer chum, have been closed since 1994 and are expected to remain closed due to Canadian domestic management concerns. A significant factor in the low exploitation rate has also been the severe constraint on Canadian sockeye and pink salmon fisheries in recent years due to concerns about weak sockeye salmon stocks and changes in the allocation of sockeye and pink salmon in Canadian fisheries.

In previous consultations, NMFS has found no information to suggest that Snake River sockeye salmon were subject to significant harvest in ocean fisheries (56 FR 58619). Mature sockeye salmon from the Snake River are not likely to be taken in Alaska or Canada because they exit the ocean prior to the onset of intercepting sockeye salmon fisheries.

Steelhead are not targeted in marine area fisheries, and are caught rarely and only incidentally in fisheries targeting other species (NMFS 2008f). Retention of steelhead in marine fisheries is generally prohibited. As a consequence, there is relatively little information on the harvest of steelhead in ocean and marine fisheries. The adult freshwater timing, the ocean distribution patterns, and the greater relative abundance of Puget Sound and Canadian-origin steelhead compared with the listed LCR and Upper Willamette winter steelhead stocks, make it unlikely that Canadian fisheries would encounter more than a few steelhead per year from any of the listed Columbia River ESUs (NMFS 2008f). The catch of Puget Sound steelhead in Canadian fisheries is unknown, but is presumed to be low based on the low number of steelhead caught in the fisheries (NMFS 2008f).

2.4.1.5.7 U.S. West Coast salmon fisheries

South of the U.S./Canadian border from the northern Washington boundary, NMFS promulgates regulations for salmon fisheries in the EEZ off the Pacific Coast of Washington, Oregon, and California pursuant to the MSA. The Pacific Coast Salmon Fishery Management Plan (FMP) provides a framework for setting annual regulations that define catch levels and allocations based on year-specific circumstances (PFMC 2022). The PFMC implements the FMP through a public process that leads to recommendations to NMFS for annual regulations.

The current FMP requires that the PFMC manage fisheries consistent with NOAA Fisheries' ESA-related impact limits and other measures, in order to avoid jeopardy to any of the ESA listed species affected by the fisheries (PFMC 2022), consistent with biological opinions issued by NMFS as described below. Additionally, the FMP includes control rules and other measures to ensure that fishery impacts on non-ESA-listed salmon are sustainable. Each year, the PFMC recommends a set of fishery management measures to NMFS for approval and implementation under the MSA.

Since 1991, 28 salmon ESUs and steelhead DPSs from the West Coast of the U.S have been listed under the ESA. NMFS has issued biological opinions addressing the effects of the fisheries on all of these listed species, and has reinitiated consultation when new information became available on the status of a species or the impacts of the FMP on a species. Table 73 lists the current opinions that considered the effects of the PFMC fisheries on listed species and their duration.

Additional information on baseline conditions on the West Coast is discussed every year in the PFMC's annual Review of Ocean Salmon Fisheries. The most recent report was released in February 2024 (PFMC 2024a). The Review focuses in particular on the status of salmon stocks, as is reflected by escapement trends over recent decades. The Review also provides detailed catch information for the West Coast salmon fishery, and other areas such as the Puget Sound and Columbia River.

2.4.1.5.8 Other fisheries

2.4.1.5.8.1 Canadian groundfish fisheries

Canadian groundfish fisheries historically catch Chinook salmon as bycatch while conducting fisheries with mid-water gear types in Canadian trawl fisheries. Chinook salmon bycatch in these fisheries ranged from 2,469 to 26,273 individual fish from 2008 to 2023, and averaged 8,283 fish (Lagasse et al. 2024). Canada estimates these fish as total encountered, with the vast majority retained, but some released. The composition is sampled for CWT and PBT genetic identification to determine salmon stock identification (Lagasse et al. 2024). In addition to stock identification, results from the PBT analysis provide information on brood year composition, which can be used to calculate salmon age by subtracting the year a fish was caught from the brood year. For example, Chinook salmon from the 2020 brood year would represent age 2 fish if caught in 2022, and age 3 fish if caught in 2023. This is done where possible, as many of the salmon caught are juvenile fish rearing in this area of the ocean. This is younger than most Chinook salmon catch in salmon-directed fisheries and therefore catch numbers in trawl and salmon fisheries may not be directly comparable in terms of adult equivalent mortality. Chinook salmon represent greater than 80% of Pacific salmon bycatch in most Canadian groundfish fishing years from 2008/09 to 2022/23 (Lagasse et al. 2024).

2.4.1.5.8.2 Gulf of Alaska groundfish fisheries

Chinook salmon are caught incidentally in the Bering Sea/Aleutian Islands (BSAI) and Gulf of Alaska (GOA) groundfish fisheries. However, the BSAI fisheries occur outside the Action Area considered in this Opinion, and occur outside the known migratory path of the four ESA-listed species of Chinook salmon considered in this Opinion. We reviewed all sources of available data on stocks of Chinook salmon contributing to these incidental catches, and there is no information to suggest that any of the affected ESA-listed salmon ESUs considered in this Opinion are affected by these fisheries. They are therefore not discussed further.

Groundfish fishing areas in the GOA are managed pursuant to the MSA through the NPFMC GOA Groundfish FMP[29]. GOA Groundfish FMP fishing areas and salmon fishing areas in SEAK overlap, although most of the groundfish fishing occurs to the west of the salmon fishing areas. The incidental bycatch of salmonids in the GOA groundfish fishery is limited primarily to Chinook and chum salmon. In previous biological opinions (NMFS 1999d); (NMFS 2007b); (NMFS 2012e); (Stelle 2014), NMFS considered the NPFMC's proposed annual bycatch limit of 40,000 Chinook salmon for the GOA fishery and other related management actions. These opinions concluded that their Proposed Actions would not jeopardize any of the affected Chinook salmon species. From 2008 to 2022 the bycatch of Chinook salmon has averaged 20,548 individual fish and ranged from 8,396 to 54,559 fish (Kurland 2023).

NMFS last reviewed the effects of the GOA groundfish fishery on ESA-listed salmon species through Section 7 consultation in 2012 (NMFS 2012e). Estimates of the take of ESA-listed Chinook salmon come from a review of tags that have been recovered in the fishery over the last 20 years[30].

2.4.1.5.8.3 PFMC groundfish fisheries

PFMC groundfish fisheries historically catch Chinook salmon as bycatch while conducting fisheries pursuant to the Pacific Coast Groundfish FMP. Chinook salmon bycatch in the groundfish fishery ranged from 3,068 to 15,319 individual fish from 2008 to 2015 and averaged 6,806 fish (NMFS 2017j). Bycatch consists of primarily subadult Chinook salmon taken annually in the groundfish fisheries.

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[29] For incidental bycatch monitoring see: https://www.fisheries.noaa.gov/alaska/bycatch/chinook-salmon-bycatch-management-alaska

[30] For annual estimates of Chinook salmon incidental catch see https://www.fisheries.noaa.gov/s3/2023-03/2022-chinook-incidental-catch-esa-annual-rpt.pdf

NMFS concluded in previous biological opinions on PFMC groundfish fishery implementation that the effects on ESA-listed Chinook salmon, of the ESUs most likely to be subject to measurable impacts, were very low (NMFS 2017j). Although both listed and unlisted ESUs contributed to bycatch, the major contributors to Chinook salmon bycatch in the at-sea sector were from ESUs not listed under the ESA. The at-sea sector contributions were, on average, Klamath/Trinity Chinook salmon (28%) followed by Southern Oregon/Northern California Coast (25%), Oregon Coast (10%), and northern British Columbia (11%) Chinook salmon (NMFS 2017j). Samples from Chinook salmon bycatch in the shore side whiting sector showed contributions from Central Valley Chinook salmon (13%). Oregon Coast showed a similar contribution, as well as a very low contribution from British Columbia Chinook salmon (NMFS 2017j). The remainder of stocks, which included contributions from listed ESUs, contributed 5% or less of the Chinook salmon bycatch in either fleet on average.

The low contribution rates to bycatch from the ESA-listed Chinook salmon ESUs (i.e., 5% or less) are consistent with qualitative characterizations of likely bycatch levels in analyses prior to the 2017 Mitchell Act Opinion (NMFS 2017j).

Salmon are also caught during commercial and recreational halibut fisheries occurring in the PFMC area. However, these catches are accounted for as part of the Pacific Coast Salmon FMP management framework when salmon fisheries are legally open for retention. Therefore, they are accounted for in the environmental baseline under the information reported above in the PFMC Salmon Fisheries section. When salmon fishing is prohibited, halibut fisheries may occasionally encounter salmon. Injuries and death from encounters with fishing gear and handling, during times and areas where salmon fishing is otherwise closed, are expected to result in the take of 4.3 fish per year from each of the following ESA-listed ESUs: Puget Sound Chinook Salmon, LCR Chinook Salmon, and Snake River Fall-run Chinook Salmon. Puget Sound salmon fisheries catch LCR Chinook salmon, UWR Chinook salmon, and Snake River fall-run Chinook salmon on occasion. However, the ERs in these fisheries, on these particular ESUs, are just fractions of 1% (NMFS 2019f).

Table 73. NOAA Fisheries' ESA decisions regarding ESUs and DPSs affected by PFMC fisheries and the duration of the 4(d) Limit determination or biological opinion (BO). Only those decisions currently in effect are included.

Date (Decision type)	Citation	Species Considered
Salmonid Species		
March 8, 1996 (BO)	(NMFS 1996b)	Snake River Spring/summer Chinook Salmon Snake River Fall-run Chinook Salmon Snake River Sockeye Salmon
April 28, 1999 (BO)	(NMFS 1999a)	Central California Coast Coho Salmon Oregon Coast Coho Salmon Southern Oregon/Northern California Coast Coho Salmon

Date (Decision type)	Citation	Species Considered
April 28, 2000 (BO)	(NMFS 2000a)	Central Valley Spring-run Chinook Salmon California Coastal Chinook Salmon
April 30, 2001 (BO)	(NMFS 2001b)	Upper Willamette River Chinook Salmon Columbia River Chum Salmon Ozette Lake Sockeye Salmon Upper Columbia River Spring-run Chinook Salmon 10 Distinct Population Segments (DPS) of Steelhead
September 14, 2001 (BO, 4(d) Limit)	(NMFS 2001a)	Hood Canal Summer-run Chum Salmon
April 27, 2012 (BO)	(NMFS 2012b)	Lower Columbia River Chinook Salmon
April 9, 2015 (BO)	(NMFS 2015b)	Lower Columbia River Coho Salmon
March 30, 2018 (BO)	(NMFS 2018f)	Sacramento River Winter-run Chinook Salmon
April 28, 2022 (BO)	(NMFS 2022l)	Southern Oregon/Northern California Coast Coho Salmon
May 13, 2022 (BO)	(NMFS 2022n)	Puget Sound Chinook Salmon Puget Sound Steelhead
Non-Salmonid Species		
April 30, 2007 (BO)	(NMFS 2007a)	Southern DPS Green Sturgeon
April 30, 2011 (BO)	(NMFS 2010a)	Puget Sound/Georgia Basin DPS Canary and Yelloweye Rockfish, and Bocaccio
April 30, 2011 (BO)	(NMFS 2011c)	Southern DPS Eulachon
April 21, 2021 (BO)	(NMFS 2021a)	Southern Resident DPS Killer Whale

2.4.1.5.8.4 Other Puget Sound fisheries

Halibut Fisheries. Commercial and recreational halibut fisheries occur in the Strait of Juan de Fuca and San Juan Island areas of Puget Sound. NMFS previously concluded that salmon are not likely to be caught incidentally in the commercial or tribal halibut fisheries when using halibut gear (NMFS 2018g), and later determined that encounters were exceptionally rare (NMFS 2023b). The total estimated non-retention mortality of Chinook salmon in Puget Sound recreational halibut fisheries is extremely low, averaging just under two Chinook salmon per year. Of these, the estimated catch of listed fish (hatchery and wild) is between one and two Puget Sound Chinook salmon per year. As the fishery occurs in mixed stock areas and the impact levels are very low, different populations within the ESUs are likely affected each year.

Puget Sound bottomfish and shrimp trawl fisheries. Recreational fisheries targeting bottom fish and the shrimp trawl fishery in Puget Sound can incidentally catch listed Puget Sound Chinook salmon. In 2012 NMFS issued an incidental take permit to the WDFW for listed species caught in these two fisheries, including Puget Sound Chinook salmon (NMFS 2012b). The permit was in effect for 5 years and authorized the total incidental take of up to 92 Puget Sound Chinook salmon annually. Some of these fish would be released. Some released fish were expected to survive; thus, of the total takes, NMFS authorized a subset of lethal take of up to 50 Chinook salmon annually. As of 2023 this permit has not been renewed. WDFW has applied for a permit allowing incidental take of 137 Chinook salmon annually in the coming years and it is currently being evaluated.

2.4.1.5.8.5 Tribal Indian fisheries

Native Americans have lived along the western coast of the present-day United States for thousands of years. Along this coast, and further south, anthropological and archaeological evidence suggests that for more than 10,000 years Native Americans have fished for salmon and steelhead, as well as for other species for ceremonial, subsistence, and economic purposes (Campbell and Butler 2010). In the late 1800s, in the contiguous U.S., they ceded most of their ancient lands to the federal government as waves of settlers encroached west and forced treaties took their lands, rivers, and fishing rights. Salmon and steelhead from the ocean have always had spiritual and cultural significance for tribes, and the fish had economic importance as both a trade and food item. The health of Native Americans, whose diets traditionally included certain quantities and qualities of fish, was heavily reliant on these resources (Harper and Walker 2015).

Anadromous fish have been harvested in the Columbia River Basin for as long as the area has been inhabited. Anthropological and archaeological evidence suggests that for more than 10,000 years Native Americans have fished for salmon and steelhead, as well as for other species, in the tributaries and mainstem of the Columbia River for ceremonial, subsistence, and economic purposes (Campbell and Butler 2010). A wide variety of gears and methods were used, including hoop and dip nets at cascades such as Celilo and Willamette Falls, to spears, weirs, and traps (usually in smaller streams and headwater areas).

Commercial fishing developed rapidly with the arrival of European settlers and the advent of preservation technologies in the 1800s. In the 1820s, the salting and export of salmon began, led by the Hudson's Bay Company. The packing industry initially relied heavily upon Native American-caught salmon. As demand grew, the non-Indian commercial fishery expanded as well (Johnson 1983). Even greater expansion was spurred by the opening of the first salmon cannery on the Columbia River by Hapgood, Hume and Company in 1864 (Johnson 1983); (Dietrich 1995). The canning industry reached its peak in 1883 with 55 canneries in operation packing 630,000 cases of salmon. The 1883 commercial harvest was 43 million pounds (Netboy 1974); (Brown 1975). Fishing pressure, especially in the late nineteenth and early twentieth centuries has long been recognized as a key factor in the decline of Columbia River salmon runs (NRC 1996).

In 1855, Columbia River Basin Native Americans entered into the Treaties of 1855 with the United States government, ceding the majority of their land but expressly reserving, among other things, the right to fish. The subsequent historical progression of legal interpretation of the Treaty Indian fishing right is described in (NMFS 2018c).

Fisheries along the U.S. West Coast, in the Puget Sound area, and in the Columbia River Basin include tribal fisheries implementing treaty fishing rights. Implementing Indian treaty fishing rights involves, amongst other things, application of the sharing principles established in various legal precedents. These precedents were established through multiple cases affecting PFMC salmon fishery implementation (e.g., *United States v. Oregon*, 302 F. Supp. 899 (D. Or. 1969); *United States v. Washington*, 384 F. Supp. 312 (W.D. Wash. 1974); and *Parravano v. Babbitt*, 70 F.3d 539 (9th Cir. 1995)). Exploitation rate, escapement, and harvest level calculations, to which the sharing principles apply, are dependent upon various biological parameters. These parameters include: the estimated run sizes for the particular year, the mix of stocks present, the status of other species intercepted, the allowable fisheries, and the anticipated fishing effort.

2.4.1.5.8.6 United States v. Oregon

As described in NMFS (NMFS 2018c), aspects of Treaty Indian fishing rights in the Columbia River Basin are addressed under the continuing jurisdiction of the U.S. District Court for the District of Oregon in the case of *United States v. Oregon* (Civil Case No. 68-513, Oregon 1968). In at least a half-dozen published legal opinions and several unpublished opinions in *U.S. v. Oregon*, as well as dozens of rulings in the parallel case of *U.S. v. Washington* (interpreting the same treaty language for Tribes in Western Washington), the courts have established a large body of case law setting forth the fundamental principles of treaty rights and the permissible limits of conservation regulation of treaty fisheries.

Since 1992 (NMFS 1992), NMFS has consulted under section 7 of the ESA on proposed *U.S. v. Oregon* fisheries in the Columbia River Basin. After the initial consultation (NMFS 1992), NMFS conducted a series of consultations to consider the effects of proposed fisheries as additional species were listed, as new information became available, and as fishery management provisions evolved to address the needs of ESA-listed species. Currently, tribal and non-tribal fisheries in the Columbia River Basin are managed under the framework established in the 2018 *U.S. v. Oregon* Management Agreement, in effect for 10 years.

NMFS completed a biological opinion on the 2018 agreement on February 23, 2018 (NMFS 2018c). The opinion concluded that fisheries management, subject to the proposed agreement, was not likely to jeopardize any of the affected ESA-listed species. The incidental take limits and expected incidental take (as a proportion of total run size) of listed salmonids for Treaty Indian and non-Indian fisheries under the current agreement are captured in Table 74. Table 74 summarizes the allowed impact rates for each ESU/DPS along with the observed annual average postseason performance after fisheries were implemented during the course of the current agreement.

Table 74. Authorized level of incidental take (as proportion of total run-size) of listed anadromous salmonids for non-Indian and Treaty Indian fisheries included for the 2018 agreement. From Feeken (2018); Feeken et al. (2019); TAC (2020); Currie et al. (2021); TAC (2022); TAC (2023).

ESU or DPS	Take Limits from 2018-2027 (%)	Range of take observed from 2018-2023 (%)	Average annual take (%)
Snake River fall-run Chinook Salmon	21.5 – 45.0[a]	21.5 – 29.6	27.0
Snake River spring/summer-run Chinook Salmon	5.5 – 17.0[a,b]	6.1 – 11.2[b]	8.5
Lower Columbia River Chinook Salmon	Managed by components listed below		
spring-run component	Managed For Hatchery Escapement Goals	Hatchery escapements met all but 2019 and 2020	[c]
tule component (fall run)	30.0 – 41.0[a,d]	25.7 – 37.7[d]	31.5[d]
bright component (late-fall run)	Managed For 5,700 Fish Escapement Goal	Escapement goal met all but 2018	n/a
Upper Willamette River Chinook Salmon[e]	15.0	3.0 – 6.4	4.4
Snake River Basin Steelhead	Managed by components listed below		
A-Index Component, non-treaty	4.0[f]	0.8 – 2.1	1.3
B-Index Component, non-treaty	2.0[g]	0.4 – 1.6	0.9
B-Index Component, treaty	15 – 22[a,g]	5.3 – 13.0	8.4[g]
Lower Columbia River Steelhead	Managed by components listed below		
winter component	2.0[e,h]	0.2 – 0.3	0.3
summer component	4.0[e]	0.6 – 0.9	0.7
Upper Willamette River Steelhead	2.0[f,h]	0.2 – 0.3	0.3
Middle Columbia River Steelhead	Managed by components listed below		
winter component	2.0[f,h]	0.2 – 0.3	0.3
summer component	4.0[e]	0.8 – 2.1	1.3
UCR spring-run Chinook Salmon	5.5 – 17.0[a,b]	6.1 – 11.2[b]	8.5
CR Chum Salmon	5.0	0.0 – 1.6	0.6
UCR Steelhead, non-treaty	4.0[f]	0.8 – 2.1	1.3
Snake River Sockeye Salmon	6.0 – 8.0[a]	1.9 – 7.1	4.9
Lower Columbia River Coho Salmon	10.0 – 30.0	7.0 – 19.5	12.2
Monitoring, Evaluation, and Research	0.1 - 0.5[i]		

[a] Allowable take depends on run size.

[b] Impacts in treaty fisheries on listed wild fish can be up to 0.8% higher than the river mouth run-size harvest rates (indicated in table above) due to the potential for changes in the proportion wild between the river mouth and Bonneville Dam.
[c] NMFS (2012c) determined fisheries have ranged from exploitation rates of 2% to 28% over the last ten years, and are expected to remain within this range through managing for hatchery escapement until actions concerning terminal fish passage in the tributaries are addressed.
[d] Total exploitation rate limits include ocean and mainstem Columbia River fisheries. NMFS (2012c) evaluated the PFMC's harvest matrix for total exploitation, including ocean and mainstem Columbia River fisheries, tiered on abundance.
[e] Limit is consistent with Upper Willamette River Chinook salmon recovery plan (ODFW and NMFS 2011)
[f] Applies to non-Indian fisheries
[g] For fall fisheries only.
[h] There is no specific harvest rate limit proposed for treaty fisheries on winter steelhead above Bonneville Dam or on A-Index summer steelhead.
[i] Includes research, monitoring and evaluation that is currently in place. For Chinook and coho ESU's, the range is 0.1–0.5% for each ESU. For Steelhead DPS' and the Snake River Sockeye Salmon ESU the range is 0.1–0.3%.

2.4.1.5.8.7 United States v. Washington

United States v. *Washington* is the ongoing Federal court proceeding that enforces and implements reserved treaty fishing rights with regard to salmon and steelhead returning to western Washington. Various orders of the *U.S.* v. *Washington* settlement mandate that many aspects of fishery management, including, but not limited to, harvest and artificial production actions, be jointly coordinated by the State of Washington and the Western Washington Treaty Tribes (*U.S.* v. *Washington* (1974)).

Findings of *U.S.* v. *Washington*, 384 F. Supp. 312 (W.D. Wash. 1974), commonly referred to as the Boldt Decision, clarified these treaties with regard to allocation of salmon harvests between tribal and non-tribal fishers, holding that tribes are entitled to a 50-percent share of the harvestable run of fish in their "usual and accustomed areas." *Hoh Indian Tribe v. Baldridge*, 522 F. Supp. 683 (W.D. Wash. 1981), a subsequent case, established the principle that fishery management plans must consider returns to individual streams if the fisheries might affect an individual tribe, thus establishing another key management principle of river-by-river or run-by-run management. These decisions added to the findings in *United States v. Oregon*, which held that the state is limited in its power to regulate treaty Indian fisheries.

The State of Washington and Puget Sound Treaty Tribes manage salmon fisheries under the purview of *U.S. v. Washington*, and on an annual or multi-year basis by agreement. As described above, in recent years, they developed agreed annual management plans for the fisheries; however, they have submitted a multi-year Resource Management Plan (RMP) to NMFS for approval under its 4(d) rule.

Salmon fisheries subject to *U.S. v. Washington* catch ESA-listed LCR Chinook salmon, UWR Chinook salmon, and Snake River Fall Chinook salmon on occasion, but the ERs in these fisheries on these ESUs are just fractions of 1% (NMFS 1996b); (NMFS 2012c). The effects of salmon fisheries within the *U.S. v. Washington* case area on Puget Sound stocks are of course higher than the effects to other stocks, because they are focused on mainly Puget Sound fish. As described previously, Puget Sound salmon fisheries are managed to keep fishery impacts within management unit-specific management objectives. This multi-year long-term RMP has been submitted to NMFS, and is currently under review. The management objectives in the RMP are similar to those used for 2024-2025.

Recent year ERs in Puget Sound fisheries ranged from 3.2 to 44.4 % since 1999 depending on stock (Table 75), and accounted for 9.9 to 73.40 % of each stock's total ER (Table 76). Not surprisingly, a higher proportion of the overall harvest impact on the Puget Sound Chinook Salmon ESU occurs in Puget Sound fisheries than in SEAK fisheries for stocks from the south and mid-Sound areas (Table 76).

Table 75. Puget Sound Chinook salmon ERs in marine area fisheries between 1999 and 2018.

Stock	SEAK Exploitation	Canadian Exploitation	PFMC Exploitation	Puget Sound Exploitation	Total Exploitation
	Average 1999 – 2018				
Nooksack River (early)	3.5%	23.3%	2.3%	3.2%	32.3%
Skagit River (early)	0.3%	13.6%	0.9%	7.6%	22.5%
Skagit River (summer/fall)	7.3%	18.9%	1.1%	12.6%	39.9%
Stillaguamish River	1.7%	20.5%	1.9%	6.8%	30.9%
Snohomish River	0.3%	14.6%	1.7%	7.2%	23.8%
Lake Washington	0.2%	14.2%	4.9%	11.0%	30.3%
Duwamish-Green River	0.2%	14.2%	4.9%	24.1%	43.4%
Puyallup River	0.2%	14.2%	4.9%	30.3%	49.6%
Nisqually River	0.1%	9.8%	6.1%	44.4%	60.4%
White River (early)	0.1%	9.6%	1.3%	16.7%	27.9%
Skokomish River	0.5%	12.6%	6.1%	36.9%	56.1%
Mid-Hood Canal Rivers	0.5%	12.8%	6.2%	5.9%	25.4%
Dungeness River (early)	1.8%	18.5%	1.5%	4.0%	25.8%
Elwha River	1.8%	18.6%	1.5%	3.8%	25.8%

Table 76. The proportional distribution of harvest impacts of Puget Sound Chinook salmon distribution in marine areas and Puget Sound fisheries between 1999 and 2018.

Stock	SEAK % of Exploitation	Canadian % of Exploitation	PFMC % of Exploitation	Puget Sound % of Exploitation
	Average 1999 – 2018			
Nooksack River (early)	10.80%	72.20%	7.20%	9.90%
Skagit River (early)	1.50%	60.70%	4.00%	33.80%
Skagit River (summer/fall)	18.20%	47.30%	2.80%	31.60%
Stillaguamish River	5.50%	66.30%	6.30%	21.90%
Snohomish River	1.40%	61.10%	7.30%	30.20%
Lake Washington	0.50%	47.00%	16.20%	36.20%
Duwamish-Green River	0.40%	32.80%	11.30%	55.50%

Stock	SEAK % of Exploitation	Canadian % of Exploitation	PFMC % of Exploitation	Puget Sound % of Exploitation
	Average 1999 – 2018			
Puyallup River	0.30%	28.70%	9.90%	61.00%
Nisqually River	0.10%	16.30%	10.10%	73.40%
White River (early)	0.50%	34.60%	4.80%	60.10%
Skokomish River	1.00%	22.40%	10.90%	65.80%
Mid-Hood Canal Rivers	2.10%	50.40%	24.40%	23.10%
Dungeness River (early)	7.10%	71.60%	5.90%	15.40%
Elwha River	7.10%	72.00%	5.90%	14.90%

2.4.1.6 Climate Change

In Section 2.2.9, we describe the on-going and anticipated temperature and marine effects of climate change. Because the impacts of climate change are ongoing, the effects are reflected in the most recent biological viability assessment for Pacific Northwest salmon and steelhead (Ford 2022) and summarized in Section 2.2.9 above. Changes in climate and ocean conditions happen on several different time scales, as explained in Section 2.2.9, and have had a profound influence on distributions and abundances of marine and anadromous fishes. Evidence suggests that marine survival among salmonids fluctuates in response to 20- to 30-year cycles of climatic conditions and ocean productivity. Recalling the more detailed discussion about the likely effects of large-scale environmental variation on salmonids described in Section 2.2.9 across their entire range, effects in the environmental baseline that may occur from climate change on salmon and steelhead include warmer water temperatures, loss of cold water refugia, altered stream flows (e.g., lower low flows in summer; higher high flows in winter), loss of coastal habitat due to sea level rise, ocean acidification, and changes in water quality and freshwater inputs (Mauger et al. 2015).

2.4.2 Eulachon

The best scientific information presently available demonstrates that a multitude of factors, past and present, have contributed to the decline of eulachon. In the 2010 status review (Drake et al. 2010), the Biological Review Team (BRT) categorized climate change impacts on ocean conditions as the most serious threat to the persistence of eulachon in all four subpopulations of the DPS: Klamath River, Columbia River, Fraser River, and British Columbia coastal rivers south of the Nass River. Climate change impacts on freshwater habitat and eulachon bycatch in offshore shrimp fisheries were also ranked in the top four threats in all subpopulations of the DPS. Dams and water diversions in the Klamath and Columbia rivers and predation in the Fraser and British Columbia coastal rivers filled out the last of the top four threats (Drake et al. 2010). These threats, together with large declines in abundance, indicated to the BRT that eulachon were at moderate risk of extinction throughout all of its range (Drake et al. 2010). Thus, as a general matter, eulachon have at least some biological requirements that are not being met in the Action Area. Eulachon are still experiencing the impact of a variety of past and ongoing federal, state, and private activities in the Action Area and that impact is expressed in the threats listed above in Section 2.2.7—all of which, in combination, are currently keeping the species from recovering and actively preventing them from having all their biological requirements met.

2.4.3 Scientific Research Effects for salmon and steelhead in the Environmental Baseline

The listed salmon and steelhead species in this Opinion are the subject of scientific research and monitoring activities. The impacts of these research activities pose both benefits and risks. Research on the listed species in the Action Area is currently covered under section 7 of the ESA or under the ESA 4(d) research programs, or included in the estimates of fishery mortality discussed in Section 2.5, Effects of the Proposed Action, in this Opinion.

For the year 2023, NMFS has issued several ESA section 10(a)(1)(A) scientific research permits allowing lethal and non-lethal take of listed species within the Action Area (NMFS 2023c). Table 77 displays the total take for the ongoing research authorized under ESA sections 4(d) and 10(a)(1)(A) within the Action Area for the listed LCR Chinook Salmon ESU, LCR Coho Salmon ESU, and Snake River Fall-run Chinook Salmon ESU.

Actual take levels associated with these activities are almost certain to be substantially lower than the permitted levels. There are three reasons for this: (1) most researchers do not handle the full number of individuals they are allowed – our research tracking system reveals that researchers, on average, end up taking about 37% of the number of fish they estimate needing; (2) the estimates of mortality for each proposed study are purposefully inflated (the amount depends upon the species) to account for potential accidental deaths, and it is therefore likely that fewer fish (in some cases many fewer), especially juveniles, than the researchers are allotted are killed; and (3) researchers within the same watershed are encouraged to collaborate on studies (i.e., share fish samples and biological data among permit holders) so that overall impacts on listed species are reduced (NMFS 2023c).

Table 77. Total requested take of ESA-listed species for scientific research and monitoring approved for 2023, plus the permits evaluated in this Opinion covering new scientific research (NMFS 2023c).

Species	Life Stage	Origin[a]	Total Requested Take	Percent of Abundance	Lethal Take	Percent of ESU/DPS killed
Puget Sound Chinook salmon[b]	Adult	LHAC	960	7.107[a]	62	0.336[a]
		LHIA	691		16	
		Natural	853	3.650	37	0.158
	Juvenile	LHAC	223,285	9,569	0.871	0.037
		LHIA	275,089	3.169	5,596	0.064
		Natural	770,310	20.661	13,768	0.369
Lower Columbia River Chinook salmon	Adult	LHAC	151	0.866[a]	13	0.069[a]
		LHIA	12		0	
		Natural	420	1.434	19	0.065
	Juvenile	LHAC	2	0.010	664	0.002
		LHIA	428	0.045	45	0.005
		Natural	514,518	4.621	6,483	0.058
Lower Columbia River coho salmon	Adult	LHAC	676	4.433[a]	42	0.263[a]
		LHIA	31		0	
		Natural	1,121	5.990	19	0.102
	Juvenile	LHAC	19,776	0.249	1,101	0.014
		LHIA	875	0.270	116	0.036
		Natural	241,705	29.226	2,926	0.354
Snake River fall Chinook salmon	Adult	LHAC	83	0.786[a]	14	0.101[a]
		LHIA	34		1	
		Natural	87	1.198	9	0.124
	Juvenile	LHAC	2,630	0.101	283	0.011
		LHIA	2,013	0.068	144	0.005
		Natural	4,529	0.566	264	0.033

[a] Abundances for adult hatchery salmonids are LHAC and LHIA combined.
[b] Abundance for these species are only known for the adult life stage, which is used to represent the entire DPS
[c] Abundances for all adult components are combined.

2.5 Effects of the Action

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the Proposed Action, including the consequences of other activities that are caused by the Proposed Action but that are not part of the action. A consequence is caused by the Proposed Action if it would not occur but for the Proposed Action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 CFR 402.02).

The methodology and best scientific information NMFS follows and assembles for analyzing hatchery effects is summarized in Appendix A to this Opinion, and the application of this methodology and our analysis of the Proposed Action is provided in Section 2.5.2. Appendix A is a reference document for NMFS's ESA hatchery consultations (revised May 2023) that guides the effects analysis of hatchery programs on salmon and steelhead populations. The effects analysis contained in Section 2.5.2 follows this guidance, including the evaluation of the six factors described in Appendix A and below. The effects of actions resulting from the Proposed Action are included in the analysis in this Opinion to the extent they can be meaningfully evaluated. Finally, in Section 2.7 of this Opinion – Integration and Synthesis, the Proposed Action, the status of ESA-protected species and their designated critical habitat, the environmental baseline, the effects of the action, and the cumulative effects of future state and private activities that are reasonably certain to occur within the Action Area are analyzed comprehensively to determine whether the Proposed Action is likely to appreciably reduce the likelihood of survival and recovery of ESA-protected species or result in the destruction or adverse modification of critical habitat.

2.5.1 Factors to Analyze When Analyzing Hatchery Effects

NMFS has substantial experience evaluating hatchery programs utilizing best available science (Hard et al. 1992); (McElhany et al. 2000); (Jones 2006); (NMFS 2004); (NMFS 2005d); (NMFS 2008a); (NMFS 2012a). For Pacific salmon, NMFS evaluates extinction processes and effects of the Proposed Action beginning at the population scale (McElhany et al. 2000). NMFS defines population performance measures in terms of natural-origin fish and four key parameters or attributes–abundance, productivity, spatial structure, and diversity–and then relates the effects of the Proposed Action at the population scale to the MPG level and ultimately to the survival and recovery of an entire ESU or DPS.

A key factor in analyzing a hatchery program for its effects is that those effects can be both positive and negative for natural-origin populations. "Because of the potential for circumventing the high rates of early mortality typically experienced in the wild, artificial propagation may be useful in the recovery of listed salmon species. However, artificial propagation entails risks as well as opportunities for salmon conservation" (Hard et al. 1992). A Proposed Action is analyzed for effects, positive and negative, on the attributes that define population viability: abundance, productivity, spatial structure, and diversity. The effects of a hatchery program on the status of an ESU or steelhead DPS and designated critical habitat "will depend on which of the four key attributes are currently limiting the ESU, and how the hatchery fish within the ESU affect each of the attributes" (70 FR 37215, June 28, 2005). The presence of hatchery fish within the ESU can positively affect the overall status of the ESU by increasing the number of natural spawners, by serving as a source population for repopulating unoccupied habitat and increasing spatial distribution, and by conserving genetic resources. "Conversely, a hatchery program managed without adequate consideration can affect a listing determination by reducing adaptive genetic diversity of the ESU, and by reducing the reproductive fitness and productivity of the ESU."

NMFS analyzes the effects of the Proposed Action in terms of effects we expect on ESA-listed species and on designated critical habitat based on the best scientific information available. This allows for quantification (wherever possible) of the effects of the six factors listed below and further described in Appendix A, to evaluate the impacts of hatchery operation on each listed species and their critical habitat. This factor-based analysis, in turn, allows NFMS to evaluate the combination of such effects with other non-hatchery based impacts accruing to the species to determine whether or not the Proposed Action is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat.

The six factors that NMFS analyzes the Proposed Action against to evaluate its effects on ESA-listed species and their designated critical habitat are:

1) The hatchery program does or does not remove fish from the natural population and use them for hatchery broodstock

2) Hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities

3) Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas, migratory corridor, estuary and ocean[31]

4) Research, monitoring, and evaluation (RM&E) that exists because of the hatchery program

5) The operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program

6) Fisheries that exist because of the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds.

For all factors other than Factor 3, the analysis following this section will focus on the relevant species present in the Columbia River Basin (i.e., Eulachon Southern DPS, LCR Chinook Salmon ESU, UCR Spring Chinook Salmon ESU, Snake River Spring/Summer Chinook ESU, Snake River Fall Chinook ESU, UWR Chinook Salmon ESU, LCR Coho Salmon ESU, CR Chum Salmon ESU, Snake River Sockeye Salmon ESU, LCR Steelhead DPS, MCR Steelhead DPS, UCR Steelhead DPS, Snake River Steelhead DPS, and UWR Steelhead DPS) because expected impacts of these factors occur within the Columbia River Basin. The analysis in Factor 3 additionally includes the Puget Sound Chinook Salmon ESU, California Coastal Chinook Salmon, and Central Valley Spring Chinook Salmon ESU because the expected impacts of

[31] While the 2017 Mitchell Act Opinion analyzed this factor as two separate factors (then Factors 3 and 4), NMFS has since combined the two factors for the purpose of evaluating impacts of hatcheries on ESA-listed species and their critical habitat (see Appendix A) because of the overlap in the respective analyses (i.e., effects in an estuary are now considered jointly with effects in freshwater migratory areas).

Factor 3 encompass impacts in some parts of the ocean (see Section 2.3, Action Area), where these species are likely to encounter the Mitchell Act-funded fish.

NMFS's analysis assigns an effect category for each factor (negative, negligible, or positive/beneficial) on each ESU or DPS impacted by a hatchery program based on general salmon or steelhead population viability. The effect category assigned is based on: (1) an analysis of each factor weighed against the affected population(s) current risk level for abundance, productivity, spatial structure and diversity; (2) the role or importance of the affected natural population(s) in salmon ESU or steelhead DPS recovery; and (3) the target viability for the affected natural population(s).

For more information on each factor and how NMFS applies those factors in an ESA consultation, please see Appendix A. The analysis of these factors as applied the NMFS's annual Mitchell Act funding of Columbia River Basin hatcheries, i.e., the Proposed Action, is contained in Sections 2.5.2.1 through 2.5.2.6 of this Opinion.

2.5.2 Analysis of the Effects of the Proposed Action on ESA-listed Species

2.5.2.1 Factor 1. The hatchery program does or does not remove fish from the natural population and use them for hatchery broodstock

For Factor 1, we weigh the risks of removing natural-origin ESA listed salmon and steelhead from the natural population to be used as broodstock against the benefits of the hatchery-origin salmon and steelhead from those integrated programs returning to spawn naturally (see Appendix A, Section 1.1).

For the UCR spring–run Chinook Salmon ESU, Snake River Spring/summer-run Chinook Salmon ESU, Snake River Fall-run Chinook Salmon ESU, Snake River Sockeye Salmon ESU, UCR Steelhead DPS, Snake River Basin Steelhead DPS, MCR Steelhead DPS, and UWR Steelhead DPS, we expect the Proposed Action to not have any measurable impacts under Factor 1 because these salmon ESUs and steelhead DPSs are not used for broodstock for hatchery programs funded under the Proposed Action.[32] We also expect the Proposed Action to have no effect on the Pacific Eulachon because they are not encountered during broodstock collection activities funded under the Proposed Action.

There are effects from Factor 1 on the LCR Chinook Salmon ESU, UWR Chinook Salmon ESU, LCR Coho Salmon ESU, CR Chum Salmon ESU, and the LCR Steelhead DPS, as shown in Table 78. However, these effects are consistent with population needs because the hatchery programs use natural-origin salmon and steelhead as broodstock to maintain the genetic diversity of the native population, while limiting the removal levels of returning adults, as discussed

[32] The 2017 Biological Opinion also found no effect for the UWR Chinook Salmon ESU; however, the Clackamas spring Chinook salmon program transitioned from a segregated to an integrated program in 2020, and broodstock collection is analyzed in this reinitiated opinion.

below. A more thorough discussion of the effects of removing natural-origin fish for broodstock is addressed in Section 2.5.2.2, Genetic effects, specifically in the discussion of gene flow management.

Table 78 shows the maximum number of adult natural-origin recruits (NORs) used for broodstock by ESU/DPS. The programs listed in Table 78 are the only Mitchell Act-funded programs to collect natural origin broodstock.

Table 78. Summary of broodstock needs for programs using ESA-listed salmon and steelhead by ESU/DPS[1]. NOR= natural origin returns

ESU/DPS	Program	Number of broodstock needed[2]
LCR Chinook Salmon ESU	North Fork Toutle fall Chinook salmon program	Maximum number of NOR broodstock (includes males, females and jacks) is 814; the maximum number of NORs that can be collected for broodstock is limited to 33% of the Toutle fall Chinook population annual NOR return.
	Washougal fall Chinook salmon program	Maximum number of NOR broodstock (includes males, females and jacks) is 978; the maximum number of NORs that can be collected for broodstock is limited to 33% of the Washougal fall Chinook population annual NOR return.
	Sandy River spring Chinook salmon	Maximum number of NOR broodstock (includes males, females and jacks) is 42; the maximum number of NORs that can be collected for broodstock is limited to 2% of the Sandy River spring Chinook population annual NOR return.
	Grays River fall Chinook Salmon Conservation Hatchery	A maximum of 154 NOR fall Chinook salmon collected from the Grays River; collection not to exceed 33% of the NOR return of fall Chinook salmon to the Grays River.
	Abernathy fall Chinook salmon Conservation Hatchery	A maximum of 48 NOR fall Chinook salmon collected from the Elochoman River; collection not to exceed 33% of the NOR return of fall Chinook salmon to the Elochoman River.
UWR Chinook Salmon ESU	Clackamas spring Chinook salmon	Maximum number of broodstock (includes males, females and jacks) is 120 NOR adults through 2025. Starting in 2026, broodstock will be collected on a sliding scale based on the number of NORs: 0 (< 1000 NOR), 21 total (1000-2500 NOR), and 45 total (>2500 NOR)
LCR Coho Salmon ESU[3]	Beaver Creek (Elochoman) coho	Maximum number of NOR broodstock (includes males, females and jacks) is 337; the maximum number of NORs that can be collected for broodstock is limited to 33% of the Elochoman/Skamokawa coho population annual NOR return.

ESU/DPS	Program	Number of broodstock needed[2]
	North Fork Toutle coho	Maximum number of NOR broodstock (includes males, females and jacks) is 96; the maximum number of NORs that can be collected for broodstock is limited to 33% of the North Fork Toutle coho population annual NOR return.
	Washougal coho salmon	Maximum number of NOR broodstock (includes males, females and jacks) is 96; the maximum number of NORs that can be collected for broodstock is limited to 33% of the Washougal coho population annual NOR return.
CR Chum Salmon ESU	Big Creek Hatchery	Maximum number of NOR broodstock (includes males, females and jacks) is 1,352.
LCR Steelhead DPS	Clackamas River winter steelhead	Maximum number of broodstock (includes males, females and jacks) is 49; adults from this program will be live-spawned and released back into the Clackamas River to potentially spawn again. The maximum number of NORs that can be collected for broodstock is limited to 5% of the Clackamas winter steelhead population annual NOR return.
	Sandy River winter steelhead	Maximum number of broodstock (includes males, females and jacks) is 50; adults from this program will be live-spawned and released back into the Sandy River to potentially spawn again. The maximum number of NORs that can be collected for broodstock is limited to 5% of the Sandy winter steelhead population annual NOR return.
	Kalama River summer steelhead	Maximum number of NOR broodstock (includes males and females) is 90; the maximum number of NORs that can be collected for broodstock is limited to 33% of the Kalama summer steelhead population annual NOR return.
	Kalama River winter steelhead	Maximum number of NOR broodstock (includes males and females) is 45; the maximum number of NORs that can be collected for broodstock is limited to 33% of the Kalama winter steelhead population annual NOR return.
	Washougal winter steelhead	Maximum number of NOR broodstock (includes males and females) 42; the maximum number of NORs that can be collected for broodstock is limited to 33% of the Washougal winter steelhead population annual NOR return.

[1] Here, NMFS is not issuing a direct take authorization of natural-origin ESA-listed fish for broodstock, as that is not part of the Proposed Action, but instead is simply ensuring it is incorporating effects known to occur as a result of funding the programs in the HOF.
[2] The maximum number of NOR listed here assumes a scenario using 100% proportion of natural-origin broodstock (pNOB).
[3] The Grays River coho program was originally analyzed for broodstock effects to the LCR coho ESU. That program was discontinued in February 2020 and transferred to the Elochoman River (Beaver Creek Hatchery). Grays River has been removed from Table 78, and Beaver Creek has been added to Table 78.

2.5.2.1.1 LCR Chinook Salmon ESU

The effects on the LCR Chinook Salmon ESU of using natural-origin fish as broodstock in Mitchell Act-funded hatchery programs is described by program.

The North Fork Toutle program has a proportion of natural-origin brood (pNOB; see Appendix A, Section 1.2.1.1.1, Key Terms) target of up to 100%. Beginning in 2017 through 2022, the North Fork Toutle program release goal under the 2017 Mitchell Act Opinion's proposed action was reduced from 1,400,000 smolts to 1,100,000 smolts, and that release goal is the same under this Proposed Action. The reduction in the program size reduced the number of NOR adults needed from 228 to approximately 179 adults. The number of NORs that can be collected for broodstock is limited to 33% of the NOR returns. With the current level of returns at 280 NORs (Table 16), the expected natural-origin brood size is 92 NORs.

The Washougal program has a pNOB target of up to 100%. Beginning in 2017 through 2022, the Washougal subyearling release goal for the integrated program increased from 900,000 to 1,200,000, and the off-station segregated program was discontinued. The larger integrated program increased the number of NOR adults needed to approximately 350 adults. With the current level of returns at 914 NORs (Table 16), the expected natural-origin brood size is 302 NORs.

The Grays River program has a pNOB target of up to 100%. This is a new program evaluated in this opinion. The release goal for this program is 361,000, and a maximum of 154 NOR fall Chinook salmon would be collected from the Grays River for broodstock. With the current level of returns at 228 NORs (Table 16), the expected natural-origin brood size is 75 NORs.

The Abernathy program has a pNOB target of up to 100%. This is a new program evaluated in this opinion. The release goal for this program is 113,000, and a maximum of 48 NOR fall Chinook salmon would be collected from the Elochoman River for broodstock. With the current level of returns at 95 NORs (Table 16), the expected natural-origin brood size is 31 NORs.

For the North Fork Toutle, Washougal, Grays River, and Abernathy programs, the removal of up to 33 percent of the natural-origin run is acceptable because the more natural-origin broodstock is incorporated, the higher PNI a program can achieve. Though these programs are not managed using PNI as a metric, a higher PNI reflects a program's ability to better maintain natural genetic diversity. While removing any natural-origin fish from the spawning population is a negative effect, NMFS believes that removal of 33 percent of the natural-fish for brood in these programs is warranted to ensure the supplementation programs remain closely linked with the natural population, thus balancing the risk of removing too many natural-origin fish with the risk of propagating hatchery fish that are substantially diverged from the natural population and improving the long-term productivity of the population.

The Sandy River spring Chinook salmon program has a pNOB target of up to 100%. The impacts of the Sandy River spring Chinook salmon program were analyzed in (NMFS 2014e). For this program, a total of 210 adults would be needed for broodstock and of these 42 would be

NOR adults. No more than 2% of the natural-origin spring Chinook salmon returning to the Sandy River Basin annually will be used for hatchery broodstock. With the current level of returns at 3,359 NORs (Table 16), the expected natural-origin brood size is 67 NORs.

The Clackamas spring Chinook salmon program release goal is proposed to increase from the level analyzed in the 2017 Mitchell Act Opinion and (NMFS 2021b) from 1,050,000 to 1,100,000 smolts. In NMFS (2021b), a sliding scale for NOR adults based on the run size estimate at North Fork Dam was used. The program currently uses 120 NOR adults through 2025. Starting in 2026, the broodstock will be collected on a sliding scale based on the number of NORs: 0 (< 1000 NOR), 21 total (1000-2500 NOR), and 45 total (>2500 NOR). For 2025, using 120 NOR adults would equate to about 3 percent of the NORs out of the the level of returns at 3,617 NORs (Table 16). For longer term operation, this program would use no more than 2.1 percent of the NORs for broodstock.

For the Sandy River and Clackamas programs, the removal of the natural-origin run is acceptable because the more natural-origin broodstock is incorporated, the higher PNI a program can achieve. Though these programs are not managed using PNI as a metric, NMFS believes that removal of the natural-origin fish for brood as described above allows for the supplementation program to remain closely linked with the natural population, thus balancing the risk of removing too many natural-origin fish with the risk of propagating hatchery fish that are substantially diverged from the natural population.

2.5.2.1.2 LCR Coho Salmon ESU

WDFW operates three integrated coho salmon programs: Beaver Creek, North Fork Toutle, and Washougal. All three take broodstock under the restriction that no more than 33% of the adult NOR run can be collected for broodstock.

The Beaver Creek coho salmon program has a pNOB target of up to 100%. The program was analyzed in the 2017 Mitchell Act Opinion for a release of 150,000 smolts, and provided for a release of up to 75,000 additional juvenile coho from the Grays River Hatchery after the termination of the program in 2022. This brought the total coho release level from the Beaver Creek Hatchery on the Elochoman River to 225,000. At this production level, a total of 200 adults would be needed for broodstock. With the current level of returns at 558 NORs (Table 44), the expected natural-origin brood size is 184 NORs.

The North Fork Toutle coho salmon program has a pNOB target of up to 100%. Beginning in 2017 through 2022, the North Fork Toutle program release goal under the 2017 Mitchell Act Opinion's Proposed Action was reduced from 150,000 smolts to 90,000 smolts. This reduction reduced the broodstock need to 82 NOR adults. With the current level of returns at 819 NORs (Table 44the expected natural-origin brood size is 82 NORs, the maximum broodstock amount.

The Washougal River coho salmon program has a pNOB target of up to 100%. Beginning in 2017 through 2022, the Washougal River program release under the 2017 Mitchell Act

Opinion's Proposed Action was reduced from 150,000 to 108,000 smolts. The broodstock needed for the reduced program (at 100% pNOB) is 74 adults. With the current level of returns at 174 NORs (Table 44), the expected natural-origin brood size is 57 NORs.

For each of the above programs, the removal of up to 33 percent of the natural-origin run is acceptable because the more natural-origin broodstock is incorporated, the higher PNI a program can achieve. Though these programs are not managed using PNI as a metric, a higher PNI reflects a program's ability to better maintain natural genetic diversity. While removing any natural-origin fish from the spawning population is a negative effect, NMFS believes that removal of 33 percent of the natural fish for brood is warranted to ensure these supplementation programs remain closely linked with the natural population, thus balancing the risk of removing too many natural-origin fish with the risk of propagating hatchery fish that are substantially diverged from the natural population, and improving the long-term productivity of the population.

2.5.2.1.3 CR Chum Salmon ESU

The Big Creek Hatchery chum salmon program is the only Mitchell Act-funded program that uses natural-origin broodstock from the CR Chum Salmon ESU. Natural-origin and hatchery chum salmon are collected at the Big Creek Hatchery for broodstock to support the reintroduction of chum salmon into Oregon tributaries to the LCR. The program has a broodstock goal of 1,352 adults with a pNOB target of up to 100%, which could result in the removal of up to 1,352 natural-origin adults, though the brood composition will likely be a mix of hatchery and natural-origin fish. The program's goal is to produce 1,690,000 eggs, with the latest release occurring in 2032. In the past, broodstock originated from natural-origin chum salmon that were collected in the Grays River, and the program operator could potentially collect adults from there again if the program's broodstock needs are not met at the Big Creek Hatchery. Broodstock was collected from the large Grays River population (recent 5-year geometric mean of 10,027 NOR adults, Table 47) until 2014, when hatchery and natural-origin adults returning to the Big Creek Hatchery began to be used from broodstock.

The Mitchell Act-funded program at the Big Creek Hatchery could handle up to 1,352 NOR adult chum salmon annually. Some of these will be used for broodstock and others will be released above the hatchery or outplanted into reintroduction areas. Effects on natural-origin chum salmon from collection and removal of adults for broodstock are expected to include the reduction in the overall abundance of the natural-origin population. However, NMFS believes this is necessary in the short-term to support the reintroduction of chum salmon into historical habitat on the Oregon side of the Columbia River. NMFS finds this level of broodstock collection acceptable because this is an expansion on a conservation program that is limited in duration (through 2032), and we expect the program to release the maximum number of 1,690,000 eggs for only one year. In addition, while we assume a pNOB of 100%, we would not expect this to occur, as the highest pNOB between 2017-2022 was 85 percent, with the average across these years being 68 percent. Thus, the actual natural-origin mortality associated with each year is likely to be lower than 1,352 NOR adults. Additionally, although the program is expected to continue as proposed into the future, impacts would be expected to decrease over time as the natural-origin populations become self-sustaining, which could eliminate the need for the hatchery program altogether. In sum, despite the removal of natural-origin fish for broodstock, this hatchery program, as proposed, is expected to contribute to the conservation of CR chum salmon genetic resources overall.

2.5.2.1.4 LCR Steelhead DPS

There are four integrated steelhead hatchery programs that use natural-origin fish from the LCR Steelhead DPS as broodstock: the Clackamas Winter, Sandy Winter, Kalama Summer, and Kalama Winter programs. The pNOB goal for each of these programs is 100%.

For the Clackamas River program, up to 49 natural-origin winter steelhead adults will be used for broodstock, which is not expected to exceed 5% of the Clackamas River NOR run. With the current level of returns at 2,819 NORs (Table 53), the expected natural-origin brood size is 49 NORs, the maximum broodstock amount.

For the Sandy River program, up to 50 natural-origin adults will be used for broodstock, which is not expected to exceed 5% of the Sandy River NOR run. With the current level of returns at 3,615 NORs (Table 53), the expected natural-origin brood size is 50 NORs, the maximum broodstock amount. Adults from these programs will be live-spawned and released back into the Clackamas and Sandy Rivers, respectively, to potentially spawn again, which will further reduce risks due to the removal of NOR adults from the spawning population.

For both of the above programs, the removal of up to 5 percent of the natural-origin run is acceptable because the more natural-origin broodstock is incorporated, the higher PNI a program can achieve. While the removal of any natural origin fish from the spawning population is a negative effect,NMFS believes that removal of 5 percent of the natural fish for brood is warranted to ensure the supplementation program remains closely linked with the natural population, thus balancing the risk of removing too many natural-origin fish with the risk of propagating hatchery fish that are substantially diverged from the natural population.

The Kalama River summer steelhead program uses up to 70 NOR adults as broodstock, using no more than 33% of the Kalama NOR returns. With the current level of returns estimated at 560 NORs for Kalama River summer steelhead (Table 53), the expected natural-origin brood size is 70 NORs, the maximum broodstock amount. Similarly, the Kalama River winter steelhead program uses up to 80 NORs, with the same 33% limit. With the current level of returns estimated at 618 NORs for Kalama River winter steelhead (Table 53), the expected natural-origin brood size is 80 NORs, the maximum broodstock amount. Because these hatchery programs live-spawn the NOR adults used for broodstock (males for the summer steelhead program and all fish for winter steelhead program) and re-release those fish, some of the NOR adults used for broodstock are only temporarily removed from the population and could potentially spawn in the wild. Thus, the reduction in overall abundance of the naturally-spawning population from broodstock collection is expected to be minimal. The incorporation of NOR adults into the broodstock for these two programs is expected to continue to contribute to the preservation of the genetic resources of Kalama River summer and winter steelhead populations.

The program's PNI management target is a 5-year average of >0.67, with a goal of achieving >0.70 annually.

The Washougal winter steelhead program at the Skamania Hatchery is proposed to transition from a segregated to integrated program, with the production goal of up to 60,000 smolts. For broodstock needs once the integrated program transition is complete, up to 42 NOR adults (no more than 33% of the natural-origin run) would be collected. The projected PNI for this program is 0.70, with a management target of a 5-year average of >0.67. With the current level of returns at 427 NORs (Table 53), the expected natural-origin brood size is 42, the maximum broodstock amount.

The removal of up to 33% of the natural-origin Kalama summer and Kalama and Washougal winter steelhead runs is acceptable because when the natural run size exceeds 560, 618, and 427 natural-origin fish, respectively, a minimum PNI of 0.67 can be achieved while removing up to 33% natural-origin fish for broodstock. When run size is lower than 560, 618, and 427 natural-origin fish, respectively, NMFS believes that removal of 33% of the natural fish for brood is still warranted in order to ensure that the supplementation programs remain closely linked with the natural population; thus balancing the risk of removing too many natural-origin fish with the risk of propagating hatchery fish that are substantially diverged from the natural population.

2.5.2.2 Factor 2. Hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities

There are three aspects to the analysis of this factor: genetic effects, adult ecological effects, and encounters at adult collection facilities. When hatchery fish return as adults to the spawning grounds, they interact with natural-origin fish that are present in the spawning sites. In addition, the HOF governing Mitchell Act-funded hatchery programs includes adult collection facilities that are operated to collect broodstock and minimize the number of hatchery-origin fish that are naturally spawned, where appropriate. Therefore, the analysis under this factor focuses on genetics effects of hatchery-origin fish interbreeding with natural-origin fish; ecological effects, which can include competition for spawning sites, redd superimposition, contributions of marine-derived nutrients to watersheds; and effects of operating the adult collection facilities.

Here, we analyze the effects of these factors on ESA-listed eulachon, salmon, and steelhead listed in Table 1 in Section 1.1 of this Opinion because they are likely to encounter the hatchery fish produced by Mitchell Act funding, as well as being encountered at facilities that produce Mitchell Act-funded fish. The analysis here is limited to the impacts from the programs in the HOF, because the programs listed in Table 4 in Section 1.3 are small and have low survival rates, thus not likely to have any impact on natural-origin species.

NMFS expects no effects under this factor on the UCR spring–run Chinook Salmon ESU, Snake River Spring/summer-run Chinook Salmon ESU, Snake River Fall-run Chinook Salmon ESU, Snake River Sockeye Salmon ESU, UCR Steelhead DPS, Snake River Basin Steelhead DPS, and UWR Steelhead DPS because it would be rare for hatchery salmon and steelhead resulting from the implementation of the HOF to stray into the areas occupied by these listed species (hundreds of miles in some cases), let alone often enough and in large enough numbers to cause any adverse effect. Encounters with natural-origin salmon or steelhead from these ESA-listed ESUs or DPSs at adult collection facilities included in the Proposed Action are also not expected to occur since none have been reported over the last twelve years (NMFS 2017e) and NMFS expects that trend to continue into the future.

The remaining expected effects under Factor 2 on other listed species are described below by ESU/DPS. We present genetic effects first. For the sake of simplicity, we discuss genetic effects on all life stages under Factor 2.

2.5.2.2.1 Pacific Eulachon Southern DPS

The analysis here does not include genetic effects because eulachon does not interbreed with hatchery-origin salmon and steelhead. Similarly, the analysis also excludes impacts of the adult collection facilities because eulachon are not expected to be encountered at such facilities.

Hatchery programs can potentially negatively affect eulachon through ecological interaction from superimposition on eulachon eggs by hatchery fish and the progeny of naturally spawning hatchery fish during spawning. These effects would only potentially occur in the Sandy, Kalama, Grays, Elochoman, and Coweeman Rivers.

There are currently no data or measurements of superimposition on eulachon eggs by spawning hatchery fish or the progeny of naturally spawning hatchery fish. What reduces the likelihood of significant impact is that returning hatchery-origin adults from the majority of programs funded in the Proposed Action will have either finished spawning before eulachon have begun their upstream migration, or they will occupy different spawning habitats. Returning adults from all Chinook salmon hatchery programs will finish spawning by the end of November (Table 14 in Sec 2.2.2.2.1), before the beginning of the adult eulachon migration.

Adult eulachon spawn timing temporally overlaps with returning adults from summer steelhead programs, but summer steelhead occupy different spawning habitats, preferring areas higher in the watershed (Table 52).

While effects from these components of the Proposed Action are discountable, the effect of the winter steelhead programs from superimposition on eulachon eggs by hatchery fish or the adult progeny of naturally spawning hatchery fish during spawning in the Sandy, Kalama, Grays, Elochoman, and Coweeman Rivers is unclear. Eulachon eggs are commonly found attached to sand or pea-sized gravel, though eggs have been found on a variety of substrates, including silt, gravel to cobble sized rock, and organic detritus (Moody 2008), similar to substrates steelhead are known to use (Kondolf and Wolman 1993). Historically, temporal and spatial overlap between natural winter steelhead run timing and eulachon is low (Crawford 1979).

The Kalama River (Early) winter steelhead program is the only program proposing to recycle adult steelhead surplus above hatchery broodstock needs back into its receiving watershed.

While this could result in continuous eulachon spawning ground interaction through superimposition by hatchery-origin adults, it will be negligible as they will not recycle winter steelhead that show signs of sexual maturity.

2.5.2.2.2 Salmon and Steelhead ESUs/DPSs

2.5.2.2.2.1 Analysis of genetic effects of Mitchell Act hatchery programs on listed Columbia Basin salmon and steelhead

Hatchery produced salmon and steelhead can pose genetic risks to their natural-origin counterparts. Such risks can manifest negative effects when genetically-based differences exist between hatchery- and natural-origin populations that interbreed in the wild. Exogenous hatchery stocks, not native to the ESU in which they are released, inherently differ from the genetic makeup of local, natural-origin populations. Interbreeding between native and exogenous stocks can disrupt co-adapted gene complexes and result in outbreeding depression (e.g. (Gilk et al. 2004)). Genetic differences can also develop between locally-founded hatchery populations and their natural-origin source populations. Such differences can arise through a combination of random genetic drift, domestication selection, and epigenetic pathways. Although domestication selection is expected to incrementally increase the fitness of the lineage under selection in the captive environment, it is unlikely to select for traits that confer high fitness in the wild (Ford, 2002).

Indeed, a large and growing body of evidence has documented that when hatchery-origin salmon and steelhead spawn in the wild they experience relatively low reproductive success, as compared to their natural-origin conspecifics (reviewed by (Koch and Narum 2021)). Importantly, low relative reproductive success of hatchery-origin fish can impact the fitness of natural-origin fish when the two interbreed, and cumulative effects of hatchery-wild interactions on spawning grounds may lead to population-level impacts on productivity (Chilcote, Goodson, and Falcy 2011). Lastly, continued gene flow from a domesticated or otherwise genetically diverged hatchery population carries potential to impact the genetic diversity and adaptive potential of recipient natural populations, further contributing to their risk of decline (Naish et al. 2007).

One commonly used approach to reduce genetic risks from hatchery programs is to include natural-origin adults among fish spawned to produce the next generation. This practice intentionally mediates gene flow from the locally-adapted natural population into the hatchery population, restoring genetic diversity to the latter and slowing genetic divergence between both.

Such “integration” is expected to bolster the fitness of hatchery-origin fish that spawn in the wild, thereby offering protection to both natural diversity and productivity. Baskett and Waples (Baskett and Waples 2013) used a modeling approach to assess the effectiveness of an integrated approach to broodstock management, relative to an isolated (a.k.a. “segregated”) approach, and found the integrated approach to be generally more effective at maintaining long-term population fitness than the isolated, unless strong natural selection occurred during the period between release of juveniles into the wild and adult reproduction, in which case both approaches were similarly effective.

In general, it is NMFS's view that integrated approaches to broodstock management represent an important tool for limiting genetic risk, particularly when interbreeding between hatchery and wild fish is difficult to manage and likely to occur. NMFS's opinion on this matter is informed by findings of the Congressionally-established Hatchery Scientific Review Group (HSRG), which evaluated hatchery operations throughout the Pacific Northwest and developed an extensive suite of general and program-specific guidelines (see (Paquet et al. 2011), which include the following recommendations to managers:

- Define the purpose of hatchery programs (e.g., conservation, harvest augmentation);
- Identify whether a hatchery program would be segregated from or integrated with the local, wild population;
- Scale the size of hatchery programs to population goals (harvest, escapement, etc.)
- Limit pHOS from integrated and segregated hatchery programs in accordance with the conservation importance of affected natural populations (see Table 79);
- For integrated hatchery programs, utilize a proportion of natural-origin broodstock (pNOB) such that the proportionate natural influence (PNI) is ≥ 0.67 for primary populations and ≥ 0.50 for contributing populations, where:

$$PNI = \frac{pNOB}{(pNOB + pHOS)}$$

- And, discontinue or modify programs if risks outweigh benefits.

The PNI recommendations issued by the HSRG were largely based on the model results of Ford (2002), which quantified the effects of gene flow from a captive population (i.e. pHOS) on the rate of phenotypic and fitness change in a recipient wild population. With relationship to integrated hatchery programs, Ford (2002) also explored how the rate of gene flow from a wild population into a captive population (i.e., pNOB) could serve to slow the pace of phenotypic change and fitness decline for the naturally spawning population. The relative influences of directional gene flow from captive (i.e., hatchery-origin) and wild (i.e. natural-origin) populations on mean phenotype and fitness in the wild are described by PNI (first defined by C. Busack, WDFW, see Paquet et al. (2011)), a metric that predicts natural selection to have a dominant and positive influence over fitness in the wild when PNI > 0.50.

Table 79. HSRG recommendations for pHOS from integrated and segregated hatchery populations into primary and contributing populations of naturally spawning salmon and steelhead. Adapted from Paquet et al. (2011).

Hatchery broodstock management strategy	pHOS goal for Primary populations	pHOS goal for Contributing populations
Integrated	<0.30	<0.30
Segregated	<0.05	<0.10

When applying these concepts of gene flow to hatchery management and species conservation, it is important to recognize that pHOS is determined *not only* by the number of hatchery-origin fish that spawn in the wild, but *also* by the number of natural-origin fish that spawn in the wild. In some cases, chronically low numbers of natural-origin salmon and steelhead have returned to spawn in primary and contributing population habitats. Such circumstances pose serious demographic risks to ESA-listed species, challenge efforts to effectively manage pHOS in accordance with HSRG guidelines, and warrant use of alternative approaches for species conservation and recovery. For example, the chronically low abundance of chum salmon returning to the LCR prompted the HSRG to recommend that one or more conservation hatchery programs be initiated to bolster the number of naturally spawning fish. Such actions involve a temporary acceptance of genetic risks associated with artificial propagation, with the expectation that these risks would be outweighed by immediate and significant demographic benefits to the supplemented population.

Accordingly, it is NMFS's opinion that the pHOS and PNI guidelines developed by the HSRG be applied on a case-by-case basis, with consideration of the relative risks posed by immediate demographic and long-term genetic factors that may, in some cases, warrant temporary relaxation of genetic risk management standards so as to readily meet goals of species abundance and distribution.

Recognizing the statuses of ESA-listed salmon and steelhead in the Columbia River Basin, and the genetic risks that hatchery fish can pose to these species, NMFS has worked with Mitchell Act-funded hatchery operators to develop management tactics within a HOF (Section 1.3) that will limit negative genetic effects from our Proposed Action and support the conservation and recovery of ESA-listed species. These management tactics are based on basic tenets of conservation biology, draw from HSRG recommendations, and address the following important biological aspects of salmon and steelhead:

- The abundance of naturally spawning populations
- Genetic diversity within natural-origin populations and MPGs
- Genetic diversity among MPGs, ESUs, and DPSs
- Domestication selection within hatchery-origin populations
- Genetic influence of hatchery-origin populations on natural-origin populations

The tactics described throughout this Section align with existing species recovery plans and are intended to recover and protect the abundance, diversity, population growth rate, and distribution of ESA-listed species. Potential genetic effects from adult salmon and steelhead produced by

Mitchell Act-funded hatcheries, and the tactics designed to limit these effects, are described below according to relevant ESUs and DPSs.

2.5.2.2.2.1.1 LCR Chinook Salmon ESU

Six Major Population Groups (MPGs) constitute the LCR Chinook Salmon ESU. They are specified by life history along with geographical boundaries, these being the Coast fall, Cascade spring, Cascade fall, Cascade late fall, and Gorge spring, and Gorge fall strata population groups. Twelve (12) Mitchell Act funded hatchery programs currently operate within the boundaries of this ESU, and three new conservation hatchery programs are planned to operate as a result of our Proposed Action. All Mitchell Act funded hatchery programs that release Chinook salmon into the LCR Chinook Salmon ESU use broodstock collected or derived from within-MPG sources. New conservation programs will also use broodstock collected from within their respective MPG. Accordingly, Mitchell Act funded programs operating within this ESU do not promote gene flow between MPGs, do not pose risk to MPG genetic diversity, and are not expected to contribute to outbreeding depression of LCR Chinook salmon.

However, as previously recognized by NMFS (2017a), high pHOS from hatchery programs operating within the boundaries of the LCR Chinook Salmon ESU poses serious genetic risk to LCR fall Chinook salmon, particularly populations in the Coast MPG (Table 80). As described earlier in this Section, pHOS serves as a proxy estimate for gene flow from hatchery populations, which may or may not be integrated with the naturally spawning populations they affect. Through the course of previous consultation, NMFS (2017a) developed a strategy to address the issue of high pHOS in the LCR Chinook Salmon ESU.

First, NMFS identified a suite of index populations in the Coast and Cascade fall strata, recognizing that the recovery plan (NMFS 2013e) had identified that these MPGs would need to exceed the Willamette-Lower Columbia (WLC) TRT criteria to compensate for uncertainties about meeting the WLC TRT's viability criteria in the Gorge strata under a final recovery scenario (NMFS 2017a).

Second, NMFS worked with hatchery program operators to establish maximum allowable pHOS limits in these index populations. In this particular case, NMFS determined population specific standards for pHOS on a case by case basis, given the chronically low abundance of natural-origin spawners and uncertain productivity of populations that had experienced prolonged exposure to high pHOS. The maximum pHOS limits established by NMFS (2017a) represented significant reductions from observed pHOS values, and were based on each population's conservation importance (i.e. primary or contributing; see NMFS (2010a) and whether hatcheries contributing to pHOS used a segregated or integrated broodstock management approach, as was determined through a third step.

In a third step, NMFS worked with hatchery operators to develop the Chinook Assessment Model (CAM), which was constructed with multi-year data from coded-wire tags recovered from Chinook salmon released from Mitchell Act funded hatcheries. The CAM uses these and other data to generate estimates for harvest and escapement rates, and coded-wire tags collected from fish on natural spawning grounds to estimate dispersion rates of returning hatchery fish into natural populations. The influences of hatchery program size, fisheries harvest, and weir operations on pHOS were then explored.

In a fourth and final step, based on CAM results, NMFS worked to identify management actions that would most effectively serve to reduce pHOS to satisfy the previously established limits (NMFS 2017a). Results from CAM analyses supported decisions to reduce production from all but two Mitchell Act funded hatchery programs operating in the Coast and Cascade fall strata. These reductions were to be implemented over the course of five years (NMFS 2017a), so as to gradually reduce pHOS in populations that might be reliant on production from hatchery-origin fish and to avoid causing a sudden dearth of prey for southern resident killer whales (SRKW). CAM analyses also supported NMFS's decision to require installation and operation of weirs in numerous LCR tributaries to further reduce pHOS and thereby achieve management goals. Similar to hatchery program reductions, weir installations were programmed to occur over a period of several years (NMFS 2017a).

These risk reduction strategies have already benefited populations; however, importantly, NMFS (2017a) acknowledged that the full effects of program changes would likely not be evident for over a decade, given the implementation schedule and continued return of adult hatchery fish that had been released as juveniles prior to program changes. To track potential trends in pHOS, as well as spawner distributions and abundance, NMFS required hatchery operators to perform regular monitoring and evaluate the effectiveness of their actions. Moreover, the Tule Chinook Workgroup was formed to develop research that could inform an adaptive management plan, as required by NMFS (2017a). Information gathered through those monitoring and evaluation efforts is considered throughout this Biological Opinion.

Following the four-step approach previously used, the Tule Chinook Workgroup held a series of ten meetings in 2024 to review and discuss relevant data, analyses, and management options. Additional subgroup meetings were held to discuss state-specific challenges and potential solutions. Analyses focused on the same set of index populations previously considered by NMFS, and data informing the influence from hatchery programs on pHOS, were updated. Although the full effects of past program changes could not yet be expected to have fully manifested, concerns expressed by the Workgroup in 2024 continued to focus on the low abundance of natural-origin spawners and high pHOS in most Coast fall Chinook populations. Table 80 presents recent averages for abundance and pHOS estimates for populations in this MPG.

Table 80. Mean spawner abundance and pHOS for Coast fall MPG populations of fall Chinook salmon, as estimated by ODFW and WDFW (unpublished data), 2017-2022. Estimates for the Clatskanie River do not include data from the Plympton Creek tributary which averaged 2,093 spawners and 97.5% pHOS.

Population	mean abundance	mean pHOS

Elochoman/Skamokawa	187	61%
Mill/Abernathy/Germany	152	87%
Grays	464	75%
Clatskanie	15	100%
Scappoose	0	0%

WDFW's Deep River Netpen program has been a major contributor to Chinook salmon pHOS in the Grays River and Abernathy Creek. This Mitchell Act funded program currently releases up to 250,000 juvenile spring Chinook salmon annually to support commercial fisheries. However, the program has realized limited fisheries benefits in recent years and WDFW has proposed to relocate this release of hatchery Chinook salmon to the Kalama River, following a final release of juveniles from Deep River netpens in the spring of 2026.

By themselves, the actions specified in the HOF are expected to significantly lessen genetic risk to Grays River, Lewis River, Abernathy Creek and other LCR fall Chinook tule salmon populations. However, as noted earlier in this Section, pHOS varies not only in function of hatchery-origin fish abundance on spawning grounds, but also in response to the abundance of natural-origin fish. Accordingly, Tule Chinook Workgroup discussions regularly focused on the chronically low abundance of natural-origin spawners in Coast fall MPG populations. Workgroup participants considered various hatchery-related management tactics to address this situation, including:

- Further reductions to hatchery programs;
- No change to hatchery programs (*status quo*); and
- Development of new conservation hatchery programs to reintroduce and supplement naturally spawning populations.

With respect to these options, effects from past hatchery program reductions had not yet come to fruition, and effects from pHOS reductions on productivity remained uncertain, because the full effects of these changes will need multiple generations before we can expect to see the predicted benefits. At the same time, we are concerned that further immediate hatchery program reductions could not be expected to boost near-term abundance of natural-origin LCR Chinook salmon, and could potentially reduce natural productivity. Yet, the chronically low abundance of natural-origin spawners in Coast MPG populations clearly warrants meaningful and carefully planned recovery actions. NMFS therefore requested state hatchery operators to investigate and present options to develop one or more conservation hatchery programs that could immediately alleviate demographic risks, offer potential to restore natural productivity, and ultimately contribute to pHOS reduction in Coast fall stratum populations. Conservation hatchery proposals developed by WDFW and ODFW are included in NMFS (2024a) and are briefly described here.

For the Grays River tule fall Chinook salmon population, WDFW proposed to initiate a conservation tule fall Chinook salmon hatchery program, with collection of local, natural-origin broodstock to begin in the fall of 2025. A maximum of 154 adult fall Chinook salmon would be collected and spawned for this program to produce up to 361,000 unmarked, but coded-wire tagged subyearling fall Chinook salmon for release into the Grays River. No more than 33% of the natural-origin adult salmon return would be collected for broodstock to support this conservation hatchery effort, which would operate for no more than three fall Chinook salmon generations (15 years).

For the aggregate tule fall Chinook population in Abernathy, Mill, and Germany creeks, WDFW proposed a spectrum of treatments, managing for different levels of hatchery influence in each creek. Beginning in 2026, Abernathy Creek would be annually stocked with up to 113,000 unmarked, but CWT-tagged subyearling fall Chinook salmon produced with natural-origin adult broodstock collected from the Elochoman River (primary broodstock source) or hatchery-origin adult broodstock collected at Big Creek Hatchery (secondary broodstock source). A maximum of 48 natural-origin fall Chinook salmon would be collected for this conservation program, not to exceed take of 33% of the natural-origin adult fall Chinook salmon return to the Elochoman River, with termination of juvenile releases to occur after 5 years.

To manage the composition of spawners in subsequent years, two new weirs or similar adult salmon collection facilities are planned to be constructed and operated annually, starting no later than 2027, one in Abernathy Creek and another in Germany Creek. Because fish produced by the Abernathy conservation program will be tagged but not marked (no adipose fin clip), they will experience lower rates of harvest in fisheries, particularly those that employ mark-selective regulations, yet will be distinguishable from most other hatchery- or natural-origin Chinook salmon. With the use of the weirs, marked (adipose fin clipped) hatchery fall Chinook salmon will not be passed into Abernathy or Germany creeks, but will instead be removed from the population. Unmarked natural- and tagged conservation hatchery-origin Chinook salmon will be passed above the adult fish collection facility on Abernathy Creek. Only untagged, unmarked (i.e. natural-origin) Chinook salmon will be passed upstream into Germany Creek. No adult fish collection facility will be installed on Mill Creek, allowing volitional migration of any hatchery- or natural-origin salmon into this system. Accordingly, the composition of adult fall Chinook in Germany, Abernathy, and Mill creeks is expected to resemble that presented in Table 81, notwithstanding effects from fish misidentification and variable weir efficiencies.

In addition to these measures, WDFW further proposed to trap up to 50% of the fall Chinook salmon fry outmigrating from Abernathy Creek during the months of February and March, and rear them at the Abernathy Fish Technology Center (pending USFWS agreement) before releasing them back to Abernathy Creek in June. This collection and short-term rearing, intended to increase the juvenile survival of natural-origin fall Chinook salmon produced in Abernathy Creek, is proposed to begin in 2029 and end in 2040. ESA-listed chum salmon also occur in Abernathy Creek and outmigrate as age 0+ juveniles, albeit typically later in the season than Chinook salmon. Analyses conducted by WDFW indicate that if juvenile Chinook salmon migrant trapping were to be conducted from day 20 until day 70 of each calendar year, approximately 80% of outmigrating Chinook salmon fry would pass by or be collected at the trap site, with less than 1% of juvenile chum salmon encountering the trap. Trapping during this period is predicted to collect an estimated 13,000 Chinook salmon fry, based on data from 2022 and an assumed 50% handling rate. Continued trapping, later into the season, would offer diminishing returns, in terms of Chinook salmon captured, with increasing impacts to chum salmon, albeit at very low levels. WDFW's analyses indicate that less than 5% of the juvenile chum salmon outmigrating from Abernathy Creek would encounter the trap by day 110. With average trap efficiencies and presumably low misidentification rates (chum salmon fry are markedly smaller than outmigrating juvenile Chinook salmon, with visible distinguishing characteristics), it can be reasonably expected that fewer than 450 chum salmon would be inadvertently collected and reared at AFTC in any given year. This level of incidental take would represent <2% of the estimated mean number of juvenile chum salmon outmigrating from Abernathy Creek, years 2017, 2018, 2021-2023.

Table 81. Composition of adult Chinook salmon expected to volitionally enter (Mill Creek) or be actively passed above new adult collection facilities (Abernathy and Germany creeks) during adult return years for Chinook salmon produced by the Abernathy Tule Chinook Conservation Hatchery program (2027-2035).

Creek	Adult spawner composition
Mill	Hatchery-origin + Conservation hatchery-origin + Natural-origin
Abernathy	Conservation hatchery-origin + Natural-origin
Germany	Natural-origin

For the Clatskanie River, ODFW proposed to release 200,000 unmarked, but CWT juvenile fall Chinook salmon into suitable reaches of the lower- and mid-section river. This program, intended to increase the abundance and distribution of naturally spawning fall Chinook salmon in the Clatskanie River, will release juvenile Chinook salmon produced with hatchery-origin broodstock collected at the Big Creek Hatchery. This program is planned to begin with collection of broodstock in 2025, first juvenile release in 2026, and conclude in 2033. Related to this action, ODFW proposed to reduce the number of marked fall Chinook released at its Youngs Bay facility from 2.5 million juveniles to 2.3 million juveniles.

In the Cascade fall MPG of LCR Chinook salmon, the Proposed Action includes an additional conservation action to supplement the North Toutle River fall Chinook salmon population, specifically in reaches located above the Sediment Retention Structure (SRS) operated by the US Army Corps of Engineers. Up to 300 adult hatchery-origin fall Chinook salmon are to be released each year for this effort to increase the distribution and abundance of the population. Because no fall Chinook salmon are released above the North Toutle SRS, hatchery Chinook salmon collected either at the North Toutle Hatchery or Toutle Fish Collection Facility are unlikely to pose genetic risk to natural-origin fall Chinook salmon. Therefore, NMFS will not establish pHOS limits for fall Chinook salmon above the North Toutle SRS during the first 10 years of this program, as the intention is for the hatchery fish to seed the unused habitat. However, fish released above the SRS could, possibly, "fallback" below the SRS and would then be subject to the 30% pHOS fall Chinook salmon limit established for below-SRS reaches of the Toutle River (Table 82).

Table 82. Expected pHOS for LCR Chinook salmon index populations following implementation of the Proposed Action. Expected pHOS is to be evaluated against four-year geometric means of estimated pHOS for Chinook salmon index populations.

Population	MPG	Primary contributor to pHOS	Expected pHOS
Grays/Chinook rivers	Coast fall	Integrated fall	50%
Elochoman/Skamokawa rivers	Coast fall	Integrated fall	50%
Mill/Abernathy/Germany Creeks	Coast fall	Integrated fall	50%
Coweeman River	Cascade fall	Segregated fall	10%
Lower Cowlitz River	Cascade fall	Integrated fall	30%
Toutle River	Cascade fall	Integrated fall	30%
NF Lewis River	Cascade fall	Segregated fall	10%
Washougal River	Cascade fall	Integrated fall	30%
Kalama River	Cascade fall	Segregated spring	10%

In all cases, conservation programs will use broodstock collected from within the respective MPG that they operate. New Coast fall MPG conservation hatchery programs will use parental-based (i.e. genetic) tags, CWT tags, or both to identify the origin and release group for fish sampled during monitoring and evaluation. Additional details of these programs are described in (NMFS 2024a).

The installation and proper operation of weirs will be critical to the success of the newly proposed tule fall Chinook salmon conservation hatchery programs. Selective passage of natural- and conservation hatchery-origin fish into Germany and Abernathy creeks underpins the experimental design proposed by WDFW. Furthermore, under the Proposed Action, NMFS will require weir operations to continue in those rivers and streams listed in Section 1.3, for purposes of broodstock collection and pHOS control. These weir operations will therefore reduce genetic risk from elevated levels of pHOS in the Coast fall and Cascade fall MPGs.

The addition of conservation and integrated hatchery programs to the HOF serves to manage demographic risks for LCR Chinook salmon, and involves a tradeoff between immediate benefits to the abundance of supplemented populations and genetic risks from elevated pHOS in these populations. In NMFS's view, the immediate demographic benefits from planned conservation hatcheries outweigh the genetic risks they pose to naturally spawning populations. Similar to the area upstream of the SRS in the Toutle River, during the periods of conservation hatchery operations and subsequent years of adult returns from these programs, the number of returning adult fall Chinook salmon produced by conservation hatcheries will not be counted against the pHOS limits in the respective watersheds, where these adult salmon return to spawn. That is, although the abundance of adult fall Chinook salmon produced by conservation hatcheries must be monitored, these abundance estimates will not contribute to calculations of pHOS for the Clatskanie, Grays, Elochoman, or aggregate Mill, Abernathy, or Germany creek populations of fall Chinook salmon. Importantly, natural-origin adults and adipose fin-clipped strays from other fall Chinook salmon hatchery programs will continue to be used to estimate pHOS for these and other index populations, which are subject to the pHOS limits presented in Table 82.

Appropriate estimation of pHOS in supplemented fall Chinook salmon populations will require hatchery operators to carefully monitor the composition and abundance of adult spawners, so as to account for and remove conservation hatchery-origin fall Chinook salmon from pHOS calculations. This approach will require accurate identification of conservation hatchery-origin fish, which is made possible through coded-wire or parental-based tagging. This conditional approach to pHOS estimation will conclude with the planned discontinuation of tule Chinook salmon conservation hatchery programs.

Effects from program changes thus far described for LCR fall Chinook salmon, including a 200,000 reduction to the number of hatchery fall Chinook juveniles released from Youngs Bay, relocation of hatchery spring Chinook salmon releases from Deep River to the Kalama River, and initiation of conservation hatcheries and associated weir operations, were analyzed with an updated and improved version of CAM (v.1.17), representing the best modelling tool and scientific information available. Results were evaluated against the pHOS limits established by this Opinion. CAM analyses predicted that, in combination with changes already implemented through NMFS (NMFS 2017a), actions described in this Opinion can be expected to reduce pHOS to levels at or below levels presented in Table 82. Furthermore, CAM analyses indicated that a proposed increase to the Bonneville Hatchery program's release of tule fall Chinook salmon, from 5 million to 6 million juveniles, would not result in any exceedance of pHOS limits set in this Opinion. This result is consistent with very rare observations of strays from this program into naturally spawning populations of LCR Chinook salmon.

CAM analyses also revealed the need for an additional program change. Namely, hatchery-origin strays from WDFW's programmed release of 2.6 million fall Chinook salmon into Fallert Creek appear likely to contribute to a pHOS exceedance in the Lewis River. Final CAM analysis indicates that reduction of this program to 2.0 million fall Chinook salmon reduces pHOS in the Lewis River fall Chinook population to levels below 10%, as required under the Proposed Action. Accordingly, through its Proposed Action, NMFS requires WDFW to reduce the release of hatchery fall Chinook from Fallert Creek to 2.0 million juvenile fish.

The Mitchell Act funds production of spring Chinook salmon through five hatchery programs operating within the LCR Chinook Salmon ESU. Among these, the Deep River Netpen program (WDFW) operates in the Coast stratum, but is being discontinued through our Proposed Action, as previously described (250,000 smolt reduction) starting with cessation of releases in 2025 (NMFS 2024a). The Mitchell Act-funded Kalama spring Chinook hatchery program (WDFW) operates in the Cascade spring Chinook salmon stratum, and will increase in size from a release of 500,000 juveniles to 750,000 juveniles, in coordination with the discontinuation of the Deep River Netpen program. The vast majority of spawning habitat for Kalama spring Chinook exists above Kalama Falls, where WDFW has previously supplemented natural spawning with surplus hatchery-origin fish (NMFS 2013e). Historical abundance of spring Chinook above the Kalama River's lower falls is uncertain (Myers et al. 2006), and NMFS (2013e) determined that this population has a "low persistence probability", given habitat limitations and harvest objectives. Nevertheless, WDFW manages the above-falls population in a manner that is expected to conserve genetic diversity and promote adaptation to the wild, with median pHOS above the falls estimated at 0.04 in years 2012-2020 (WDFW, unpublished data). Although some spring Chinook salmon spawning likely occurs below the falls, and WDFW does not monitor pHOS for spring Chinook salmon in lower reaches, productivity and genetic interactions are believed to be few. Given WDFW's commitment to continue pHOS monitoring and management for Kalama spring Chinook salmon, it is unlikely that the planned increase of this hatchery program will generate meaningful genetic effects that could potentially harm the naturally spawning population.

It is important to note that hatchery-origin spring Chinook salmon that return to the Kalama Hatchery as adults will primarily be used to meet broodstock needs, but will secondarily be used for a reintroduction effort in the North Toutle River, similar to that proposed for fall Chinook salmon. Up to 300 adult spring Chinook salmon will be released above the North Toutle SRS for this conservation effort. The Kalama Hatchery stock was identified by WDFW and NMFS as the most appropriate source population for this reintroduction, as very few if any natural-origin spring Chinook salmon are believed to have persisted in the North Toutle River following the eruption of Mount St. Helens, and the Kalama Hatchery offers an abundant, within-MPG source of spawners to re-establish natural-production of spring Chinook salmon in the North Toutle River. Because the objective of this program is to re-establish natural spawning of spring Chinook salmon with hatchery-origin spawners, NMFS believes it is appropriate to suspend pHOS limits for spring Chinook salmon in the Toutle River during the first 10 years of the program, but will require WDFW to monitor the distribution of spawners and progress of the program.

The Sandy River spring Chinook salmon hatchery program (ODFW) also operates in the Cascade spring Chinook salmon stratum. This Mitchell Act funded program has previously been evaluated by an existing biological opinion (NMFS 2014e), which requires pHOS for Sandy River spring Chinook to not exceed 10%, based on a three-year moving average (NMFS 2014e).

Monitoring reports (ODFW and WDFW 2021) indicate that, in this decade, mean pHOS for Sandy River spring Chinook has dropped well below the 10% limit (Figure 66) and has remained near 5% in most recent years (https://nrimp.dfw.state.or.us/RecoveryTracker/Explorer).

Accordingly, spring Chinook salmon produced by the Sandy River Hatchery are unlikely to meaningfully affect the genetic diversity or productivity of the naturally spawning population. Nevertheless, pHOS should continue to be carefully monitored and managed to remain within prescribed limits (Table 82).

The USFWS operates three Mitchell Act funded, segregated broodstock hatchery programs in the geographic range of the Gorge fall and Gorge spring Chinook salmon strata of the LCR Chinook Salmon ESU: the spring Chinook salmon programs at Little White Salmon and Carson NFHs, and the Willard NFH's Upriver Bright Fall Chinook salmon program. These hatchery programs are operated with authorization by (NMFS 2016j), which states that genetic risks from these programs are limited, in part because they operate in areas where no ESA-listed spring Chinook salmon populations occur and strays from these programs into neighboring populations are rare.

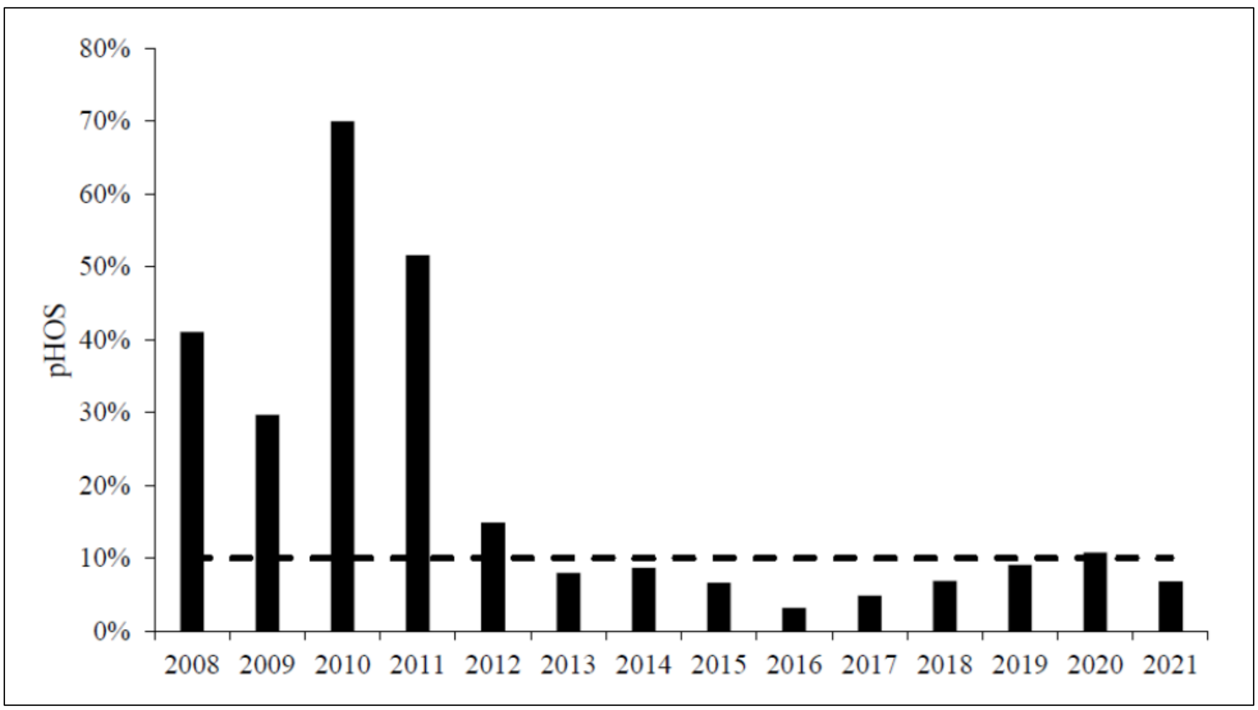

Figure 66. Estimated pHOS for spring Chinook salmon in the Sandy River, 2008-2021 (ODFW and WDFW 2021).

2.5.2.2.2.1.2 UWR Chinook Salmon ESU

The Mitchell Act funds production of Clackamas Hatchery spring Chinook salmon. This program operates in the UWR ESU to mitigate for effects from Clackamas and Columbia River hydroelectric projects, and support commercial and recreational fisheries. NMFS has previously consulted on the operation of this hatchery program, and the biological opinion for this consultation (NMFS 2021b) is incorporated here by reference because funding this program is part of the Proposed Action. However, the Proposed Action includes funding for an additional 50,000 smolts, beyond current production, for a total production of 1,100,000 smolts starting as early as 2025. In this section we consider the genetic impacts of that program increase.

With respect to limiting genetic risks, in 2020, this program transitioned from using an segregated broodstock toward integration with the Clackamas River local natural-origin population. Up to 120 natural-origin adults were authorized to be collected and spawned during the first three years of the program's transition, with expectation not to exceed 5% take of the natural-origin return to the North Fork Dam (NMFS 2021b). The program is currently authorized to use of up to 600 adults, total, such that pNOB during the first three years of integration was expected to approach 20% (NMFS 2021b). Following the first three years of integration, collection and use of natural-origin broodstock would be guided by a "sliding scale" of natural-origin abundance, informed by adult counts at North Fork Dam.

Records provided by ODFW (B. Walczak, ODFW, pers. comm.) demonstrate that recent pNOB for this program (broodyears 2022-2024) has averaged 10%. Concurrently, average pHOS has dropped to less than 3% (https://nrimp.dfw.state.or.us/RecoveryTracker/Explorer), well below the established 10% pHOS limit for this population (NMFS 2021b), and indicative of PNI > 0.76. Accordingly, the Clackamas spring Chinook salmon hatchery program satisfies NMFS's pHOS requirements and is unlikely to seriously affect the genetic diversity or productivity of the local, naturally spawning population. Moreover, the modest 50,000 smolt increase planned for this program is unlikely to generate significant additional genetic risk to the natural-origin population.

2.5.2.2.2.1.3 LCR Coho Salmon ESU

Hatchery coho produced or released into the LCR by Mitchell Act funded programs all use broodstocks originating from within their respective MPG sources, such that these hatchery operations pose no significant risk to genetic diversity structured among major population groups. However, at local levels, Mitchell Act funded hatcheries could pose genetic risks to natural-origin coho salmon populations through straying, interbreeding, and related genetic impacts discussed at the beginning of this Section.

To evaluate and address these potential risks from Mitchell Act funded coho salmon programs in the LCR Coho Salmon ESU, NMFS adopted a four-step approach similar to that used for LCR Chinook salmon, whereby we:

1) Developed a set of index populations for pHOS evaluation;

2) Established pHOS limits;

3) Evaluated the relative roles of different programs on pHOS in index populations;

4) Modified hatchery programs or identified other actions to reduce pHOS to acceptable levels.

For this analysis, NMFS's adopted the set of index populations and pHOS limits previously established by NMFS (2017e), as these represent primary and contributing populations of the ESU most likely to be affected by Mitchell Act funded hatchery programs, and established limits reflect HSRG recommendations. Index populations for the LCR Coho Salmon ESU, pHOS limits, and recent averages for pHOS are presented in Table 83, which indicates that average pHOS in several index populations has recently exceeded established limits. The highest average pHOS reported for a LCR coho salmon index population was for the Grays River population, at 42%.

Table 83. Maximum pHOS limits by ESA-listed natural population where hatchery coho salmon originating from Mitchell Act funded hatchery programs are known to stray. Limits are evaluated against three-year running geometric means. Mean pHOS (2020-2022) for each population is provided in the far right column.

Population	Coho salmon program type contributing to pHOS	pHOS limit	Average pHOS (2020-2022)
Grays/Chinook Rivers	Integrated	30%	42%
Elochoman/Skamokawa Rivers	Integrated	30%	25%
Clatskanie River	Segregated	10%	15%
Scappoose River	Segregated	10%	2%
Lower Cowlitz River	Integrated late	30%	15%
Coweeman River	Segregated	10%	13%
South Fork Toutle	Segregated	10%	14%
North Fork Toutle	Integrated late	30%	16%
East Fork Lewis	Segregated	10%	11%
Washougal River	Integrated late	30%	27%
Clackamas River	Segregated late	10%	9%

To evaluate the relative contributions from Mitchell Act funded hatchery programs to pHOS in LCR coho salmon populations, and to explore likely effects from hatchery program adjustments, NMFS worked with hatchery operators to develop and conduct analyses with a model similar to that used for LCR Chinook salmon, in this case known as the Coho Assessment Model (CoAM).

In brief, CoAM analyses predicted that program changes to be implemented under our Proposed Action would serve to reduce pHOS in the Grays River and other LCR coho salmon populations monitored by WDFW to acceptable levels, below the limits in Table 89. Foremost among these program changes are both the immediate discontinuation of the Grays River Hatchery coho program (75,000 smolt reduction) and the discontinuation of the Deep River Netpen program (700,000 smolt reduction), the latter being planned to occur in 2027. Both of these programs are known to contribute to pHOS in the Grays River, and discontinuation of these programs is expected to significantly reduce pHOS in the most affected LCR coho salmon index population. Related to the Grays River Hatchery program discontinuation, the Beaver Creek Hatchery on the Elochoman River will increase its coho salmon production by a commensurate 75,000 smolts, using integrated stock. However, genetic effects from this change are expected to be manageable, as weirs in the Elochoman River offer an effective means to limit pHOS.

Mean pHOS in the East Fork Lewis River has recently been 11% (Table 83). However, Mitchell Act funded hatchery programs, such as the Bonneville coho, NF Toutle coho, and Kalama coho programs, are minor contributors to Lewis River coho pHOS, relative to the Lewis River coho hatchery program (not funded by Mitchell Act funds), which has been contributing ~90% pHOS. Thus, the impacts of pHOS contributed from the Mitchell Act-funded programs are relatively small for coho salmon in the East Fork Lewis River.

Of the three LCR coho salmon index populations monitored by ODFW, recent 3-year mean pHOS in the Clackamas and Scappose populations is below 10%, while pHOS in the Clatskanie population has averaged 15%. Importantly, recent mean pHOS in the Clatskanie population was inflated by data from 2021, a year with low abundance (18 adult coho salmon carcasses recovered) and anomalously high pHOS (33%). A similar situation (low abundance and high pHOS) also occurred in 2018. Yet, over the past 20 years (2003-2023), an average 214 known-origin carcasses have been recovered from the Clatskanie River, and pHOS has averaged 3.95% with the exclusion of data from 2018 and 2021, indicative of low genetic influence from stray hatchery fish.

Under the Proposed Action, Mitchell Act funds will support the recovery of LCR coho salmon through hatchery-based reintroduction efforts, similar to the strategy applied for LCR Chinook salmon. In particular, under the Proposed Action, up to 450 adult North Toutle Hatchery-origin coho salmon will be released into upper reaches of the North Toutle River, above the SRS, for a period of five years. Following the initial five years, hatchery-origin adults may be used to supplement upstream passage of natural-origin coho salmon, so as to achieve a minimum of 200 adults above the SRS, but not to exceed this total through additional hatchery supplementation. Total program duration will be ten years, with formal evaluations performed at years 3, 5, and 10. NMFS believes that the demographic benefits of this reintroduction program outweigh any risks from genetic effects, and pHOS limits for coho salmon will not apply above the SRS for the 10-year duration of the program. The 30% pHOS limit for coho salmon in the North Toutle River below the SRS will remain in effect to protect the genetic integrity and productivity of naturally spawning coho salmon in this river.

2.5.2.2.2.1.4 CR Chum Salmon ESU

The Big Creek chum salmon hatchery program is designed and operated to support conservation and recovery of CR chum salmon. The program was initiated in 2010, when broodstock from the Grays River chum salmon population (Washington) were spawned to produce eggs that were then transferred to, incubated at, and released from Big Creek Hatchery (Oregon) in 2011. Until 2019, this conservation hatchery program continued to be supported, in part, through egg transfers from the Grays River. But in recent years, this hatchery program has become self-sustaining, using only chum salmon returning to Big Creek for its production needs. In some years (e.g. 2013-2015, 2020-2023), returning adults that exceeded the program's broodstock needs have been released into Big Creek and the Clatskanie River to facilitate reintroduction and expand the species' distribution in natural habitats (ODFW and WDFW 2023). Reintroduction efforts have also involved the use of "remote site incubators" to stock chum salmon fry into nearby streams (ODFW 2021).

These actions are consistent with NMFS's recovery plan for CR chum salmon (NMFS 2013e), which recognizes and supports Oregon's plan(ODFW 2010) to expand its chum salmon recovery efforts in the LCR Coast Stratum through habitat restoration and hatchery-based reintroductions. ODFW has proposed to increase its hatchery production of Big Creek chum salmon from 300,000 to 1,690,000 juvenile fish for release. The demographic benefits of this increase are expected to outweigh any genetic risks of hatchery fish interbreeding with the natural chum populations posed by this conservation hatchery program.

ODFW currently uses otolith marking and parental-based tagging to track the proportion of natural-origin broodstock (pNOB) used in the Big Creek chum salmon hatchery program, and to detect hatchery-origin strays in naturally spawning populations that have not been targeted for supplementation. Results from these RM&E efforts indicate that, since 2016, pNOB has exceeded 50% (Table 84) and that relatively few hatchery-origin strays enter non-target populations (ODFW and WDFW 2023). Future RM&E is expected to continue to track pNOB in this hatchery population, estimate pHOS from this program in naturally spawning populations, and explore methods to implement PNI-based management for Big Creek chum salmon.

Table 84. The origin of adult chum salmon (*Oncorhynchus keta*) collected at Big Creek Hatchery for the conservation broodstock, as determined from PBT and otolith thermal marks. Source: ODFW ODFW and WDFW (2023).

Brood Year	Males	Females	Total	% of Fish	
				Unmarked	Marked
2014	44	40	85	0	100
2015	87	87	173	27.6	72.4
2016	26	16	42	78.6	21.4
2017	22	38	60	85.0	15.0
2018	45	56	101	58.4	41.6
2019	28	28	56	66.1	33.9
2020	161	159	320	76.9	23.1
2021	169	168	337	56.7	43.3
2022	174	176	350	60.0	40.0

2.5.2.2.2.1.5 LCR Steelhead DPS

The Mitchell Act funds fourteen hatchery programs that release juvenile steelhead within the boundaries of the LCR Steelhead DPS, albeit at lower production levels than most Chinook or coho salmon hatcheries (see Table A of Proposed Action). These programs involve the production and release of both summer and winter steelhead to support fisheries. As with hatchery programs for other anadromous salmonids, LCR steelhead hatchery programs pose some level of genetic risk to naturally spawning populations. Significant progress has been made in recent years to limit this risk, and additional tactics to reduce risk will be implemented through NMFS's Proposed Action.

Previously, and in accordance with NMFS (2017a), multiple steelhead hatchery programs operating in the LCR transitioned from the practice of using exogenous broodstocks to developing and using locally-derived broodstocks. Specifically, in 2018, the Klineline Ponds (Salmon Creek) and Kalama winter steelhead programs, both operated by WDFW, discontinued use of the Chambers Creek stock, which originated from Puget Sound, and began development and use of an early-returning hatchery stock derived from Kalama River winter steelhead (i.e. the "KEWS" stock). These broodstock transitions undoubtedly served and continue to reduce genetic risks from LCR steelhead hatcheries by safeguarding among-DPS diversity. At present, all Mitchell Act funded LCR steelhead hatcheries use broodstocks derived from LCR steelhead populations, and NMFS's Proposed Action will continue to require this practice, thereby promoting conservation of among-DPS genetic diversity.

To further limit genetic risks from LCR Steelhead hatcheries, the Kalama summer, Kalama winter, Clackamas winter, and Sandy winter steelhead hatchery programs use integrated broodstock management approaches. As previously discussed, integrated broodstock management reduces genetic risk from domestication effects that can stem from hatchery practices and impact natural-origin populations. Through NMFS's Proposed Action, WDFW's Skamania Hatchery winter steelhead program will also transition from using a segregated broodstock approach to begin integrating the broodstock, founded with local, natural-origin adult steelhead from the Washougal River.

For these integrated steelhead programs, NMFS will use PNI as the preferred metric to measure compliance with limitations for genetic effects. NMFS believes that PNI represents a more holistic measure of hatchery genetic effects than pHOS, and that when PNI ≥ 0.67 natural selection has greater influence than hatchery domestication over maintenance of population genetic diversity. For this reason, NMFS expects hatchery operators to manage integrated steelhead programs according to the values presented in Table 91. In the Proposed Action (see Table 8), and as outlined in the HOF, NMFS establishes these PNI values as limits for primary and contributing LCR steelhead populations (see (NMFS 2013e) associated with integrated hatchery programs (see Table 8 and Table 85).

Table 85. Minimum PNI expected for integrated LCR Steelhead hatchery programs. Three-year running geometric means are to be calculated from annual PNI estimates and evaluated against the expected values presented here and in Table 8. Primary (P) or contributing (C) designations are indicated for natural populations (see (NMFS 2013e)).

LCR Major Population Group	Population	Recovery Designation	Integrated Hatchery Program	Recent mean PNI (2020-2022)[1]	Expected Minimum PNI[2]
Cascade	Kalama summer	Primary	Kalama summer steelhead	0.76	≥0.67
Cascade	Kalama winter	Primary	Kalama winter steelhead	0.97	≥0.67
Cascade	Clackamas winter	Primary	Clackamas winter steelhead	0.59	≥0.67
Cascade	Sandy winter	Primary	Sandy winter steelhead	0.90	≥0.67
Cascade	Washougal winter	Contributing	Skamania winter steelhead	NA[3]	≥0.67

[1] Data source summarized in (NMFS 2024g)
[2] PNI estimates are to be calculated as three-year running geometric means and evaluated against these expected values.
[3] No PNI estimates are available for this program, which is to be initiated through the Proposed Action.

The hatchery programs listed in Table 85 are expected to meet the PNI limits established in the Proposed Action (Table 8), as they have a history of meeting or trending toward these targets under current management practices (Figure 67), and no major program increases are planned to occur. In the Sandy River, ODFW has estimated mean pHOS for steelhead returning in years 2018-2023 to have been 4.1%, with a decreasing trend from 8.5% in 2018 to 2.0% in 2023 (Jim Brick, ODFW, pers. comm. 11/06/2023). Mean integration rate (pNOB) during this period for the Sandy Hatchery winter steelhead program equaled 18% (Scott Patterson, ODFW, pers. comm., 11/08/2024). In the Clackamas River, ODFW has estimated mean pHOS for steelhead returning in years 2018-2023 to have been 8.5%, with a decreasing trend from 11.6% in 2018 to 3.1% in 2023 (Jim Brick, ODFW, pers. comm. 11/06/2023). Mean integration rate (pNOB) during this period for the Clackamas Hatchery winter steelhead program equaled 11.2% (Scott Patterson, ODFW, pers. comm., 11/08/2024). These data indicate that both the Clackamas and Sandy winter steelhead hatchery programs have been operating within their prescribed pHOS target of 10% (NMFS 2017a) and that integrated LCR steelhead programs can be expected to meet the PNI limits established through the Proposed Action (Table 8).

Taken together, although the Mitchell Act funded steelhead hatchery programs continue to pose a risk of genetic effects to the LCR steelhead DPS, these data indicate that ODFW and WDFW are managing in a manner that effectively limits genetic risks from integrated steelhead hatchery programs in the Sandy, Clackamas, and Kalama rivers. The Proposed Action will also fund the continued use of segregated broodstocks for steelhead hatchery programs. In such cases, pHOS must be monitored and managed within limits that safeguard against serious genetic effects to naturally spawning populations. Maximum pHOS values expected to safeguard genetic diversity for primary and contributing LCR steelhead populations, potentially affected by Mitchell Act funded hatchery programs, are presented in Table 86.

In several rivers of the LCR Steelhead DPS, hatchery operators release more than one stock of steelhead, and in some cases these involve hatchery programs with both integrated and segregated broodstock management practices. Examples include the Kalama, Sandy, and Clackamas rivers, all of which are stocked with summer and winter hatchery steelhead.

In both the Sandy and Clackamas rivers, ODFW estimates pHOS from their summer steelhead hatchery programs as a proportion of all steelhead pHOS (i.e. winter and summer runs), when winter steelhead pHOS exceeds 5% (Neerman et al. 2024). This is because when pHOS is below 5%, the risk is minimal regardless of the proportion of hatchery fish which are summer steelhead. In only two years since 2018 has winter steelhead pHOS exceeded 5% in the Sandy River, and in those two years (2018 and 2019) ODFW estimated no contribution from summer steelhead to pHOS (Eric Brown, ODFW, pers. comm. 11/08/2024). In the Clackamas River, ODFW estimated pHOS from summer steelhead to be 2.5% in 2018 and 8.8% in 2019 (Eric Brown, ODFW, pers. comm., 11/08/2024). However, since 2020, ODFW has estimated 0% pHOS from the Clackamas Hatchery summer steelhead program. This indicated that these summer steelhead programs are being managed appropriately to minimize potential genetic effects.

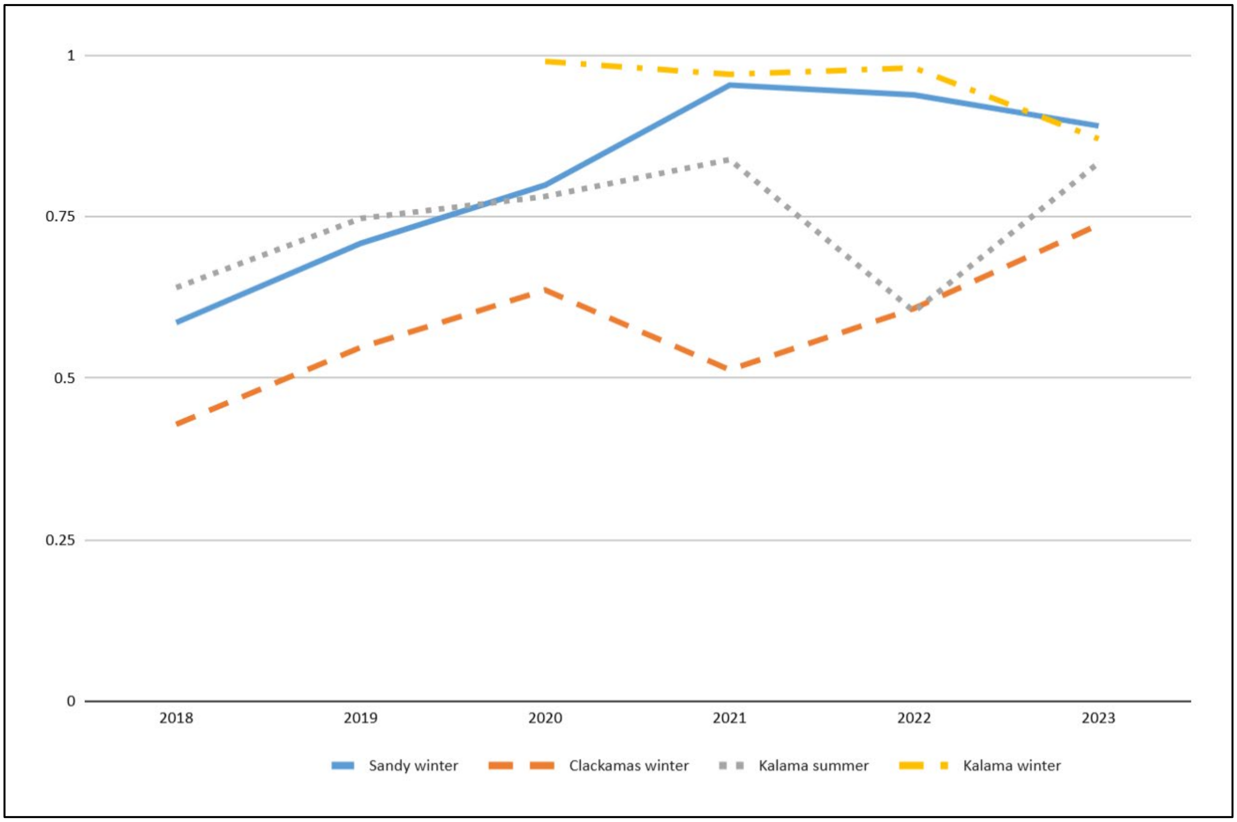

Figure 67. Proportionate natural influence (PNI) for integrated winter and summer steelhead programs in the Clackamas, Sandy, and Kalama rivers for years 2018-2023 (ODFW unpublished data; WDFW unpublished data).

In other primary and contributing populations of the LCR Steelhead DPS, recent data similarly indicate that current management serves to limit genetic risks from Mitchell Act funded hatchery programs to levels required by the Proposed Action (Table 85 and Table 86). For example, average pHOS (2020-2023) for the South Toutle summer, Washougal summer, Kalama winter, and Coweeman winter steelhead populations are estimated to be 0.1%, 1.0%, 2.2%, 0.8%, respectively (NMFS 2024a). Given past and projected pHOS estimates (NMFS 2024a), NMFS does not expect this modest increase to significantly increase genetic risk to the LCR steelhead DPS or any of the affected populations.

Table 86. Expected steelhead pHOS and gene flow for primary (P) and contributing (C) populations of the LCR Steelhead DPS, into which hatchery steelhead originating from Mitchell Act funded hatchery programs are known to stray. Estimates of pHOS and gene flow are to be calculated as three-year running geometric means and evaluated against the expected values presented here and in Table 7.

Potentially affected steelhead population	Segregated Hatchery Program	Expected pHOS	Expected gene flow
Clackamas winter (P)	Clackamas summer steelhead*	≤5.0%	≤2.0%
Sandy winter (P)	Sandy summer steelhead*	≤5.0%	≤2.0%
South Toutle winter (P)	Toutle summer steelhead*	≤5.0%	≤2.0%
Washougal summer (P)	Skamania summer steelhead*	≤5.0%	≤2.0%
Kalama winter (P)	Kalama winter steelhead**	≤5.0%	≤2.0%
Coweeman winter (P)	Coweeman winter steelhead**	≤5.0%	≤2.0%

*Program uses Skamania summer steelhead stock
**Program uses Kalama Early Winter Steelhead (KEWS) stoc

The Washougal winter steelhead population represents a noteworthy exception, where recent pHOS has averaged 61.4% (NMFS 2024a). The vast majority of pHOS in this population is believed to originate from the Skamania Hatchery's winter steelhead program, which used a segregated broodstock until the program was discontinued in 2024. While there will be immediate benefits to discontinuing this program, it will take at least a generation to reduce pHOS. Moving forward, WDFW will develop and use an integrated broodstock for hatchery production of winter steelhead in the Washougal River. To reduce pHOS, relative to past operations, WDFW will release fewer winter steelhead (60,000 smolts) than in previous years (85,000 smolts), and comply with the PNI limit presented in Table 85. NMFS expects that these management changes will greatly reduce genetic risk to Washougal winter steelhead from Mitchell Act funded hatchery operations and from the former Skamania program.

Informed management of genetic risks from hatchery programs typically relies on monitoring data, often obtained through counts of hatchery- and natural-origin fish at passage facilities or from spawning ground surveys. In accordance with NMFS's Proposed Action, WDFW will be required to develop a monitoring program to estimate pHOS and genetic effects from the release of KEWS steelhead at Klineline Ponds, which potentially interact with the stabilizing Salmon

Creek steelhead population. Effects from capturing adult salmon and steelhead for this monitoring activity are discussed further in Section 2.5.2.2.2.3.

2.5.2.2.2.1.6 MCR Steelhead DPS

The Interior Columbia Technical Recovery Team recognized Klickitat steelhead as an intermediate-sized population of the Cascades Eastern Slope Tributaries MPG. Within the Klickitat River basin, WDFW and the Yakama Nation operate the Klickitat Hatchery summer steelhead program, which releases 90,000 smolts of Skamania stock summer steelhead. The Proposed Action includes no near-term changes to this *U.S. v. Oregon* program.

The Skamania stock of summer steelhead was developed at the Skamania Hatchery on the Washougal River, within the LCR Steelhead DPS, from a mixture of summer steelhead from the Klickitat and Washougal rivers (Crawford 1979) and is managed as a segregated broodstock. As mentioned above, the Skamania Hatchery program itself was discontinued, but the Klickitat hatchery program will continue use of stock that originated in the discontinued program.

As is the case for many steelhead monitoring programs, efforts to quantify genetic effects through pHOS estimates from spawner counts are challenged by high water conditions during spawning and relatively few carcass recoveries, due in part to iteroparity (multiple reproductive events for individual fish). Accordingly, radio telemetry studies and genetic surveys have respectively been used to estimate spatiotemporal overlap of hatchery- and natural-origin spawners, and the level of genetic structure and interaction among steelhead within the basin.

Zendt et al. (2023) reported average pHOS for Klickitat River steelhead to be 12.0% (95% CI = 7.5-18%; 2010-2014), but used radio telemetry data to demonstrate that spatiotemporal overlap of hatchery- and natural-origin steelhead was limited within the basin, with 75% of hatchery-origin spawning occurring between November 1 and March 23, and 75% of NOR spawning occurring between March 23 and May 31 (Zendt et al. 2023). The authors found that most (90%) of the known-fate hatchery-origin steelhead spawned in lower river reaches (below rkm 32), whereas 64% of natural-origin steelhead spawned upstream of rkm 32. These results suggest that incomplete spatiotemporal overlap of naturally spawning hatchery- and natural-origin steelhead likely limits genetic interactions between the two in the Klickitat River.

Using genetic data from 446 juvenile steelhead collected from the Klickitat River and Washougal Hatchery, Narum et al. (2006) found significant genetic structure within the Klickitat River, and marked differentiation between the Klickitat and Washougal Rivers populations (mean F_{ST} = 0.078). Narum et al. (2006) also found that only 4% of the juvenile fish sampled in the Klickitat River could be genetically assigned to the Skamania stock, reflective of low levels of natural reproduction by hatchery-origin fish in this system and a low level of genetic impact.

More recently, Collins et al. (2023) examined 3,108 adult and 2,624 juvenile steelhead samples collected from the Klickitat River and found that most hatchery (80%) and natural-origin (78%) adults in their study had originated from the Klickitat Hatchery or Klickitat River, respectively. Their findings revealed relatively high genetic diversity in Klickitat River steelhead, but they also identified genetic influences from a variety of natural- and hatchery-origin populations outside the Klickitat basin, including the Snake River. Moreover, through an analysis of genetic data from unmarked juvenile steelhead sampled in the Klickitat River, the authors estimated 8.7% introgression from the Skamania stock, and 21.3% introgression from Snake River and other stocks. These findings suggest that geneflow from the Skamania hatchery population could be exceeding the 5% limit established by NMFS for this population, although it is unclear what proportion of observed introgression might be the legacy of past hatchery practices.

2.5.2.2.2.1.7 UCR Steelhead DPS

Only one steelhead hatchery program funded by the Mitchell Act has a possibility of genetically impacting natural-origin steelhead populations in the UCR: the program at Ringold Springs. No data have shown that fish from this program spawn in any of the four UCR watersheds that harbor ESA-listed steelhead populations (Entiat, Methow, Wenatchee, Okanogan). However, radio telemetry data indicate that returning steelhead from the program do move upstream beyond Ringold Springs (WDFW 2016). Therefore, genetic interactions with steelhead populations in this DPS are a possibility. However, we expect the likelihood to be small due to the great distance between Ringold Springs and any of those other watersheds, and the fact that the fish are distinctly marked (both the right ventral and adipose fins are clipped), so that those that travel upstream and are not harvested can be readily identified and removed at dam and hatchery traps. An analysis of recent data (2020-2024) for PIT-tagged steelhead detected at Priest Rapids Dam revealed that less than 2.5% of tag detections (90 of 3,641) originated from the Ringold summer steelhead hatchery program, and that only five Ringold summer steelhead were estimated to have entered any of the four major tributaries of the UCR Steelhead DPS (Michael Tonseth, WDFW, pers. com. 12/12/2024). Thus, we consider gene flow from hatchery steelhead released at Ringold Springs a low risk to the diversity and productivity of natural-origin UCR steelhead populations, with the extent of interbreeding below any detectable level.

2.5.2.2.2.1.8 Synopsis and risk reduction measures

As described throughout this section, NMFS finds that most Mitchell Act-funded hatchery programs have only minor genetic effects on ESA-listed species of salmon and steelhead. However, where genetic effects do appear to pose serious risk, the Proposed Action includes various measures to be implemented that are expected to drastically reduce negative genetic effects to ESA-listed species. These measures, their expected effects, and implementation schedule are listed in Table 87.

2.5.2.2.2.2 Ecological Effects

In this section, NMFS analyzes the ecological effects for this factor (i.e., hatchery fish and the progeny of naturally spawning hatchery fish on the spawning grounds), which include beneficial effects from marine-derived nutrients and ecological services and negative effects from spawning site competition and redd superimposition (See Section 1.2.2. of Appendix A). Combined, ecological effects on the spawning grounds may range from positive to negative. The level of interaction between hatchery-origin and natural-origin fish, as well as the effect of encounters with natural-origin fish at fish collection locations, can affect the viability of natural populations (Section 2.2.1.1). The effect of this factor on these VSP parameters also ranges from positive to negative.

2.5.2.2.2.2.1 Marine Derived Nutrients and Ecological Services

The return of hatchery fish likely contributes nutrients to the freshwater areas of the Action Area. Decaying carcasses of spawned adult hatchery-origin fish would contribute nutrients that increase productivity in watershed areas, enhancing food resources for naturally produced salmon and steelhead (Cederholm et al. 1999); (Scheuerell et al. 2005). Table 88 shows that adult hatchery-origin salmon and steelhead spawning naturally could contribute an estimated 2,723 kg of phosphorous to the freshwater areas of the Action Area annually, which likely compensates for some marine-derived nutrients lost from declining numbers of natural-origin fish. However, this estimate is based off of the number of fish returning to the mouth of the Columbia River and does not account for fish lost to harvest or other pathways prior to reaching spawning grounds; therefore, the amount of phosphorus delivered to the spawning grounds is likely less, though such delivery is still an overall benefit to salmon and steelhead.

Table 87. Measures to reduce genetic effects from Mitchell Act-funded hatchery programs, to be implemented through the Proposed Action.

Affected ESU/DPS	MPG	Population	Proposed measure	Intended effect	Year of Implementation	First year of effect
LCR Chinook Salmon	Coast fall	Mill-Abernathy-Germany	Installation and operation of a weir in Germany Creek	Reduce pHOS for Germany Creek fall Chinook salmon	2026	2026
LCR Chinook Salmon	Coast fall	Mill-Abernathy-Germany	Installation and operation of a weir in Abernathy Creek	Reduce pHOS for Abernathy Creek fall Chinook salmon	2027	2027
LCR Chinook Salmon	Coast fall	Grays	Installation and operation of an improved weir in Grays River	Reduce pHOS for Grays River fall Chinook salmon	2027	2027
LCR Chinook Salmon	Cascade fall	Lewis	Reduce Fallert Creek release of fall Chinook salmon to 2 million	Reduce pHOS for Lewis River fall Chinook salmon	2025	2028
LCR Coho Salmon	Coast	Grays	Discontinue Grays River coho salmon hatchery program	Reduce pHOS for Grays River fall Chinook salmon	2025	2028
LCR Coho Salmon	Coast	Grays	Discontinue Deep River coho salmon netpen program	Reduce pHOS for Grays River fall Chinook salmon	2027	2030
LCR Steelhead	Cascade winter	Washougal	Initiate integrated winter steelhead hatchery program	Increase PNI for Washougal River steelhead	2025	2029
LCR Chinook salmon LCR Coho salmon	Coast	Elochoman	Continued operation of Elochoman River weir	Reduce pHOS for Elochoman River Chinook and coho salmon	2025	2025
LCR Chinook salmon LCR Coho salmon	Cascade	South Fork Toutle	Continued operation of South Fork Toutle River weir	Reduce pHOS for South Fork Toutle River Chinook and coho salmon	2025	2025
LCR Chinook salmon LCR Coho salmon	Cascade	Coweeman	Continued operation of Coweeman River weir	Reduce pHOS for Coweeman River Chinook and coho salmon	2025	2025
LCR Chinook salmon LCR Coho salmon	Cascade	North Fork Lewis	Continued operation of NF Lewis River weir	Reduce pHOS for Lewis River Chinook and coho salmon	2025	2025
LCR Chinook salmon LCR Coho salmon	Cascade	Washougal	Continued operation of Washougal River weir	Reduce pHOS for Washougal River Chinook and coho salmon	2025	2025

Affected ESU/DPS	MPG	Population	Proposed measure	Intended effect	Year of Implementation	First year of effect
LCR Chinook salmon LCR Coho salmon	Cascade	Kalama	Continued operation of Kalama River weir	Reduce pHOS for Kalama River Chinook and coho salmon	2025	2025

Table 88. Total phosphorous imported by adult returns from the proposed hatchery programs based on the equation (Imports=hatchery adults*mass*phosphorous concentration) in Scheuerell et al. (2005).

Estimated number of adult returns to Columbia River[1]	Adult mass (kg)	Concentration of phosphorous (kg/adult)	Phosphorous imported (kg/year)
130,279	5.5	0.0038	2,723

[1] The estimated number is the number of returns to the mouth of the Columbia River and not to spawning grounds or specific tributaries. It is important to note that this method does not account for fish lost to harvest or other pathways prior to reaching spawning grounds.

Adult salmon spawners provide additional ecological services, including streambed disturbance, nutrient release and retention, and release of aquatic invertebrates and salmon eggs from the substrate (e.g., (Collins et al. 2015), and references therein). These services may function synergistically with the import of marine-derived nutrients to boost aquatic ecosystem productivity. As a result, abundances of resident and freshwater-rearing anadromous salmonids have increased with increasing spawner abundances in some systems (e.g., (Nelson and Reynolds 2014); (Swain and Reynolds 2015); (Benjamin et al. 2020)). Conversely, low spawner numbers may deprive the river system of nutrients and suppress the productivity of fish populations and the aquatic ecosystem (Scheuerell et al. 2005); (Copeland and Meyer 2011). Returning hatchery-origin salmon may provide marine-derived nutrients and ecological services to the freshwater areas of the Action Area. Pathways for delivery of these benefits include hatchery-origin fish and their progeny that spawn in the wild, and carcasses from hatchery-origin fish that return to the hatchery. In addition to nutrients, salmon can also transfer contaminants via their carcasses (Ewald et al. 1998); (O'Toole et al. 2006). Analyses show that as fish burn fat on their migration, they do not metabolize persistent chemicals such as polychlorinated biphenyls (PCBs)(Ewald et al. 1998).

2.5.2.2.2.2.2 Spawning Site Competition and Redd Superimposition

The added spawner density resulting from hatchery-origin fish spawning in the wild can have negative consequences in that to the extent there is spatial overlap between hatchery and natural spawners, the potential exists for hatchery-origin fish to superimpose or destroy the eggs and embryos of ESA-listed species (See Section 1.2.2. of Appendix A). One management practice that can affect hatchery fish distribution and the potential to spatially overlap with natural-origin spawners is the acclimation of hatchery juveniles prior to release. Acclimation of hatchery juveniles prior to release increases the probability that hatchery adults will home back (return) to the release location reducing their potential to stray into natural spawning areas. Dittman and Quinn Dittman and Quinn (2008) and Keefer and Caudill Jepson et al. (2013) provide extensive literature reviews regarding homing in Pacific salmon and steelhead.

When there is spatial overlap between hatchery-origin adults and natural-origin adults, two potential negative interactions can occur: spawning site competition and redd superimposition. Competition between adults is most likely to occur for spawning sites because adults entering freshwater are generally assumed not to feed and to migrate quickly to their natal streams. Redd superimposition may occur if fish overlap in habitat, but it is difficult to assess this effect without knowing microhabitat details. However, run-timing (Table 89) and habitat segregation limit the potential for these negative interactions (NMFS 2013e).

Table 89. Estimated timing of listed salmon and steelhead juveniles and adults, both hatchery and natural, in various habitat types (Busby et al. 1996); (NMFS 2024g).

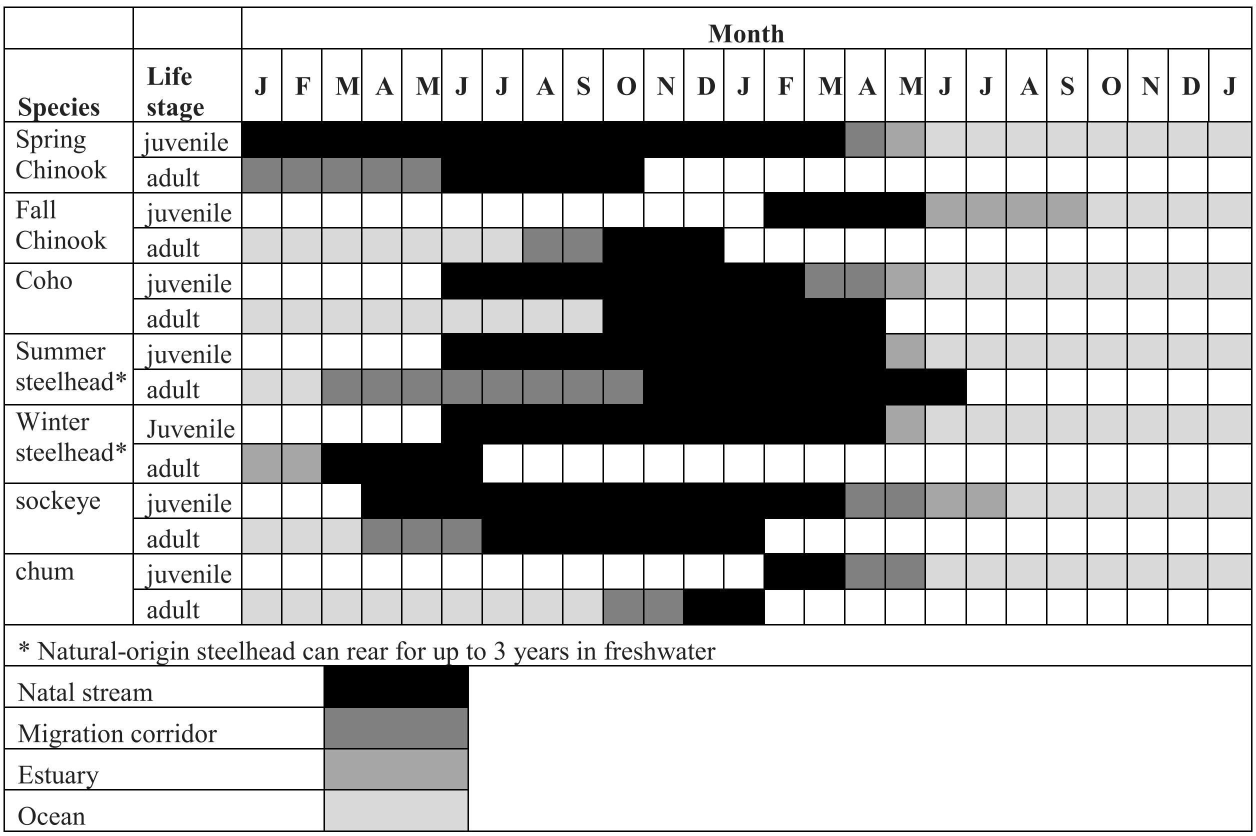

Table 90 summarizes the likelihood and rationale for competitive interactions and redd superimposition between adult salmon and steelhead species based on information in Table 89**.**

Additional rationale behind our designations for competition and redd superimposition likelihood in Table 90 among species is as follows:

- Sockeye salmon spawn in lake systems, which may separate them from spawning habitat of other Pacific salmon and steelhead species (Groot and Margolis 1991) because no other listed Pacific salmonid is known to spawn in lakes.
- Chum salmon spawn in shallower, slower-flowing streams and side channels more often than other salmon species and spawn soon after freshwater entry (Johnson et al. 1997)
- Spring Chinook salmon return to natal streams before any of the other salmon species and spawn far upriver (Myers et al. 1998)
- Fall Chinook salmon return to natal streams at the same time as coho and chum salmon, and spawn in the mainstem or lower tributaries of rivers within a few days to weeks of freshwater entry (Myers et al. 1998)
- Coho salmon entry into natal streams is highly dependent on freshets; delays in fall rains could delay river entry and spawn timing (Weitkamp et al. 1995)
- Summer steelhead usually spawn further upstream than winter steelhead and spend more time in freshwater (Busby et al. 1996)
- Sympatric species (such as spring Chinook salmon and steelhead) have species-specific differences in habitat preference (NMFS 2013e)

Interactions that result in a high likelihood of competition are those that occur between fish of the same species and run-type (e.g., hatchery-origin and natural-origin spring Chinook salmon) because they share the same habitat requirements, have the same run and spawn times, and are similar in size (NMFS 2013e). Hatchery fish of the same species in a spawning area could potentially increase the likelihood for intraspecific competitive interactions. However, management of pHOS limits this potential (see above, Section 2.5.2.2.2.1) by controlling the number of hatchery fish spawning naturally.

Table 90. Likelihood and rationale for competitive interactions and redd superimposition between adult salmon and steelhead species based on information in Table 89.

Natural Salmon Species	Proposed Action Hatchery Salmon Species				
	Spring Chinook	Fall Chinook	Coho	Chum	Steelhead
Spring Chinook	High: same habitat, timing and body size	Low: different habitat and timing	Low: different habitat, timing, body size	Low: different habitat and timing	Medium: different habitat and body size, same timing
Fall Chinook	Low: different habitat and timing	High: same habitat, timing and body size	Medium: different habitat and body size, same timing	Medium: different habitat and body size, same timing	Low: different timing and body size

Coho	Low: different habitat, timing, body size	Medium: different habitat and body size, same timing	High: same habitat, timing, and body size	Medium: different habitat and body size, same timing	Low: different timing and body size
Sockeye	Low: different habitat	Low: different habitat	Low: different habitat	Low: different habitat and timing	Low: different timing and body size
Chum	Low: different habitat and timing	Medium: different habitat and body size, same timing	Medium: different habitat and body size, same timing	High: same habitat, timing and body size	Low: different timing and body size
Steelhead	Medium: different habitat and body size, same timing	Low: different timing and body size	Low: different timing and body size	Low: different timing and body size	High: same habitat, timing and body size

2.5.2.2.2.3 Analysis of Encounters at Adult Collection Facilities

Here, we consider the effects of incidental encounters with ESA-listed fish that are intercepted during broodstock collection and adult management activities (see Appendix A, Section 1.2.3).

Broodstock collection typically takes place at or near hatchery facilities. Natural- or hatchery-origin returning (NOR, HOR) adults volunteer via adult traps, fish ladders, fishways, and/ or weirs. Adult management activities refer to the removal of hatchery-origin adults from a watershed to manage the composition of a spawning population in a given MPG. Adults are usually intercepted and removed at weirs (temporary or permanent) or by other adaptive management tools, such as beach seines and/or hook-and-line.

The number of incidental encounters of ESA-listed HORs and NORs during broodstock collection and adult management activities under the HOF varies depending on the watershed's management needs and the individual hatchery program(s). As described below, there is a high annual variability in the number of fish returning to each adult collection site. While the expected maximum numbers of natural-origin salmon and steelhead being handled at each location are described below, there may be circumstances where adaptive management is required. For example, the Beaver Creek Hatchery and the Elochoman Weir are located close to each other. Therefore, broodstock collection and/or adult management activities at these sites impact the same population(s). In such circumstances, we may allow for a higher level of adult handling at Beaver Creek Hatchery or the Elochoman Weir so long as the combined impact of the two activities does not exceed what has been analyzed in this section. Such impacts will be assessed on an as-needed basis, but will adhere to the maximum effect analyzed hereforth.

2.5.2.2.2.4 Encounters at the Hatchery Trap

Table 91 presents the expected maximum number of natural-origin salmon and steelhead that could be encountered at the hatchery facilities rearing Mitchell Act-funded production in the Columbia River Basin during broodstock collection and/or adult management activities and the maximum incidental mortality related to the handling of those adults. Based on recent (NMFS 2024a), the incidental mortality is expected to be no more than 3% of the numbers encountered at the trap.

The expected maximum number of NORs encountered, and the maximum mortalities, substantially exceed what has actually been observed at the hatchery facilities that rear Mitchell Act-funded fish. For example, at Bonneville Hatchery, estimates of up to 2,300 NOR coho salmon could be encountered during broodstock collection, considerably greater than the estimated 447 NOR coho salmon that were encountered in 2020. The Bonneville data illustrate the variability in the NOR returns, which have ranged from 447 in 2020 to 2,257 in 2019. Thus, the actual number of NOR salmon and steelhead encountered is likely to be less than reported. Another example is the encounters in the Snake River, where the current natural-origin population status of Snake River fall Chinook salmon and Snake River sockeye salmon makes encounters at these facilities extremely unlikely. However, as these population abundances start to increase through other conservation efforts (NMFS 2018b, 2023a), we expect the encounter levels to increase as populations of NORs increase naturally.

Table 91. Expected maximum number of natural-origin salmon and steelhead that could be encountered at hatchery facilities rearing Mitchell Act-funded production, located within specific watersheds within the Columbia River Basin (data from (NMFS 2024g)).

Watershed	Hatchery Facility	ESU/DPS from which fish are expected to be collected.	Expected maximum number that could be encountered	Estimated maximum mortalities (≤ 3%)	Comment
Mainstem Columbia River	Bonneville Hatchery	LCR and SR Fall Chinook Salmon	2,600	≤78	Unmarked URB, fall Chinook salmon, could be from other non-listed populations or hatchery programs.
		LCR Coho Salmon	2,300	≤69	
		CR Chum Salmon	100	≤3	
		LCR, MCR, UCR, and SR Steelhead	110	≤3	Could be from any these DPSs due to the proximity of the hatchery to the mainstem Columbia River

Watershed	Hatchery Facility	ESU/DPS from which fish are expected to be collected.	Expected maximum number that could be encountered	Estimated maximum mortalities (≤ 3%)	Comment
		SR Sockeye Salmon	<10	1	Sockeye could be from SR or from unlisted sockeye salmon populations
	Ringold Springs	UCR Steelhead	50	≤2	Handled during recycling activities.
Big Creek	Big Creek Hatchery	LCR Fall Chinook Salmon	200	≤6	
		LCR Coho Salmon	700	≤21	Passed above the hatchery.
		CR Chum Salmon	2,500	≤75	
Youngs Bay	Klaskanine Hatchery and SF Clatsop Co. Fisheries Hatchery	LCR Fall Chinook Salmon	20	1	
		LCR Coho Salmon	120	≤4	Released above the hatchery.
		CR Chum Salmon	50	≤3	
Clackamas River	Clackamas Hatchery	LCR Steelhead	200	≤6	
		UWR Spring Chinook Salmon	350	≤11	
		LCR Coho	100	≤3	
Sandy River	Sandy Hatchery	LCR Chinook Salmon	200	≤6	
		LCR Steelhead	400	≤12	
		LCR Coho	2000	≤60	
Elochoman River	Beaver Creek	LCR Fall Chinook Salmon	20	1	
		LCR Coho Salmon	500	≤15	
		CR Chum Salmon	500	≤15	
Kalama River	Kalama Falls Hatchery and	LCR Fall Chinook Salmon	2,000	≤60	

Watershed	Hatchery Facility	ESU/DPS from which fish are expected to be collected.	Expected maximum number that could be encountered	Estimated maximum mortalities (≤ 3%)	Comment
	Fallert Creek Hatchery	LCR Spring Chinook Salmon	500	≤15	
		LCR Coho Salmon	2,000	≤60	
		LCR Steelhead (summer)	1,000	≤30	
		LCR Steelhead (winter)	3,000	≤90	
		CR Chum Salmon	25	1	
Washougal River	Washougal Hatchery	LCR Fall Chinook Salmon	1,200	≤36	
		LCR Coho Salmon	1,000	≤30	
		CR Chum Salmon	25	1	
		LCR Steelhead (summer)	250	≤8	
		LCR Steelhead (winter)	50	≤2	
	Skamania Hatchery	LCR Fall Chinook Salmon	10	1	
		LCR Coho Salmon	25	1	
		CR Chum Salmon	10	1	
		LCR Steelhead (summer)	200	≤6	
		LCR Steelhead (winter)	200	≤6	
Klickitat River	Klickitat Hatchery	MCR Steelhead	10	1	
Wind River	Carson NFH	LCR Chinook Salmon	0	0	
		LCR Coho Salmon	≤5	≤2	
		LCR Steelhead	≤5	≤2	
Little White Salmon	Little White NFH	LCR Chinook Salmon	≤50	≤2	
		LCR Coho Salmon	500	N/A	

Watershed	Hatchery Facility	ESU/DPS from which fish are expected to be collected.	Expected maximum number that could be encountered	Estimated maximum mortalities (≤ 3%)	Comment
		Steelhead (incl. MCR, LCR, UCR, and Snake)	≤50	≤2	
		Snake River Sockeye	≤50	≤2	
Eagle Creek	Eagle Creek NFH	LCR Chinook Salmon	0	0	
		LCR Coho Salmon	≤100	≤3	
		LCR Steelhead	≤50	≤2	
Snake River	Lostine River	Snake River Fall Chinook Salmon	≤ 50	≤1	
		Snake River Steelhead	≤ 25	≤1	
		Snake River Sockeye Salmon	≤ 5	≤1	
	Wallowa Hatchery	Snake River Fall Chinook Salmon	≤ 50	≤1	
		Snake River Steelhead	≤ 25	≤1	
		Snake River Sockeye Salmon	≤ 5	≤1	

Most ESA-listed hatchery-origin spring Chinook, fall Chinook, and coho salmon and steelhead that volunteer at these locations shall not be returned to the river; consequently, up to 100% of ESA-listed hatchery-origin spring Chinook, fall Chinook, and coho salmon and steelhead encountered will be taken by handling, collection, and/or retention (Archibald 2024). In addition, all unmarked coho salmon entering the Little White Salmon trap (up to 500 annually) will be handled and culled while operating the trap to reduce hatchery spawners on the spawning grounds. Majority of these coho salmon are likely to be hatchery coho salmon that were not accurately clipped or have no externally visible mark. Baker Baker, Smith, and Headley (2023) indicated that approximately 90% of ad-intact coho salmon were hatchery-origin fish, with the remaining 10% being composed of LCR coho salmon and natural-origin strays from non-ESA listed populations. Thus, we expect that less than 50 LCR coho salmon will be impacted by this activity.

As described in Section 1.2.3 of Appendix A, the handling of natural-origin fish at these broodstock collection facilities would be expected to increase the potential for injury and stress due to delay, crowding in the trap, sorting (including netting, handling, anesthetizing), and from transport and release. The mortality incidental to handling may occur immediately due to injury or may be delayed due to increased stress. Best management practices are used at these facilities to reduce the potential for injury or stress of NOR salmon and steelhead. These practices include, but are not limited to, monitoring adult holding ponds to prevent overcrowding; processing returning adults frequently to remove NOR adults and limit the delay in upstream migration; maintaining adequate flows in the holding ponds to reduce stress; and maintaining adequate processing facilities that minimize stress during anesthesia, sorting, and transport. All of these actions will help ensure that the level of impact on NOR adult salmon and steelhead is kept to a minimal effect.

NMFS expects the very low rates of mortality due to handling to remain the same over time or perhaps decrease as handling methods improve. However, conditions can vary from year to year. Programs could see up to a three percent increase in mortality over average rates in a single year due to factors beyond the operator's control. Any one-time increase that is larger than three percent more than the estimated maximum encounters (Table 91) would indicate that the mortality effects of handling are greater than previously thought.

2.5.2.2.2.5 Encounters at the Weirs

Adult collection facilities can also include weirs not directly adjacent to hatchery facilities. WDFW proposes to operate ten weirs for adult management activities and/or broodstock collection. These ten weirs include eight existing and two new weirs in Abernathy and Germany Creeks (NMFS 2024a). This analysis looks at the weirs' installation and operation impacts on the distribution and productivity of adult salmon and steelhead.

Some existing weirs have a permanent concrete sill that the weir is attached to (e.g., Elochoman River weir). The two new weirs, and most of those currently operated, are Resistance Board Weirs (RBW). These are semi-permanent weirs installed and operated for seasonal use. These river-spanning weirs generally consist of floating resistance board sections, a live trap box or boxes, and fixed panel sections. The resistance board sections are attached to the bottom of the river to a sill plate, usually a long metal angle iron anchored to the substrate.

The anchoring of the weirs to the substrate can shift bottom sediments at the point of attachment and the "footprint", where the weir rests on the river bottom, since it would preclude the natural movement of sediment from river flow within. However, this effect is confined to the specific location of the weir, and upon removal, sediment will again shift with the water movement. The weirs are in fact located within a stream to maximize the collection of adult fish while minimizing the disturbance to the substrate. The majority of these weirs are located in lower river sections where the substrate is primarily gravel and cobble which allows for the weirs to be installed without intrusive machinery. Furthermore, after the weir is removed, the first major freshet would obscure any evidence of the weir installation in terms of disturbed substrate.

Impacts to the substrate associated with weir placement, presence, and removal are minimal in their physical and temporal extent. Because any disturbances are limited to the immediate area of the weir and are brief, these effects are insignificant to the physical and biological features of critical habitat, and to individual fish that are present in these areas.

The timing of weir operation depends on the species being targeted for removal and monitoring. For fall Chinook salmon, weirs are generally operated from August to October, whereas for coho salmon, operation could extend through December. A common goal of weirs is to intercept all HOR fish that might otherwise pass that location in a given return year, which means that up to 100% of the co-occurring NOR fish may also encounter the weir. Interception of the entire run is rarely achieved, as high water events can reduce the effectiveness of a weir and often lead to early removal.

As described in Section 1.2.4 of Appendix A, the operation of weirs and associated traps can impact ESA-listed salmon and steelhead through a number of factors, but can be reduced to three main factors: weir rejection, migration delay, and delayed mortality after release due to collection and handling at the weir. These effects can sometimes lead to measurable changes in the distribution, peak spawn timing and productivity of naturally spawning populations.

To analyze the effects on ESA-listed species, NMFS must consider the high level of variability in the natural environment in the rivers and locations for each weir, as they range from tributaries near the mouth of the Columbia River upstream to tributaries near Bonneville Dam. Furthermore, even excluding the effects of these types of local environmental conditions coupled with weather events, there is natural variability due to the factors outside each location that affect the survival and productivity of the natural-origin populations. These outside factors affect smolt-to-adult survival as illustrated by the variations in survival manifested in changes in the abundance of natural-origin adults returning as seen across the years in Section 2.2.1 for each ESU or DPS. Variability is also seen in things like spawning distribution (Schroeder et al. 2013) and time of first spawning and peak spawning (Whitman, Cannon, and Walker 2014) for any run of salmon or steelhead. Determining impacts on listed species from the operation of the weirs versus changes due to natural variation has been estimated by comparing things such as redd distribution, peak spawning date, and pre-spawning mortality before and after the operation of the weirs.

The weirs operated under the HOF have been in operation for a number of years in the LCR including the Grays, Elochoman, Coweeman, Kalama, and Washougal Rivers. Impacts on listed species from the operation of the weirs, as indicated above, would be expected when changes in redd distribution, time of peak spawning, and an increase in pre-spawning mortality are substantially outside the ranges observed prior to the installation of the weirs. The pre-weir ranges for these measurements would be expected to represent the range of natural environmental effects on the populations and not those associated with the weir operations. If the observed changes in redd distribution below the weir increase by more than 10% outside the pre-weir range, this would indicate that the operation of the weir is having an adverse effect on the natural-origin population. Additionally, an increase in delayed mortality by more than 5% and a change in the peak migration timing would also indicate that the weir is having an adverse impact beyond our expectations. Evaluations of weir effects have shown that the installation and operation of the weirs could lead to changes in spawning distribution (indicating weir rejection), time of peak spawning (indicating delayed migration), and increased pre-spawn mortality (indicating increased mortality due to handling) for those populations affected (NMFS 2014e).

NMFS expects this experience and results to be replicated at each additional site, given they all exist in a similar geographic area, while trapping operations occur during the same season, and in watersheds with similar hydrologic profiles.

To minimize the effects of weir operation, best management practices include, but are not limited to:

- Checking the trap daily, at a minimum. When fish passage is heavy the trap may be checked multiple times daily.
- Monitoring recruitment of fish into the trap box to inform modifications in protocol necessary to minimize passage delays of NOR fish and maximize collection of hatchery fish.
- Paying close attention to the recruitment of fish into the adult trap and the accumulation of fish below the trap. If fish are not adequately moving into the trap, modifications will first be made to adjust flow and/or trap box configuration and try to increase trapping efficiency. If this does not encourage fish to move into the live box, a beach seine may be used to either capture fish or crowd them into the live box or an area where they can be safely processed.
- Modifying schedules or protocols if there is over-crowding in the trap or if fish numbers are building-up downstream of the trap and migration may be delayed. Modification of sampling schedule or trapping protocols will consider both the benefits of improved passage and the adverse impact on pHOS. This can be accomplished by opening the upstream gate on the trap or removing (or submerging) a section of the weir.
- Monitoring of recruitment into the trap and the abundance of adult fish below the weirs that move into the trap may indicate that an alternative location for weir placement would be appropriate to minimize delay and weir rejection.
- Modify weir operations between 18℃ and 21℃ and with additional measures above 21℃, as described in the HOF.

Table 92 lists the estimated number of natural-origin adult and jack salmon and steelhead that would be authorized to be handled annually at each of the weirs. Under these handling allowances, each weir can be operated to meet its goals of collecting broodstock, monitoring escapement, and removing hatchery-origin fish not intended to be spawned naturally, even if the returns are greater than expected or the weir is more efficient in a particular year. Most ESA-listed hatchery-origin spring Chinook, fall Chinook, and coho salmon and steelhead that volunteer at these locations shall not be returned to the river; consequently, up to 100% of ESA-listed hatchery-origin spring Chinook, fall Chinook, and coho salmon and steelhead encountered will be taken by handling, collection, and/or retention (Archibald 2024). This will prevent the weir from being removed before all hatchery fish return. The estimated mortalities for both life stages are based on data about recent operations (NMFS 2024a), and we expect it to be no more than 3% of the number of adults and juveniles handled.

The estimated direct handling mortality level is based on past handling experience, but actual mortality rates are expected to be lower due to the best management actions for handling fish described above and the experience of the technicians operating the weirs. The loss is expected to be no more than 3% of the adults handled and would have only a minor effect on the abundance of the natural-origin populations. New information on the status of natural populations gained by the operation of the weirs and the reduction in hatchery strays will be beneficial and, perhaps, at least partially offset handling mortality.

Table 92. Operational and proposed weirs[1] to be operated by WDFW for the collection of broodstock and adult management[2]; the maximum number of natural-origin adults and jacks of each species expected to be encountered at the weirs, and the estimated mortalities (assumes a ~ 3% indirect handling mortality). MA denotes weirs currently funded by the Mitchell Act.

Watershed	Status	Species encountered	Number Adults & Jacks encountered	Estimated Adult & Jacks mortalities	Number Juveniles Encountered	Estimated Juvenile mortalities
Grays (MA)	In place	Fall Chinook	750	≤23	100	≤3
		Coho Salmon	800	≤24	100	≤3
		Chum Salmon	8,500	≤255	0	0
Elochoman (MA)	In place 2 locations: Foster Road and Beaver Creek Sill	Fall Chinook	750	≤23	100	≤3
		Coho Salmon	2000	≤60	100	≤3
		Chum Salmon	1,000	≤30	0	0
Abernathy Germany	New	Fall Chinook	750	≤23	100	≤3
		Coho Salmon	1,500	≤45	100	≤3
		Chum Salmon	250	≤8	0	0

Watershed	Status	Species encountered	Number Adults & Jacks encountered	Estimated Adult & Jacks mortalities	Number Juveniles Encountered	Estimated Juvenile mortalities
South Fork Toutle	In place	Fall Chinook	350	≤11	50	≤2
		Spring Chinook	50	≤2	50	≤2
		Coho Salmon	5,500	≤165	100	≤3
		Chum Salmon	250	≤8	0	0
		Winter Steelhead	50	≤2	50	≤2
		Summer Steelhead	50	≤2	50	≤2
North Fork Toutle River	In place	Fall Chinook Salmon	2,700	≤81	100	≤3
		Spring Chinook	250	≤8	100	≤3
		Coho Salmon	12,300	≤369	100	≤3
		Steelhead (winter)	10	1	100	≤3
		Steelhead (summer)	10	1	0	0
		CR Chum Salmon	250	≤8	0	0
Coweeman (MA)	In place	Fall Chinook	1,600	≤48	100	≤3
		Coho salmon	800	≤24	100	≤3
		Chum Salmon	100	≤3	0	0
		Winter steelhead	50	≤2	100	≤3
		Summer Steelhead	10	1	0	0
Cedar Creek (Lewis River Tributary) (MA)	In place 2 locations: Lower Cedar Ck. and Grist Mill Fish Ladder	Fall Chinook	1200	≤36	100	≤3
		Spring Chinook	50	≤2	50	≤2
		Coho Salmon	1200	≤36	100	≤3
		Chum Salmon	250	≤8	0	0

Watershed	Status	Species encountered	Number Adults & Jacks encountered	Estimated Adult & Jacks mortalities	Number Juveniles Encountered	Estimated Juvenile mortalities
		Summer Steelhead	50	≤2	50	≤2
		Winter Steelhead	250	≤8	50	≤2
Washougal (MA)	In place	Fall Chinook	3000	≤90	100	≤3
		Coho Salmon	200	≤6	100	≤3
		Chum Salmon	250	≤8	0	0
		Summer Steelhead	200	≤6	100	≤3
		Winter Steelhead	10	1	100	≤3
Kalama (Located at Modrow Rd.) (MA)	In place	Fall Chinook	7,200	≤216	50	≤2
		Spring Chinook	50	≤2	50	≤2
		Coho Salmon	1,150	≤35	100	≤3
		Chum Salmon	250	≤8	0	0
		Summer Steelhead	500	≤15	50	≤2
		Winter Steelhead	0	0	50	≤2

[1] May also be referred to as Adult Collection Facility (ACF) in the HOF
[2] Adult management activities include, but are not limited to, broodstock collection, biodata collection, genetic sampling, marking and or tagging.

2.5.2.2.2.6 Encounters through Other Adult Collection Methods

The HOF also includes adult collection methods outside of the hatchery facilities that rear Mitchell Act-funded fish and weirs described above. These adult collection methods may include seining, angling, netting, or other new trapping techniques, primarily to remove hatchery-origin fish from the spawning grounds, though these processes may be used for a secondary purpose of broodstock collection. Table 93 describes the proposed locations, the maximum level of expected encounters, and the maximum level of mortality associated with such handling. Table 93 describes the limits such that when either the encounter or the mortality numbers are reached, the adult collection operation in that particular watershed will cease for the year.

Table 93. Maximum number of natural-origin salmon and steelhead expected to be encountered through other adult collection methods outside of the hatchery facilities and weirs described above and associated maximum expected mortality levels.

Watershed	Species encountered	Number Adults & Jacks encountered	Estimated Adult & Jack mortalities	Number Juveniles Encountered	Estimated Juvenile mortalities
Grays	Fall Chinook	100	≤3	100	≤3
	Coho Salmon	250	≤8	100	≤3
	Chum Salmon	250	≤8	0	0
Abernathy	Fall Chinook	100	≤3	100	≤3
	Coho Salmon	250	≤8	100	≤3
Germany	Chum Salmon	50	≤2	0	0
South Fork Toutle	Fall Chinook	100	≤3	50	≤2
	Spring Chinook	10	1	50	≤2
	Coho Salmon	250	≤8	100	≤3
	Chum Salmon	10	1	0	0
	Winter Steelhead	10	1	50	≤2
	Summer Steelhead	10	1	50	≤2
Coweeman	Fall Chinook	100	≤3	100	≤3
	Coho Salmon	250	≤8	100	≤3
	Chum Salmon	10	1	0	0
	Winter Steelhead	10	1	100	≤3
	Summer Steelhead	10	1	0	0
Lewis River/Cedar Creek	Fall Chinook	600	≤12	200	≤6
	Coho Salmon	600	≤12	200	≤6
	Chum Salmon	50	≤2	0	0
	Summer Steelhead	50	≤2	100	≤3
	Winter Steelhead	10	1	100	≤3
Washougal	Fall Chinook	250	≤8	100	≤3
	Coho Salmon	250	≤8	100	≤3

Watershed	Species encountered	Number Adults & Jacks encountered	Estimated Adult & Jack mortalities	Number Juveniles Encountered	Estimated Juvenile mortalities
	Chum Salmon	50	≤2	0	0
	Summer Steelhead	50	≤2	100	≤3
	Winter Steelhead	50	≤2	100	≤3
Kalama	Fall Chinook	500	≤16	50	≤2
	Spring Chinook	50	≤2	50	≤2
	Coho Salmon	250	≤8	100	≤3
	Chum Salmon	10	1	0	0
	Summer Steelhead	50	≤2	50	≤2
	Winter Steelhead	10	1	50	≤2
Toutle	Fall Chinook	250	≤8	100	≤3
	Spring Chinook	50	≤2	100	≤3
	Coho Salmon	250	≤8	100	≤3
	Chum Salmon	10	1	0	0
	Winter Steelhead	10	1	100	≤3
	Summer Steelhead	10	1	0	0

To minimize the effects of these adult collection methods, best management practices include, but are not limited to:

- Each site will be evaluated to determine what method is likely to be most effective at capturing fish with the least impact to natural origin fish.
- Seining/netting locations are inspected prior to net deployment to identify any potential net snagging hazards. These hazards are avoided.
- Netting activities use soft small mesh seines (generally less than 1") or small mesh “tangle” nets to minimize potential for gilling.
- All nets are actively monitored to minimize soak times and regulate the number of fish captured per set.
- Angling may be used in areas where snagging hazards prevent deployment of nets.

- Electrofishing will follow NMFS guidelines and is generally used to coax fish to move into locations where they can be captured with other methods.
- Staff use standard fish handling protocols for tagging and sampling, including the use of approved anesthetics and recovery times.
- Natural origin fish captured for broodstock or transport will be moved using transport tubes and/or aerated tanks.
- All crews will be led by experienced staff and all staff will be trained in safe handling protocols and safety requirements.

The estimated direct handling mortality is based on past handling experience, but actual mortality rates are expected to be less, due to the best management actions for handling fish described above, and the experience of the technicians operating the weirs. NMFS expects these fish to experience mortality after being released as a result of gear effects, capture, and handling. Such mortality will be estimated for each encounter using best available science associated with the method of removing hatchery-origin fish from the spawning grounds. While there are impacts of handling on natural-origin salmon and steelhead, there is also a benefit to the natural-origin populations because these actions reduce the genetic risks to the natural-origin populations by reducing pHOS (see Section 2.5.2.2.2.1).

2.5.2.3 Factor 3. Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas, the migratory corridor, estuary and ocean

In addition to the factors discussed above, NMFS also analyzes the potential for competition, predation, and disease when the progeny of naturally spawning hatchery fish and hatchery releases share juvenile rearing areas. This factor can have effects on the productivity of the natural population. Competition and a corresponding reduction in productivity and survival may result from direct interactions when hatchery-origin fish interfere with the accessibility to limited resources by natural-origin fish or through indirect means, when the utilization of a limited resource by hatchery fish reduces the amount available for fish from the natural population (Rensel et al. 1984). Natural-origin fish may be competitively displaced by hatchery fish early in life, especially when hatchery fish are more numerous, are of equal or greater size, take up residency before naturally produced fry emerge from redds, and residualize.

Here, we analyze the effects of these factors on all ESA-listed eulachon, salmon, and steelhead listed in Table 1 because they are likely to encounter the hatchery fish released from programs outlined in the HOF in their migratory corridor and the estuary, even if some of these species are not encountered in the rearing areas or the ocean. The analysis here is limited to the impacts from the programs in the HOF because the programs listed in Table 4 are small and have low survival rates, thus not likely to have any impact on natural-origin species.

2.5.2.3.1 Ecological Effects on the Pacific Eulachon Southern DPS

Under this factor, NMFS analyzes the potential for competition, predation, and disease when the progeny of naturally spawning hatchery fish and hatchery releases share juvenile rearing areas with other species. For purposes of this analysis, we first examined the likelihood that the production and release of hatchery-produced salmon and steelhead would be expected to co-occur in space and time in the Action Area with eulachon. With co-occurrence and exposure established, we then examined the extent to which hatchery-produced and released salmon and steelhead may affect eulachon. The three effect pathways we considered in this analysis were predation, competition, and the potential for hatchery-produced and released salmon and steelhead to transmit diseases to adult, juvenile, sub-adult, and larval eulachon.

2.5.2.3.1.1 Effects of Predation

Predation, either direct (direct consumption) or indirect (increases in predation by another predator species due to enhanced attraction) can result from hatchery fish being released into the wild. Salmon and steelhead are piscivorous and are known to feed on other fishes, including eulachon (Osgood et al. 2016). Based on the temporal distribution of emigrating/migrating eulachon and salmonid fishes as shown in Table 68 and Table 69 in Section 2.2.7, and Table 94 in this section, there is spatial and temporal co-occurrence of adult eulachon and hatchery-produced and released spring Chinook salmon, winter steelhead, and summer steelhead in the migratory corridor from December to June (NMFS 2014f). There is likely to be limited predation of adult eulachon by adult spring Chinook salmon, winter steelhead, and summer steelhead as they migrate through the LCR between the ocean and Bonneville Dam.

Juvenile eulachon may overlap with juvenile salmon and steelhead in the LCR and estuary as they migrate to the ocean in the spring. Eulachon larvae in the LCR can number in the trillions during their downstream drift-migration to the ocean. Hatchery salmon released at a later stage (yearlings) tend to emigrate quickly to the ocean (Teel et al. 2014), but, depending on timing, they are likely to encounter, and therefore prey upon, larval eulachon. Sub-yearling hatchery produced and released salmonids (i.e., ocean-type salmon) tend to take longer than yearling salmonids (i.e. stream-type salmon) to migrate through the freshwater-estuarine portions of rivers, as they tend to utilize off-channel and marsh habitats for extended periods prior to emigrating to the ocean (McNatt, Bottom, and Hinton 2016), thus their impact on eulachon in terms of predation is likely larger.

Table 94. Seasonal patterns of occurrence for ESA-listed salmonid stocks in the Lower Columbia River. Black regions indicate times of peak abundance.

Adult Salmonids	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chinook												
Snake River Fall												
Snake River Spring/Summer												
Upper Columbia River Spring												
Lower Columbia River												
Upper Willamette												
Sockeye												
Snake River												
Chum												
Lower Columbia River												
Coho												
Lower Columbia River												
Steelhead												
Upper Columbia River												
Snake River												
Middle Columbia												
Upper Willamette												
Lower Columbia River												
Juvenile Salmonids	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Chinook												
Snake River Fall												

Snake River Spring/Summer												
Upper Columbia River Spring												
Lower Columbia River												
Upper Willamette												
Sockeye												
Snake River												
Chum												
Lower Columbia River												
Coho												
Lower Columbia River												
Steelhead												
Upper Columbia River												
Snake River												
Middle Columbia												
Upper Willamette												
Lower Columbia River												

Once hatchery-produced and released fish reach the ocean, it is likely they would continue to prey on larval eulachon in the nearshore-ocean environment, as well as on juvenile, sub-adult, and adult eulachon that are encountered during their residence (years) in the nearshore and open ocean environments. In addition to hatchery-produced and released salmon and steelhead that emigrate to the ocean, some hatchery-produced and released fish may not emigrate and instead take up residence in the freshwater environments (residuals). Predation intensity on larval and adult eulachon may therefore increase due to an increase in exposure potential.

The winter steelhead programs released in the Sandy, Kalama, Grays, Elochoman, and Coweeman Rivers would have the most significant overlap with eulachon. To minimize these potential overlaps, WDFW will implement the following BMPs so that hatchery fish move quickly out of the Sandy, Kalama, Grays, Elochoman, and Coweeman Rivers: rearing juveniles to the sizes and under conditions identified in the relevant HGMPs, and acclimating hatchery juveniles prior to release. These actions will facilitate returning fish homing to their release sites low in each watershed and limit the potential for spawning ground interactions. Rearing fish to the sizes identified in the HGMPs will achieve maximum smolting condition, therefore the majority of hatchery fish will rapidly migrate out of the freshwater subbasins where they are released.

By employing the aforementioned BMPs and producing actively migrating smolts, co-occurrence of the two species and adverse effects are expected to be negligible. Research indicates hatchery fish are less efficient predators as compared to their natural-origin conspecifics, reducing the potential for predation impacts of hatchery origin winter steelhead ((Sosiak, Randall, and McKenzie 1979); (Bachman 1984); (Olla, Davis, and Ryer 1998)). Coupled with the small size and transparency of the emergent eulachon fry, the distribution of eulachon fry in the water column, and the rapid emigration of eulachon juveniles from these rivers post spawning, this will aid in ensuring levels of predation by hatchery origin winter steelhead on eulachon will be negligible.

As noted above, eulachon overlap throughout the Action Area in space and time with the production and release of hatchery-produced salmon and steelhead under the Proposed Action. The hatchery-produced and released salmon and steelhead that are proposed to be funded through the Mitchell Act are likely to have direct effects that will adversely affect eulachon. Although the amounts of larval, juvenile, sub-adult, and adult eulachon consumed by hatchery-produced and released salmon and steelhead under the Proposed Action cannot be quantified, we do not expect the duration and magnitude of predation to meaningfully affect eulachon productivity and abundance at the Columbia River subpopulation or DPS level. Salmon and steelhead, while predators of eulachon, are not known to selectively prey on eulachon (Drake et al. 2010). Therefore, the hatchery-produced salmon and steelhead resulting from the Proposed Action are not likely to have a significant impact on the survival and recovery of eulachon.

Although the amounts of larval, juvenile, sub-adult, and adult eulachon consumed by hatchery-produced and released salmon and steelhead under the Proposed Action cannot be quantified, we do not expect the duration and magnitude of predation to meaningfully affect eulachon productivity and abundance at the Columbia River subpopulation or DPS level. Salmon and steelhead, while predators of eulachon, are not known to selectively prey on eulachon (Drake et al. 2010). Therefore, the hatchery-produced salmon and steelhead resulting from the Proposed Action are not likely to have a significant impact on the survival and recovery of eulachon.

2.5.2.3.1.2 Effects of Competition and Disease

The potential effects of the Proposed Action considered here include competition for space, and the likelihood that Mitchell Act-funded hatchery-produced Chinook salmon and steelhead would act as a disease vector for eulachon. Adult eulachon typically spawn in the lower reaches of larger rivers fed by snowmelt (Hay and McCarter 2000). Spawning substrates can range from silt, sand, or gravel to cobble and detritus (Vincent-Lang, Alexandersdottir, and McBride (1993); as cited in (NMFS 2017d), but sand appears to be most common (Langer, Shepherd, and Vroom 1977); as cited in (NMFS 2017d)).

We do not expect Mitchell Act-funded hatchery-produced salmon and steelhead that return as adults to the spawning grounds to compete for space with eulachon as they generally utilize different substrates and have limited overlap in run timing. Eulachon larvae are carried downstream and are dispersed to the ocean by river, estuarine, and tidal currents, and are generally distributed throughout the water column. Yearling hatchery-produced Chinook salmon smolts generally migrate rapidly through the Columbia River and Columbia River estuary and tend to be more surface oriented (Birtwell and Kruzynski 1989). Sub-yearling hatchery produced Chinook salmon tend to take longer to migrate through the freshwater and estuarine portions of rivers, and tend to utilize off-channel and marsh habitats prior to emigrating to the ocean (McNatt, Bottom, and Hinton 2016). Therefore, we do not expect the effects of the Proposed Action on competition for space to be too dissimilar from natural conditions, and what effects for space may occur are likely to be minor.

We are not aware of disease transmission between salmonids and eulachon. Therefore, we expect the effects of the Proposed Action in terms of the likelihood of the transmission of diseases to eulachon to be no more than minor.

2.5.2.3.2 Ecological Effects on Salmon and Steelhead

Juvenile natural-origin ESA-listed salmon and steelhead may be exposed to ecological effects—that is, competition, predation, and/or disease—from hatchery-released fish and the progeny of hatchery-origin fish that spawn in the wild. Numerous factors may influence the degree of ecological effects, described in detail below, and in previous Section 2.5.2.2 and Appendix A. Direct interactions occur when hatchery-origin fish interfere with the accessibility to limited resources by natural-origin fish, and indirect interactions occur when the utilization of a limited resource by hatchery fish reduces the amount available for natural-origin fish (Rensel et al. 1984). In an assessment of the potential ecological impacts of hatchery fish production on naturally produced salmonids, the Species Interaction Work Group (Rensel et al. 1984) concluded that naturally produced coho and Chinook salmon and steelhead are all potentially at risk due to competition (both interspecific and intraspecific) from hatchery fish of any of these species. In contrast, the risk to naturally produced pink, chum, and sockeye salmon due to competition from hatchery salmon and steelhead was found to be low. Hatchery-origin fish may also alter natural-origin salmonid migratory responses or movement patterns, leading to a decrease in foraging success by the natural-origin fish (Hillman and Mullan 1989); (Steward and Bjornn 1990).

Several factors influence the risk of competition posed by hatchery releases: whether competition is intraspecific (members within the same species compete) or interspecific (members of different species compete); the duration of freshwater and marine co-occurrence of hatchery and natural-origin fish; relative body sizes of the two groups; prior residence of shared habitat; environmentally induced developmental differences; and density in shared habitat (Tatara and Berejikian 2012). Tatara et al. (2012) further concluded that of all factors, fish density of the composite population in relation to habitat carrying capacity likely exerts the greatest influence.

One component of this is the phenomenon of residualism. A proportion of the smolts released from a hatchery may not migrate to the ocean but rather reside for a period of time in the vicinity of the release point. These non-migratory smolts (residuals) may directly compete for food and space with natural-origin juvenile salmonids of similar age. Although this behavior has been studied and observed, most frequently in the case of hatchery steelhead, residualism has been reported as a potential issue for hatchery coho and Chinook salmon as well. Adverse impacts of residual hatchery Chinook and coho salmon on natural-origin salmonids can occur, especially given that the number of smolts per release is generally higher than steelhead releases. However, the issue of residualism for these species has not been as widely investigated compared to steelhead. Therefore, for all species, monitoring of natural stream areas in the vicinity of hatchery release points may be necessary to determine the potential effects of hatchery smolt residualism on natural-origin juvenile salmonids.

Hatchery programs typically minimize risk associated with competitive interactions between hatchery- and natural-origin fish by:

- Releasing hatchery smolts that are physiologically ready to migrate. Hatchery fish released as smolts emigrate seaward soon after liberation, minimizing the potential for competition with juvenile naturally produced fish in freshwater (Steward and Bjornn 1990); (California HSRG 2012).

- Operating hatcheries such that hatchery fish are reared to a size sufficient to ensure that smoltification occurs in nearly the entire population.

- Releasing hatchery smolts in lower river areas, below areas used for stream-rearing by naturally produced juveniles.

- Monitoring the incidence of non-migratory smolts (residuals) after release and adjusting rearing strategies, release location, and release timing if substantial competition with naturally rearing juveniles is determined likely.

For outmigrating hatchery smolts, the possible predation on naturally-occurring juvenile fish is another way in which negative effects can occur from hatchery releases. Predation, either direct (consumption by hatchery fish) or indirect (increases in predation by other predator species due to enhanced attraction), can result from hatchery fish released into the wild. Predation considered in this Opinion includes consumption by hatchery-origin fish and the progeny of hatchery fish released into the wild. Hatchery fish might alter natural-origin salmonid behavioral patterns and habitat use, making natural-origin fish more susceptible to predators (Hillman and Mullan 1989); (Steward and Bjornn 1990). In general, the threat from predation is greatest when natural populations of salmon and steelhead are at low abundance, when spatial structure is already reduced, when habitat, particularly refuge habitat, is limited, and when environmental conditions favor high visibility. Hatchery fish are released at a later stage to reduce predation from hatchery fish on natural-origin egg, fry and fingerling, and so they are more likely to emigrate quickly to the ocean, and can prey on fry and fingerlings that are encountered during the downstream migration.

Studies (Berejikian et al. 2000); (Melnychuk et al. 2014) also suggest that predator selection for hatchery-origin and natural-origin fish in commingled aggregations is not equal. Rather, the relatively naïve hatchery-origin fish may be preferentially selected in any mixed schools of migrating fish until they acclimate to the natural environment. Predator buffering (also termed predator swamping) may yield beneficial effects to affected natural populations. However, this mechanism is not yet well studied or understood.

Of note, this section only analyzes the impacts of juvenile hatchery-origin salmon and steelhead. While the natural-origin fall Chinook salmon fry rearing and release in the Abernathy Creek could lead to additional ecological interactions, we expect such interactions between natural-origin fish. That is, even though fry are to be briefly reared at the Abernathy Fish Technology Center, they are still part of the natural population, and the ecological interactions among natural fish are part of a natural process. Therefore, the impacts of releasing the natural-origin fry are considered part of the baseline and species status, rather than an effect of the action, and are not discussed below.

2.5.2.3.2.1 Effects in the migratory corridor and estuary

Our analysis of effect in the migratory corridor and estuary consists of using an ecological interaction model, as well as looking at salmon and steelhead's diet composition and the effects of predator attraction.

2.5.2.3.2.1.1 Gauging Effects in the migratory corridor and estuary using an ecological interaction model

Our analysis of juvenile competition and predation in the migratory corridor to the mouth of the Columbia River uses the PCDRisk ecological interactions model developed by Pearsons and Busack (Lauver et al. 2012). This model is used to understand the risks to natural-origin salmon and steelhead from predation by, and direct (contest) competition with, released hatchery fish from the point of release to the mouth of the Columbia River. It does not estimate interactions among natural fish or among hatchery fish, although both interaction scenarios are likely to occur. While this model uses some quantitative estimates of ecological interactions, the estimates are derived from parameters based on best available science and professional judgment on qualitative information. Therefore, the most appropriate way to think of these estimates is as a relative measure of which species and populations are most likely to be adversely affected by the release of hatchery fish from Mitchell Act funded programs.

The logic used in the PCD Risk model was described by Lauver et al. (2012), but since that time has been modified to increase supportability and reliability. Notably, the current version no longer operates in a stand-alone graphical user interface environment and no longer has a probabilistic mode. NMFS also further refined the model by allowing for multiple hatchery release groups of the same species to be included in a single run and by allowing both natural-origin and hatchery-origin fish to grow over the modeled residence period. Modification to the model logic included an elimination of competition equivalents and replacement of the disease function with a delayed mortality metric in 2018. The 2023 version also changed the way delayed mortality was calculated.

The rationale behind the changes described above was to make the model more realistic. In previous use of the model, competition rarely directly resulted in death because it takes many competitive interactions for a fish to suffer enough weight loss to cause mortality by starvation. Weight loss is how adverse competitive interactions were captured in the model. However, fish that experience competition and resulting weight loss are likely more vulnerable to mortality from other factors such as disease. In the revised application, at the end of each model run, the competitive impacts for each fish are assessed, and the fish has a probability of delayed mortality based on the amount of growth lost due to competitive impacts. This function will be subject to further refinement based on the availability of new research. For now, the probability of delayed mortality is equal to the proportion of a fish's weight relative to the potential increase in weight without competitive interactions.

Similar to the use of models for biological systems elsewhere, this model cannot possibly account for all the variables that could influence competition and predation on natural-origin juveniles. For example, the model assumes that if a hatchery fish is piscivorous and stomach capacity is available, the hatchery fish will consume natural-origin prey. In reality, hatchery-origin fish could choose to eat a wide variety of fauna, such as other fish species (e.g., minnows) or aquatic and terrestrial insects, in addition to natural-origin steelhead juveniles. However, NMFS believes that with this model we are generating, to the best of our ability, and based on the best available science, a reasonable estimate of the effects on natural-origin juvenile steelhead.

For this consultation, NMFS assumed some of the parameter inputs consistent with other consultations in which we use this model (Table 95). We assumed that habitat complexity was low, at only 10 percent, to conservatively account for habitat degradation in the Columbia River Basin. We used habitat segregation estimates of 0.3 for conspecifics, and 0.6 for other salmon and steelhead; a dominance mode of 3; and maximum encounters per day of 1, based on what was decided in the HETT (2014) database for hatchery programs of the same life stage and species. All other input parameters specific to each model segment may be found in (NMFS 2024g).

Table 95. Parameters in the PCD Risk model that are the same across all programs.

Parameter	Value
Habitat Complexity	0.1
Population overlap	1.0
Habitat segregation	0.3 for conspecifics, 0.6 for all other species
Dominance mode	3
Probability dominance results in weight loss	0.05
Proportion of weight loss causing death	0.5
Maximum encounters per day	1
Predatory:prey length ratio for predation	0.25

2.5.2.3.2.1.1.1 Overview of Tributary Life Cycle Model

Very few tributaries in the project area with hatchery-origin releases have empirical estimates of natural-origin juveniles suitable for modeling the ecological effects of competition and predation. Consequently, simple life cycle models were used to develop sub-basin-specific fry, parr, and smolt abundance assumptions for the tributary PCD Risk scenarios. The life cycle models were likely imprecise and ignored annual variability in productivity. However, the models provided a standard methodology for estimating representative natural-origin production in the tributaries that could be used to evaluate competition and predation using the PCD Risk model.

The models estimated the number of fish produced based upon the geometric mean number of spawners from 2015 to 2019 (Ford 2022). ESU-specific generic models were developed for each species of interest (fall Chinook salmon, spring/summer Chinook salmon, steelhead, coho salmon, and chum). Each generic model included assumptions for fecundity, egg to fry survival rate, fry to parr survival rate, annual age-specific freshwater survival rates, and age-specific smoltification rates. Average species- specific fecundity and egg to fry survival rates were drawn from Myers et al. (1998) Appendix A) and Quinn (2005); Table 15-1), respectively. Lifestage-specific survival rates and smoltification rates were not available; consequently, each model was calibrated by trial and error to have the proportion of outmigrants by age and smolt to adult ratios be similar to those reported in Myers et al. (1998); Appendix A) and Quinn (2005); Table 15-1), respectively. The life cycle models assumed that fry and older life stage survival rates increased with age. For matching the smolt to adult ratios from Quinn (2005); Table 15-1), the models assumed a life cycle production value of 1.0; in other words, smolts survived at a rate to return the number of spawners. For those tributaries, egg to fry survival or fry to parr survival rates were adjusted in the life cycle model to match the reported smolt production.

The life cycle models also included spatial and temporal overlap parameters to account for rearing areas outside of the migration corridor downstream of release sites and for natural-origin smolts that depart the tributary prior to hatchery-origin releases. Spatial overlap was estimated visually using fish distribution layers in WDFW's SalmonScape mapper or StreamNet Mapper. Temporal overlap was based upon proposed hatchery-origin release times and outmigration timing reported in (Hillson et al. 2017). The life cycle models were run for each tributary and listed species of interest. Output from the life cycle models were the PCD Risk parameters for the number of natural-origin fish and proportion by life stage that would be vulnerable to encounters by hatchery-origin fish in the tributary.

2.5.2.3.2.1.1.2 Overview of PCDRisk Methods

There are 14 programs above Bonneville Dam, and 36 programs below Bonneville Dam. For programs above Bonneville Dam, we reviewed the existing information from the *U.S. v. Oregon* biological opinion (NMFS 2018c) and incorporated that data for our input parameters. For input parameters below Bonneville Dam, we requested data from our comanagers or relied on published literature. Comanagers and hatchery operators provided the temperatures at release sites, averaged for the release day or window. For the few programs where temperature was not available, we used the closest location with data. Mean length and coefficient of variation (cv) length were provided by the comanagers in millimeters (mm) or fish per pound (fpp), and if necessary were converted using the conversion from Piper et al. (1986). Where length or cv was not available, we used the averages for the same species and age class.

We visually assessed the spatial population overlap between hatchery fish and ESA-listed natural-origin Chinook salmon and steelhead[33] in tributaries to the Columbia River, using WDFW SalmonScape and the Pacific States Marine Fisheries Commission StreamNet Mapper, to estimate the percentage of overlap in the migration corridor downstream of the hatchery release locations and habitat for natural-origin fish upstream of the hatchery. We assessed temporal overlap between natural- and hatchery-origin fish by looking at the release times for hatchery programs provided by comanagers, with percent cumulative abundance by month from Hillson et al. (2017) for Lower Columbia River chum, Chinook, coho, and steelhead.

For tributary releases, we calculated residence time by taking the number of river miles from release to the confluence of the Columbia River, divided by the rate of travel (RM/day). For programs above Bonneville Dam, the comanagers provided PIT tag data, where the residence time is known. For programs below Bonneville Dam, there is minimal data available to calculate residence time. Therefore, we used the best available travel rates from literature. For sub-yearling fall Chinook, we used 15.7 mi/day (Schroeder et al. 2016); yearling spring Chinook we used 19.3 mi/day (Schroeder et al. 2016); coho we used 10.4 mi/day (Dawley et al. 1986); and steelhead we used 8.1 mi/day (Wilson, pers comm. November 2024). For residence times under half a day, we do not expect the released fish to have meaningful interactions with natural-origin fish during this short stretch. Therefore, this release site was treated as if the fish were directly released on the mainstem. Survival rates for releases below Bonneville Dam are not available;

[33] We aggregated summer-run and winter-run steelhead into a single group of natural-origin fish for this analysis.

therefore, we used mortality per day information from programs above Bonneville Dam, calculated in the *US v. Oregon* biological opinion (NMFS 2018c). We multiplied the mortality per day by the residence time to find the estimated survival rate to the confluence of the Columbia River.

In addition to running the model in the relevant tributaries, we aggregated the mainstem runs. To do this, we combined the hatchery-origin abundance in the Columbia River by multiplying the hatchery production and any buffer by the survival rate to the confluence of the Columbia River. We ran the model in different segments – Snake River to Lower Granite Dam, Upper Columbia River to Priest Rapids Dam, between Lower Granite and Priest Rapids dams and McNary Dam, between McNary and Bonneville Dam, and between Bonneville Dam to the estuary.

2.5.2.3.2.1.1.3 Results

Modeled results indicate juvenile mortalities may accrue as a result of the Proposed Action. However, given the generally low smolt-to-adult survival rate for salmon, we find it more informative to estimate potential adult equivalent mortality from competition and predation resulting from Mitchell Act-funded programs. To calculate impacts to natural-origin adults, first natural-origin juvenile abundance is based on PIT tag detections at dams and at Tongue Point in the Columbia River estuary, averaged for 2017-2020. Then using average smolt-to-adult return (SAR) ratios from each ESU/DPS we are able to determine the number of adults impacted based off of the modeled juvenile mortality. The information provided is not intended for direct comparison, but providing context for modeled mortality results. Model inputs and results may be found in (NMFS 2024g).

Our effects analysis is based on factors such as listing status and other circumstances unique to each species, which is used to categorize the risk levels of juvenile competition and predation in the migratory corridor to the mouth of the Columbia River as creating a minor, moderate, or high risk of impacting the VSP parameters.

Moreover, the model is intended to describe these particular hatchery effects as they have existed since the programs' inception. It does not indicate additional impacts above the baseline effects, and as the programs evolve to lessen their negative effects, the effects examined in the model will lessen and will likely indicate increased abundance.

Also, the PCD Risk model uses numbers to characterize effects, but cannot accurately quantify them. Models cannot take account of all factors in a complex natural environment, and fish behavior is subject to myriad circumstances. What the model does, however, is indicate a signal that effects can occur, and as the numbers trend up or down, it can indicate a change in the strength of that signal. Thus, while it cannot be taken as a literal depiction of quantified effects, it can benefit our understanding of those effects by giving us an indication of the scope of effects, as well as a way to detect trends in the effects.

2.5.2.3.2.1.1.4 Summary of PCDRisk Model Results

In general, the aggregate runs between Bonneville and the mouth of the Columbia River estuary had the greatest impact on listed natural-origin species. This is expected because this is the reach with the greatest number of both natural and hatchery-origin salmon and steelhead. Our results are also likely an overestimate of total mortality, because we were unable to consider temporal or spatial overlap in aggregate runs, because different hatchery programs release at different times and there is some variation in the outmigration of natural-origin juveniles.

Actual impacts on natural-origin fish would depend on the degree of dietary overlap, food availability, size-related differences in prey selection, foraging tactics, and differences in microhabitat use (Steward and Bjornn 1990). Not all populations within a given ESU or DPS may be affected by competition and predation in freshwater. Risk to individual affected populations is expected to be minor for all species, based on the variables described above. Most populations are likely to incur only negligible or low risk based on our extensive experience completing site-specific hatchery consultations for all purposes (e.g., harvest, salmonid conservation) across the Columbia River Basin (see Section 2.4, Environmental Baseline).

NMFS also expects that the progeny of naturally spawning hatchery-origin fish will have similar ecological effects, as those described in the preceding sections, on competition and predation in freshwater environments from hatchery-origin fish. However, naturally spawning hatchery-origin fish are likely to be less efficient at reproduction than their natural-origin counterparts (Christie, Ford, and Blouin 2014). The progeny of such hatchery-origin spawners are not likely to make up a sizable portion of the juvenile fish population because of the pHOS limits described in Factor 2 (Section 2.5.2.2). However, ecological impacts on listed species may increase in the future if these ESA-listed salmon and steelhead populations grow. In the short-term, we do not believe current densities are limiting natural-origin salmon and steelhead production. Further, NMFS expects that the monitoring efforts would detect negative impacts before they reach problematic levels, and we include language in the ITS (Section 2.9, Incidental Take Statement) to ensure that appropriate monitoring takes place.

The incidental take of listed species from this factor is addressed in the ITS. NMFS is relying on the timing of fish releases and the production level – the number of fish released – to reflect the level of incidental take. The Mitchell Act-funded programs have addressed this risk by committing to release strategies that adequately mitigate the effects of competition and predation from smolt releases, such that if they are timed properly and the production size is in compliance, it would remain a low, negative effect to the affected species. There are additional aspects to release strategies identified with each program, such as the release location and the size of individual fish upon release, which are important details which we expect the program operators to comply with. We do not include every such detail in the incidental take statement, because the level of take is adequately gauged using timing and production level limits. However, compliance with all program standards remains important and NMFS expects program operators to document compliance in their annual reporting requirements.

We will also discuss other aspects of salmon and steelhead biology that influence ecological interactions based on current scientific literature that were not considered in the model, or otherwise require more elaboration. These are: (1) diet composition; (2) predator attraction; and

(3) disease. All of these aspects must be considered when assessing the effects of hatchery fish on natural populations of salmon and steelhead, and these factors assist in understanding the uncertainty in our modeled estimates of direct competition and predation.

2.5.2.3.2.1.2 Diet Composition

A review by Weitkamp et al. (2014) found that the primary prey consumed by salmon and steelhead in tidal freshwater are aquatic and terrestrial insects (e.g., dipterans, hemipteran), amphipods, mysids, and freshwater crustaceans. In the brackish waters, the primary prey are larval and juvenile fish, amphipods, insects, krill (euphasiids), and copepods. In the estuary, the diets of Chinook and coho salmon and steelhead are dominated by amphipods and dipteran insects. Thus, diet overlap among salmon and steelhead in all estuarine zones is high.

Schabetsberger et al. (2003) found that juvenile salmonids in the Columbia River plume tend to feed selectively on highly pigmented and relatively large prey (i.e., crab larvae, amphipods, adult krill), even though these species are less dominant than other zooplankton. The threshold size for piscivory was 80 mm fork length (Keeley and Grant 2001); (Schabetsberger et al. 2003), with a large fish component in the diets of Chinook and coho salmon exceeding that length. The richer diet consumed in the ocean may confer survival benefits on juveniles that move quickly through the estuary (Daly et al. 2014).

Chinook and coho salmon off the coasts of Oregon and Washington ate primarily the same prey in May and June (Brodeur et al. 2011). Diet was comprised of adult krill, and juvenile sand lance (*Ammodytes hexapturus*), rockfish (*Sebastes* spp.), and greenling (*Hexagrammos* spp.). However, Chinook salmon also ate sculpin (cottids) and amphipods, while coho salmon also ate crab larvae (*Cancer* spp.). As salmon continued to grow during their residence in coastal marine waters, diet shifts occurred based on the size of these fish. Coho salmon shifted from a diet of mainly rockfish, crab larvae, and adult krill to predominately juvenile forage fish, when they reached a size of 240 mm fork length. For Chinook salmon, fish comprised 55% of their diet from 80-100 mm fork length and 95% of their diet at > 375 mm fork length (Daly, Brodeur, and Weitkamp 2009); (Daly et al. 2014).

2.5.2.3.2.1.3 Predator Attraction

Throughout a salmon's lifecycle, they are at risk to predation from a variety of birds, fish, and marine mammals. Predation on natural-origin salmon may be affected directly or indirectly by hatchery-origin salmon that change the density of prey (hatchery and natural-origin fish) available to predators (ISAB 2015).

Feeding rates of individual predators along with predator abundance and the length of time that prey remain vulnerable all lead to the total consumption of prey by predators (ISAB 2015). When individual predators become satiated, they reduce their feeding rate even if prey density is increasing. This response is known as a depensatory function response and can be offset by a compensatory increase in the number of predators due to either (1) aggregation in the short term, or (2) increased reproduction in the long term (ISAB 2015).

2.5.2.3.2.1.3.1 Avian Predation on Outmigrants

When comparing natural and hatchery-origin salmon predation rates, multiple studies in the Columbia River have shown that hatchery-origin salmonids are more susceptible to avian predation compared to natural-origin salmonids (Collis et al. 2001); (Hatch and Branssetter 2003); (Kennedy, Gale, and Ostrand 2007); (ISAB 2015). Additionally, a study by Hostetter et al. (Hostetter et al. 2012) identified that hatchery-origin steelhead and steelhead that were in an “externally degraded condition” were consumed more frequently by double-crested cormorants (which pursue prey underwater) compared to natural-origin steelhead. This study suggested that avian predators may prefer to consume smolts that are less likely to survive to adulthood (Hostetter et al. 2011); (Hostetter et al. 2012); (ISAB 2015). However, this does not exclude the notion that avian predation occurs on a substantial amount of “non-degraded” smolts (Hostetter et al. 2012); (ISAB 2015).

2.5.2.3.2.1.3.2 Effects of the Proposed Action on Predator Attraction

Large releases of hatchery-origin fish may have a positive effect on natural-origin fish by preventing predator consumption on natural-origin fish due to the large number of hatchery-origin fish in the same area. Hatchery-origin fish are more likely to be preyed upon if there is a higher ratio of hatchery-origin fish to natural-origin fish in the same vicinity, creating a “buffer” for the natural-origin fish from the predators (ISAB 2015). However, large releases of hatchery-origin fish may have a negative effect on natural-origin fish by affecting the number of predators in the area; a large presence of fish has been shown to correlate with an increase of predators (e.g., pikeminnow) at the same time as hatchery releases increased (Kirn, Ledgerwood, and Nelson 1986); (Beamesderfer and Rieman 1991); (ISAB 2015). If predator populations followed this trend continually, the “buffering” function that hatchery-origin fish could provide natural-origin fish would essentially be cancelled out by the sheer number of predators in the area. Ideally, predator levels should not rise above where they would be if hatchery releases did not occur in that area (ISAB 2015). Flagg et al. Flagg and Mobrand (2010), according to (ISAB 2015), concluded that releases of hatchery-origin fish affect the behavior of predator populations in the Columbia River. However, no studies have demonstrated what these effects mean to natural-origin populations. Thus, we assume that the effects of predator attraction are reflected in the current status of the species, and will continue at similar levels. As above sections have described, many of these influential factors are inter-related and inter-dependent, such as competition, density dependence, and predation.

2.5.2.3.2.2 Disease Effects

The hatchery programs are operated in compliance with state co-manager fish health protocols pertaining to movement and monitoring of cultured fish (Pacific Northwest Fish Health Protection Committee). Best management practices and state, Federal, and tribal fish health policies limit the disease risks associated with hatchery programs (PNFHPC 1989); (IHOT 1995); (ODFW 2003);(NWIFC 2006); (NWIFC and WDFW 2006); (USFWS 2022). Specifically, the policies govern the transfer of fish, eggs, carcasses, and water to prevent the spread of exotic and endemic reportable pathogens. For all reportable and non-reportable pathogens, pathogen spread and amplification are minimized through regular monitoring (typically monthly), removing mortalities, and disinfecting eggs. Hatchery programs implement policies and practices for preventing, monitoring, and controlling pathogens in the hatchery environment. These protocols and practices help contain pathogen outbreaks at hatchery facilities, minimize release of infected fish from hatcheries, and reduce the risk of fish pathogen transfer and amplification to natural origin fish (Naish et al. 2007).

Frequent inspections and fish health monitoring allow for rapid detection and treatment of pathogens and disease. Treatments for nearly all commonly encountered pathogens are usually effective within hours to weeks, minimizing the length of time pathogens may be shed and amplified in the hatchery. When egg-to-release survival rates are high for fish propagated in the hatchery programs that are part of the HOF, this indicates that protocols for monitoring and addressing the health of fish in hatcheries have been effective at limiting mortality. In addition, hatchery fish from these programs migrate out of the basin relatively quickly (Section 2.5.2.3.2.1.1), limiting exposure time and/or pathogen shedding in freshwater. Although fish are monitored monthly during rearing, there are rare situations where fish that may be infected with pathogens are released into the watershed. Sometimes this may occur by decreasing stressors such as crowding in the hatchery environment, but the disease may not manifest. Hatchery operators and/or fish health specialists alert NMFS when the situation may warrant early release and discuss options for handling of infected/diseased fish.

Although a variety of pathogens have been detected at the facilities that rear Mitchell Act funded fish included in the HOF, over the last few years, no novel or exotic pathogens have been found (Table 96). However, it is important to note that detection of a pathogen does not mean that disease was observed. Table 97 indicates the number of epizootics (20-30 per year) occurring from some pathogen infections is much less than the number of pathogen detections (3,000-4,000 per year). In addition, all of the epizootics, with the exception of bacterial kidney disease (BKD) and infectious hematopoietic necrosis virus (IHNV), are curable using treatments approved for use in fish culture such as formalin, hydrogen peroxide, and various antibiotics. Table 98 describes the pathogens with the associated diseases they cause.

Table 96. Pathogens detected at facilities producing fish funded by the Mitchell Act (Data for 2021-2023).

Pathogen Group	Pathogen	Detection ('+' indicates detection, '-' not detected)											
		ODFW			WDFW			USFWS			Yakama Nation		
		2021	2022	2023	2021	2022	2023	2021	2022	2023	2021	2022	2023
External Parasite	*Ichthyobodo* sp.	+	+	+	+	+	+	-	-	+	+	-	-
	Trichodinids	+	+	+	+	+	+	-	-	-	-	-	-
	Gyrodactylus sp.	+	+	+	+	-	-	-	-	-	-	-	-
	Ichthyophthirius multifiliis	+	+	+	+	+	+	-	-	-	-	-	-
	Nanophyetus sp.	+	+	-	+	-	+	-	-	-	-	-	-
	Sanguinicola sp.	+	+	-	-	-	+	-	-	-	-	-	-
	Copepods	+	+	+	-	-	-	+	+	+	+	+	+
Bacteria	*Renibacterium salmoninarum*	+	+	+	-	-	+	+	+	+	+	+	+
	Aeromonas salmonicida	+	+	+	+	+	-	-	-	-	-	-	-
	Flavobacterium psychrophilum	+	+	+	+	+	+	+	+	+	+	+	+
	Flavobacterium columnare	+	+	+	+	+	+	-	-	-	-	-	-
	Flavobacterium sp.	+	+	+	+	+	+	-	-	-	-	-	-
	Yersinia ruckeri	-	-	-	-	-	-	-	-	-	-	-	-
	Aeromonas sp./ *Pseudomonas* sp.	+	+	+	-	-	+	-	-	-	-	-	-
Virus	*Infectious Hematopoietic Necrosis Virus (IHNV)*	-	+	-	-	-	-	-	-	-	-	-	-
Fungus	*Various species*	+	+	+	+	+	+	+	+	+	+	+	+
Internal Parasite	*Ceratonova shasta*	+	+	+	-	-	-	+	+	+	+	+	+
	Myxobolus cerebralis	-	-	-	-	-	-	-	-	-	-	-	-
	Spironucleus	+	+	+	-	-	-	-	-	-	-	-	-
	Nanophyetus sp.	+	+	+	-	-	-	-	-	-	-	-	-
	Sanguinicola sp.	+	+	+	-	-	-	-	-	-	-	-	-

Table 97. Frequency of pathogen related epizootics at facilities producing fish funded by the Mitchell Act (Data for 2021-2023)

Pathogen Causing Epizootic		Number of Epizootics											
		ODFW			WDFW			USFWS			Yakama Nation		
		2021	2022	2023	2021	2022	2023	2021	2022	2023	2021	2022	2023
	Ichthyobodo sp.	3	2	1	1	3	5	-	-	-	-	-	-

Pathogen Causing Epizootic		Number of Epizootics											
		ODFW			WDFW			USFWS			Yakama Nation		
		2021	2022	2023	2021	2022	2023	2021	2022	2023	2021	2022	2023
External Parasite	Trichodinids	-	-	-	2	1	2	-	-	-	-	-	-
	Gyrodactylus sp.	-	-	-	2	-	-	-	-	-	-	-	-
	Ichthyophthirius multifiliis	4	4	-	3	4	4	-	-	-	-	-	-
	Nanophyetus sp.	-	1	3	1	-	2	-	-	-	-	-	-
	Sanguinicola sp.	3	2	-	-	-	1	-	-	-	-	-	-
	Copepods	-	-	-	-	-	-	-	-	-	-	-	-
Bacteria	*Renibacterium salmoninarum*	-	-	-	-	-	1	-	1	-	1	2	-
	Aeromonas salmonicida	15	10	15	-	4	-	-	–	-	-	-	-
	Flavobacterium psychrophilum	16	8	16	10	9	11	-	1	-	-	-	-
	Flavobacterium columnare	12	11	7	8	4	8	-	-	-	-	-	-
	Flavobacterium sp.	4	1	1	1	2	4	-	-	-	-	-	-
	Yersinia ruckeri	-	-	-	-	-	-	-	-	-	-	-	-
	Aeromonas sp./ *Pseudomonas* sp.	-	-	1	-	-	2	-	-	-	-	-	-
Virus	*Infectious Hematopoietic Necrosis Virus (IHNV)*	-	-	-	-	-	-	-	-	-	-	-	-
Fungus	*Various species*	-	-	-	2	1	3	-	-	-	-	-	-
Internal Parasite	*Ceratonova shasta*	2	2	1	-	-	-	-	-	-	-	-	-
	Myxobolus cerebralis	-	-	-	-	-	-	-	-	-	-	-	-
	Tetracapsuloides bryosalmonae	-	-	-	2	1	1	-	-	-	-	-	-
	Spironucleus	1	1	1	-	-	-	-	-	-	-	-	-
	Nanophyetus sp.		1	3	-	-	-	-	-	-	-	-	-
	Sanguinicola sp.	3	2		-	-	-	-	-	-	-	-	-

Table 98. Glossary of pathogens with the names of associated diseases.

Pathogen	Associated Disease or Other Common Name
Ichthyobodo sp.	Ichthyobodo, Costia
Trichodinids	Trichodina
Gyrodactylus sp.	Gyrodactylus
Ichthyophthirius multifiliis	Ich, White Spot Disease
Nanophyetus sp.	Nanophyetus

Sanguinicola sp.	Sanguinicola, blood fluke
Copepods	Copepods
Renibacterium salmoninarum	Bacterial kidney disease, BKD
Aeromonas salmonicida	Furunculosis
Flavobacterium psychrophilum	Cold water disease, CWD
Flavobacterium columnare	Columnaris
Flavobacterium sp.	Bacterial gill disease
Yersinia ruckeri	Enteric Red Mouth, ERM
Aeromonas sp./ *Pseudomonas* sp.	Aeromonas/ Pseudomonas Septicemia, bacterial septicemia, gram negative septicemia, APS
Infectious Hematopoietic Necrosis Virus (IHNV)	IHNV
Fungus	Fungus, *Saprolegnia*, *Phoma herbarium*
Ceratonova shasta	Ceratomyxosis
Myxobolus cerebralis	Whirling Disease
Tetracapsuloides bryosalmonae	Proliferative Kidney Disease, PKD
Spironucleus sp	Spironucleus, Hexamita

The low frequency of epizootics from native pathogens, in combination with frequent monitoring and treatment options under current fish health policies suggest that the amplification of pathogens during rearing of fish in hatcheries on natural-origin salmon and steelhead is likely indiscernible from natural pathogen levels in the natural environment. During an epizootic, hatchery fish can shed pathogen into the hatchery effluent and ultimately, the environment, amplifying pathogen numbers. However, few, if any, examples of hatcheries contributing to an increase in disease in natural populations have been reported (Steward and Bjornn 1990); (Naish et al. 2007).

In the future, migration from out-of-area-stocks (e.g., Rogue River) to native stock for propagation will also reduce disease risk. This is because native salmon and steelhead may already have some level of tolerance or resistance to endemic pathogens that non-native fish do not possess (Atkinson and Bartholomew 2010). Thus, non-native fish may be more likely to amplify pathogen levels than native fish because fewer pathogens are required to cause the disease (Hallett et al. 2012). Currently, there is no evidence showing that hatchery programs meaningfully elevate pathogen risks beyond baseline levels (i.e., that are present naturally from natural-origin fish). During site-specific consultations, NMFS evaluates whether safeguards proposed by hatchery operators are sufficient for minimizing disease risk to natural populations.

2.5.2.3.2.3 Competition and Predation in the Pacific Ocean

Hatchery fish produced as a result of the Proposed Action are expected to distribute across a broad area of the Pacific Ocean, as described in Section 2.3, Action Area. Based on this distribution, we expect that competition and predation in marine areas may affect ESA-listed salmon and steelhead from the following Recovery Domains and ESUs/DPSs:

- Willamette/LCR: all salmon ESUs and steelhead DPSs
- Interior Columbia River: all salmon ESUs and steelhead DPSs
- Puget Sound Chinook Salmon
- North Central California Coast: California Coastal Chinook Salmon
- Central Valley: Central Valley Spring-Run Chinook Salmon

Salmon and steelhead from Recovery Domains or ESUs/DPSs not listed above are not expected to occur in the Action Area or are not expected to experience adverse effects.

The analysis of competition and predation in the ocean is presented below in four subsections, as follows:

- Subsection 2.5.2.3.2.3.1, Ocean Distribution of Mitchell Act Salmon and Steelhead. The anticipated ocean distribution and abundance of Mitchell Act fish is described.

- Subsection 2.5.2.3.2.3.2, Evidence for Competition in the Pacific Ocean. General evidence for salmonid forage resource limitation and competition is described in the Pacific Ocean.

- Subsection 2.5.2.3.2.3.3, Evidence for Predation in the Pacific Ocean. Evidence for predation on salmonids by other salmon in the Pacific Ocean is described.

- Subsection 2.5.2.3.2.3.4, The information and evidence described in the preceding subsections is applied to assess risk of the Mitchell Act program to fish from ESA-listed ESUs and DPSs, by Recovery Domain, likely to occur in the Pacific Ocean portion of the Action Area.

2.5.2.3.2.3.1 Ocean Distribution Of Mitchell Act Salmon And Steelhead

Mitchell Act funding may be used to produce juvenile hatchery Chinook, coho, and chum salmon and steelhead. Each of these species behaves differently as they enter the Pacific Ocean from the Columbia River, as described in this subsection.

2.5.2.3.2.3.1.1 Chinook salmon

Mitchell Act funding is proposed to produce various life history types of juvenile Chinook salmon, including spring-run (Upper Columbia, Lower Columbia, and Willamette River) and fall-run (tules and brights) fish. Upon entering the ocean in spring, yearling (typically spring-run) Columbia River Chinook salmon distribute broadly along the continental shelf and are found primarily in areas near the Columbia River mouth northward into southeast Alaska during summer (June through July or August) (Trudel et al. 2009); (Tucker et al. 2011); (Tucker et al. 2012); (Fisher et al. 2014). Subyearling outmigrants (typically fall-run) do not distribute as far north (Trudel et al. 2009);(Tucker et al. 2011). Of the two primary Columbia River fall-run ecotypes—tules and brights—both remain relatively near the Columbia River mouth through September, though tules have a more northerly distribution that extends north from the mouth along the Washington coast (Fisher et al. 2014); (Teel 2004). Brights, on the other hand, have a more southerly distribution that extends south along the northern Oregon coast (generally north of Heceta Head), though some distribute northward along the Washington coast as well. Columbia River juvenile Chinook salmon, including hatchery-origin fish, occur as far south as southern Oregon and northern California, where they have been observed by early summer (June–July) (Brodeur et al. 2004); (Trudel et al. 2009); (Fisher et al. 2014); (Hassrick et al. 2016).

Juvenile Columbia River Chinook salmon in general comprise the substantial majority (greater than about 80–90%) of juvenile Chinook salmon from northern Oregon (north of about Heceta Head) to southeast Alaska during the summer (Tucker et al. 2011); (Tucker et al. 2012); (Teel et al. 2015); (Hassrick et al. 2016); (Van Doornik et al. 2019). The precise distribution of juvenile Columbia River Chinook salmon to other areas is not well known, but appears to be very small. In southern areas (southern Oregon and northern California), juvenile surveys along the coast find very few Columbia River Chinook salmon (Brodeur et al. 2004); (Trudel et al. 2009); (Fisher et al. 2014); (Hassrick et al. 2016). Columbia River Chinook salmon were so rarely encountered in southern Oregon and northern California juvenile surveys during June–July, 2010–2012, that Hassrick et al. (2016) omitted them from their model of stock-specific juvenile Chinook salmon distribution in this area. Modeling of Columbia River subadult and adult Chinook salmon ocean distribution shows a similar pattern (Figure 68), though first ocean-year juvenile distribution and contribution to abundance in southern Oregon and northern California is likely less than that indicated for subadults and adults because, with the exception of fish from the “far north” migrating Upper Columbia stocks, juveniles are known to remain closer to the Columbia River mouth during their first ocean year (Trudel et al. 2009).

In Puget Sound and the Strait of Juan de Fuca, juvenile survey data collected during July–September, 2002–2022, and reported in RMIS show that 908 CWT-present Chinook salmon were sampled, only 1 of which, or 0.1%, was from the Columbia River. Though field collection of these data was not necessarily intended to be representative of the entire area, many of the fish were collected in the Strait of Juan de Fuca (219 fish) and northern Puget Sound (494 fish), areas where fish from outside the Salish Sea might be expected to be more prevalent compared to other farther-away areas such as southern Puget Sound. A systematic 2003 survey for juvenile Chinook salmon in Puget Sound pelagic habitats (Rice et al. 2011) found no Columbia River fish. In their review of CWT recoveries from juvenile salmon surveys in the Strait of Juan de Fuca during 3–4 years of sampling in the early 2000s, Fisher et al. (2014) found a small number (5) of juvenile Chinook salmon from stocks proposed to be propagated as part of the Proposed Action (LCR spring, Upper Willamette spring), amounting to a very small catch per unit effort compared to other areas. Based on this very small number of observations, we conclude that most Columbia River Chinook salmon that contribute to subadult and adult abundance in the Salish Sea (Figure 68) likely move into this area after their first ocean year.

By winter (February–March), juvenile “far north” migrating Upper Columbia spring Chinook salmon have moved off the continental shelf into the open ocean (Trudel et al. 2009); (Shelton 2024b). Fish from other Columbia River Chinook salmon stocks, which comprise the majority (85%) of proposed Mitchell Act-funded production, appear to generally remain on the shelf and exhibit a slight northward shift in distribution from the first ocean year to the second. For example, Trudel et al. (2009) found that Columbia River fall Chinook salmon that entered the sea as subyearlings were primarily recovered along the northern Oregon and Washington coast during their first year at sea, but along the Washington coast and the west coast of Vancouver Island during their second year at sea.

As subadults and adults, Columbia River Chinook salmon are found primarily from northern Oregon through southeast Alaska, based on CWT and genetic stock identification evaluations (Quinn 2018); (Riddell et al. 2018), and references therein; (Shelton et al. 2019); (Shelton et al. 2021). There are some exceptions, the most notable of which are fish from the “far-north” migrating stocks (such as Upper Columbia spring Chinook salmon) mentioned above which are not believed to remain on the shelf, but rather move into the open ocean (Shelton 2024b). Figure 68 shows modeled distribution of subadult and adult Mitchell Act-funded Chinook salmon and their contribution to abundance in coastal marine areas from California to southeast Alaska. The distribution estimates (Figure 68, top panel) were derived from data presented in Shelton et al. (2019), as updated in 2024 (Shelton 2024a). The contribution to abundance estimates (Figure 68, bottom panel) are from FRAM-Shelton modeling (Appendix B). Relative to the current Mitchell Act program (NMFS 2017e), the Proposed Action represents a minor increase in the total hatchery release goal (all programs combined) and minor changes in the proportional distribution of release numbers across stocks. As shown in Figure 68, these changes will not substantively affect the distribution of Mitchell Act funded Chinook salmon in continental shelf areas, nor their contribution to total Chinook salmon abundance in these areas.

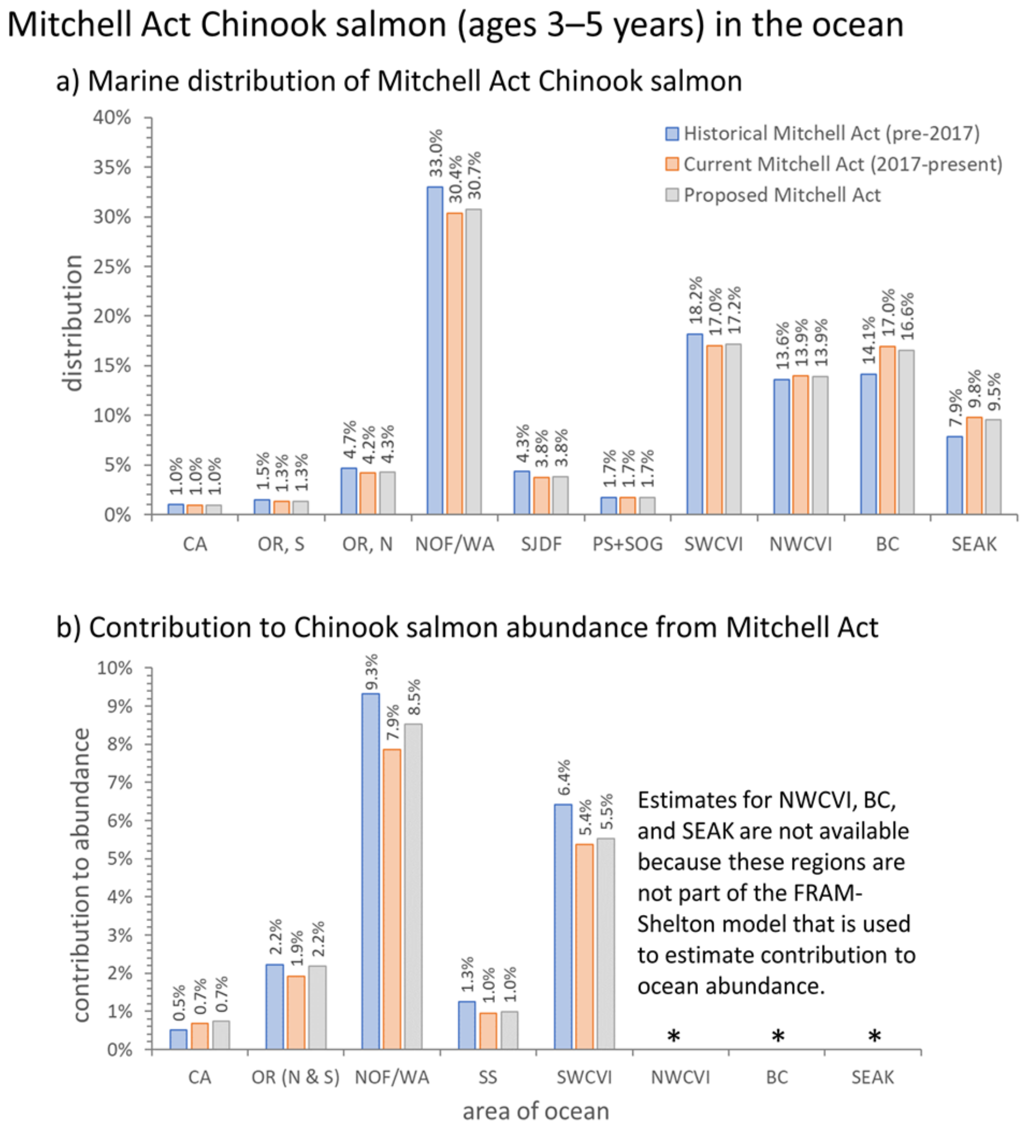

Figure 68. Mitchell Act-funded hatchery Chinook salmon (ages 3–5 years) in the ocean under three production scenarios: historical (prior to the 2017 Biological Opinion); current (2017–present); and proposed (this consultation). Panel a shows the approximated marine distribution of Mitchell Act-funded fish (see text for methods). Panel b shows the proportional contribution of Mitchell Act-funded fish to overall Chinook salmon (hatchery- and natural-origin) abundance (Appendix B). Ocean area abbreviations are as shown in Figure 63 (in Section 2.3, Action Area). PS+SOG = Puget Sound and Strait of Georgia; SJDF = Strait of Juan de Fuca; SS = Salish Sea (PS+SOG and SJDF combined).

2.5.2.3.2.3.1.2 Chum salmon

Oceanic migration and dispersal patterns for juvenile CR chum salmon are not well known. As subyearlings, these fish likely begin exiting estuary habitat and entering the Pacific Ocean by May (Weitkamp, Bentley, and Litz 2012); (Urawa et al. 2018); (Weitkamp, Bentley, and Litz 2012). In general, juvenile chum salmon are believed to remain primarily on the continental shelf (or in inner areas such as the Salish Sea for Salish Sea-origin fish) at least until August when they begin moving more offshore into the open ocean, though juvenile chum salmon may still be found on the continental shelf into November and possibly through the winter (Johnson et al. 1997); (Fisher et al. 2007); (Urawa et al. 2018) It is uncertain where along the continental shelf CR chum salmon, or chum salmon from Washington and Oregon in general, move to the open ocean; that is, some may move to the open ocean near to their area of origin, while others may move northward prior to entering the open ocean (Johnson et al. 1997).

2.5.2.3.2.3.1.3 Coho salmon

Juvenile Columbia River coho salmon enter the ocean primarily as yearlings from mid-April through early June, typically peaking in May (Morris et al. 2007); (Weitkamp, Bentley, and Litz 2012); (Fisher et al. 2014). They exhibit two broad migratory behaviors upon entering the ocean: 1) a fast-migrating component that moves rapidly north over the continental shelf to southeast Alaska and beyond as early as June; and, 2) a slow component that remains on the continental shelf relatively near the Columbia River mouth and north to the west coast of Vancouver Island. Both components appear to remain on the shelf at least until November or December (Morris et al. 2007); (Beacham et al. 2016), and by winter (February–March) have moved to the open ocean (Morris et al. 2007); (Beamish, Neville, and Radchenko 2022). After moving to the open ocean, early fall-run (type S) fish distribute primarily south of the Columbia River as far northern California, and late fall-run (type N) fish distribute primarily north of the Columbia River through British Columbia.

2.5.2.3.2.3.1.4 Steelhead

Juvenile Columbia River basin steelhead enter the ocean from mid-April through early June, typically peaking in May (Weitkamp, Bentley, and Litz 2012); (Weitkamp et al. 2022). They migrate rapidly from the river mouth, across the continental shelf, to the open ocean. Daly et al. (2014) determined that Columbia River steelhead reach the open ocean at the western edge of the continental shelf in about 10 days based on 13–14 years of sampling along the Washington and northern Oregon coast, including the Columbia River plume. Steelhead generally remain in open ocean waters until they mature and migrate back across the shelf as adults, seemingly making an equally rapid transit across the shelf to the mouth of the Columbia River, as evidenced by their very rare capture in continental shelf fisheries (NMFS 2001a); (NMFS 2018d).

2.5.2.3.2.3.2 Evidence For Competition In Marine Areas

The main limiting resource for salmon and steelhead in ocean habitats that could be affected through competition posed by hatchery-origin fish is food. Researchers have looked for evidence that marine carrying capacity—the number of organisms an ecosystem can support (Chapman and Byron 2018)—can limit salmonid survival (e.g., (Beamish, Mahnken, and Neville 1997);

(HSRG 2004); (Ruggerone et al. 2023); (Beamish 2018a). That is, researchers have looked for density-dependent effects, used here to imply negative effects to fish growth and survival because there is not enough food to support the number of individuals present (Grossman and Simon 2020). Some evidence suggests density-dependence in the abundance of returning adult salmonids associated with cyclic ocean productivity and competitor abundance (Ruggerone et al. 2023); (Beamish 2018a). Collectively, studies indicate that competition for limited food resources in the marine environment may affect survival (also see (Brodeur, Myers, and Helle 2003). The possibility that large-scale hatchery production could exacerbate density dependent effects in the ocean, particularly when ocean productivity is low and/or when abundance of other competitors is high, deserves consideration. For example, Puget Sound origin salmon survival may be intermittently limited by competition with almost entirely natural-origin odd-year pink salmon originating from Puget Sound and the Fraser River watersheds (Ruggerone and Goetz 2004), particularly when ocean productivity is low (Nickelson 1986); (Beamish 1993); (Beamish, Mahnken, and Neville 1997); (Mahnken et al. 1998).

The degree to which food is limiting depends upon the density of both predator and prey species. Importantly, these factors vary across the ocean at different spatial and temporal scales, and any observed competition in one area of the ocean does not necessarily mean that there is similar competition in another (Beamish 2018a). For example, regional differences likely explain why researchers in some oceanic regions (western Bering Sea and western North Pacific Ocean) have found that the oceanic salmonid prey base is plentiful, but researchers in other regions of the ocean (closer to Alaska) show evidence of the opposite (i.e., negative competitive effects) (Ruggerone et al. 2023). Thus, in evaluating the possible effects of hatchery fish on ESA-listed natural-origin fish, it is imperative to consider the ecological context in the spatial areas where those fish overlap. Evidence for competition in marine areas, and the potential role of hatchery fish from the Proposed Action, is described below.

2.5.2.3.2.3.2.1 <u>Continental Shelf</u>

Ecological interactions from the Proposed Action may occur on the continental shelf, where hatchery-origin and ESA-listed natural-origin juveniles of all species except steelhead rear for at least several months. The early marine life stage that extends through the first summer at sea is a critical life history period during which limited food resources can have a large effect on growth and survival (Beamish and Mahnken 2001); (Duffy 2009); (Beamish 2018a). On the shelf, juvenile hatchery fish from the Proposed Action will primarily occur from Heceta Head, Oregon in the south to Yakutat Bay, Alaska in the north, as described above. Interactions with ESA-listed salmonids may thus occur in these areas. Along the North American continental shelf, there is some limited, and in some cases equivocal, evidence of competition and negative density-dependent interactions occurring within some groups or populations of Chinook (Riddell et al. 2018), coho (Beamish 2018a), and chum (Anderson et al. 2021) salmon. This evidence is described in the following paragraphs.

Competitive effects to salmonids in marine environments are largely indirect in nature (i.e., indirect competition) (Beamish 2018a). Such competitive effects may occur via two general pathways: 1) prey resource depletion, whereby competitors that eat the same prey types in the same areas at the same times deplete the pool of prey resources; or, 2) a "trophic cascade," whereby species that forage at lower trophic levels (e.g., plankton) consume so much food that productivity and abundance of species at higher trophic levels (e.g., forage fish) becomes limited. Hatchery Chinook or coho salmon may contribute to prey resource depletion but not to a trophic cascade because Chinook and coho salmon generally forage at higher trophic levels than other salmon species. With prey resource depletion, the degree of competitive effects to natural-origin ESA-listed species is dictated by the amount of prey that hatchery salmon consume relative to the total amount of prey available. For example, under a hypothetical condition of resource limitation (low forage abundance and/or high competitor abundance), if hatchery salmon consume 1% of all available prey, the effect to natural-origin ESA-listed salmonids is correspondingly small.

Throughout the southern part of the Action Area (west coast of Vancouver Island and south), the abundance of juvenile salmon during the early marine critical period is relatively low compared to other potential competitors. Orsi et al. (2007) observed that juvenile salmon (all species and origins combined) made up only 1.8–2.1% of epipelagic fish abundance during May–October, 2000–2004, in coastal areas from California to Vancouver Island. Pacific herring, Pacific sardines, and northern anchovies made up the substantial majority of the catch. These species may compete with juvenile salmon during their early marine residence (e.g., (Sturdevant, Orsi, and Fergusson 2012), but may provide a forage resource as the salmon grow larger. Northward from Vancouver Island, juvenile salmon become more prevalent. For example, though Orsi et al. (2007) did not sample between Vancouver Island and the very northern extent of southeast Alaska, their sampling along coastal areas of the Gulf of Alaska found that juvenile salmon (all species and origins combined) made up 35–50% of epipelagic fish abundance, the majority of which was pink salmon (55% of salmon). Chinook, coho, and chum salmon comprised < 0.1%, 3.9%, and 7.8% of the catch, respectively. Sampling in northern southeast Alaska has yielded similar results, though species other than salmon are occasionally found in very high relative abundances at some times and places (Orsi et al. 2011); (Orsi et al. 2012); (Fergusson, Sturdevant, and Orsi 2013); (Fisher et al. 2014); (Orsi and Fergusson 2015); (Orsi and Fergusson 2016); (Fergusson et al. 2018). These observations suggest that competitive interactions throughout the Action Area are likely to be driven by species other than those from the Proposed Action.

Early studies suggested that juvenile Chinook and coho salmon along the Washington and Oregon coast were not food-limited during their early marine residence (Peterson, Brodeur, and Pearcy 1982); (Brodeur 1990a), cited in (Brodeur 1992); (Brodeur 1992). These studies occurred during times when Columbia River Chinook salmon releases were at their peak. However, Daly, Brodeur, and Weitkamp (2009) found that the percent of empty stomachs in both juvenile Chinook and coho salmon along the Oregon and Washington coast increased by 63% and 69%, respectively, from the 1980s to the early 2000s, despite 25% fewer Columbia River hatchery Chinook salmon being released during the latter time period. The authors noted that oceanographic conditions changed during this time, affecting the fish community and potentially the quantity of food available. Thus, changing ocean conditions may have triggered forage limitations and induced competitive effects that previously did not exist or were more minor.

Brodeur et al. (2007) evaluated juvenile salmon feeding patterns (stomach contents) in coastal waters from northern California to the western Gulf of Alaska during April–November, 2000–2002. For Chinook and coho salmon, there were proportionally more empty stomachs along the Oregon and Washington coast (about 5–15% of sampled fish), than in more northerly areas (about 0–3% of sampled fish). With some exceptions, feeding intensity (prey consumed as a percent of predator body weight) was also lower for both species along the Oregon and Washington coast. These findings suggest that competition may have been more intense along the Oregon and Washington coast during the few years studied, although feeding intensity may not be correlated with prey availability (e.g., (Brodeur 1990a), cited in (Brodeur 1990b); (Brodeur 1990b).

Fisher et al. (2007) evaluated regional variation in summer marine growth (millimeters per day) of juvenile coho salmon and subyearling and yearling Chinook salmon along the North American west coast during 2002–2004. There were no apparent differences in growth of subyearling Chinook salmon (about 0.7–1.0 mm/day) along the Washington-Oregon coast in comparison to the other regions sampled. Coho salmon growth along the Washington-Oregon coast (1.2–1.3 mm/day) was slightly lower than in southeast Alaska (about 1.3–1.4 mm/day). Similarly, yearling Chinook salmon growth was lower along the Washington-Oregon coast (about 0.7–0.9 mm/day) than in southeast Alaska (about 1.0–1.3 mm/day). The authors speculated that the lower growth along the Washington-Oregon coast was likely due in part to more intense interspecific competition here relative to the more northern areas (e.g., southeast Alaska) citing Orsi et al. (2007) and Brodeur et al. (2007).

Daly et al. (2012) evaluated early marine characteristics of hatchery- and natural-origin juvenile Chinook salmon yearling outmigrants from five Columbia River spring Chinook populations during May and June across 11 years (1999–2009) along the Washington and northern Oregon coast. The authors found extensive spatial and dietary overlap between the hatchery- and natural-origin fish. Each group of fish had similar feeding intensities and growth rates, despite the natural-origin fish being consistently smaller, suggesting that neither group was outcompeting the other. Growth rates (IGF-1) were sampled in May (4 years) and June (2 years). For May, the two years with the highest growth (2007 and 2008) had the highest catch per unit effort (CPUE), suggesting that ocean conditions or other variables were more important than intraspecific competition in determining fish growth. Similar results were apparent in June. The two low-growth years (2006 and 2007) corresponded with low adult returns two years later. Feeding intensity was comparable across years, indicating that feeding intensity had no bearing on growth or survival.

Miller et al. (2013) evaluated survival (smolt-to-adult return ratio [SAR]) of UCR summer-fall Chinook salmon subyearling outmigrants during an 11-year time series (outmigration years 1998–2008). Variables that were evaluated for their effect on survival included river and ocean environmental conditions, and fish size, condition (length-weight relationship), growth, and abundance during early ocean residence (June and September) along the Washington and Oregon coast. Unexpectedly, the authors found that survival was negatively related to September juvenile condition indices, and that these condition indices were the best individual predictors of survival. That is, years with smaller, slower-growing, “poorer” condition fish in September had better survival than years with larger, faster-growing, and better condition September fish. Similar results were observed along the California coast for Central Valley fall Chinook salmon (Sabal et al. 2016). No density-dependent response was observed in juvenile attributes (length, weight, condition factor, growth), which the authors thought may have been due to the absence of intraspecific competition or inadequate spatial coverage of ocean sampling (Miller et al. 2013). Nonetheless, competition or size-selective mortality could have led to the findings of smaller yet better surviving fish during years of more productive ocean conditions (Miller et al. 2013); (Sabal et al. 2016).

Daly, Brodeur, and Weitkamp (2009) noted a near doubling in the percentage of empty Chinook and coho salmon stomachs along the Oregon and Washington coast from the 1980s (observed by (Brodeur 1992) to the late 1990s and early 2000s. The authors suggest that changes in oceanographic conditions and the pelagic nekton community were likely responsible. This suggests that forage resources were more limiting and competition more intense in more recent years. However, in a review of existing literature, Beamish (2018a) concluded that "compelling evidence for density dependence for Coho Salmon in marine environments along the Washington and Oregon coasts is currently lacking." Studies indicate a greater likelihood of density dependence in Chinook salmon along the coast, as described above and by Riddell et al. Riddell et al. (2018). The evidence for density dependence in Chinook salmon in the Action Area is limited to the juvenile life history stage. We are not aware of any data or information indicating density dependence at subadult or adult life history stages.

Buckner et al. (2023) evaluated the effects of climate and oceanographic variables and pink salmon abundance on growth to adult stage (length-at-age) of 48 hatchery Chinook salmon stocks from the Columbia River Basin, coastal Washington and Oregon, and Puget Sound. They found a negative correlation between Chinook salmon growth and North American pink salmon abundance for Chinook stocks that have a more northerly distribution (north of Vancouver Island), which makes sense because pink salmon are much more abundant in northern areas (e.g., (Orsi et al. 2007). Spawning populations of pink salmon do not occur along the Washington coast, in the Columbia River, or in areas to the south (Carroll et al. 1996). Pink salmon are therefore relatively rare in Washington and Oregon coastal waters (Fisher et al. 2007). This likely at least partially explains why Ruggerone and Goetz (2004) did not observe any odd-even year patterns in survival of Chinook salmon populations that spawn in Washington coastal rivers. Thus, to the extent that pink salmon are a primary driver of marine food web interactions, these effects are extremely minor, if nonexistent, along the Washington and Oregon coast.

Chum salmon have been found to contribute to negative density dependence in some areas (Cunningham, Westley, and Adkison 2018); (Urawa et al. 2018); (Anderson et al. 2021). Cunningham et al. (2018) found that Japanese hatchery chum salmon abundance had a notably larger and more supported effect on Yukon River Chinook salmon than pink salmon. Japanese hatchery chum salmon typically make up about 30% of all salmon hatchery releases into the Pacific Ocean, and would not affect fish from the continental United States. Anderson et al. (2021) observed negative correlations between chum salmon's first ocean year growth across 16 brood years (1997–2012), two separate salmon abundance indices (one for Puget Sound chum salmon and one for Puget Sound pink salmon), and an indicator of ocean conditions (copepod species richness along the Pacific Northwest coast). Though the authors don't assert this, the observed negative density dependence likely occurred within the Salish Sea (i.e., not in coastal areas where CR chum salmon occur) given that both Puget Sound chum and pink salmon rear in the Salish Sea through the summer (Orsi et al. 2007); (Greene et al. 2023) when most first ocean year growth occurs and density-dependent growth effects are most likely to occur. Juveniles of both chum and pink salmon are many times more dense and abundant in the Salish Sea than in coastal areas (Orsi et al. 2007), and abundance in coastal areas north of Washington is much greater than that to the south (Fisher et al. 2007); (Weitkamp, Bentley, and Litz 2012), reflecting: 1) the small chum populations and limited chum hatchery production along the Washington and Oregon coasts and the Columbia River, compared to the much larger Salish Sea populations (Figure 68); and, 2) the near absence of pink salmon spawning and absence of pink salmon hatchery production along the Washington and Oregon coasts and within the Columbia River, compared to the large Salish Sea spawning populations (pink salmon hatchery production is minimal in Puget Sound) (Figure 69)(Carroll et al. 1996); (Radchenko et al. 2018). Because of these differences between the Salish Sea and areas near the Columbia River mouth and along the Washington coast, the findings of Anderson et al. (2021) for density-dependence within Puget Sound chum salmon cannot be assumed for CR chum salmon.

Juvenile chum salmon abundance in general is relatively low along the northern Oregon and Washington coasts compared to more northerly areas (Fisher et al. 2007); (Weitkamp, Bentley, and Litz 2012). This is because chum salmon spawning populations in the southern areas (Washington and Oregon coasts, including the Columbia River) are at the very southern edge of the species range and are substantially smaller than those in Puget Sound and areas north. Hatchery production is also less in the southern areas (Ruggerone and Irvine 2018). Orsi et al. (2007) found that juvenile chum salmon comprised a very small proportion (< 0.5%) of the epipelagic fish community in southern areas, despite including some large natural chum salmon production areas (Puget Sound and southwest British Columbia). To estimate the approximate contribution of the Proposed Action to overall juvenile chum salmon abundance in this area, we used approximate ratios of natural to hatchery chum salmon for return years 1990–2015 (Ruggerone and Irvine 2018), and hatchery production corresponding with the same return years from RMIS (accessed October 18, 2024) (brood years 1986–2011). Based on these data, the Proposed Action will comprise approximately 0.1% of all natural and hatchery juvenile chum salmon production across this area (northwest United States and southwest British Columbia), and even less when production feeding the northern part of the Action Area is considered. Thus, if chum salmon from the Proposed Action will comprise no more than 0.1% of all juvenile chum salmon in the area, and juvenile chum salmon in general comprise < 0.5% of the epipelagic fish community (Orsi et al. 2007), then chum salmon from the Proposed Action will comprise < 0.05% of the epipelagic fish community. Such a small relative abundance of fish is unlikely to present any degree of risk to listed species.

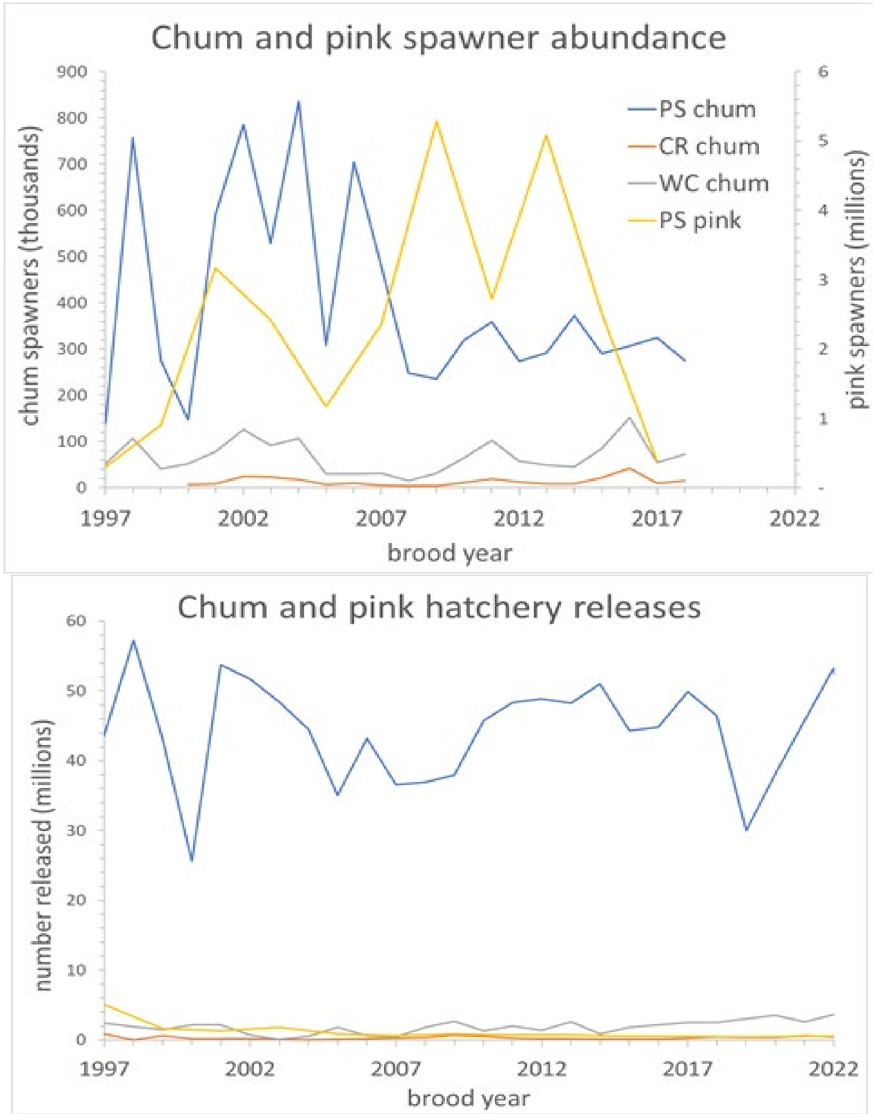

Figure 69. Chum and pink salmon in the Columbia River, Washington coast, and Puget Sound. Upper panel shows spawner abundance for BYs 1997–2018 (data for later BYs were not available for many populations); note difference in y-axis scale between chum and pink salmon. Lower panel shows hatchery release abundances for BYs 1997–2022. CR = Columbia River; PS = Puget Sound; WC = Washington coast. Spawner abundance data sources: WDFW SCORE website (https://fortress.wa.gov/dfw/score/score/) and NMFS SPS website (https://www.webapps.nwfsc.noaa.gov/apex/f?p=261:HOME). Hatchery release data source: RMIS (https://www.rmpc.org/). All data accessed October 18–23, 2024.

The above evidence suggests that competition likely occurs at some times and places along the continental shelf. To the extent that competition does occur, hatchery fish abundance does not appear to be a primary driver. Rather, ocean conditions and abundance of other competitors—primarily pink salmon in northern areas and non-salmonid species in southern areas—are likely the dominant factors influencing forage availability and competitive effects. In years when these dominant competitors are particularly abundant and/or when ocean conditions are unfavorable, forage resources may become limited. Though it is possible that this may trigger negative density-dependent interactions among salmon species that utilize similar habitats and forage resources, effects are likely small relative to those from pink salmon in northern areas and non-salmonid species in southern areas. There is no direct evidence that competition from hatchery salmon has any more than a small effect (both in absolute terms and relative to those from other competitors) to natural salmon in these areas. To the extent that such effects occur, available data are insufficient to be able to predict precisely where such areas may occur, other than that they may occur at some level within certain broad geographic regions.

Available knowledge and research abilities are insufficient, at the present time, to discern the precise contribution of hatchery salmon to any density-dependent interactions affecting salmon and steelhead growth and survival in marine areas. From the scientific literature described above, we conclude that the influence of density-dependent interactions on growth and survival is likely very small compared with the effects of large-scale and regional environmental conditions and abundance of natural-origin salmonid and non-salmonid competitors. The evidence described above indicates that salmonid survival and size may be reduced during years of limited food supply, but that hatchery fish are not a primary driver of nor substantial contributor to these effects. Mitchell Act program fish, particularly Chinook salmon, could exacerbate density-dependent effects in some parts of the Action Area during years of low marine productivity and/or high competitor abundance. However, there are no studies that demonstrate or suggest the magnitude of hatchery salmon smolt release numbers that might be associated with adverse changes in natural salmonid population survival rates in marine areas.

For the reasons discussed in this section, we expect competition from fish released as part of the Proposed Action to have a small effect on the survival of ESA-listed natural-origin Chinook salmon in the Action Area during years of low ocean productivity and/or high abundance of competitors other than hatchery-origin fish. During other years, we expect any competitive interactions from Mitchell Act program fish to be negligible.

2.5.2.3.2.3.2.2 Open Ocean

Ruggerone and Irvine (2018) estimated that approximately 5.5 billion hatchery salmon are released into the Pacific Ocean, and that about 40% of salmon biomass in the Pacific Ocean is made up of hatchery-origin fish. Using these estimates, Mitchell Act-funded production has contributed < 0.3% to salmon biomass in the Pacific Ocean. The proposed Mitchell Act-funded production would not substantively change this. This 0.3% figure is a very coarse approximation that does not account for all important variables, though it provides a useful indicator of the approximate degree to which the Mitchell Act-funded production has and will contribute to overall salmon abundance in the Pacific Ocean.

Open ocean ranges and distributions at the scale of populations, let alone ESUs and DPSs, are unknown (Beamish 2018a). Thus, we do not know the spatiotemporal scale at which hatchery salmon from the Proposed Action may overlap with ESA-listed salmonids in the open ocean given the vast area over which these species may range. Broadly speaking, fish originating from the continental United States are generally expected to occur primarily in the eastern North Pacific Ocean (e.g., Gulf of Alaska, California Current). Though research is limited, there is no evidence of either inter- or intra-specific ecological effects in the open ocean to any listed salmonid species from proposed Mitchell Act-funded species (hatchery-origin Chinook, chum, or coho salmon, or steelhead trout) originating from the continental United States (Beamish 2018a).

Regarding chum salmon, large abundances of hatchery- and natural-origin chum salmon in the Pacific Ocean were implicated as possibly inducing negative intra-specific density dependence from the 1970s to the 1990s (Urawa et al. 2018). However, the focus of this work was in the central north Pacific Ocean and the Bering Sea, where Asian-origin chum salmon have the predominant influence. Release abundances of hatchery-origin chum salmon from Asia were substantially larger than those from North America during this time (Ruggerone and Irvine 2018). Hatchery production contributed approximately 70% to chum salmon abundance in Asia, but only 35% in North America. Anderson et al. (2021) did not observe any indicators of negative intra-specific density dependence in Washington-origin (Puget Sound) chum salmon spanning 16 broodyears (1997–2012), a period when North American chum salmon abundances (hatchery- and natural-origin) were stable, and Asian-origin chum salmon abundances were very high (Ruggerone and Irvine 2018). No similar studies have been done for Columbia River-origin chum salmon. Nonetheless, the Anderson et al. (2021) results indicate that, at the very least, open ocean intra-specific density dependence in Washington-origin chum salmon is not occurring. The Proposed Action is unlikely to change this, as the Proposed Action would increase North American hatchery-origin chum salmon releases by less than 0.2% compared to the Anderson et al. (2021) study period.

There is evidence that pink salmon (not a species proposed to be propagated with Mitchell Act funds) may induce ecological effects to a variety of salmonid and non-salmonid species in the open ocean (e.g., (Ruggerone, Irvine, and Connors 2022); (Ruggerone et al. 2023). Such negative consequences are presumed to arise via food web interactions. That is, large numbers of pink salmon may: 1) overconsume the same prey that other salmonids rely on; and/or, 2) overconsume prey at lower trophic levels (e.g., plankton) leading to less abundances of prey at the higher levels (e.g., fish) that other salmonids, such as Chinook and coho salmon, rely on (i.e., a “trophic cascade”). NMFS concludes these effects appear unique to pink salmon for reasons that may include but not be limited to the following:

1. Pink salmon (hatchery- and natural-origin) are substantially more abundant in the open ocean than other salmonid species (Ruggerone and Irvine 2018); (Ruggerone, Irvine, and Connors 2022).

2. Pink salmon are especially voracious consumers compared to other salmonids (i.e., they have fuller stomachs, consume higher caloric prey, and have high daily rations), particularly in warmer ocean conditions (Ruggerone et al. 2023).

3. Pink salmon's biennial abundance pattern, unique among salmonids, exerts a similarly unique influence on the ecosystem (Ruggerone et al. 2023). For example, an important prey item for Pacific salmon (including pink salmon) and steelhead in the open ocean is the squid species *Berryteuthis anonychus*, which has a two-year life cycle. Pink salmon's biennial abundance pattern may act in concert with this species two-year life cycle to magnify effects of pink salmon predation.

Natural-origin pink salmon are abundant in the eastern North Pacific Ocean, though hatchery-origin pink salmon (mostly from Alaska) contributed about 22% to the total abundance of North American pink salmon abundance during 1990–2015 (Ruggerone and Irvine 2018). Possible pink salmon-induced forage resource limitations in the open ocean could conceivably mean that hatchery production of the proposed Mitchell Act-funded species would exacerbate effects to ESA-listed natural-origin fish. However, any such effects are currently hypothetical, speculative, and lack empirical evidence, though little research has been done in this area. The open ocean area over which pink salmon, ESA-listed natural-origin fish, and Mitchell Act-funded hatchery fish may range is vast. The extent to which Mitchell Act-funded species and ESA-listed natural-origin fish utilize areas of the ocean affected by pink salmon resource depletion at spatiotemporal scales sufficient to induce an effect from Mitchell Act-funded production is not known. For these reasons—the lack of evidence described in this paragraph, in combination with the very low level of proposed Mitchell Act-funded hatchery production at the scale of the Pacific Ocean—we are unable to determine that the Proposed Action will have any measurable effect on listed salmon and steelhead species in the open ocean.

2.5.2.3.2.3.3 Evidence Of Predation In The Pacific Ocean

Adult, immature, and large juvenile Chinook and coho salmon in marine waters feed heavily on fish, particularly forage fish, and are large enough to prey on younger juvenile salmonids (Beamish 2018a); (Riddell et al. 2018). However, there is substantial available information showing that predation on juvenile salmonids by Chinook and coho salmon in marine waters is rare. Many diet studies of adult, immature, and large juvenile Chinook and coho salmon in marine waters only identify specific taxa that made up more than about 1–5% of the diet (i.e., "common" prey taxa), and do not mention specific taxa that were consumed at lower levels (e.g., (Silliman 1941); (Beacham 1986); (Daly, Brodeur, and Weitkamp 2009); (Daly et al. 2012); (Brodeur, Buchanan, and Emmett 2014); (Thayer, Field, and Sydeman 2014); (Hertz et al. 2015); (Osgood et al. 2016); (Daly, Brodeur, and Auth 2017); (Hertz et al. 2017). Juvenile salmonids are not identified as common prey taxa in these studies. Of studies that have identified all consumed taxa regardless of their prevalence in the diet, the substantial majority have found no juvenile salmonids in Chinook or coho salmon stomach contents (Prakash 1962); (Brodeur, Lorz, and Pearcy 1987); (Brodeur 1990a); (Landingham, Sturdevant, and Brodeur 1998); (Hunt, Mulligan, and Komori 1999); (Kaeriyama et al. 2004); (Wainwright et al. 2008); (Chamberlin 2021); (Weitkamp et al. 2022).

Where juvenile salmonids have been consumed by Chinook or coho salmon (Reid 1961); (Fresh, Cardwell, and Koons 1981); (Wing 1985); (Duffy et al. 2010); (Sturdevant, Orsi, and Fergusson

2012); (Daly et al. 2019); (Beauchamp et al. 2020), they have been a rare component of the diet, and they have been consumed almost exclusively at times and in places where large densities of juvenile salmonids are present (i.e., in Puget Sound, near the mouth of the Columbia River, and in inside areas of southeast Alaska during early summer after large pulses of small juvenile fish have entered these areas). Outside of these areas, predation by Chinook or coho salmon on salmonids in marine waters is exceedingly rare.

As mentioned above, juvenile steelhead move rapidly across the continental shelf to the open ocean in a very short time, about 10 days. During this time, they feed on a variety of prey items, including fish, but predation on juvenile salmon appears to be rare. For example, Daly et al. (2014) found that only 2 juvenile salmonids (chum salmon, 53–55 mm TL) were consumed among 671 juvenile steelhead collected along the northern Oregon and Washington coast during May–September, 1998–2011. In a small sample of juvenile steelhead (n = 16) taken from just one year near the Columbia River mouth, Fresh et al. (1981) observed that juvenile Chinook salmon comprised 33% of the overall prey biomass, perhaps indicating a high consumption rate. However, it is likely that this consisted of a single fish because a small number of fish can make up a large proportion of the biomass. For example, in the same study, Fresh et al. (1981) found that a single herring accounted for half of the total prey biomass among 21 juvenile steelhead sampled in Puget Sound. Nonetheless, the findings of Daly et al. (2014) are more representative given the much broader spatial and temporal coverage of the study. The short amount of time that steelhead spend in coastal waters, combined with the rarity of salmonids in their diet here, suggest a low predation risk to juvenile listed salmon.

Juvenile chum salmon in coastal waters are generally too small to prey on the sizes of salmon typically present in marine habitats, and thus present no to very low predation risk.

2.5.2.3.2.3.4 Effects Of Competition And Predation In The Ocean To Listed ESUs And DPSs In The Action Area

2.5.2.3.2.3.4.1 Chinook Salmon ESUs

This subsection described effects of the Proposed Action to the following Chinook salmon ESUs:

- All Columbia River Chinook Salmon ESUs
- Puget Sound Chinook Salmon ESU
- California Coastal Chinook Salmon ESU
- Central Valley Spring-run Chinook Salmon ESU

Risk attributable to the Proposed Action from competition on all Columbia River and Puget Sound Chinook Salmon ESUs in the Pacific Ocean is low.[34] Low-level negative intraspecific density-dependent effects to Chinook salmon may occur at some times and in some places

[34] Moreover, natural-origin juveniles may also prey on hatchery-origin juveniles, which may cancel out some of these negative interactions through competition and predation.

depending primarily on ocean conditions and interspecific competitor abundance, as described above. The addition of hatchery Chinook salmon via the Mitchell Act program may have a small effect in exacerbating these effects. However, the Mitchell Act program would not be a primary driver of or substantial contributor to density-dependent competitive effects due to the much larger abundance of other salmonid and non-salmonid competitors, including other hatchery- and natural-origin Chinook salmon. Available information is insufficient to be able to quantify a relationship between hatchery Chinook salmon abundance and adverse competitive effects to natural listed Chinook salmon (e.g., identifying rates of slower growth by population, decreased survival estimates by ESU). However, NMFS has determined that the available information allows for a qualitative assessment of adverse competitive effects to listed species.

Risk from predation is negligible. Numerous diet surveys have demonstrated the extreme rarity of predation on juvenile salmonids by Chinook and coho salmon and steelhead in marine waters, particularly in coastal areas, as described above. Further, ESA-listed juvenile Chinook salmon are expected to occur in very low abundances relative to preferred prey taxa and other juvenile salmonids in the broad spatial areas where they may overlap with Mitchell Act fish. The combined risk from competition and predation to Columbia River and Puget Sound Chinook salmon in the Pacific Ocean is low because risk from competition is low and risk of predation is negligible, as described above.

Regarding the California Coastal Chinook Salmon ESU, on average, less than 16% of Chinook salmon from this ESU are likely to occur along the Washington and northern Oregon coasts, and less than 1.5% are likely to occur north of Washington (Shelton et al. 2019). Risk to this ESU from Mitchell Act-funded hatchery releases is lower than that described above for Columbia River and Puget Sound Chinook salmon given the relatively small proportion of California Coastal Chinook Salmon ESU fish expected to occur in the Action Area.

Regarding the Central Valley spring Chinook Salmon ESU, the proportion of fish from this ESU that distribute into the Action Area is inferred from CWT recoveries of fish originating from only two populations (Shelton 2024a), which are the only populations that are tagged: Feather River and Butte Creek. The Feather River population is represented by fish from the Feather River Hatchery. Feather River fish have regularly occurred throughout the Action Area, from its southern extent to northern Vancouver Island, albeit in low numbers. Butte Creek fish, on the other hand, have never been observed in the Action Area. This discrepancy could be related to the lower numbers of tagged fish released from Butte Creek: if Central Valley spring Chinook salmon are relatively rare in the Action Area, as suggested by the Feather River recoveries, it follows that many tagged fish need to be released to generate any recoveries. This appears to be an unlikely cause for the lack of Butte Creek recoveries in the Action Area, though, because even Feather River brood years represented by relatively few tagged fish (9 brood years; 41,000–314,000 tagged fish released per brood year) generated recoveries in the Action Area, often multiple recoveries per brood year. If Butte Creek exhibited a similar oceanic distribution as Feather River, the cumulative release of 1.8 million tagged Butte Creek fish should have generated at least a few recoveries in the Action Area.

A more plausible explanation lies in the ancestral origins of the Feather River fish. Ocean distribution is largely genetically programmed, and researchers have remarked on the consistency with which genetically related populations from specific geographic areas and run-timings use the same areas of the ocean year after year despite fluctuating ocean conditions (e.g., (Weitkamp 2010); (Tucker et al. 2012)). Though the ancestral origins of the Feather River Hatchery stock are not known with certainty, evidence suggests the hatchery lineage has been heavily introgressed with fall Chinook salmon (NMFS 2016f); (SWFSC 2022). Fall Chinook salmon from the Central Valley are known to use the Action Area at similar proportions and with a similar distribution as the Feather River Hatchery spring Chinook salmon (Shelton et al. 2019). Genetic studies and other evidence suggest that other Central Valley spring Chinook salmon populations, including Butte Creek, have not been affected by introgression from Feather River Hatchery fish or fall Chinook salmon (SWFSC 2022). Thus, it appears likely that Feather River Hatchery spring Chinook salmon occur in the Action Area because it is an expression of their ancestral hybridization with fall Chinook salmon. It further appears likely that Butte Creek spring Chinook salmon, unaffected by such hybridization, are more representative of the rest of the Central Valley spring Chinook salmon populations in terms of their ocean distribution. Therefore, risk to the ESU is negligible because only fish from the Feather River population are likely to be affected, and only a small proportion of fish from the Feather River population would be affected.

2.5.2.3.2.3.4.2 <u>Steelhead DPSs</u>

Risk from competition to all Interior Columbia and Willamette/Lower Columbia Recovery Domain steelhead DPSs in the Pacific Ocean, associated with the Proposed Action, is negligible. Columbia River Basin steelhead migrate rapidly from the river mouth to the outer edge of the continental shelf. Based on 13–14 years of sampling along the Washington and northern Oregon coast, including the Columbia River plume, Daly et al. (2014) determined that juvenile steelhead from the Columbia River Basin reached the western edge of the continental shelf in just a few days, and spent about 10 days in continental shelf waters before moving to open ocean areas off the shelf. Steelhead generally remain in open ocean waters until they mature and migrate back across the shelf as adults, seemingly making an equally rapid transit across the shelf to the mouth of the Columbia River, as evidenced by their very rare capture in continental shelf fisheries (NMFS 2001a); (NMFS 2018e).

Risk from predation to all steelhead DPSs in the Pacific Ocean is negligible. Numerous diet surveys have demonstrated the extreme rarity of predation on juvenile salmonids by Chinook and coho salmon and steelhead in marine waters, particularly in coastal areas, as described above. Further, ESA-listed juvenile steelhead are expected to occur in very low abundances relative to preferred prey taxa and other juvenile salmonids in the broad spatial areas where they may overlap with Mitchell Act fish.

The combined risk from competition and predation to Interior Columbia and Willamette/Lower Columbia Recovery Domain steelhead in the Pacific Ocean is negligible because risk from competition is negligible and risk of predation is negligible, as described above.

2.5.2.3.2.3.4.3 Columbia River Chum Salmon ESU

Risk from competition to Columbia River chum salmon in the Pacific Ocean is negligible. Juvenile Chinook and Coho salmon are typically found in shallower water than juvenile chum salmon during their first ocean year on the continental shelf (Fisher et al. 2007); (Beamish et al. 2018); (Riddell et al. 2018); (Urawa et al. 2018). In addition, juvenile chum salmon typically feed at a lower trophic level than juvenile Chinook and Coho salmon during this time, with the former consuming mostly zooplankton while the latter transitions to a mostly fish-based diet (Brodeur et al. 2007); (Beamish 2018b); (Riddell et al. 2018); (Urawa et al. 2018). Similar to juveniles, dietary overlap at the subadult and adult stages is minimal, with Chinook and Coho salmon continuing to feed at higher tropic levels than chum salmon (e.g., (Johnson and Schindler 2009); (Beamish 2018a); (Riddell et al. 2018); (Urawa et al. 2018).

Risk from predation is negligible. Numerous diet surveys have demonstrated the extreme rarity of predation on juvenile salmonids by Chinook and coho salmon and steelhead in marine waters, particularly in coastal areas, as described above. Further, ESA-listed juvenile chum salmon are expected to occur in very low abundances relative to preferred prey taxa and other juvenile salmonids in the broad spatial areas where they may overlap with Mitchell Act fish.

The combined risk from competition and predation to CR chum salmon in the Pacific Ocean is negligible because risk from competition is negligible and risk of predation is negligible, as described above.

2.5.2.3.2.3.4.4 Lower Columbia River Coho Salmon ESU

Risk from competition to LCR coho salmon in the Pacific Ocean is negligible. Juvenile Columbia River coho salmon disperse broadly on the continental shelf during their first ocean year, from northern Oregon to Kodiak Island, Alaska (Fisher et al. 2014), where they may overlap at broad geographic scales with Mitchell Act hatchery salmon. At a broad scale, Chinook and coho salmon utilize somewhat similar habitat and forage resources in marine areas, including along the Washington and Oregon coast. Similarities in general spatial distribution (e.g., (Bi et al. 2008) and depth selection (e.g., (Fisher et al. 2007) have been observed. Though data are limited, there is evidence that Chinook and coho salmon occur in loose aggregations or patches at large spatial scales (e.g., (Peterson et al. 2010); (Berdahl et al. 2016); (Pearcy and Fisher 1990) evaluated the distribution and abundance of juvenile salmonids along Washington and Oregon coastal areas during May–September, 1981–1985. They observed a high degree of co-occurrence of juvenile Chinook and coho salmon. That is, the two species were frequently captured in the same purse seine sets. The number of sets with both species was significantly greater than the expected number if co-occurrence was random ($p < 0.05$). Conversely, Pool et al. Pool, Reese, and Brodeur (2012) observed that juvenile Chinook and coho salmon along the Oregon coast selected different habitat types.

Studies have documented a moderate to high degree of dietary overlap between coho and Chinook salmon juveniles (e.g., (Peterson, Brodeur, and Pearcy 1982); (Brodeur 1990a); (Schabetsberger et al. 2003); (Brodeur et al. 2007); (Miller and Brodeur 2007); (Wainwright et al. 2008); (Daly, Brodeur, and Weitkamp 2009); (Brodeur, Buchanan, and Emmett 2014) and adults (e.g., (Brodeur, Lorz, and Pearcy 1987); (Brodeur, Buchanan, and Emmett 2014) along the west coast of North America, including coastal Washington and Oregon and the Columbia River plume. However, the current limited evidence is insufficient to determine that coho salmon suffer from density dependence within the oceanic portion of Action Area (Beamish 2018a). For these reasons, it is unlikely that hatchery salmon from the Proposed Action will affect the growth and survival of coho salmon within the Action Area.

Risk from predation is negligible. Numerous diet surveys have demonstrated the extreme rarity of predation on juvenile salmonids by Chinook and coho salmon and steelhead in marine waters, particularly in coastal areas, as described above. Further, ESA-listed juvenile coho salmon are expected to occur in very low abundances relative to preferred prey taxa and other juvenile salmonids in the broad spatial areas where they may overlap with Mitchell Act fish.

The combined risk from competition and predation to LCR coho salmon in the Pacific Ocean is negligible because risk from competition is negligible and risk of predation is negligible, as described above.

2.5.2.3.2.3.4.5 <u>Snake River Sockeye Salmon ESU</u>

Risk from competition to Snake River sockeye salmon in the Pacific Ocean is negligible. There is no stock-specific ocean distribution information available for Snake River sockeye salmon. Juvenile sockeye salmon stocks from Puget Sound and the Columbia River migrate north on the continental shelf during the summer (Tucker et al. 2009); (Beacham et al. 2014) where they may overlap with hatchery salmon released as part of the Proposed Action (Tucker et al. 2011);(Tucker et al. 2012). Juvenile Chinook and Coho salmon (subyearlings and yearlings) are typically found in shallower water than juvenile sockeye salmon during their first ocean year on the continental shelf (Fisher et al. 2007); (Beamish 2018a); (Farley, Beacham, and Bugaev 2018); (Riddell et al. 2018). Researchers have found very little overlap in diet between juvenile sockeye salmon and Chinook and coho salmon in these areas (Brodeur 1990a); (Landingham, Sturdevant, and Brodeur 1998); (Brodeur et al. 2007); (Beamish 2018a); (Farley, Beacham, and Bugaev 2018); (Riddell et al. 2018). Studies show that juvenile Chinook and coho salmon feed at a higher trophic level than sockeye salmon. That is, juvenile Chinook and coho salmon in the ocean are primarily piscivores, whereas juvenile sockeye salmon are largely planktivores (Brodeur et al. 2007); (Farley, Beacham, and Bugaev 2018); (Riddell et al. 2018). For these reasons, any potential competitive effects during this time are discountable.

Risk from predation is negligible. Numerous diet surveys have demonstrated the extreme rarity of predation on juvenile salmonids by Chinook and coho salmon and steelhead in marine waters, particularly in coastal areas, as described above. Further, ESA-listed juvenile sockeye salmon are expected to occur in very low abundances relative to preferred prey taxa and other juvenile salmonids in the broad spatial areas where they may overlap with Mitchell Act fish. The combined risk from competition and predation to Snake River sockeye salmon in the Pacific

Ocean is negligible because risk from competition is negligible and risk of predation is negligible, as described above.

2.5.2.3.2.4 Summary of Ecological Effects for Salmon and Steelhead

The above sections discuss the ecological effects of the Proposed Action analyzed in this Opinion include predation and competition in the freshwater/estuary and marine environments (both along the continental shelf and in the open ocean), predator attraction, and disease.

Effects of competition and predation in the migratory corridor to the mouth of the Columbia River were analyzed using the PCDRisk ecological interactions model, which assesses the extent of risks to natural-origin salmon and steelhead by, and with, hatchery-origin fish. While the model is not able to account for all ecological processes or precisely quantify effects, it does provide a relative measure of the species most likely to be adversely affected by the Proposed Action. The model results indicate a minor impact on UCR Spring Chinook Salmon ESU, UCR Steelhead DPS, LCR Chinook Salmon ESU, LCR Steelhead DPS, LCR Coho Salmon ESU, CR Chum Salmon ESU, SR Sockeye Salmon ESU, SR Fall Chinook Salmon ESU, SR Spring/summer Chinook Salmon ESU, SR Steelhead DPS, MCR Steelhead DPS, UWR Chinook Salmon ESU and UWR Steelhead DPS from competition and predation.

We also considered the effects of predator attraction by hatchery-origin fish. While large numbers of hatchery-origin fish may attract predators, a high ratio of hatchery-origin fish may buffer natural-origin fish from predation. For these reasons, we assume the effects of predator attraction are reflected in the current status of the species, and will continue at similar levels for all ESUs and DPSs, i.e., the Proposed Action will have negligible effects.

For effects of pathogens and disease from the Proposed Action, best management practices and state, Federal, and tribal fish health policies limit the disease risks associated with hatchery programs, and currently there is no evidence showing that hatchery programs meaningfully elevate pathogen risks beyond baseline levels (i.e., that present naturally from natural-origin fish).

In the marine environment along the continental shelf, the evidence for effects of predation and competition suggests that ocean conditions and abundance of other competitors (non-Mitchell Act-funded fish) are likely the dominant factors influencing forage availability and competitive effects. There is no direct evidence that competition from hatchery salmon has any more than a small effect (both in absolute terms and relative to those from other competitors) to natural salmon in these areas.

In the open ocean, we expect competition from fish released as part of the Proposed Action to have a small effect on the survival of ESA-listed natural-origin Chinook salmon in the Action Area during years of low ocean productivity and/or high abundance of competitors other than hatchery-origin fish. During other years, we expect any competitive interactions from Mitchell Act program fish to be negligible.

As for the effects of predation in the open ocean, there is substantial available information showing that predation on juvenile salmonids by Chinook and coho salmon, and steelhead in marine waters is rare, and juvenile chum salmon are generally too small to prey on salmon in the marine environment. Therefore, the predation risk from hatchery-origin fish to listed juvenile salmon is low. Additionally, steelhead are rarely predated upon in marine waters, and therefore risk from predation is negligible.

For these reasons, we have determined that the ecological effects to all ESUs considered in this Opinion is low, and for all other ESUs and DPSs is negligible. Additionally, the risk from predation to all ESUs and DPSs is negligible. These minimal risk levels can be managed to some extent by the practices outlined in Section 2.9.4, Terms and Conditions. As with all generalizations, there are exceptions, but operators must conform to the following:

- Release date and location. The potential for ecological interactions increases as more overlap occurs between hatchery and natural-origin fish. To limit overlap, releases of salmon or steelhead yearling smolts should, if possible, take place after the majority of natural-origin fish have exited the system or have grown to a size where they are less likely to be eaten. In general, hatchery yearling smolts released downstream of McNary Dam should not be released before the last week of March. Release location can also influence interaction potential, so releases should be made only at sites specified in the BA (NMFS 2024a).
- Average size of fish released. The size of the smolts released relates directly to the extent to which any interactions result in harm or mortality to natural-origin fish: the larger a smolt is at release, the more likely it could out-compete or prey on others. Average smolt size and variability should not exceed that specified in the BA (NMFS 2024a).
- Number of fish released. The more fish released, the greater the potential for ecological interactions. Typically hatchery programs tend to take eggs in excess of need (usually) to cope with possible shortfalls due to a variety of operation causes. This usually leads to more fish being released than planned. The release numbers shall not exceed the one-year maximum level nor the five year average production levels that are specified in Section 1.3.
- Number of residualized fish released. Ecological interactions can also increase when hatchery fish residualize due to early sexual maturation (precocity). Residualism itself cannot be determined at the hatchery, but the rate of precocity serves as a logical surrogate. In any year the rate of precocity should be kept under 5%, and the 5-year average should not exceed 3%. It should be noted that while these standards are appropriate for the suite of current and planned Mitchell Act funded programs, they may have to be modified for any future funding of upstream programs.

Although information to date suggests that some negative effects are occurring from the release of hatchery fish on listed natural-origin fish, critical research is still needed to further investigate this topic to better understand the magnitude of the negative effect and to improve the estimates of model parameters.

2.5.2.4 Factor 4. Research, monitoring, and evaluation that exists because of the hatchery program

NMFS expects no effects under this factor on the UCR Spring–run Chinook Salmon ESU, Snake River Spring/summer-run Chinook Salmon ESU, Snake River Fall-run Chinook Salmon ESU, UWR Chinook Salmon ESU, SR Sockeye Salmon ESU, UCR Steelhead DPS, and UWR Steelhead DPS because natural-origin salmon or steelhead considered part of these ESUs or DPSs are not encountered as a result of hatchery funding decisions that lead to RM&E activities, and NMFS is not aware of any subsequent effects to these ESUs or DPSs given the locations and descriptions of RM&E activities provided by (NMFS 2024g).

Effects to ESA-listed species by the Proposed Action under this factor are described below. The effects are grouped by the affected species and not by the RM&E project. The same information is presented in the ITS grouped by RM&E project. Impacts from delayed or displaced natural spawning resulting from surveys for spawner distribution, and redd superimposition is not likely to occur. Therefore, impacts are expected in the LCR tributaries, during surveys determining the abundance of natural-origin fish and hatchery-origin fish on the spawning grounds or during similar surveys in the Klickitat River. Also, as verified through reporting, take is not expected to occur during LCR and tributary fishery monitoring activities or monitoring of the Nez Perce Tribe's Snake River Coho Salmon Restoration Program activities, both of which are funded through the Proposed Action. NMFS continues to expect no impacts on ESA-listed species to occur during these activities.

2.5.2.4.1 Pacific Eulachon Southern DPS

In Mill, Abernathy, and Germany creeks, adults from the Pacific Eulachon Southern DPS are expected to be encountered at a low level as a result of RM&E activities from the Abernathy conservation hatchery program. Expected capture, handling, and associated mortality estimates are presented in Table 99.

All other RM&E activities funded through the Proposed Action do not pose a risk to the viability of the eulachon Southern DPS because these activities only affect salmon and steelhead. Eulachon juveniles will not be present in the vicinity near study sites when state agencies may perform electrofishing activities. Eulachon adults typically enter the Columbia River from December to May with peak entry and spawning during February and March. Length of incubation ranges from about 28 days in 4°-5° C waters to 21-25 days in 8°C waters depending upon stream temperature. Sampling activities associated with RM&E activities will occur outside these months, so eulachon will not be present and these activities therefore pose no risk to eulachon.

Table 99. Maximum adult Pacific Eulachon Southern DPS expected to be annually encountered and killed as the result of RM&E activities under the Abernathy conservation hatchery program funded through the Proposed Action (NMFS 2024g).

Location	Adult Encounters	Adult Mortalities
Mill Creek	≤30	≤1
Abernathy Creek	≤30	≤1
Germany Creek	≤30	≤1

2.5.2.4.2 LCR Chinook Salmon ESU

During RM&E activities funded through the Proposed Action in the Grays, Elochoman, Coweeman, North and South Fork Toutle, Kalama, East Fork Lewis, Salmon Creek, and Washougal Rivers electrofishing activities will encounter juvenile LCR fall and spring Chinook salmon during activities associated with steelhead genetic monitoring from hatchery steelhead programs. NMFS (2024a) describes expected capture, handling, tagging and sampling; and mortality estimates resulting from proposed RM&E activities and this information is presented in Table 100 for reference.

Table 100. Natural-origin juvenile LCR Chinook salmon expected to be annually encountered, sampled/tagged, and killed as the result of RM&E activities under steelhead genetic monitoring funded through the Proposed Action (NMFS 2024g).

MPG	Population (State)	Encountered	Mortality	Adult Equivalent	Average % of recent spawning population
Cascade Spring	North Fork and South Fork Toutle (WA)	2,000	≤80	0	0
	Kalama (WA)	2,000	≤80	1	0
Gorge Spring	White Salmon (WA)	2,000	≤80	0	n/a
Coastal Fall	Grays/Chinook (WA)	10,000	≤400	0	0
	Elochoman/ Skamokawa (WA)	10,000	≤400	0	0
	Mill/Abernathy/ Germany (WA)	10,000	≤400	2	5.43
Cascade Fall	North Fork and South Fork Toutle (WA)	20,000	≤800	1	0.49

MPG	Population (State)	Encountered	Mortality	Adult Equivalent	Average % of recent spawning population
	Coweeman (WA)	10,000	≤400	1	0.2
	Kalama (WA)	8,000	≤320	1	0.04
	Lewis (WA)	10,000	≤400	1	0.05
	Salmon (WA)	10,000	≤400	1	n/a
	Washougal (WA)	10,000	≤400	1	0.11
Gorge Fall	Lower Gorge (WA)	10,000	≤400	1	0.03
	Upper Gorge (WA)	10,000	≤400	1	0.24
	White Salmon (WA)	10,000	≤400	1	0.45

We calculated adult equivalents for Chinook juvenile mortalities using the SAR from either the: 1) matching hatchery HGMP, if available; then 2) Columbia Basin Research SAR data, if available; then 3) nearest geographic hatchery HGMP. The sources for each SAR are provided in the Biological Assessment (NMFS 2024g). These estimated adult equivalents allowed us to calculate the percentage of the spawning population the juvenile mortalities may account for by dividing the adult equivalents by the most recent 5-year average of total spawners in each watershed, if averages were available in the most recent Viability Assessment (Ford 2022.).

The result for the RM&E activities under the steelhead genetic monitoring project for LCR Chinook salmon is that juvenile mortality represents less than 5.43% of any individual natural population's total adult spawner average. NMFS concludes that capture, handling, tagging, sampling, and expected mortality from steelhead genetic monitoring is negligible and does not pose a risk to the viability of LCR Chinook salmon populations, individually or collectively.

RM&E conducted during the operation of the North Fork Toutle River Fish Collection Facility will include trapping, handling, tagging, and release mortality of LCR Chinook salmon. Up to 50 natural-origin Chinook salmon adults would be trapped, handled, and/or tagged before being released back into the North Fork Toutle River. As a result, 2 would be killed through handling mortality. This represents 0.73% of the recent 5-year average based on information in Ford (Ford 2022.). This impact level is inconsequential and is mitigated by enabling passage to otherwise inaccessible habitat which increases natural population spatial distribution. Therefore, NMFS concludes the expected effects from trapping, handling, and mortality from the North Fork Toutle River Fish Collection Facility to be negligible.

In the Kalama River, RM&E activities performed as part of the Kalama Research Program will encounter both adult and juvenile LCR spring Chinook salmon. Expected capture, handle, tag and sample, and mortality estimates are presented in Table 101.

Table 101. Maximum natural-origin juvenile LCR spring Chinook salmon expected to be annually encountered, sampled/tagged, and killed as the result of RM&E activities under Kalama Research program monitoring funded through the Proposed Action (NMFS 2024h).

MPG	Population (State)	Encountered	Mortality	Adult Equivalent	Average % of recent spawning population
Cascade Spring	Kalama (WA)	Up to 502 (adults)	Up to 13	n/a	0.61
		Up to 1,330 (juvenile)	Up to 65	0	0

Adult mortalities from the Kalama Research Program Monitoring are expected to be less than 0.61% of the recent spawning population, and the adult equivalents of the juvenile mortalities to be less than 0.0%. This impact level is inconsequential, and NMFS concludes the expected effects from capture, handling, tagging, sampling, and mortality from the Kalama Research Program are negligible.

In Mill, Abernathy, and Germany creeks, adult and juvenile LCR Chinook salmon will be encountered as a result of RM&E activities from the Abernathy conservation hatchery program. Expected capture, handling, tagging, sampling, and associated mortality estimates are presented in Table 102.

Table 102. Maximum natural-origin juvenile LCR spring Chinook salmon expected to be annually encountered, sampled, tagged, and killed as the result of RM&E activities under the Abernathy conservation hatchery program funded through the Proposed Action (NMFS 2024g).

MPG	Population (State)	Encountered	Mortality	Adult Equivalent	Average % of recent spawning population
Coast Fall	Mill/Abernathy/Germany (WA)	≤12,000 (juvenile)	≤180	1	2.44
		≤15 (adult)	≤3	n/a	10.71
	Elochoman/ Skamokawa (WA)	≤24,000 (juvenile)	≤720	1	0.68
		≤5 (adult)	≤1	n/a	1.05

For the Mill, Abernathy, Germany creek fall Chinook salmon population, the maximum adult mortalities from the sampling target of this program is 10.7% of the recent 5-year average adult total spawning population, which is just 28 fish (Ford 2022). However, these maximum rates are based on ideal sampling numbers and not recent spawning returns. Given that the mortalities occur through handling, and handling mortality is expected to be 3% of the fish encountered, actual Chinook salmon sampling in the RM&E for the Abernathy hatchery program will not exceed 3% of the juvenile or returning adult spawning population. For the Elochoman River, sampling mortality will result in the mortality of, at most, 1.1% of the recent returning spawning population. This level of impact is inconsequential and NMFS considers the expected effects from encounters and mortality from capture, handling, tagging, and sampling in RM&E activities at the Abernathy hatchery to be negligible.

In the Grays River, adult and juvenile LCR Chinook salmon will be encountered in RM&E activities as part of the Grays River conservation hatchery program. Through the assessment of this new hatchery program, up to 24,000 juvenile and 5 adult LCR Chinook salmon will be encountered through juvenile migrant trapping. Up to 720 juveniles and 1 adult will be killed through handling mortality. The adult equivalents of the juvenile mortalities would be 0.28% of the recent returning spawning population and the adult mortalities would be 0.44%. This level of impact is inconsequential and NMFS considers the effects from juvenile migrant trapping to be negligible.

In the Clatskanie River and Big Creek, natural- and hatchery-origin adult and juvenile LCR Chinook salmon will be encountered during RM&E activities conducted as part of the newly proposed Clatskanie River Tule Supplementation and ongoing Big Creek Chum Programs (Table 103). A smolt trap will be operated near the head of tide on the Clatskanie River to evaluate stream survival of direct-released fall tule Chinook, alongside the ongoing monitoring for the Big Creek Chum program.

Table 103. Maximum natural-origin juvenile LCR spring Chinook salmon expected to be annually encountered, sampled, tagged, and killed as the result of RM&E activities under the Clatskanie River Tule program funded through the Proposed Action (NMFS 2024g).

MPG	Population (State)	Encountered	Mortality	Adult Equivalent	Average % of recent spawning population
Coast Fall	Clatskanie/Big Creek (OR)	50,000 (juvenile)	1,500	3	0.22
		500 (adults)	5	n/a	0.06

The Clatskanie River Tule Supplementation Program sampling estimates include hatchery and natural origin Chinook in the Clatskanie River and Big Creek. The most recent average of returning spawners was 2,282 combined, with only 3 wild-origin spawners in the Clatskanie River and none in Big Creek. Adult mortalities from the Clatskanie River Tule Supplementation and Big Creek Chum programs are expected to be less than 0.22% of the total recent spawning population, and the adult equivalents of the juvenile mortalities to be less than 0.06%. This impact level is inconsequential, and NMFS concludes the expected effects from capture, handling, tagging, sampling, and mortality from the Clatskanie River Tule Supplementation and ongoing Big Creek Chum Programs are negligible.

In the Sandy River, juvenile LCR Chinook salmon will be encountered during trapping activities conducted through the operation of the Sandy River Screw Trap (Table 104). The relatively small amount of juvenile mortality from the Sandy River Screw Trap is not equivalent to one adult Chinook mortality, based on the Sandy River hatchery SAR. This impact level is inconsequential, and NMFS concludes the expected effects from capture, handling, tagging, sampling, and mortality from the Sandy River Screw Trap are negligible.

Table 104. Maximum natural-origin juvenile LCR spring Chinook salmon expected to be annually encountered, sampled, tagged, and killed as the result of RM&E activities under the Sandy River Screw Trap program funded through the Proposed Action (NMFS 2024g).

MPG	Population (State)	Encountered	Mortality	Adult Equivalent	Average % of recent spawning population
Cascade	Sandy (OR)	1000 (juvenile)	30	0	0

NMFS concludes these expected impact levels do not pose a risk to the viability of LCR Chinook salmon natural populations in their respective watersheds, either individually or collectively.

Additional RM&E activities funded through the Proposed Action which are not expected to impact LCR Chinook salmon are:

- Population abundance and spawning composition of LCR Chinook populations. Surveys would occur, but any natural adult salmon observed during spawning ground surveys would not be negatively impacted. The effects would be negligible as adults temporarily move away from the observers.
- Population abundance and spawning composition of LCR steelhead populations. The activities occur during natural steelhead spawning occurrence (depicted in Table 52). Returning adults from each Chinook salmon natural population will finish spawning activity prior (based on timing depicted in Table 52) to steelhead spawning occurrence so surveys performed will not affect LCR Chinook salmon.
- Harvest monitoring activities in the mainstem Columbia River sport and commercial fisheries, as well as tributary-level sport fisheries. Given that the sampling occurs on previously harvested and killed salmon and steelhead, there is no impact associated with these sampling activities in and of themselves. NMFS concludes these activities have no effect on LCR Chinook salmon.
- Coho reintroduction monitoring activities occurring in the Snake River. These include weir operations (October-December) in Lapwai Creek, Clear Creek, and the Lostine River, and PIT tagging of portions of the juvenile coho releases to track the outmigration and survival of the fish. These activities occur outside the range of LCR Chinook salmon and there is no anticipated impact associated with these sampling activities. NMFS concludes that these activities will have no effect on LCR Chinook salmon.
- Klickitat River monitoring and evaluation activities. These include spawning ground surveys, adult salmonid monitoring and genetic sampling at Lyle Falls Fishway, adult salmonid monitoring and genetic sampling at Castile Falls, juvenile outmigration monitoring, sediment and habitat monitoring, and water quality analysis. These activities occur outside the range of LCR Chinook salmon and there is no anticipated impact associated with these sampling activities. NMFS concludes these activities have no effect on LCR Chinook salmon.

2.5.2.4.3 CR Chum Salmon ESU

RM&E electrofishing activities in the Grays, Elochoman, Coweeman, North and South Fork Toutle, Kalama, East Fork Lewis, Salmon Creek and Washougal Rivers will encounter juvenile CR chum salmon while monitoring steelhead introgression from hatchery steelhead programs. Expected capture, handle, tag and sample, and mortality estimates are presented in Table 105.

Table 105. Natural-origin juvenile Columbia River chum salmon expected to be annually encountered, sampled/tagged, and killed as the result of RM&E activities under the Proposed Action.

MPG	Population (State)	Encountered	Mortality	Adult Equivalent	Average % of recent spawning population
Coast	Grays/Chinook (WA)	100	10	0	0.00
	Elochoman/ Skamokawa (WA)	100	10	0	n/a
	Mill/Abernathy/ Germany (WA)	100	10	0	n/a
Cascade	Toutle (WA)	20	2	0	n/a
	Coweeman (WA)	10	1	0	n/a
	Kalama (WA)	10	1	0	n/a
	Lewis (WA)	10	1	0	n/a
	Washougal (WA)	10	1	0	0.00

We calculated adult equivalents for the juvenile mortalities expected for CR chum using two sources for comparison. Groot and Margolis (1991) report that natural chum salmon mortality rates (fry to adult) range from 97% to 99.7%. Groot and Margolis (1991) suggests a general application to all chum salmon is warranted given fluctuations between various Pacific Ocean chum stocks SAR is small. The most conservative mortality rate of 97% was used to calculate adult equivalents of juvenile mortalities. These estimated adult equivalents allowed us to calculate the percentage of the spawning population the mortalities may have accounted for in the Grays and Washougal Rivers, where the most recent 5-year average of total spawners were available (Ford 2022). However, several populations do not currently have total spawner estimates, and Table 105 thereby only reports the expected adult equivalents killed as a result of handling mortalities of juveniles during RM&E activities. This approach estimates these juvenile removals represent less than 0.01% of any given population's total spawners or less than one adult equivalent given the average known SAR of chum salmon.

In Mill, Abernathy, and Germany Creeks, adult and juvenile CR Chum salmon will be encountered as a result of RM&E activities from the Abernathy conservation hatchery program. Expected capture, handle, tag and sample, and mortality estimates are presented in Table 106.

Table 106. Maximum natural-origin juvenile CR Chum salmon expected to be annually encountered, sampled/tagged, and killed as the result of RM&E activities under the Abernathy conservation hatchery program funded through the Proposed Action (NMFS 2024g).

MPG	Population (State)	Encountered	Mortality	Adult Equivalent	Average % of recent spawning population
Coast Fall	Mill/Abernathy/Germany (WA)	≤31,000 (juvenile)	≤310	9	n/a
		≤45 (adult)	≤3	n/a	n/a
	Elochoman/ Skamokawa (WA)	≤93,600 (juvenile)	≤2,808	84	n/a
		≤15 (adult)	≤1	n/a	n/a

For the Mill, Abernathy, Germany Creek and Elochoman River fall Chum salmon populations, there are no spawner estimates available. While the overall impact level is difficult to determine because spawner estimates are not available, this level of impact is likely inconsequential because the RM&E activities are to monitor a conservation program that aims to increase the overall natural-origin abundance.

In the Grays River, adult and juvenile CR chum salmon will be encountered in RM&E activities as part of the Grays River conservation hatchery program. Through the assessment of this new hatchery program, up to 833,000 juveniles and 15 adult salmon will be encountered through trapping migrant juveniles. Up to 20,000 juveniles and 1 adult will be killed through handling mortality associated with trapping. Using the highest survival rate from Goot and Margholis (1991) above, the juvenile mortalities would account for 5.98% of the recent spawning population, however this likely overestimates the survival of the wild Grays River chum population. The adult mortalities would be 0.01% of the recent average returning spawning population. There is no wild or hatchery SAR available for this population, but this level of impact is inconsequential and NMFS considers the effects from juvenile migrant trapping to be negligible.

In the Clatskanie River and Big Creek, natural and hatchery origin adult and juvenile CR Chum salmon will be encountered during RM&E activities conducted as part of the newly proposed Clatskanie River Tule Supplementation and ongoing Big Creek Coho Programs (Table 107). A smolt trap will be operated near the head of tide on the Clatskanie River to evaluate stream survival of direct-released fall tule Chinook, alongside the ongoing monitoring for the Big Creek Coho program. This trap will be operated through 2033.

For the Clatskanie River and Big Creek Chum salmon populations, there are no spawner estimates. While the overall impact is difficult to determine because spawner estimates are not available, this level of impact is likely inconsequential because the sampling targets include wild and hatchery origin fish, and most of the fish encountered will likely be of hatchery origin. This level of impact is inconsequential and NMFS considers the effects from juvenile migrant trapping to be negligible.

Table 107. Maximum natural-origin juvenile and adult CR chum salmon expected to be annually encountered, sampled, tagged, and killed as the result of RM&E activities under the Clatskanie River Tule program funded through the Proposed Action (NMFS 2024g).

MPG	Population (State)	Encountered	Mortality	Adult Equivalent	Average % of recent spawning population
Coast Fall	Clatskanie/Big Creek (OR)	50,000 (juvenile)	3,250	98	n/a
		500 (adults)	35	n/a	n/a

Additional RM&E activities funded through the Proposed Action which do not result in impacts to CR chum salmon include:

- Population abundance and spawning composition of CR chum salmon. Surveys would occur but any natural adult salmon observed during spawning ground surveys would not be negatively impacted because the effects would be negligible as adults temporarily move away from the observers.
- Population abundance and spawning composition of LCR steelhead populations. The activities occur during steelhead spawning (Table 52). Returning adults from each chum salmon population will finish natural spawning before (based on timing depicted in Section 2.2.4) steelhead spawning, and surveys will not affect CR chum salmon.
- Harvest monitoring in the mainstem Columbia River sport and commercial fisheries, and tributary-level sport fisheries. Given that the sampling occurs on previously harvested and killed salmon and steelhead, there is no impact on CR chum from these sampling activities. NMFS concludes these activities have no effect on CR chum salmon natural populations.

- Operation of the North Fork Toutle River Fish Collection Facility. This includes adult salmonid monitoring, sampling, handling and tagging in the North Fork Toutle River. No chum salmon have been recorded at the facility during operation. NMFS concludes these activities have no effect on the CR chum salmon natural populations.
- Coho reintroduction monitoring activities occurring in the Snake River. These include weir operations during October through December in Lapwai Creek, Clear Creek, and the Lostine River, and PIT tagging to track the outmigration and survival of the fish (NMFS 2024g). These activities occur outside the range of CR chum salmon, and NMFS concludes these activities have no effect on the CR chum salmon populations, individually or collectively.
- RM&E activities in the Kalama River. No chum salmon have been recorded during past operations, so NMFS concludes these activities will have no effect on CR chum salmon natural populations.
- Klickitat River monitoring and evaluation activities. This includes spawning ground surveys, adult salmonid monitoring and genetic sampling at Lyle Falls Fishway, adult salmonid monitoring and genetic sampling at Castile Falls, juvenile outmigration monitoring, sediment and habitat monitoring, and water quality analysis. These activities occur outside the range of CR chum salmon, so NMFS expects that these activities will have no effect on CR chum salmon natural populations.

2.5.2.4.4 LCR Coho Salmon ESU

Electrofishing activities in the Grays, Elochoman, Coweeman, North and South Fork Toutle, Kalama, East Fork Lewis, Salmon Creek, and Washougal Rivers will encounter juvenile LCR coho salmon during RM&E activities associated with steelhead genetic monitoring. Expected capture, handle, tag and sample, and mortality estimates are presented in Table 108.

Table 108. Natural-origin juvenile LCR coho salmon expected to be annually encountered, sampled/tagged, and killed in steelhead genetic monitoring under the Proposed Action.

MPG	Population (State)	Encountered	Mortality	Adult Equivalent	Average % of recent spawning population
Coastal Fall	Grays/Chinook (WA)	10,000	≤400	8	3.77
	Elochoman/ Skamokawa (WA)	10,000	≤400	3	0.48
	Mill/Abernathy/ Germany (WA)	10,000	≤400	3	0.60
Cascade Fall	North Fork Toutle (WA)	10,000	≤400	10	1.23
	South Fork	10,000	≤400	10	0.93

MPG	Population (State)	Encountered	Mortality	Adult Equivalent	Average % of recent spawning population
	Toutle (WA)				
	Coweeman (WA)	10,000	≤400	8	0.42
	Kalama (WA)	8,000	≤320	7	15.55
	North Fork Lewis (WA)	10,000	≤400	12	0.96
	East Fork Lewis (WA)	10,000	≤400	12	1.78
	Salmon (WA)	10,000	≤400	12	n/a
	Washougal (WA)	10,000	≤400	6	0.70
Gorge	Lower Gorge (WA)	10,000	≤400	1	3.17
	Upper Gorge/ White Salmon (WA)	10,000	≤400	1	2.04

We calculated adult equivalents for the coho juvenile mortalities from RM&E activities using the SAR from either the: 1) matching hatchery HGMP, if available; then 2) Columbia Basin Research SAR data, if available; then 3) nearest geographic hatchery HGMP. The sources for each SAR are provided in the Biological Assessment (NMFS 2024g). These estimated adult equivalents allowed us to calculate the percentage of the spawning population the juvenile mortalities may account for by dividing the adult equivalents by the most recent 5-year average of total spawners in each watershed, if averages were available in the most recent Viability Assessment (Ford 2022).

Using this approach the estimated adult equivalents in Table 108 we calculated the average percentage of each natural spawning population that would be mortalities. For every population, we estimate that the coho juvenile removals from steelhead genetic monitoring represent less than 3.77% of any population's total recent spawner abundance, except in the Kalama River (Ford 2022). In the Kalama River, the maximum sampling target would be 15.55% of the most recent spawning average. However, it is highly unlikely that this number of spring Chinook will actually be encountered in the Kalama River. For this RM&E activity the mortalities occur solely through handling mortality, which is expected to be 3% of the fish encountered. NMFS concludes that impacts from capturing, handling, tagging, and sampling as part of steelhead genetic monitoring is negligible and does not pose a risk to the viability of LCR coho salmon populations, individually or collectively.

The Kalama River Research Program would encounter up to 1,300 juvenile coho and 200 fry through trapping, handling, sampling, and tagging. Due to handling mortality and some intentional lethal sampling, these RM&E activities would result in the death of up to 65 juveniles and 10 fry. This accounts for approximately 3.16% and 0.49%, respectively, of the total natural-origin spawner average (Ford 2022). The population is listed as a contributing population for recovery, and this rate of mortality for natural-origin adult spawners via this factor would lead to a low negative risk rating, given that the population averages less than 100 fish annually.

RM&E conducted during the operation of the North Fork Toutle River Fish Collection Facility will include trapping, handling, and tagging and release mortality of LCR coho salmon. Up to 600 adult coho would be trapped, handled, and or tagged before releasing them, and 6 adult fish would die as result of these activities. This represents 1.47% of the recent 5-year average based on information in Section 2.2.3 (Table 44). This impact level is inconsequential and is mitigated by enabling passage to otherwise inaccessible habitat which increases natural population spatial distribution. Therefore, NMFS concludes the expected effects from trapping, handling, and mortality on LCR Coho salmon at the North Fork Toutle River Fish Collection Facility to be negligible.

In Mill, Abernathy, and Germany creeks, adult and juvenile LCR Coastal Fall coho salmon will be encountered in RM&E activities at the Abernathy conservation hatchery program. Expected capture, handle, tag and sample, and mortality estimates are presented in Table 109.

Table 109. Maximum natural-origin juvenile LCR Fall coho salmon expected to be annually encountered, sampled/tagged, and killed as the result of RM&E activities under the Abernathy conservation hatchery program funded through the Proposed Action (NMFS 2024g).

MPG	Population (State)	Encountered	Mortality	Adult Equivalent	Average % of recent spawning population
Coast Fall	Mill/Abernathy/Germany (WA)	46,000 (juvenile)	427	3	0.63
		45 (adult)	3	n/a	0.66
	Elochoman/ Skamokawa (WA)	9,200 (juvenile)	92	1	0.11
		15 (adult)	1	n/a	0.18

For both populations, we estimate that the juvenile removals from the Abernathy conservation hatchery program are below 1% of the recent adult spawning population, and the adult removals are less than 1% (Ford 2022). This level of impact is inconsequential and NMFS considers the expected effects on LCR coho salmon to be negligible.

In the Grays River, adult and juvenile LCR coho salmon will be encountered in RM&E activities as part of the Grays River conservation hatchery program. Through the assessment of this new hatchery program, up to 15,000 juveniles and 15 adult salmon will be encountered through trapping. Up to 150 juveniles and 1 adult will be killed through handling mortality. The adult equivalents of the juvenile mortalities would be 1.42% of the recent returning spawning population and the adult mortalities would be 0.01%. This level of impact is inconsequential and NMFS considers the expected effects on LCR coho salmon to be negligible.

In the Clatskanie River and Big Creek, natural and hatchery origin adult and juvenile LCR Chinook salmon will be encountered during RM&E activities conducted as part of the newly proposed Clatskanie River Tule Supplementation and ongoing Big Creek Coho Programs (Table 110). A smolt trap will be operated near the head of tide on the Clatskanie River to evaluate stream survival of direct-released fall tule Chinook, alongside the ongoing monitoring for the Big Creek Coho program. This trap will be operated through 2033.

Table 110. Maximum natural-origin juvenile LCR spring Coho salmon expected to be annually encountered, sampled, tagged, and killed as the result of RM&E activities under the Clatskanie River Tule program funded through the Proposed Action (NMFS, 2024g).

MPG	Population (State)	Encountered	Mortality	Adult Equivalent	Average % of recent spawning population
Coast Fall	Clatskanie/ Big Creek (OR)	150,000 (juvenile)	4,150	28	6.81
		900 (adults)	8	1	1.96

The Clatskanie River Tule Supplementation Program sampling estimates include hatchery and natural origin coho in the Clatskanie River and Big Creek. The most recent average of returning spawners was 408 combined, with 199 wild-origin spawners in the Clatskanie River and none in Big Creek. Adult mortalities from the Clatskanie River Tule Supplementation and Big Creek Coho programs are expected to be less than 6.81% of the total recent spawning population, and the adult equivalents of the juvenile mortalities to be less than 1.96%. This impact level is inconsequential, and NMFS concludes the expected effects from capture, handling, tagging, sampling, and mortality from the Clatskanie River Tule Supplementation and Big Creek Coho Programs are negligible.

In the Sandy River, juvenile LCR coho salmon will be encountered during trapping activities conducted through the operation of the Sandy River Screw Trap (Table 111).

Table 111. Maximum natural-origin juvenile LCR spring Coho salmon expected to be annually encountered, sampled, tagged, and killed as the result of RM&E activities under the Sandy River Screw Trap program funded through the Proposed Action (NMFS, 2024).

MPG	Population (State)	Encountered	Mortality	Adult Equivalent	Average % of recent spawning population
Cascade	Sandy (OR)	6,000 (juvenile)	80	0	0

The relatively small amount of juvenile mortality from the Sandy River Screw Trap is not equivalent to one adult coho mortality, based on the Sandy River hatchery SAR. This impact level is inconsequential, and NMFS concludes the expected effects from capture, handling, tagging, sampling, and mortality from the Sandy River Screw Trap are negligible.

Additional RM&E activities funded through the Proposed Action that will not affect LCR coho salmon:

- Population abundance and spawning composition of LCR coho salmon. Surveys would occur but any adult salmon observed during spawning ground surveys would not be negatively impacted because the effects would be negligible as adults temporarily move away from the observers.
- Population abundance and spawning composition of LCR steelhead populations. These activities would occur during steelhead spawning (Table 52). Coho will finish spawning activity before (Table 41) steelhead spawning, so surveys performed will not affect LCR coho salmon.
- Harvest monitoring in the mainstem Columbia River sport and commercial fisheries, and tributary-level sport fisheries. Given that the sampling occurs on previously harvested and killed salmon and steelhead, there is no additional impact associated with these sampling activities. NMFS concludes that these activities will have no effect on LCR coho salmon.
- Coho reintroduction monitoring activities occurring in the Snake River. These include weir operations during October through December in Lapwai Creek, Clear Creek, and the Lostine River, and PIT tagging to track the outmigration and survival of the fish. These activities occur outside the range of LCR coho salmon, so NMFS concludes these activities have no effect on LCR coho salmon.
- Klickitat River monitoring and evaluation activities. This includes spawning ground surveys, adult salmonid monitoring and genetic sampling at Lyle Falls Fishway, adult salmonid monitoring and genetic sampling at Castile Falls, juvenile outmigration monitoring, sediment and habitat monitoring, and water quality analysis. These activities occur outside the range of LCR coho salmon, therefore NMFS concludes that these activities would have no effect on the LCR coho salmon.

2.5.2.4.5 LCR Steelhead DPS

Mitchell Act funded monitoring of LCR steelhead natural population abundance and spawning composition occurs during steelhead spawning (Table 52). This is typically done through trapping, netting, or hook-and-line sampling of adults. Expected capture, handle, tag and sample, and mortality estimates are presented in Table 112.

Table 112. Natural-origin adult LCR steelhead expected to be annually encountered, sampled/tagged, and killed as the result of RM&E activities associated with population abundance (NMFS 2024a).

MPG	Population (State)	Encountered	Mortality	Average % of recent spawning population
Cascade Summer	Kalama (WA)	Included in the Kalama River Research Project		
	EF Lewis (WA)	Up to 200	Up to 4	0.62
	Washougal (WA)	Up to 600	Up to 12	1.86
Cascade Winter	SF & NF Toutle (WA)	Up to 300	Up to 6	0.91
	Coweeman (WA)	Up to 200	Up to 4	0.76
	Kalama (WA)	Included in the Kalama River Research Project		
	EF Lewis (WA)	Up to 200	Up to 4	0.65
	Salmon Creek (WA)	Up to 100	Up to 2	n/a
	Washougal (WA)	Up to 600	Up to 12	2.81
Gorge Summer	Upper Gorge (WA)	Up to 600	Up to 12	1.91
	White Salmon (WA)	Up to 300	Up to 6	n/a
Gorge Winter	Upper Gorge (WA)	Up to 200	Up to 4	n/a
	Lower Gorge (WA)	Up to 200	Up to 4	n/a

For all of the steelhead natural populations affected by this RM&E activity, the expected maximum adult mortalities represent less than 3% of the recent 5-year average adult total spawning abundance (Ford 2022). NMFS rates the risk from this impact level as low negative collectively to the LCR Steelhead DPS, because the majority of these are primary populations necessary for recovery.

Electrofishing activities in the Kalama, East Fork Lewis, North Fork Lewis, Washougal, South Fork Toutle, North Fork Toutle, Coweeman, Salmon Creek, and Washougal Rivers and in the Upper and LCR Gorge will encounter juvenile LCR steelhead during RM&E activities associated with monitoring hatchery steelhead genetic monitoring. Expected capture, handle, tag and sample, and mortality estimates are presented in Table 113.

Table 113. Natural-origin juvenile LCR steelhead expected to be annually encountered, sampled/tagged, and killed as the result of RM&E activities associated with steelhead genetic monitoring funded through the Proposed Action (NMFS 2024g).

MPG	Population (State)	Encountered	Mortality	Adult Equivalent	Average % of recent spawning population
Cascade Summer	Kalama (WA)	7,400	104	6	1.08
	EF Lewis (WA)	7,400	104	9	1.34
	NF Lewis (WA)	7,400	104	9	n/a
	Washougal (WA)	7,400	104	4	0.64
Cascade Winter	SF Toutle (WA)	14,800	208	4	0.66
	NF Toutle (WA)	14,800	208	4	1.06
	Coweeman (WA)	14,800	208	4	0.82
	Kalama (WA)	7,400	104	2	0.35
	NF Lewis (WA)	7,400	104	4	0.59
	EF Lewis (WA)	7,400	104	4	n/a
	Salmon Creek (WA)	14,800	208	7	n/a
	Washougal (WA)	7,400	104	2	0.04
Gorge Summer	Upper Gorge (WA)	7,400	104	1	0.02
	White Salmon (WA)	7,400	104	1	n/a

MPG	Population (State)	Encountered	Mortality	Adult Equivalent	Average % of recent spawning population
Gorge Winter	Lower Gorge (WA)	7,400	104	5	0.07
	Upper Gorge (WA)	7,400	104	5	n/a

We calculated adult equivalents for the steelhead juvenile mortalities from RM&E activities using the SAR from either the: 1) matching hatchery HGMP, if available; then 2) Columbia Basin Research SAR data, if available; then 3) nearest geographic hatchery HGMP. The sources for each SAR are provided in the Biological Assessment (NMFS 2024g). These estimated adult equivalents allowed us to calculate the percentage of the spawning population the juvenile mortalities may account for by dividing the adult equivalents by the most recent 5-year average of total spawners in each watershed, if averages were available in the most recent Viability Assessment (Ford 2022.).

WDFW expects steelhead fry to be encountered and killed during RM&E activities in each watershed. The expected maximum adult mortalities represent less than 2% of the recent 5-year average adult total spawning abundance in all rivers. NMFS concludes these expected effects pose a negligible risk to LCR steelhead.

RM&E conducted during the operation of the North Fork Toutle River Fish Collection Facility will include trapping, handling, and tagging and release mortality of LCR steelhead. Up to 1,000 natural origin winter steelhead adults and up to 40 natural-origin summer steelhead adults would be trapped, handled, and or tagged before releasing them back into the North Fork Toutle River. As a result, less than 2%, or 10 adult winter and 1 adult summer steelhead, would die as result of these activities. The effect on winter steelhead population productivity is expected to be offset or mitigated by enabling passage to otherwise inaccessible habitat and increasing natural population spatial structure. NMFS concludes these expected effects are negligible and do not pose a risk to the viability of the North Fork Toutle River steelhead natural population.

Both adult and juvenile LCR steelhead will be encountered in the Kalama River during activities performed as part of the Kalama Research Program. Expected capture, handle, tag and sample, and mortality estimates are presented in Table 114.

These expected adult mortalities represent 2.86% of the recent 5-year average adult total abundance of summer steelhead in the Kalama River and 3.75% of the winter spawner abundance (Ford 2022). Both populations are categorized as primary (necessary for recovery). NMFS concludes that the effects of this activity pose a negative risk to the viability of the Kalama summer and winter steelhead population.

In the Sandy River, juvenile LCR coho salmon will be encountered during trapping activities conducted through the operation of the Sandy River Screw Trap (Table 115).

Table 114. Natural-origin juvenile LCR steelhead expected to be annually encountered, sampled/tagged, and killed as the result of RM&E activities under Kalama Research program monitoring funded through the Proposed Action (NMFS 2024g).

MPG	Population (State)	Encountered	Mortality	Adult Equivalent	Average % of recent spawning population
Cascade Summer	Kalama (WA)	1,012 (adults)	16	n/a	3.75
		6,500 (juvenile)	445	26	4.63
		1,500 (fry/eggs)	115	7	1.20
Cascade Winter	Kalama (WA)	1,552 (adults)	21	n/a	2.86
		8,000 (juvenile)	445	9	1.65
		1,500 (fry/eggs)	115	2	0.43

Table 115. Maximum natural-origin juvenile LCR steelhead expected to be annually encountered, sampled, tagged, and killed as the result of RM&E activities under the Sandy River Screw Trap program funded through the Proposed Action (NMFS 2024g).

MPG	Population (State)	Encountered	Mortality	Adult Equivalent	Average % of recent spawning population
Cascade	Sandy (OR)	3,600 (juvenile)	38	0	0

The relatively small amount of juvenile mortality from the Sandy River Screw Trap is not equivalent to one adult coho mortality, based on the Sandy River hatchery SAR. This impact level is inconsequential, and NMFS concludes the expected effects from capture, handling, tagging, sampling, and mortality from the Sandy River Screw Trap are negligible.

Additional RM&E activities funded through the Proposed Action which will not impact LCR steelhead are:

- Population abundance and spawning composition of LCR steelhead. Surveys would occur but any adult steelhead observed during spawning ground surveys would not be

negatively impacted because the effects would be negligible as adults temporarily move away from the observers.
- Harvest monitoring in mainstem Columbia River sport and commercial fisheries, and tributary-level sport fisheries. Given that the sampling occurs on previously harvested and killed salmon and steelhead, there is no additional impact associated with the sampling activities. NMFS concludes these activities have no effect on LCR steelhead.
- Coho reintroduction monitoring activities occurring in the Snake River. These include weir operations during October through December in Lapwai Creek, Clear Creek, and the Lostine River, and PIT tagging to track the outmigration and survival of the fish. These activities occur outside the range of LCR coho salmon, therefore, NMFS concludes that these activities will have no effect on the LCR steelhead.
- Klickitat River monitoring and evaluation activities. This includes spawning ground surveys, adult salmonid monitoring and genetic sampling at Lyle Falls Fishway, adult salmonid monitoring and genetic sampling at Castile Falls, juvenile outmigration monitoring, sediment and habitat monitoring, and water quality analysis. These activities occur outside the range of LCR steelhead, therefore NMFS concludes these activities would have no effect on the LCR steelhead.

2.5.2.4.6 MCR Steelhead DPS

MCR steelhead will be encountered during the following RM&E activities in the Klickitat river: spawning ground surveys, adult salmonid monitoring and genetic sampling at Lyle Falls Fishway, adult salmonid monitoring and genetic sampling at Castile Falls, juvenile outmigration monitoring, sediment and habitat monitoring, and water quality analysis encounters. Expected capture, handling, tagging, and sampling encounter and mortality estimates are presented in (Table 116).

Table 116. Natural-origin MCR steelhead expected to be annually encountered, sampled/tagged, and killed as the result of RM&E activities funded through the Proposed Action in the Klickitat River (NMFS 2024g).

MPG	Population (State)	Encountered	Mortality	Adult Equivalent	Average % of recent spawning population
Cascade Eastern Slope Tributaries	Klickitat River (adults)	1,005	26	n/a	1.7
	Klickitat River (juveniles)	10,000	100	2	0

Similar to the other RM&E effects determinations made above, we estimated the total adult equivalents calculated using SARs for converting juveniles and calculating the percentage of the spawning population the mortalities may have accounted for, using the most recent 5-year average of total spawners in the associated watershed, in this case the Klickitat River (Table 60). We estimate these removals represent less than 2% (1.7% for adults and juveniles combined) of the Klickitat River's natural-origin steelhead spawning population's total 5-year recent average.

MCR steelhead will also be encountered during RM&E activities associated with steelhead population abundance monitoring. Through these research activities, 300 adult fish from the White Salmon River will be encountered, and 6 will be killed. There is not currently an estimate of spawning population in the White Salmon, as this population was considered extirpated but is currently recolonizing. NMFS does not anticipate the impacts from RM&E activities associated with steelhead abundance will affect the recolonizing steelhead population in the White Salmon River.

All other RM&E activities funded through the Proposed Action occur outside the range of MCR steelhead and there is no anticipated effect on MCR steelhead associated with these sampling activities. NMFS concludes these activities have no effect on the MCR steelhead.

2.5.2.4.7 Snake River Basin Steelhead DPS

Snake River steelhead will be encountered during the following RM&E activities on the Klickitat River: spawning ground surveys, adult salmonid monitoring and genetic sampling at Lyle Falls Fishway, adult salmonid monitoring and genetic sampling at Castile Falls, juvenile outmigration monitoring, sediment and habitat monitoring, and water quality analysis. Up to 50 adult natural-origin Snake River Basin steelhead will either be captured, handled, tagged, and/ or sampled, and up to two adults will be killed. This level of impact is insignificant compared to the Snake River Basin's recent 5-year average returning spawning population of over 20,000 salmon (Ford 2022) NMFS concludes the effects from Klickitat River RM&E do not pose a risk to the viability of the Snake River steelhead natural populations.

All other RM&E activities funded through the Proposed Action occur outside the range of Snake River Basin steelhead and there is no anticipated impact associated with these sampling activities. NMFS concludes these activities will have no effect on the Snake River.

2.5.2.5 Factor 5. The operation, maintenance, and construction of hatchery facilities that are associated with Mitchell Act grant funds

The construction/installation, operation, and maintenance of hatchery facilities can alter fish behavior and can injure or kill eggs, juveniles, and adults. It can also degrade habitat function and reduce or block access to spawning and rearing habitats altogether. Here, NMFS discusses changes to riparian habitat, channel morphology and habitat complexity, in-stream substrates, and water quantity and water quality attributable to operation, maintenance, and construction activities and confirms whether water diversions and fish passage facilities are constructed and operated consistent with NMFS criteria.

Most, but not all, hatchery facilities use surface water from adjacent rivers and streams, the withdrawal of which risks entraining fish into water intakes and or impinging fish on intake infrastructure such as screening. Intake structures and screening designed and operated under current NMFS screening criteria (NMFS 2022o) substantially minimize this risk. Structures that meet previous NMFS criteria (NMFS 1995b); (NMFS 1996c); (NMFS 2011a) may also reduce risk. Structures that do not meet the criteria may present a high risk at the scale of the individual animal but may present a negligible or low risk at the population scale if the facility's intake is small in scale relative to the size of the waterbody in which the hatchery is located and/or the intake infrastructure is located in an area where few ESA-listed fish are likely to occur. Hatchery water use is typically non-consumptive, though the relative quantity of surface water withdrawn and relative locations of withdrawal and discharge points may present risks to migration, spawning, and rearing habitat utilized by ESA-listed fish. Facilities that withdraw a small proportion of total stream discharge and/or discharge near their withdrawal point(s) minimize these risks.

The effects analysis for facilities that rear Mitchell Act-funded fish in NMFS's BA (NMFS 2024g) identifies and evaluates the potential effects on ESA-listed fish from the hatchery facilities' construction, operations, and maintenance described in the HOF. The HOF utilizes 25 facilities that are either partially or fully funded through the Mitchell Act grant. Of those 25 facilities, NMFS determined that 19 had no to negligible impact and six had low-negative levels of impact ((NMFS 2024a), Table 117 below).

Table 117. The hatchery facilities that rear Mitchell Act-funded fish identified for infrastructure improvements required to meet NMFS's intake screening and fish passage design criteria.

Hatchery Facility	Improvement Needed	Impact
Fallert Creek Hatchery (Kalama R.)	Fallert Creek intake lost in the 2016 flood will need to be updated to meet current criteria and to provide passage for NOR adults. Mainstem Kalama River pump screens have been updated but may not meet the 2022 criteria.	Low-Neg
Klaskanine Hatchery	Mainstem intake #1 does not meet current criteria, including providing adult passage. Intake #2 was decommissioned. Intake #3 does meet the 2012 criteria. Main intake #1 has a construction plan with an estimated completion date of 2030.	Low-Neg
NF Toutle Hatchery	Surface intake does not meet the criteria. A feasibility study completed in 2012 is awaiting funding. Funding for the project is on the Washington State 10-year capital improvements plan.	Low-Neg
Kalama Falls Hatchery	Intake screens were updated in 2006 but may not meet 2022 criteria.	Low-Neg
Washougal Hatchery	Intake screens do not meet current criteria. It will be updated under the Inflation Reduction Act of 2022 (IRA). Projects funded are estimated to be completed by 2029.	Low-Neg
Klickitat Hatchery	The surface intake structure does not meet the current criteria. It will be updated under the IRA-funded projects.	Low-Neg

The primary source of effects on ESA-listed species from Mitchell Act-funded hatchery operations is the withdrawal of surface water from various sources and the facilities' water intake at those facilities that do not meet NMFS screening criteria (NMFS 2022o). However, all of the Mitchell Act-funded facilities meet earlier standards (NMFS 1995b); (NMFS 1996c); (NMFS 2011a).

Moreover, the Proposed Action also provides funding to operate intake screens at IDFG's facilities, which has been determined to likely not have an adverse effect on ESA-listed species (NMFS 2000c). This is because these screens comply with NMFS's screening criteria, so we anticipate that it will have a beneficial effect on listed salmon and steelhead and that it will have negligible probability of taking such fishes or adversely modifying their critical habitat.

There are 22 facilities operated under the HOF, some of which receive Mitchell Act grant funds for operation and maintenance, and others which only receive Mitchell Act grant funds for particular artificial propagation program(s) on-site. Table 117 identifies those facilities needing improvements, the improvements required, and the level of impact analyzed in the Mitchell Act BA (NMFS 2017a).

The impact level assigned to those improvement needs identified in Table 117 is based on the cumulative effects of the operation of the hatchery facility on ESA-listed species. A facility is considered to have a "low negative" impact if the intake screens do not meet current NMFS screening criteria, but hatchery water withdrawals are consistent with established water rights and in-stream flow requirements. The facilities are operated to maintain minimum flows between the intake structure and the hatchery outfall, and barriers to adult passage are operated to minimize delay and handling effects. These facilities have essentially minimized the effects of their operations on the ESA-listed species.

NMFS also identifies some facilities as having a "negligible effect." Facilities identified as such use water from non-anadromous sources (e.g., from above natural barriers, from wells, natural springs, and/or non-fish bearing streams); do not use surface water (e.g., net-pens) and/or use relatively small amounts of stream flow over a short distance for a limited period of time (e.g., small acclimation ponds); and/or meet current NMFS screening and fish passage requirements.

Surface water diversion at a hatchery can impede habitat utilization between a facility's water intake structure(s) and effluent outflow. Specific minimum flow requirements for anadromous fish habitat vary significantly depending on the species that occupy the habitat in question and the time of year. Thus, adverse habitat impacts can only be inferred through hydrological modeling that is discrete to a reach in a watershed. Each hatchery and/or acclimation site facility is not ubiquitous in design, and each water source is physiographically dependent. Therefore, mandating a universal minimum flow is not feasible.

Considering this, NMFS looked at each facility's permitted water rights and estimated water use to identify facilities where water use may affect the habitat in the bypass reach between the facility's surface water intake and effluent outfall (NMFS 2024g). Of the 22 hatchery facility operations managed under the HOF, six have been identified as having potential effects on ESA-listed species (Table 117). Facilities that rear Mitchell Act-funded fish that have undergone prior evaluation under site-specific consultations, including those that are interrelated to the HOF, are a part of the Environmental Baseline and are not a part of this effects analysis but are included in our Integration and Synthesis and this overall Opinion (Section 2.4).

Due to environmental stochasticity, some rivers, streams, or tributaries experience low surface flows during mid-summer and early fall. Each salmon or steelhead species occupying a given reach of a stream or river is equally interdependent on the water source shared but also independent in their habitat quality and quantity needs throughout their life history. Facilities located in areas that experience seasonal low water flows consider this when planning their production programs. Managers do not schedule on-station production requiring additional water usage other than the minimum required for daily operations to continue during the seasonal low flow duration.

Hatchery water discharge into adjacent surface waters may affect several water quality parameters in the aquatic system. Hatchery facility waste products may include uneaten food, fish waste products (i.e., fecal matter, mucus excretions, proteins, soluble metabolites such as ammonia), chemotherapeutic agents (e.g., Formalin), cleaning agents (e.g., chlorine), drugs and antibiotics, nutrients (e.g., various forms of nitrogen and phosphorus), bacterial, viral, or parasitic microorganisms, and algae. Some waste products are suspended and settleable solids, while others are dissolved in the water. Water temperature may increase, and dissolved oxygen may decrease as water flows through hatchery raceways and holding ponds. Maintenance activities, such as vacuuming and removal of accumulated sediment on the bottoms of hatchery ponds and raceways, may temporarily elevate the concentration of some contaminants in the hatchery water system.

The direct discharge of hatchery facility effluent is regulated by the EPA under the CWA through NPDES permits. For discharges from hatcheries not located on federal or tribal lands within Washington State, the EPA has delegated its regulatory oversight to the State. Washington Department of Ecology is responsible for issuing and enforcing NPDES permits that ensure that water quality standards for surface and marine waters remain consistent with public health and enjoyment of State waters and the propagation and protection of fish, shellfish, and wildlife. In Oregon, the Oregon Department of Environmental Quality (DEQ) is responsible for issuing and enforcing NPDES permits. At the same time, the Idaho Department of Environmental Quality (IDEQ) is the authority that issues and enforces NPDES permits in Idaho. NPDES permits are not required for hatchery facilities that release less than 20,000 pounds of fish per year or feed less than 5,000 pounds of fish food during any calendar month. Additionally, Native American tribes may adopt their water quality standards for permits on tribal lands (i.e., tribal wastewater plans). Hatcheries that require an NPDES permit operate pollution abatement ponds to remove suspended and settleable solids from the effluent before the effluent is discharged.

Most, if not all, chemicals used at hatcheries are used periodically (not constantly) and in relatively low volumes (NMFS 2004). This is particularly true for chemotherapeutic agents (e.g., formaldehyde, sodium chloride, iodine, potassium permanganate, hydrogen peroxide, antibiotics), which must be used at levels that will not appreciably affect the fitness or survival of juvenile salmonids rearing at the hatchery. In addition, many of these agents break down quickly in the water and/or are not likely to bioaccumulate in the environment. For example, formaldehyde readily biodegrades within 30 to 40 hours in stagnant waters. Similarly, potassium permanganate would be reduced to low-toxicity compounds within minutes. Aquatic organisms can also transform formaldehyde through various metabolic pathways into non-toxic substances, preventing bioaccumulation in organisms (EPA 2015). Although potentially more harmful cleaning agents may be used periodically at hatcheries, those agents are diluted before discharge, thus resulting in highly diminutive discharge levels for any receiving waterbody.

Hatchery discharge volumes are typically a relatively small proportion of the receiving waterbody’s flow. Thus, hatchery effluent is often rapidly diluted near the discharge point to the receiving waterbody. The likelihood of injury to listed salmonids from exposure to effluent is related to the frequency of occurrence, length of time the salmonids are exposed (e.g., how long they remain near the effluent discharge points), and the concentration of substances within the effluent water. Due to the periodic nature of chemical and chemotherapeutic use and the low concentrations commonly achieved at or near the point of discharge, NMFS does not expect any deleterious effects on ESA-listed salmon and steelhead.

Compliance with NPDES requirements does not assure that effects on ESA-listed salmonids will not occur, but rather that they will likely occur up to a certain limit associated with the permit. Hatchery facilities use water specifically to incubate and rear juvenile salmon. Survival of eggs and juveniles in hatcheries is typically much higher than in the natural environment (Bradford 1995). Egg and juvenile survival within the hatchery programs included in this consultation indicate generally good water quality at those facilities. Chemicals are used periodically and diluted before discharge. Effluent discharge volumes are relatively small compared to the volumes of the receiving waters. Therefore, pollutants in the effluent are expected to be rapidly diluted near the point of discharge. In addition, any increase in temperature or decrease in dissolved oxygen that may have occurred in the hatchery would quickly return to background levels. For these reasons, effluent from the facilities included in this consultation is believed to present minimal risk to ESA-listed salmonids.

Maintenance of hatchery equipment and infrastructure (e.g., weirs, fish ladders, holding ponds, raceways) occurs intermittently and for short periods. Such maintenance may generate disturbance from noise (equipment operation) and resuspension of fine sediments localized near the hatchery operation. Adult and larger juvenile salmonids are highly mobile and able to detect and avoid areas of disturbance. Salmonids in these age classes can quickly move around or pass through sediment plumes. Individuals who may pass through a sediment plume will be exposed to elevated turbidity levels for brief periods (less than 1 hour) and are not expected to be measurably affected. Noise from heavy equipment is not likely to reach levels that would be harmful. Therefore, direct effects associated with short-term exposure to elevated turbidity and or noise from maintenance activities are not expected to be meaningful to ESA-listed salmonids in the Columbia River Basin.

The operation of net pens associated with Mitchell Act-funded programs may affect water quality, native substrates, and benthos near those operations. Effects are typically minor in scale, localized near the facility, and do not have any measurable effects on listed species.

Herbicides (primarily glyphosate-based chemicals) are used at many hatchery facilities to maintain landscaping and lawns. Herbicides are used following the manufacturer’s label guidelines and are applied during dry weather conditions (i.e., not raining or expected to rain) to prevent runoff into surface waters. Roundup is often used around buildings and landscaped areas and is not applied within 300 feet of water. Rodeo is often used for applications closer to water. Backpack sprayers or equivalent are often used for application. Herbicide use is typically relatively low, and conservation measures are implemented to prevent chemicals from entering the water.

To define potential effects related to a hatchery facility's operational water needs, NMFS looked at each facility required to operate under an NPDES permit. Effluent from each facility with an NPDES permit is monitored weekly to ensure compliance with permit requirements. Several acclimation sites associated with Mitchell Act-funded programs where fish are prepared for release into the natural environment do not need an NPDES permit because fish rearing levels are below permit minimums. Any sediment from the maintenance of instream structures at hatchery facilities would be localized and temporary and would not be expected to affect ESA-listed anadromous fish species.

NMFS (2024a) describes the effects of the operation of the hatchery facilities that rear Mitchell Act-funded fish under the HOF on ESA-listed species. Effects on ESA-listed species are considered a "low negative" if the facility's intake screens meet (NMFS 2022o) operational and screening criteria, water withdrawals are consistent with established water rights, and barriers to adult passage are operated to minimize delay and handling effects. These facilities are found to have essentially minimized the effects of their operations on the ESA-listed species. Additionally, facilities subject to seasonal low flows are required to maintain flows suitable for adult passage, juvenile rearing, and migration between the intake structure and the hatchery outfall.

(NMFS 2024g) also identifies some facilities that rear Mitchell Act-funded fish as having a "negligible effect." Facilities identified as such use water from sources that do not contain anadromous fish (e.g., from above natural barriers, from wells, natural springs, and or non-fish bearing streams), do not use surface water (e.g., net-pens), and or use relatively small amounts of stream flow over a short distance for a limited period (e.g., small acclimation ponds and facilities that pump effluent back into the source directly downstream the intake).

NMFS (2024g) finds that for the following ESUs/DPSs, hatchery facilities and operations described in the HOF have a negligible or low negative effect: UCR spring-run Chinook Salmon ESU; Snake River Spring/summer-run Chinook Salmon ESU; Snake River Fall-run Chinook Salmon ESU; Snake River Sockeye Salmon ESU; UCR Steelhead DPS; UWR Steelhead DPS; and Snake River Basin Steelhead DPS. NMFS finds that further review and analysis for these ESUs/DPS is, therefore, not warranted.

Not all populations within a given ESU or DPS may be affected by hatchery operations and maintenance. At a population scale, the risk from hatchery operations and maintenance may range from negligible to moderately negative depending on a variety of factors, including but not limited to the extent of facility compliance with current NMFS safe fish passage and screening criteria and the proportion of the population in question that is exposed to hatchery facility effects. Most, if not all, affected populations are likely to incur only negligible or low risk based on NMFS's experience completing site-specific consultations (see Section 2.4). For these reasons, we expect that the facilities operations and maintenance risk associated with Mitchell Act funding will result in negligible to low-negative risk at the ESU and DPS scale.

ESA-listed ESUs and DPSs on which facilities that rear Mitchell Act-funded fish and operations are identified as having a low or medium effect are discussed below.

2.5.2.5.1 Pacific Eulachon Southern DPS

Most of the hatchery facilities funded through the Proposed Action are not located within Pacific Eulachon Southern DPS designated critical habitat (see additional discussion in Section 2.12.4). Those few that are located within designated critical habitat operate intake screens during periods of the year when adult and juvenile eulachon are not present in the river. As a result no effects on the Pacific Eulachon Southern DPS are expected from the operation of these facilities.

2.5.2.5.2 LCR Chinook Salmon ESU

The facilities and operations listed in Table 117 above may affect ESA-listed LCR Chinook salmon, except for the Klickitat Hatchery, which is located outside the ESU's geographical boundary.

In the Kalama River, fall Chinook salmon do not, nor were they known to historically, migrate above the Kalama Falls or the Fallert Creek intake structures and thus would not be affected. The mainstem Kalama River intake at the Fallert Creek Hatchery is operated only in the summer months when fall Chinook salmon juveniles are absent, but it may affect juvenile LCR spring Chinook salmon. However, the lower Kalama River conditions during the summer are not conducive to juvenile rearing due to elevated river temperatures.

The operation of the North Fork Toutle and Washougal Hatchery facilities can also affect LCR fall Chinook salmon. The North Fork Toutle intake screens have not been updated since 1978 and do not meet current NMFS criteria. Some natural-origin fall Chinook salmon may be entering the facility, though they are likely entering the ponds that rear hatchery-origin fall Chinook salmon without major injuries because the intake is gravity fed without any pumps. However, because the hatchery-origin fall Chinook salmon in these ponds are not marked yet, there is no feasible option to distinguish between hatchery-origin and natural-origin fall Chinook salmon. These natural-origin fall Chinook salmon that enter the ponds are reared alongside the hatchery-origin fall Chinook salmon and released volitionally when they are physically ready to emigrate, possibly with a higher survival rate than had they been reared in nature. There is no indication that natural-origin fall Chinook salmon are entering ponds of other hatchery-origin species. A feasibility plan for upgrading the intake was developed in 2012; flows in the bypass reach are sufficient, and requirements for minimum flows are not necessary. The North Fork Toutle intake is on the Washington State infrastructure needs list and is awaiting funding through state budget appropriations.

WDFW is currently working on facility upgrades to the Washougal Hatchery, which are expected to be completed by 2029. Stream flows are maintained in the bypass reach between the intake and the outfall. The effects of the Washougal Hatchery intake on natural LCR fall Chinook salmon are expected to be minimal because the intakes exceed the upper extent of the fall Chinook salmon spawning grounds.

The Klaskanine Hatchery's intake structure is not expected to affect LCR fall Chinook salmon because fall Chinook salmon do not migrate above or past the facility.

2.5.2.5.3 LCR Coho Salmon ESU

The LCR Coho Salmon ESU is affected by the operation of the same hatchery facilities that affect the LCR Chinook Salmon ESU. These effects are the same except for the operations at the Fallert Creek and Klaskanine hatcheries. The intake structure does not meet NMFS criteria at Fallert Creek Hatchery, and the hatchery facility blocks passage of coho salmon above the hatchery into Fallert Creek. This limits the spatial distribution of the coho salmon population in the Kalama River and possibly its productivity. Similarly, the Klaskanine Hatchery intake #1 does not meet NMFS criteria, affecting out-migrating juvenile coho salmon that encounter the screen. The hatchery intake structure blocks the upstream passage, and all NOR coho salmon are collected and transported above the two other hatchery intake structures (#2 and #3). Effects can occur if adult coho salmon fall back downstream of the two upstream intake structures and become trapped due to these intake structures not incorporating upstream passage. Such effects are localized to the North Fork Klaskanine River above the hatchery, which represents only a small proportion of the habitat within the Youngs Bay coho salmon population, which is considered a sustaining population with a low viability goal in recovery planning (Table 3-1 in (NMFS 2013e)).

As discussed above, the intake screen on the NF Toutle Hatchery does not meet NMFS screening criteria. For the same reason discussed under the LCR Chinook salmon subsection, natural-origin coho salmon entering the hatchery-origin salmon ponds are likely to experience a higher survival rate. However, there are some indications that natural-origin coho are entering the hatchery-origin fall Chinook salmon ponds, though the exact numbers have not been tracked. These fish are removed from the ponds and returned to the stream when the fall Chinook salmon are getting marked in late April through early June. The natural-origin coho and hatchery-origin fall Chinook salmon are close in size, such that predation by the hatchery-origin fall Chinook salmon is not likely. In addition, because the hatchery operation provides more food than what can be found in nature, natural-origin coho is likely to experience less competition effects than rearing in the natural stream. Based on anecdotal numbers, NMFS expects no more than 1,000 natural-origin coho to be detected in the ponds for the hatchery-origin fall Chinook salmon, with no more than 3% mortality from handling, based on data for other handling effects analyzed in Section 0.

LCR coho salmon are passed above the Washougal Hatchery for spawning, and because the facility's intake screens do not meet current NMFS criteria, the facility imparts a low-negative effect on the population. As stated, WDFW has received funding through the IRA for facility improvements to elevate this operational effect. These impacts are expected to be small because the intake is screened, but it is unclear if the approach velocities exceed current NMFS criteria.

2.5.2.5.4 LCR Steelhead DPS

Impacts on LCR Steelhead are similar to those identified for the LCR Chinook Salmon and LCR Coho Salmon ESUs, where the steelhead DPS distribution overlaps that of the two ESUs. The facility improvements mentioned above will also benefit LCR steelhead populations. While LCR steelhead may enter into the intake at NF Toutle Hatchery, they have not been observed in the past.

2.5.2.5.5 UWR Chinook Salmon ESU and UWR Steelhead DPS

The Clackamas Hatchery is the only facility described in the HOF that is identified as affecting the UWR Chinook Salmon ESU. The intake consists of two self-cleaning rotating drums, each with a diameter of 54'' and a width of 80''. The screening around each drum is stainless wedge wire with an opening of 1.07mm (0.069"), which complies with all NOAA criteria. This new system has no adverse effect on ESA-listed salmon and steelhead and will provide a potential benefit to the wild population by increasing hatchery homing fidelity. The Clackamas Hatchery operates under an NPDES permit. Facility effluent is monitored to ensure compliance with permit requirements.

2.5.2.5.6 MCR Steelhead DPS

The Klickitat Hatchery is the only facility described in the HOF that operates within the MCR Steelhead DPS designated critical habitat. The hatchery's gravity-fed intake does not meet NMFS criteria (NMFS 2022o) screening criteria but has undergone evaluation in 2012 and, most recently, in 2019 (Kleinschmidt Associates 2019). The surface flow (pumped) intake does meet the 2011 criteria. The hatchery facility management (Yakama Nation) has submitted a funding request under the IRA for facility infrastructure needs that will bring the facility into full compliance with the NMFS screening criteria. This would significantly reduce the identified effects on the ESA-listed MCR Steelhead DPS. Until these projects are completed, the facility's operations may delay downstream migration of the listed steelhead juveniles. Delays would occur until all of the fish are released from pond 25. The intake begins in the spring, removing a small proportion (< 3%) of the Klickitat River flow to supplement water supplied from Wonder Springs.

2.5.2.5.7 CR Chum Salmon ESU

Effects on the CR Chum Salmon ESU are expected to be similar to those identified for the LCR Chinook salmon ESU. Effects on chum salmon from the operation of the hatchery facilities described in the HOF are expected to be less than those identified for the LCR Fall Chinook Salmon ESU because the natural distribution of chum salmon in the LCR is less than that observed for fall Chinook salmon; thus limiting the potential for interactions between chum salmon and Mitchell Act-funded hatchery facilities and operations. Any improvements to the hatchery facilities listed in the table above would also be expected to reduce impacts on chum salmon where the two overlap.

2.5.2.5.8 Summary

Facility operations for Mitchell Act-funded programs are annually reported to NMFS, ensuring safeguards are in place so that hatchery facility operation and maintenance do not pose an unacceptable risk to natural salmon and steelhead populations. Additionally, during ESA consultations, NMFS evaluates whether the safeguards proposed by hatchery operators are sufficient to minimize such risk. If existing safeguards are insufficient, NMFS imposes Terms and Conditions on hatchery operations so that the risk to ESA-listed species is sufficiently minimized and accountable. Such safeguards may include but are not limited to timelines for when hatchery operators must complete infrastructure upgrades to bring water intake structures and screening into compliance with current NMFS standards and to establish and implement flow criteria for safe fish passage (Table 117).

The effects of Mitchell Act-funded hatchery facilities and operations that are evaluated under Factor 5 of NMFS's reference document (see Appendix A) on the relevant listed salmonid ESUs/DPSs do not rise to the level where these effects would be expected to limit the abundance and productivity of individual populations within the ESUs/DPSs. Moreover, the facilities that do not meet current screening and or fish passage criteria are working towards upgrades. Still, operations at these facilities only affect the proportion of the natural-origin adults and juvenile migrants within a relevant ESU or DPS within the vicinity of the hatchery in question for a short duration. Thus, the adverse effects on those juvenile and adult migrants who encounter the screens or other intake structures not meeting NMFS's current criteria are not expected to reduce the abundance or spatial distribution of the ESA-listed populations.

2.5.2.6 Factor 6. Fisheries that exist because of the hatchery program

Fisheries are not a part of the Proposed Action. However, there are fisheries that exist because of the Proposed Action. Certain terminal fisheries within the tributaries of the LCR downstream of Bonneville Dam meet the "but for" test, meaning these fisheries would not occur "but for" the Proposed Action. The majority (in some cases 100%) of the hatchery salmon and steelhead produced in these tributaries are a direct result of current Mitchell Act funding, and this will continue under the Proposed Action. While NMFS can analyze the effects of these fisheries, we are not authorizing them through this consultation. Fisheries existing outside of these terminal tributary areas, those in the mainstem Columbia River and the Pacific Ocean would exist with or without the Proposed Action and have previously been evaluated in separate biological opinions (NMFS 2018a); (NMFS 2012c); (NMFS 2015c).

Pacific eulachon, as a result of the Proposed Action, will not be affected by these tributary fisheries. These fisheries target salmon or steelhead in the terminal freshwater areas when neither of these species are present. Therefore, NMFS has determined there will be no effects to these ESA-listed species via this factor under the Proposed Action.

NMFS expects no effects under this factor on the UCR Spring–run Chinook Salmon ESU, Snake River Spring/summer-run Chinook Salmon ESU, Snake River Fall-run Chinook Salmon ESU, UWR Chinook Salmon ESU, CR Chum Salmon ESU, SR Sockeye Salmon ESU, LCR Steelhead DPS, UCR Steelhead DPS, Snake River Basin Steelhead DPS, MCR Steelhead DPS, and the UWR Steelhead DPS as a result of the Proposed Action because these fish are not likely to be encountered in these fisheries. Any fisheries encountering these species throughout the Action Area have current consultations in place and these effects are described in the Environmental Baseline (Section 2.4).

Effects of this factor on ESA-listed species are described in the following sections.

2.5.2.6.1 LCR Chinook Salmon ESU

Hatchery releases of Chinook salmon in the Sandy River, Washougal River, Kalama River, and Big Creek are 100% funded by the Proposed Action. Fisheries targeting hatchery Chinook salmon therefore exist in these terminal rivers as a result of the Mitchell Act-funded hatchery programs. Terminal fisheries were analyzed in 2003 (NMFS 2003a) for their effects to LCR Chinook Salmon, where NMFS determined that WDFW and ODFW adequately addressed the criteria for Limit 4 of the final 4(d) rule for ESA-listed LCR salmon in the relevant FMEPs. These FMEPs limited tributary harvest levels of managed fisheries to achieve the 5,700 escapement goal for bright fall-run Chinook salmon. The FMEPs expected that fisheries in terminal areas would continue to implement mark selective fisheries (MSFs[35]) with the advent of mass-marking hatchery releases. The plans also kept harvest rates limited to those below the rate developed during the PFMC process described above in the Ocean Harvest Section for fall-run tule Chinook salmon (see Section 2.4.1.5). However, in 2012 NMFS evaluated an alternate management approach for the LCR Chinook Salmon ESU in an ABM[36] (abundance-based management approach matrix (NMFS 2012c) for the tule component of the ESU. While this new approach of using an ABM matrix resulted in weak-stock management to the degree possible at the time, by reducing the allowable exploitation rate when abundance is low, it also reduced extinction risk to the LCR tule components of the LCR Chinook Salmon ESU by approximately 4% (NMFS 2012c). This action was evaluated with a population specific risk evaluation, based in large part using data on the same populations affected by the Proposed Action analyzed in this Opinion. These effects are captured in the Environmental Baseline (Section 2.4). This short review helps frame our expectations relative to pre-terminal fisheries analyses that inform the interrelated effects of terminal fisheries.

Terminal area fisheries are not currently included in the calculated exploitation rate tiers as part of the ABM matrix approach that NMFS evaluated in 2012 (NMFS 2012c). The two vectors of effect are removal of hatchery fish from terminal areas via MSFs, so the ability to affect pHOS levels, and incidental mortality of natural-origin fish via encountering fish while trying to access hatchery returning fish. As discussed in Section 2.2.2.2.1 and elsewhere, these natural populations still have high levels of hatchery fish (i.e., pHOS) on the spawning grounds. This indicates that terminal area fisheries are not achieving high levels of success for capturing adult hatchery returns or fisheries are restricted for other reasons. The ABM matrix approach was considered equivalent to a long-term effect of a fixed exploitation rate of 37% on the tule component of the ESU, a decrease from the 49% rate incorporated into NMFS' 2003 evaluation of FMEPs addressing the criteria for Limit 4 of the final 4(d) rule for ESA-listed LCR salmon (NMFS 2003d). Preterminal fishery restrictions increasing fish back to terminal areas exists where management of fisheries for a 5,700 escapement goal for bright fall-run Chinook salmon

[35] Mark-selective fisheries only target hatchery salmon identified by external marks allowing fisheries to exclude or release unmarked natural-origin fish.
[36] As discussed in Section 2.4.1.5, an ABM (or abundance-based management) matrix is where a tier of associated harvest or exploitation rate is set based on the abundance of fish, generally with lower abundances resulting in lower rates and vice versa for increased abundances.

in the Lewis River has resulted in consistent and increasing large escapements that exceed the minimum goal. Therefore, assuming the same level of terminal area fishing pressure authorized under NMFS's 2003 evaluation (NMFS 2003d) the resulting decrease in pre-terminal fisheries has passed more fish, both hatchery and natural-origin, into the terminal areas. Here NMFS is not authorizing or examining a take level for fisheries, as they are not part of the Proposed Action, but instead is simply ensuring it is incorporating the effects of actions that occur as a result of the Proposed Action.

As a result of the Mitchell Act-funded programs, weirs will be operated in every river mentioned at the beginning of this section. In the recent past, state-managed fisheries upstream of weirs have been closed as weirs have removed harvestable hatchery fish at their location. NMFS expects this practice to continue where it implements weirs as part of its Proposed Action (except at the lower Washougal River weir because the operation of the weir there is primarily for broodstock collection rather than pHOS control in the Washougal River). Because new weirs are needed to control hatchery strays, terminal fishery pressure in these specific areas is likely to decrease from current levels. Therefore, the negative effects of terminal fisheries are included in the baseline, but as a result of the Proposed Action those effects are likely to be reduced as a result of implementation of the Proposed Action, and the effects to natural-origin populations from incidental mortality associated from catch and releasing natural-origin fish while targeting hatchery-origin fish will decrease as areas upstream of weirs are restricted to fishing.

In the future, it would be beneficial if funding grantees decide to continue fisheries in terminal areas that are implemented as result of the Mitchell Act-funded programs, to submit detailed updated FMEPs evaluating fishery effects on each LCR Chinook salmon natural population for ESA authorization.

2.5.2.6.2 LCR Coho Salmon ESU

Hatchery releases of coho salmon in the Sandy River, Washougal River, Kalama River, Big Creek, and Klaskanine River are 100% funded by the Proposed Action. Fisheries targeting hatchery coho salmon therefore exist in these terminal rivers as a result of the Mitchell Act-funded programs. The effects of terminal fisheries in these areas have not been authorized in separate opinions for their effects on ESA-listed species. However, similar to Chinook salmon, NMFS has available information relative to pre-terminal fisheries analyses that inform the interrelated effects of terminal fisheries. Here NMFS is not authorizing or examining take levels for fisheries, as they are not part of the Proposed Action, but instead is simply ensuring it is incorporating the effects of actions that occur as a result of the Proposed Action.

In 2014 NMFS evaluated an updated harvest matrix the PFMC proposed for LCR coho salmon. The PFMC proposed to manage fisheries, including fisheries in the mainstem Columbia River up to Bonneville Dam, based on exploitation rate limits using two levels of parental escapement and five levels of marine survival (NMFS 2014a). As described in Section 2.4.1.5, NMFS evaluated this strategy in a 2014 biological opinion and concluded that PFMC Fisheries managed via this manner were not likely to jeopardize the continued existence of the LCR Coho Salmon ESU (NMFS 2014a). While terminal area fisheries are not currently included in the calculated exploitation rate tiers in the coho harvest matrix, the resulting escapements that currently contribute to LCR coho salmon population status are the result of any fisheries implemented at both the preterminal and terminal levels. These escapements were used for evaluating the proposed alterations to the coho harvest matrix. Similar to the previous subsection on LCR Chinook salmon immediately above, this brief review of baseline effects for LCR coho salmon (discussed in more detail in Section 2.4), directly informs our expectations for interrelated effects of fishing in the terminal areas.

While it is unclear if fishing pressure has changed in the terminal areas during the timeframe similar to LCR Chinook salmon, LCR coho salmon harvest rates have been reduced substantially over the last two decades and this has resulted in the level of escapements captured in Section 2.2.3. The two vectors of effect are the same as we described for Chinook salmon, removal of hatchery fish from terminal areas via MSFs, so the ability to affect pHOS levels, and incidental mortality of natural-origin fish via encountering fish while trying to access hatchery returning fish. As discussed in Section 2.2.3 and elsewhere, these natural populations still have high levels of hatchery fish (i.e., pHOS) on the spawning grounds. This indicates that terminal area fisheries are not achieving high levels of success for capturing adult hatchery returns or fisheries are restricted for other reasons.

As a result of the Mitchell Act-funded programs, weir operations have been implemented, notably for coho in the Elochoman River. In the recent past, state-managed fisheries upstream of weirs have been closed as weirs have removed harvestable hatchery fish at their location. NMFS expects this practice to extend where weirs are implemented as a result of the Mitchell Act-funded programs, and therefore terminal fishery pressure in these specific areas is likely to decrease from levels that currently may be occurring. Therefore, terminal fishery effects are likely to be reduced as a result of implementation of the weir operation, and effects on natural-origin populations from incidental mortality associated with catching and releasing natural-origin fish while targeting hatchery-origin fish will decrease as areas upstream of weirs are restricted to fishing.

In the future, it would be beneficial if funding grantees decide to continue fisheries in terminal areas that are implemented as result of the Proposed Action, to submit detailed updated FMEPs evaluating fishery effects on each LCR coho salmon natural population for ESA authorization.

2.5.2.7 Effects of the Proposed Action on Critical Habitat

This consultation analyzed the Proposed Action for its effects on the designated critical habitat of ESA-listed salmonids and has determined that funding the operation of hatchery programs under the Mitchell Act will have a negligible effect on physical or biological features (PBFs) in the Action Area. These effects of the Proposed Action are summarized below.

As discussed in Section 2.1 Analytical Approach, the designation(s) of critical habitat for Puget Sound Chinook Salmon ESU, UWR Chinook Salmon ESU, LCR Chinook Salmon ESU, LCR Coho Salmon ESU, LCR Steelhead DPS, UWR Steelhead DPS, Columbia River Chum Salmon ESU, Snake River Spring/Summer-run Chinook Salmon ESU, Snake River Fall-run Chinook

Salmon ESU, UCR Spring-run Chinook Salmon ESU, Snake River Sockeye Salmon ESU, MCR Steelhead DPS, UCR Steelhead DPS, and Snake River Basin Steelhead DPS use(s) the term primary constituent elements (PCEs) or essential features. The 2016 final rule (81 FR 7414; February 11, 2016) that revised the critical habitat regulations (50 CFR 424.12) replaced this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this Opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

NMFS determines the range-wide status of critical habitat by examining the condition of its PBEs that were identified when critical habitat was designated. These features are essential to the conservation of the listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration and foraging). The species in Table 1 have overlapping ranges, similar life history characteristics, and, therefore, many of the same PBFs. These PBFs include sites essential to support one or more life stages (spawning, rearing, and/or migration) and contain the physical and biological features essential to the conservation of each species. For example, important features include spawning gravels, forage species, cover in the form of submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks and migration corridors free of artificial obstruction with sufficient water quantity and quality.

There may be a small beneficial effect on critical habitat from the introduction of marine-derived nutrients resulting from naturally spawning hatchery fish in their respective tributaries. Marine-derived nutrients can also come from the outplanting of hatchery carcasses. As described in Section 2.5.2.2.2.2.1 (Nutrient enhancement/gravel conditioning), the hatchery carcasses provide a direct food source for juvenile salmonids and other fish, aquatic invertebrates, and terrestrial animals, and their decomposition supplies nutrients that may increase primary and secondary production. These marine-derived nutrients can increase the growth and survival of the ESA-listed species by affecting PBFs associated with juvenile rearing, such as increasing forage species (i.e., aquatic and terrestrial insects), aquatic vegetation, and riparian vegetation, to name a few.

Other possible effects of the Proposed Action on ESA-listed salmonids' critical habitat would occur in freshwater migration corridors. Indications that the handling of natural-origin adults at the weirs contributes to pre-spawning mortality are monitored by the evaluation of carcasses that are recovered during spawning ground surveys. Pre-spawning mortality has the potential to affect nutrient and gravel bed conditioning, as discussed in Section 2.5.2.2.2.2.1. In the 2017 Mitchell Act Biological Opinion, NMFS identified hatchery facilities that rear Mitchell Act-funded fish that, at the time, required improvements likely to result in additional construction or disturbance of riparian or streambed habitat (i.e., weirs and or intake structures) and provided that plans for such improvements would be consulted on independently to determine effects on designated critical habitat. This Opinion identifies additional future construction or other improvements that may result in disturbance of riparian or streambed habitat will also be consulted on independently to determine effects on designated critical habitat.

Effects of water withdrawal and effluent are expected to be small and transitory through continued funding of hatchery facilities. Most hatchery intakes are screened to prevent fish removal from streams. NMFS has been working with hatchery operators at facilities rearing Mitchell Act-funded fish to upgrade the screens on intake structures in order to reduce the impingement of fish. This work, which is on-going, is intended to reduce the adverse impacts of hatchery facilities on critical habitat. Juvenile rearing and migratory habitat may also be affected by removing water from stream reaches between the hatchery intake and hatchery outfall (where the water returns to the river). Removing a small proportion of the river flow is expected to have a negligible effect regardless of the distance between the intake and outflow. Minimum flow requirements are maintained as part of required hatchery operations in those sections of streams where the water withdrawal removes a substantial proportion of the flow during specific times of the year. Minimum flow requirements protect migration corridors and provide rearing habitat for juvenile fish.

Habitat impacts from the installation and operation of the weirs (as described in Section 2.5.2.5) are expected to be limited to the weir location and short-lived. The placement of weirs will temporarily impact habitat. Each weir is designed to be installed and removed annually, eliminating the requirement for permanent structures in the related waterbody. When the weirs are operational, they will impact the PBFs for migration as follows:

- The installation of weirs can disturb the substrate, increasing the potential for increased concentrations of suspended solids and sediment, but these effects are expected to be minimal due to weir installation only affecting a small section of the stream bed; the weirs are temporarily limiting the duration of effects, and high flows that occur after weir removal will remove any evidence of weir placement.
- The impacts on designated critical habitat from the installation of "permanent" weirs (those with permanent structures within the stream) have already occurred. The effects of these weirs are described below.
- The installation of weirs in any river described in the Proposed Action (Section 1.3) could potentially lead to the handling of the majority of natural-origin ESA-listed salmon returning to the respective basin. Monitoring associated with spawning ground surveys has and will continue to be used to determine if the presence of the weirs cause natural-origin ESA-listed salmon or steelhead to spawn downstream of the weirs.
- Operation of weirs in any river could potentially result in the handling of the majority of natural-origin ESA-listed salmon returning to that basin. Monitoring associated with spawning ground surveys has and will continue to be used to determine if the presence of the weirs cause natural-origin ESA-listed salmon or steelhead to spawn downstream of the weirs.
- The weirs, based on their installation date, may encounter out-migrating winter steelhead kelts (fish that have already spawned). However, so long as annual installation takes place after June, as described in greater detail in the HOF, kelts would be unlikely to be

encountered and are expected to be uncommon because winter steelhead spawning is usually completed by early May (Schroeder 2013) Adult winter steelhead would not be expected to be encountered during weir operations because they return after the weirs are removed and before the weirs are installed.

To date, the evaluation of carcasses that have been recovered during spawning ground surveys indicate that the handling of natural-origin adults at the weirs may contribute to pre-spawning mortality. Monitoring associated with spawning ground surveys will continue to further evaluate whether the presence of weirs contribute to pre-spawning mortality and/or cause natural-origin ESA-listed salmon or steelhead to spawn downstream of the weirs. In the future, if the adverse impact of weirs on naturally occurring fish is found to exceed the expected adverse impact from daily handling and tagging of fish, operators will address this by adjusting weir design and placement, using trained personnel, and implementing procedures to minimize the time that salmon and steelhead are held.

Additionally, as described in the Sections above, the proposed hatchery programs funded under the Mitchell Act would have a negligible effect on designated critical habitat for the following reasons:

- No new construction of hatchery facilities is proposed. As described in Section 1.3, all newly proposed hatchery programs and facilities would be independently reviewed for ESA and NEPA compliance.
- The hatchery programs proposed to be funded under the Mitchell Act and described in the HOF, see Section 1.3, are expected to slightly increase the level of marine-derived nutrients in the watersheds where program managers outplant hatchery-origin carcasses for nutrient enhancement. This increase is anticipated to enrich the watershed ecology and rearing habitat for juvenile anadromous ESA-listed fish and improve their survival prior to migration.
- The water diversion at each acclimation facility (Coweeman Pond, South Fork Toutle R. CGAAP, and Gobar Pond in Washington; and Clear Creek, and Foster Creek in Oregon) is screened to protect juvenile fish from entrainment and injury.
- Most hatchery facilities that rear Mitchell-Act funded fish meet NMFS 2022, or earlier, screening criteria, and divert less than 4% of streamflow, with most diverting approximately 2% of streamflow. These small levels of withdrawals may only have a negligible effect on fish passage or rearing capacity for ESA-listed anadromous fish populations. Intakes and/or fish passage structures that do not meet the 2022 screening criteria will be brought into compliance when the relevant facility determines it needs to repair or replace those structures.
- Access to habitat in the Kalama River above the Kalama Falls Hatchery will continue to be provided to natural-origin salmon and steelhead.
- Access to habitat in Big Creek above the Big Creek Hatchery will continue to be provided to natural-origin salmon.

- Any sediment from the maintenance of instream structures at hatchery facilities would be localized and temporary and would not be expected to affect ESA-listed anadromous fish species.
- The operation of net pens associated with Mitchell Act-funded programs may affect water quality, native substrates, and benthos near those operations.
- Effects of net pens are typically minor in scale, localized near the facility, and do not have any measurable effects on listed species. Only one program remaining associated with Mitchell Act funding still utilizes the operation of net pens.

2.6 Cumulative Effects

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

Some continuing non-federal activities are reasonably certain to contribute to climate effects within the Action Area. However, it is difficult if not impossible to distinguish between the Action Area's future environmental conditions caused by global climate change that are properly part of the environmental baseline *vs.* cumulative effects. Therefore, all relevant future climate-related environmental conditions in the Action Area are described earlier in the discussion of Environmental Baseline (Section 2.4), Status of Listed Species (Section 2.2.1), Climate Change Effects on Salmon and Steelhead (Section 2.2.9), and Effects of the Action (Section 2.5) sections.

2.6.1 Salmon and Steelhead

Some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on salmon and steelhead populations and PBFs. Many of these activities have occurred in the recent past and their effects are therefore included in the environmental baseline. Some of these activities are also considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired), and those future effects are addressed as cumulative effects.

Within the Action Area, non-federal actions are likely to include human population growth (e.g., expansion of the built environment; conversion of forests and open space to residential, commercial, and industrial uses; increased effluent discharge from municipal wastewater treatment), water withdrawals (i.e., those pursuant to senior state water rights), and land use practices (e.g., forestry, agriculture). All of these activities can contaminate local or larger areas with hydrocarbon-based materials and other pollutants. State, tribal, and local government actions are likely to be in the form of legislation, administrative rules, or policy initiatives, shoreline growth management, and resource permitting. Private activities include continued resource extraction, vessel traffic, development, and other activities which contribute to poor water quality and continued vessel and construction noise in the freshwater and marine environments of Puget Sound and the Columbia River Basin. Although these activities and their effects are ongoing to some extent and likely to continue in the future, past occurrence is not a guarantee of a continuing level of activity. That will depend on the pace at which human population growth and its corresponding environmental ramifications continues, as well as the emergence, adoption, implementation, and/or effectiveness of economic, administrative, and legal impediments to activities with adverse effects, and safeguards to minimize or prevent adverse effects. Therefore, NMFS finds it likely that the cumulative effects of these activities will have adverse effects commensurate to those of similar past activities, as described in the Environmental Baseline. Additionally, in areas upstream of where the 2018 *U.S. v Oregon* Agreement governs fisheries, (e.g., the UCR and Snake River upstream into Idaho) within the Action Area, relevant state, tribal, and local government actions may include fishing permits. These continuing upstream commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations.

Activities occurring in the Puget Sound area were considered in the discussion of cumulative effects in several broad-scale section 7 consultations, including the following:

- Salish Sea Nearshore Programmatic Consultation (NMFS 2022m)
- Issuance of Permits for Projects under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act for Actions related to Structures in the Nearshore Environment of Puget Sounc; (NMFS 2021d); (NMFS 2022i)
- Puget Sound Harvest Resource Management Plan (NMFS 2024d)
- Washington State Department of Transportation Preservation, Improvement, and Maintenance Activities (NMFS 2013b)
- Washington State Water Quality Standards (NMFS 2008c)
- National Flood Insurance Program (NMFS 2008d)

Activities occurring in the Columbia River Basin were considered in the discussion of cumulative effects in several broad-scale section 7 consultations, including the following:

- Issuance of NPDES Permits for Eight Federal Dams on the Lower Columbia and Lower Snake Rivers (NMFS 2021e)
- Operations and Maintenance Dredging of the Federal Navigation Channel at Tongue Point, Clatsop County, Oregon; Elochoman Slough, Wahkiakum County, Washington; Lake River, Clark County, Washington; and Oregon Slough, Multnomah County, Oregon (NMFS 2021f)
- Continued Operation and Maintenance of the Columbia River System (NMFS 2020b)
- 2018-2027 *U.S. v. Oregon* Management Agreement (NMFS 2018c)
- Willamette River Basin Flood Control Project (NMFS 2008e)
- Washington State Department of Transportation Preservation, Improvement, and Maintenance Activities (NMFS 2013b)
- Washington State Water Quality Standards (NMFS 2008c)

- National Flood Insurance Program (NMFS 2008d)

As discussed in the above-cited biological opinions, we expect salmon and steelhead spawning and rearing habitat, foraging and migration habitat, and water quality to continue to be negatively affected by the following: forestry; agriculture and grazing; channel and bank modifications; road building and maintenance; urbanization; sand and gravel mining; dams; irrigation impoundments and withdrawals; boat traffic in rivers, estuaries, and the ocean; wetland loss; forage fish/species harvest; and, climate change. We anticipate that the effects described in these previous analyses will continue into the future and therefore we incorporate these opinions' discussions by reference here. These opinions discussed the types of actions taken in coordination with the federal actions consulted upon to protect listed species through habitat protection and restoration, hatchery and harvest reforms, and management of activities that affect aquatic resources.

Most hatchery programs throughout the Action Area have completed ESA consultation, and are thus considered in the Environmental Baseline. At the beginning of FY23, NMFS had approved – or was in the process of approving – the following HGMPs by geographic area: (1) of 100 HGMPs in Puget Sound, 53 (53%) were authorized and the remaining 47 (47%) were in progress; and (2) of 160 HGMPs in the Columbia River Basin, 145 (90%) had been authorized and an additional 15 (10%) were in progress. Washington coast hatchery programs do not require HGMP ESA review by NMFS because they operate in areas (freshwater) where there are no ESA-listed salmon and steelhead under NMFS jurisdiction. Most Puget Sound and Columbia River Basin programs that have not had HGMP ESA review, as well as Washington coast programs, are established, ongoing programs producing fish for harvest or other needs of the operators (e.g., harvest management, salmonid conservation and recovery). Therefore, the ongoing effects of these programs on listed fish should be similar in type and scope to those described in the Environmental Baseline.

The effects of past operations of State or tribal programs that are ongoing but have not yet completed consultation are included in the Environmental Baseline. We expect these programs to continue to release similar species in similar or lower abundances for the duration of the Proposed Action evaluated in this consultation, understanding that there may be some changes arising from shifting demands on hatchery production due to changes in conservation needs or harvest regime changes. Though we have not analyzed the effects of these programs, and cannot therefore be certain what those effects are, it is reasonable to assume that those programs have many, most, or all of the same adverse effects as those described in the Environmental Baseline.

While past effects from ongoing programs are in our Environmental Baseline, and though NMFS finds it likely that the cumulative effects of these activities are likely to have adverse effects commensurate to those of similar past activities, as described in the Environmental Baseline, NMFS addresses some anticipated additional cumulative effects from Habitat and Hydropower (Section 2.6.1.1) and Hatcheries and Harvest (Section 2.6.1.2) activities, separately, below.

2.6.1.1 Habitat and Hydropower

In NMFS's 2014 opinion (NMFS 2014i) on the FCRPS we described information provided by the states of Idaho, Oregon, and Washington for ongoing, future, or expected projects that were reasonably certain to occur and that were expected to benefit recovery efforts in the Interior Columbia River Basin. Here, we briefly update that in the relevant sections below.

State of Oregon – Oregon Plan for Salmon and Watersheds. The Oregon Plan for Salmon and Watersheds includes voluntary restoration actions by private landowners, monitoring, and scientific oversight that is coordinated with state and Federal agencies and tribes. The Oregon Legislature allocates monies drawn from the Oregon Lottery and salmon license plate funds, which have provided $100 million and $5 million, respectively, to projects benefiting water, salmon, and other fish throughout Oregon. Projects include reducing road-related impacts on salmon and trout streams by improving water quality, fish habitat, and fish passage, providing monitoring and education support, helping local coastal watershed councils, and providing staff technical support.

State of Washington – Governor's Salmon Recovery Office. The Governor's Salmon Recovery Office arose from Washington's Salmon Recovery Act, and it includes the Salmon Recovery Funding Board (SRFB). SRFB has helped finance more than 900 salmon recovery projects focused on habitat protection and restoration. SRFB administers two grant programs (general salmon recovery grants and Puget Sound Acquisition and Restoration grants). Municipalities, tribal governments, state agency non-profit organizations, regional fisheries enhancement groups, and private landowners may apply for these grants. The Lower Columbia Conservation and Sustainable Fisheries Plan (CSF Plan) (WDFW and LCFRB 2015) provides the framework for implementing recovery plan hatchery and harvest actions in the LCR. The goal of the CSF Plan is to: (1) support efforts to recover salmon and steelhead populations to healthy, harvestable levels; and (2) sustain important fisheries. The CSF Plan encompasses the tenets of the recovery plan, and acknowledges that an "all H" (Habitat, Hatcheries, Harvest, Hydro) approach to recovery is necessary.

All these actions are either completed or ongoing and were, thus, part of the Environmental Baseline for this consultation, or are reasonably certain to occur and therefore qualify here as cumulative effects. Both beneficial and adverse cumulative effects related to habitat and hydropower are addressed in this Opinion. Additionally, the description of the cumulative effects from our 2020 opinion (NMFS 2020b) on the Columbia River System is incorporated by reference here, and reviewed immediately below.

Non-federal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. They also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems. Significant actions and programs contributing to these benefits include growth-management programs (planning and regulation); a variety of stream and riparian habitat projects; watershed planning and implementation; acquisition of water rights for instream purposes and sensitive areas; instream flow rules; stormwater and discharge regulation; total maximum daily load (TMDL) implementation to achieve water-quality standards; hydraulic project permitting; and increased spill and bypass operations at hydropower facilities. NMFS determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in their designated critical habitat. These activities are likely to improve conditions for the salmon and steelhead in the Columbia River Basin.

2.6.1.2 Hatcheries and Harvest

It is likely that the type and extent of salmon and steelhead hatchery programs, including those funded under the Mitchell Act, and the numbers of fish released in the Action Area will change over time. Although adverse effects will continue, these changes are likely to reduce effects such as competition and predation on natural-origin salmon and steelhead compared to current levels, especially for those species that are listed under the ESA. This is because all salmon and steelhead hatchery and harvest programs funded and operated by non-federal agencies and tribes in the Columbia River Basin have to undergo review under the ESA to ensure that listed species are not jeopardized and that “take” under the ESA from salmon and steelhead hatchery programs is minimized or avoided. Although adverse effects on natural-origin salmon and steelhead will likely not be completely eliminated, effects would be expected to decrease from current levels over time to the extent that hatchery programs are reviewed and approved by NMFS under the ESA. Currently, this is only the case in certain tributary sections of the Action Area in the LCR, specifically in the Cowlitz and Lewis Rivers. For example, review of the Lewis River coho program is anticipated to lead to a reduction in pHOS because the Lewis River coho program is currently contributing to the majority of the pHOS in the East Fork Lewis River. While past effects from hatchery programs are in our Environmental Baseline, future effects are included here.

Further, we anticipate reductions in future effects on listed salmon and steelhead are likely to occur through changes in:

- Hatchery monitoring information and best available science,
- Times and locations of fish releases to reduce risks of competition and predation,
- Management of overlap in hatchery- and natural-origin spawners to meet gene flow objectives,
- Better isolation of segregated programs,
- Increased use of integrated hatchery programs for conservation purposes,

- Incorporation of new research results and improved best management practices for hatchery operations,
- Creation of wild fish only areas,
- Changes in the species propagated and released into streams and rivers and in hatchery production levels,
- Termination of programs,
- Increased use of marking and/or tagging of hatchery-origin fish,
- More accurate estimates of natural-origin salmon and steelhead abundance for abundance-based fishery management approaches.

For example, although not supported by Mitchell Act funding, a perennial contributor to pHOS in the Grays River and other LCR tributaries has been the Select Area Brights hatchery program, operated by ODFW. This hatchery program, which was established with an exogenous stock from the Rogue River, has previously been identified as a source of genetic risk to Grays River fall Chinook salmon (Roegner and Teel 2014). In response to Tule Chinook Workgroup discussions about this program and its potential genetic effects on listed species, ODFW made the decision to discontinue the Select Area Brights hatchery program in 2024, following the release of juvenile fish on hand (S. Clements, ODFW, pers. comm.).

While we may anticipate some trend of beneficial changes to hatchery operations not covered by the proposed action in this Opinion, we cannot assume at this time that these changes would occur or would result in specific changes in effects on ESA-listed species. The general improving trend is encouraging, but is too uncertain to attribute specific changes at this time. Therefore, our Opinion expressed below is not predicated on changes to hatchery operations not covered by the proposed action

With respect to harvest, in areas upstream of where the 2018 *U.S. v Oregon* Agreement governs fisheries, (e.g., the UCR and Snake River upstream into Idaho) within the Action Area, state, tribal, and local government actions are likely to be in the form of fishing permits. These continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations. Future tribal, state and local government actions will likely be in the form of legislation, administrative rules, or policy initiatives and fishing permits. These actions may include changes in ocean policy and increases or decreases in the types of activities that currently occur, including changes in fishing activities, resource extraction, or designation of marine protected areas, any of which could impact listed species or their habitat. These actions are subject to political, legislative and fiscal uncertainties. These realities, added to the geographic scope, which encompasses several entities exercising various authorities, and the changing economies of the region, make analysis of cumulative effects speculative.

2.6.2 Eulachon

The contribution of non-federal activities to the current status of eulachon include agriculture, forest management, mining, road construction, urbanization, water development, and river restoration. Those actions were driven by a combination of economic conditions that characterized traditional natural resource-based industries, general resource demands associated with settlement of local and regional population centers, and the efforts of social groups dedicated to river restoration and use of natural amenities, such as cultural inspiration and recreational experiences.

Resource-based industries caused many long-lasting environmental changes that harmed eulachon and their critical habitat, such as state-wide loss or degradation of stream channel morphology, spawning substrates, instream roughness and cover, estuarine rearing habitats, wetlands, riparian areas, water quality (e.g., temperature, sediment, dissolved oxygen, contaminants), fish passage, and habitat refugia. Those changes reduced the ability of subpopulations to sustain themselves in the natural environment by altering or interfering with their behavior in ways that reduce their survival throughout their life cycle. The environmental changes also reduced the quality and function of critical habitat PBFs that are necessary for successful spawning, production of offspring, and migratory access necessary for adult fish to swim upstream to reach spawning areas and for juvenile fish to proceed downstream and reach the ocean. Without those features, the species cannot successfully spawn and produce offspring. However, the declining level of resource-based industrial activity and rapidly rising industry standards for resource protection are likely to reduce the intensity and severity of those impacts in the future.

The adverse effects of non-Federal actions stimulated by general resource demands are likely to continue in the future driven by changes in human population density and standards of living. These effects are likely to continue to a similar or reduced extent in the rural areas in the Action Area. Areas of growing population in the Action Area are likely to experience greater resource demands, and therefore more adverse environmental effects. Land use laws and progressive policies related to long-range planning will help to limit those impacts by ensuring that concern for a healthy economy that generates jobs and business opportunities is balanced by concern for protection of farms, forests, rivers, streams and natural areas. In addition to careful land use planning to minimize adverse environmental impacts, larger population centers may also partly offset the adverse effects of their growing resource demands with more river restoration projects designed to provide ecosystem-based cultural amenities, although the geographic distribution of those actions, and therefore any benefits to eulachon or their critical habitat, may occur far from the centers of human populations.

It is not possible to predict the future intensity of specific non-Federal actions related to resource-based industries at this program scale due to uncertainties about the economy, funding levels for restoration actions, and individual investment decisions. However, the adverse effects of resource-based industries in the Action Area are likely to continue in the future, although their net adverse effect is likely to decline slowly as beneficial effects spread from the adoption of industry-wide standards for more protective management practices. These effects, both negative and positive, will be expressed most strongly in rural areas where these industries occur, and therefore somewhat in contrast to human population density. The future effects of river restoration are also unpredictable for the same reasons, but their net beneficial effects may grow with the increased sophistication and size of projects completed and the additive effects of completing multiple projects in some watersheds.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the Action Area. However, it is difficult if not impossible to distinguish between the Action Area's future environmental conditions caused by global climate change that are properly part of the environmental baseline vs. cumulative effects. Therefore, all relevant future climate-related environmental conditions in the Action Area are described in the Environmental Baseline.

In summary, resource-based activities such as timber harvest, agriculture, mining, shipping, and energy development are likely to continue to exert an influence on the quality of freshwater and estuarine habitat in the Action Area. The intensity of this influence is difficult to predict and is dependent on many social and economic factors. However, the adoption of industry-wide standards to reduce environmental impacts and the shift away from resource extraction to a mixed manufacturing and technology-based economy should result in a gradual decrease in influence over time. Additional residential and commercial development and a general increase in human activities are expected to cause localized degradation of freshwater and estuarine habitat.

Non-Federal habitat and hydropower actions are supported by state and local agencies, tribes, environmental organizations, and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat and the restoration of degraded salmonid habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat and mainstem habitat that may also yield incremental benefits for eulachon. Significant actions and programs contributing to these benefits include growth management programs (planning and regulation), various stream and riparian habitat projects, watershed planning and implementation, acquisition of water rights for instream purposes and sensitive areas, instream flow rules, stormwater and discharge regulation, TMDL implementation to achieve water-quality standards, hydraulic project permitting, and increased spill and bypass operations at hydropower facilities. NMFS has determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PBFs in designated critical habitat. Although these actions target salmon and steelhead habitat, they may also yield incremental beneficial cumulative effects for eulachon.

NMFS has also noted that some types of human activities, such as development and harvest, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects are activities that occurred in the recent past and are included in the Environmental Baseline. Some of these activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the Action Area, non-Federal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. Continuing commercial and sport fisheries, which have some incidental catch of listed species, will have adverse impacts through removal of fish that would contribute to spawning populations. Attaching LED lights to the fishing lines of ocean shrimp trawls appears to greatly reduce the number of eulachon bycatch for this commercial fishery (Hannah, Lomeli, and Jones 2015); (Lomeli et al. 2018).

Overall, we anticipate that projects to restore and protect salmon and steelhead habitat may result in minor beneficial effects for eulachon compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on eulachon in the Action Area.

2.6.3 Summary

Overall, we anticipate that projects to restore and protect habitat, restore access and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the Action Area; however, we anticipate these activities will be mindful of ESA-listed species and will perhaps be less harmful than would have otherwise occurred in the absence of the current body of scientific work that has been established for anadromous fish. In general, although we cannot attribute specific changes to effects from these factors at this time, we think the level of adverse effects will be lower than those in the recent past, and much lower than those in the more distant past. NMFS anticipates that available scientific information will continue to grow and tribal, public, and private support for salmon recovery will remain high. This will continue to fuel state and local habitat restoration and protection actions as well as hatchery, harvest, and other reforms that are likely to result in improvements in fish survival.

2.7 Integration and Synthesis

The Integration and Synthesis section is the final step in assessing the risk that the Proposed Action poses to listed 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.

For the ESA-listed species, including listed salmon and steelhead ESUs/DPSs, evaluated in this Opinion, the impacts to those species were evaluated in combination, looking at the effects of the Proposed Action in the context of the environmental baseline and cumulative effects from other actions, as well as in the context of past Mitchell Act hatchery programs' compliance with the 2017 Mitchell Act Opinion and ITS. Taken together, this information is analyzed to determine whether those impacts are expected to affect the species' abundance, diversity, spatial distribution, and productivity VSP parameters (Section 2.2). For the purpose of analysis here and where relevant, the six factors described in Section 2.5.2. are categorized into risks posed by: (1) the facilities, directly (such as trapping) or indirectly (such as water withdrawal); (2) RM&E; and (3) biological interactions with the ESA-listed populations, including genetic and ecological risks and benefits. This combination of risk factors serves to translate the threats posed by the Proposed Action under each factor into a determination as to whether the Proposed Action as a whole would appreciably reduce the likelihood of survival and recovery of the listed species.

2.7.1 Reinitiation of the 2017 Mitchell Act Opinion, Revisions to the Proposed Action, and Adaptive Management

The Proposed Action, described above, was prompted by both changes to its implementation (including instances of noncompliance) and by the 2017 Mitchell Act Opinion's phased approach, which did not extend past 2025. As described above, NMFS learned in 2022 that WDFW had not successfully implemented weirs[37] in 11 locations in LCR tributaries in order to control the straying of hatchery-origin adult salmon (particularly Chinook and coho) to the spawning grounds occupied by natural-origin fish. NMFS reinitiated consultation to prompt the necessary changes to implementation (particularly the weirs) and to cover grants beyond 2025, as reflected in the Proposed Action.

Much of the 2017 Mitchell Act Opinion was implemented and the programs have shown or are beginning to show the beneficial changes to ongoing hatchery operations that had been anticipated in that opinion.The failure of hatchery operators to implement all of the weirs required under the 2017 Mitchell Act Opinion created instances where those anticipated benefits were not realized. These past impacts have been included in the effects analysis in this Opinion (Section 2.5).

In addition, to help mitigate these past impacts, the current Proposed Action does several things. It continues to fund the programs which were implemented consistently with the 2017 Opinion. It establishes required actions for those programs which did not achieve compliance. Finally, it goes beyond the 2017 Mitchell Act Opinion by incorporating measures that better isolate "segregated" hatchery programs and better integrate "integrated" hatchery programs than the Proposed Action evaluated in the 2017 Opinion. Specifically, it includes the following changes:

- Terminate and or relocate hatchery programs to reduce interactions between natural- and hatchery-origin salmon and steelhead, including: Washougal Segregated Winter

[37] The purpose of the weirs in the former Proposed Action were to remove returning hatchery-origin salmon and steelhead encountered, in order to better isolate hatchery programs that were not designed to supplement natural-spawning populations. This was expected to result in limiting pHOS for ESA-listed populations in the Grays River, Skamokawa River, Elochoman River, Mill Creek, Abernathy Creek, Germany River, South Fork Toutle River, Coweeman River, Cedar Creek, Washougal River, and Kalama River.

Steelhead, Deep River Net Pens Spring Chinook Salmon, and Deep River Net Pens Coho Salmon;
- Maintain existing and/or implement new weirs to reduce the number of hatchery-origin fish interacting with ESA-listed salmon and steelhead in: Abernathy Creek, Cedar Creek, Coweeman River, Elochoman River, Germany Creek, Grays River, Green River (North Fork Toutle), the Kalama River, the South Fork Toutle River, and the Washougal River;
- Initiate conservation hatchery programs for Chinook salmon in Abernathy Creek and in the Grays River; and
- Accelerate the reintroduction of Coho salmon and initiate reintroduction of spring and fall Chinook salmon to the upper North Fork Toutle River.

In addition, as part of our adaptive management of the Mitchell Act funding program, NMFS may consider future hatchery program adjustments, as required, to continue to improve conditions for listed fish in the Columbia River Basin, and to ensure that NMFS's continued Mitchell Act funding will not appreciably reduce the likelihood of the survival or recovery of a listed species in the wild, or diminish the value of designated critical habitat.

In assessing the overall risk of the Proposed Action to each listed species and its designated critical habitat, NMFS considers the risks presented under each factor discussed in Section 2.5.2. above, in combination with our consideration of the likely additive effects of these risks to each other in the context not only of the Environmental Baseline, but also of the cumulative effects of other actions within the Action Area and the potential benefits to listed species provided by the reform measures included in the Proposed Action. This comprehensive analysis is contained in this Integration and Synthesis section.

We discuss these collective risks for each affected ESU or DPS below.

2.7.2 Pacific Eulachon Southern DPS

NMFS most recent status review affirmed the status of this DPS as threatened due to a moderate risk of extinction ((NMFS and NOAA 2014)). Factors that limit the DPS have been, and continue to be, climate change impacts on both freshwater and ocean habitat as well as habitat alteration and degradation from a variety of activities. However, after taking into account the current viability status of the species, the Environmental Baseline, and cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the effects of the Proposed Action added to the effects of all human activities in the Action Area will not appreciably reduce the likelihood of survival and recovery of the Pacific Eulachon Southern DPS in the wild, based on the summarized rationale below.

Predation by salmonids on eulachon was identified as a threat to eulachon recovery as outlined in the "Endangered Species Act Recovery Plan for the Southern Distinct Population Segment of Eulachon (*Thaleichthys pacificus*)" ((NMFS 2017h)). As noted above (Section 2.2.7), eulachon occur throughout the Action Area and overlap in space and time with hatchery-produced salmon and steelhead that would be produced and released under the Proposed Action. These hatchery-produced and released salmon and steelhead are likely to have direct effects (predation) that will affect eulachon abundance (reduction). Although the quantities of larval, juvenile, sub-adult, and adult eulachon consumed by these hatchery-produced and released salmon and steelhead under the Proposed Action cannot be directly quantified, we do not expect the magnitude of predation to meaningfully affect eulachon productivity and abundance at the subpopulation or DPS level as salmon and steelhead (wild and hatchery-produced) are not known to selectively prey on eulachon (Osgood et al. 2016). Therefore, we conclude that the Proposed Action will not appreciably reduce the likelihood of survival and recovery of the Pacific Eulachon Southern DPS. Eulachon abundance is driven largely by positive ocean conditions and any decrease in abundance from the Proposed Action is likely to be insignificant compared to unfavorable ocean conditions.

While the Proposed Action may have some small effect on the species' abundance (by killing a relatively small proportion of eulachon), it is not likely to have an appreciable effect on their productivity, diversity, or structure. In summary, the effects of the Proposed Action (Section 2.5), when added to the Environmental Baseline (Section 2.4) and the Cumulative Effects (Section 2.6), and taking into account the Status of the Species and Critical Habitat (Section 2.2), would not reduce appreciably the likelihood of either the survival or recovery of eulachon.

2.7.3 Upper Columbia River (UCR) ESU/DPS

2.7.3.1 UCR Spring Chinook Salmon ESU

Best available science and information indicates that the UCR Spring Chinook Salmon ESU is at high risk and remains endangered (NMFS 2022h). Because none of the programs included in the Proposed Action occur in or directly or indirectly affect the UCR area, we concluded that facility, RM&E and genetic effects were nonexistent for the UCR Spring Chinook Salmon ESU. Thus, the only effects to consider in our integration and synthesis for this listed species are ecological effects, which can affect the abundance and productivity VSP parameters (Section 2.2).

Focusing on ecological effects, our analysis looked at whether outmigrating UCR Chinook juveniles would face increased competition or predation as a result of the Proposed Action, as they traveled through the Lower Columbia River and out into the Pacific Ocean. Our modeling showed that the ecological impact of the hatchery releases competing with and preying on natural-origin Chinook salmon juvenile outmigrants produced in the basins, based on the most up-to-date interactions modeling available, is minor. However, those impacts are nearly identical to the situation that would occur in a hypothetical environment without hatchery production, with more abundant natural production. At some point, densities can be expected to slow growth and perhaps affect survival of the naturally produced component of the population. This is a natural consequence of survival and recovery in the wild. NMFS will monitor whether increased productivity or abundance of natural-origin fish may necessitate more aggressive adult management, and/or reconsideration of hatchery program size in the future to limit impacts to these VSP parameters in this ESU (Section 2.2).

Added to the Species' Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area, including those intended to reduce threats to listed species. Such actions are improving habitat conditions for UCR spring Chinook salmon in the Columbia River Basin and resulting in hatchery and harvest practices designed to protect Chinook salmon – such as those outlined in the HOF. NMFS expects this trend to continue.

The effects described above differ little from the baseline conditions, which were considered low level effects, and future management actions could further limit impacts to the ESU. Therefore, after taking into account the current viability status of these species (including ecological effects), the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the effects of the Proposed Action, added to the effects of all human activities in the Action Area, will not appreciably reduce the likelihood of survival and recovery of these ESA-listed Chinook salmon ESUs in the wild.

2.7.3.2 UCR Steelhead DPS

Best available information indicates that the UCR Steelhead DPS is at high risk of extinction and remains threatened under the ESA (NMFS 2022h). Although land and water management activities in the UCR have improved, there is no evidence yet demonstrating that these improvements in habitat conditions have led to improvements in population viability for the UCR Steelhead DPS (NMFS 2022h). Because none of the programs included in the Proposed Action occur in or directly or indirectly affect the UCR area, we concluded that RM&E effects were nonexistent for the UCR Steelhead DPS. Thus, the only effects to consider in our integration and synthesis for this listed species are impacts of facilities outside of the UCR and genetic, and ecological effects, which can affect the diversity, abundance and productivity VSP parameters (Section 2.2). After taking into account the current viability status of the species, the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the effects of the Proposed Action, added to the effects of all human activities in the Action Area, on these ESA-listed DPSs will not appreciably reduce the likelihood of survival and recovery of the UCR Steelhead DPS in the wild. This conclusion is discussed in more detail below.

Genetic effects from Mitchell Act-funded hatchery programs pose a low risk to the diversity and productivity of UCR steelhead populations. Gene flow from only one Mitchell Act funded hatchery program (at Ringold Springs Hatchery) is possible, albeit at very low levels. The distance from the release site for those hatchery fish to the UCR watersheds, as well as the marking scheme for the hatchery-origin fish, likely limit the number of strays from the hatchery program to , and facilitate detection and removal of strays at hatchery and fish passage facilities.

The hatchery programs in the HOF also pose a low risk to the abundance of UCR steelhead populations as a result of encounters during broodstock collection and adult management activities. While a small number of UCR steelhead are expected to be encountered at the Bonneville and Ringold Springs hatchery facilities, the majority of those fish are released back into the river and allowed to continue migration to their spawning grounds. Moreover, the encounters at the Bonneville Hatchery could include encounters with other DPSs (LCR or MCR steelhead); thus, the analysis of these facility interactions in Factor 2 likely overestimates impacts on the UCR Steelhead DPS.

Our effects analysis showed that the ecological impact of the hatchery releases competing with and preying on natural-origin steelhead juvenile outmigrants produced in the basins, based on the most up-to-date interactions modeling available, is minor. At some point, densities can be expected to slow growth and perhaps affect survival of the naturally produced component of the population. This is a natural consequence of survival and recovery in the wild. NMFS will monitor whether increased productivity or abundance of natural-origin fish may necessitate more aggressive adult management, and/or reconsideration of hatchery program size in the future to limit impacts to these VSP parameters in this DPS (Section 2.2).

Added to the Species' Status, Environmental Baseline and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area, including those intended to reduce threats to listed species. For example, the recovery plans for the UCR Steelhead DPS (NMFS 2013e) describe, in detail, the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to the DPS. Such actions are improving habitat conditions for the DPS and result in hatchery and harvest practices designed to protect steelhead - such as those outlined in the HOF. NMFS expects this trend to continue.

2.7.4 Snake River ESUs/DPSs

2.7.4.1 Snake River Spring/Summer Chinook Salmon ESU

The Snake River Spring/Summer Chinook Salmon ESU remains threatened after our most recent 5-year review (NMFS 2022e). Because only two programs occur in the Snake River Basin (coho salmon programs that propagate non-listed coho salmon), we concluded that facility, RM&E, and genetic effects were minimal for the Snake River Spring/Summer Chinook Salmon ESU. After taking into account the current status of these species, the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the effects of the Proposed Action, added to the effects of all human activities in the Action Area, will not appreciably reduce the likelihood of survival and recovery of these ESA-listed Chinook salmon ESUs in the wild. This conclusion is discussed in more detail below.

Our effects analysis showed that the ecological impact of the hatchery releases competing with and preying on natural-origin Chinook salmon juvenile outmigrants produced in the basins, based on the most up-to-date interactions modeling available, is minor. At some point, densities can be expected to slow growth and perhaps affect survival of the naturally produced component of the population. This is a natural consequence of survival and recovery in the wild. NMFS will monitor whether increased productivity or abundance of natural-origin fish may necessitate more aggressive adult management, and/or reconsideration of hatchery program size in the future to limit impacts to these VSP parameters in this ESU (Section 2.2).

Added to the Species' Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area, including those intended to reduce threats to listed species. The recovery plans for the Snake River Spring/Summer Chinook Salmon ESU (NMFS 2017g) describe the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to the ESU. Such actions are improving habitat conditions for the ESU in the Columbia River Basin and resulting in hatchery and harvest practices better designed to protect Chinook salmon – such as those outlined in the HOF. NMFS expects this trend to continue.

2.7.4.2 Snake River Fall Chinook Salmon ESU

The Snake River Fall Chinook Salmon ESU remains threatened after our most recent 5-year review (NMFS 2022e). Because only two Mitchell Act-funded programs occur in the Snake River Basin (coho salmon programs that propagate non-listed coho salmon), we concluded that genetic effects were minimal for the Snake River Fall Chinook Salmon ESU. After taking into account the current viability status of these species, the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the effects of the Proposed Action, added to the effects of all human activities in the Action Area, will not appreciably reduce the likelihood of survival and recovery of these ESA-listed Chinook salmon ESUs in the wild.

Our analysis of the risks posed by facilities that rear Mitchell Act-funded fish on the Snake River Fall Chinook Salmon ESU, namely the incidental trapping and handling of adults during broodstock collection and adult management, indicates that the Snake River fall Chinook salmon are only encountered at the Bonneville Hatchery and in the Snake River Basin. At the Bonneville Hatchery, the fish encountered from this ESU are not externally distinguishable from other, non-listed fall Chinook salmon populations, and the maximum total salmon mortality is expected to be less than 3% of the encounters. Therefore, the best available information shows that Snake River fall Chinook salmon mortality resulting from handling at the Bonneville Hatchery is low. Similarly, the encounters and associated mortality for this ESU are currently minimal in the Snake River Basin. Moreover, if the encounters and associated mortality for this ESU in the Snake River Basin were to increase to the maximum level described in (Table 91), NMFS would conclude that such encounters and associated mortality were the result of increases in the abundance of these fish as a result of conservation efforts. In this case, the Snake River fall Chinook salmon populations would be more robust and could likely withstand the maximum level of encounters and associated mortality described in Table 91. Therefore, such encounters would not be likely to have an impact on the VSP parameters (Section 2.2.2).

Our effects analysis showed that the ecological impact of the hatchery releases competing with and preying on natural-origin Chinook salmon juvenile outmigrants produced in the basins, based on the most up-to-date interactions modeling available, is minor. At some point, densities can be expected to slow growth and perhaps affect survival of the naturally produced component of the population. This is a natural consequence of survival and recovery in the wild. NMFS will monitor whether increased productivity or abundance of natural-origin fish may necessitate more aggressive adult management, and/or reconsideration of hatchery program size in the future to limit impacts to these VSP parameters in this ESU (Section 2.2.2).

Added to the Species' Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area, including those intended to reduce threats to listed species. For example, the recovery plans for the ESU (NMFS 2017g) describe the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to the Snake River Spring/Summer Chinook Salmon ESU. Such actions are improving habitat conditions for the ESU and resulting in hatchery and harvest practices designed to protect Chinook salmon - such as those outlined in the HOF. NMFS expects this trend to continue.

2.7.4.3 Snake River Steelhead DPS

The Snake River Steelhead DPS remains threatened after our most recent 5-year review (NMFS 2022d). Because only two programs occur in the Snake River Basin (coho salmon programs that propagate a non-listed coho salmon), we concluded that genetic effects were minimal for the Snake River Steelhead DPS. After taking into account the current viability status of the species, the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the effects of the Proposed Action added to the effects of all human activities in the Action Area on the Snake River Steelhead DPS will not appreciably reduce the likelihood of survival and recovery of ESA-listed steelhead in the wild. This conclusion is discussed in more detail below.

Our effects analysis showed that the ecological impact of the hatchery releases competing with and preying on natural-origin steelhead juvenile outmigrants produced in the basins, based on the most up-to-date interactions modeling available, is minor. At some point, densities can be expected to slow growth and perhaps affect survival of the naturally produced component of the population. This is a natural consequence of survival and recovery in the wild. NMFS will monitor whether increased productivity or abundance of natural-origin fish may necessitate more aggressive adult management, and/or reconsideration of hatchery program size in the future to limit impacts to these VSP parameters in this DPS (Section 2.2.6.2.3).

The programs in the HOF pose a low risk to the diversity and productivity of Snake River steelhead populations through broodstock collection and adult management activities. These activities capture and possibly delay a small number of Snake River steelhead, and may on occasion kill a few of these fish, which may affect the spatial structure VSP parameter (Section 2.2.6.2.3); however, the effect is small. Moreover, the broodstock collection and adult management activities under the HOF occur during a time when adult Snake River steelhead are not present, so the probability of encountering a Snake River steelhead is low based on the small overlap in time.

Similarly, the RM&E activities in the HOF may capture and possibly delay a small number of Snake River steelhead, and may on occasion kill a few of these fish, but the risk to the species is negligible. This is because of the essential nature of the RM&E activities in terms of: understanding the status of the species survival and recovery in the wild; making sure the programs comply with best management practices; providing information on population status; providing information on the performance of the hatchery programs and their interactions with respective natural populations; and coordinating with RM&E programs elsewhere to provide much needed information on how to align Mitchell Act funding with the goals of reducing extinction risk and promoting recovery of target species, while not disadvantaging non-target species.

Added to the Species' Status, Environmental Baseline and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area, including those intended to reduce threats to listed species. The recovery plan (NMFS 2017g) describes, in detail, the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to the Snake River Steelhead DPS. Such actions are improving habitat conditions for the DPS and resulting in hatchery and harvest practices better designed to protect steelhead - such as those outlined in the HOF. NMFS expects this trend to continue.

2.7.4.4 Snake River Sockeye Salmon ESU

NMFS's recent 5-year review affirmed the status of this ESU as endangered due to the high risk of extinction (NMFS 2022f). Factors that limit the ESU have been the legacy effects of historical commercial fisheries, poor ocean conditions, survival through the Snake and Columbia River hydropower system, and reduced tributary stream flows and high temperatures. Improvements in fish passage, harvest, and habitat conditions have improved survival for fish in this ESU, and a specially designed hatchery program has increased abundance and reduced extinction risk in the short-term. All of this has put the Snake River Sockeye Salmon ESU on an improving trend, but there is still much to do because the ESU is vulnerable to catastrophic loss and adverse effects to genetic diversity. Because only two programs occur in the Snake River Basin (coho salmon programs that propagate non-listed coho salmon), we conclude that facility, RM&E, and genetic effects are minimal for the Snake River Sockeye Salmon ESU. After taking into account the current viability status of the species, the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the effects of the Proposed Action added to the effects of all human activities in the Action Area will not appreciably reduce the likelihood of survival and recovery of the Snake River Sockeye Salmon ESU in the wild.

Our analysis of the risks posed by hatchery facilities that rear Mitchell Act-funded fish to this ESU, namely the incidental trapping and handling of adults during broodstock collection and adult management, indicates that the Snake River sockeye salmon are only encountered at the Bonneville Hatchery and in the Snake River Basin. At the Bonneville Hatchery, the fish from this ESU encountered are not externally distinguishable from other, non-listed sockeye salmon populations, and the maximum total salmon mortality is expected to be less than 3% of the numbers encountered. Therefore, the best available information indicates that the handling of fish at the Bonneville Hatchery is not likely to lead to Snake River sockeye salmon mortality. Similarly, the encounters with hatchery facilities and associated mortality for this ESU are currently minimal in the Snake River Basin. Moreover, if such encounters and associated mortality in the Snake River Basin were to increase to the maximum level described in Table 91, NMFS would conclude that such encounters and associated mortality were the result of conservation efforts to increase the abundance of Snake River sockeye salmon; that is that the Snake River sockeye salmon populations had grown more robust. In this case, the ESU could likely withstand the maximum level of encounters and associated mortality described in Table 91, and such encounters would not be likely to have an impact on the VSP parameters (Section 2.2.5.1.1).

Our effects analysis showed that the ecological impact of the hatchery releases competing with and preying on natural-origin sockeye salmon juvenile outmigrants produced in the basins, based on the most up-to-date interactions modeling available, is minor. At some point, densities can be expected to slow growth and perhaps affect survival of the naturally produced component of the population. This is a natural consequence of survival and recovery in the wild. NMFS will monitor whether increased productivity or abundance of natural-origin fish may necessitate more aggressive adult management, and/or reconsideration of hatchery program size in the future to limit impacts to these VSP parameters in this ESU (Section 2.2.5.1.1).

Added to the Species' Status, Environmental Baseline and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area, including those intended to reduce threats to listed species. For example, the Federally approved recovery plan (NMFS 2015e) for Snake River Sockeye Salmon ESU describes the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed sockeye salmon. Such actions are improving habitat conditions for Snake River sockeye salmon in the Columbia River Basin and resulting in hatchery and harvest practices designed to protect Snake River sockeye salmon - such as those outlined in the HOF. NMFS expects this trend to continue.

2.7.5 Mid-Columbia River (MCR) DPS

2.7.5.1 MCR Steelhead DPS

NMFS's recent status review affirmed the status of the MCR Steelhead DPS as threatened due to a moderate to high risk of extinction (NMFS 2022c). Factors that limit the DPS have been, and continue to be, loss and degradation of spawning and rearing habitat, impacts of mainstem hydropower dams on upstream access and downstream habitats, and the legacy effects of historical harvest. After taking into account the current viability status of the species, the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the effects of the Proposed Action added to the effects of all human activities in the Action Area will not appreciably reduce the likelihood of survival and recovery of the MCR Steelhead DPS in the wild.

We conclude that the effects of facilities used for Mitchell Act production on the abundance, spatial structure, and diversity VSP parameters of the MCR Steelhead DPS are negligible for hatchery operations and low for broodstock collection and adult management activities. This includes the current Klickitat River intake, which does not meet NMFS's current screening criteria (NMFS 2022o) and does not prevent juvenile fish from entering the hatchery rearing pond 25. The effect of this condition is expected to be minimal because the intake is only operated beginning in the spring, prior to the peak migration of natural-origin juvenile fish in the DPS. We note that the Yakama Nation, NMFS, and the BPA are currently working on a remodel of the Klickitat Hatchery that will include upgrades or modifications to the mainstem intake facility, which could lessen effects in the future. Moreover, the incidental encounters of MCR steelhead is expected to be at low levels during broodstock collection and adult management activities because no more than 10 adult MCR steelhead are expected to volunteer into the adult holding ponds during spring Chinook salmon broodstock collection at the hatchery, and the steelhead are released back into the river unharmed. As a result, facility effects have a low effect on the abundance VSP parameter (Section 2.2.6.2.1) of the MCR Steelhead DPS.

The programs in the HOF also pose a low risk to the diversity and productivity of MCR steelhead populations through broodstock collection and adult management activities. The activities capture and possibly delay a small number of MCR steelhead, and may on occasion kill a few of these fish, which may affect the spatial structure VSP parameter (Section 2.2.6.2.1), but the effect is small. Moreover, the expected encounters and resulting mortality rate at the Little White Salmon NFH includes impacts on multiple DPSs that cannot be distinguished from one another; therefore, the actual impact on the MCR steelhead is likely lower than described in Section 2.5.2.2.2.3- Analysis of Encounters at Adult Collection Facilities.

The risks from RM&E effects on the abundance, spatial structure, and diversity VSP parameters of the MCR Steelhead DPS are negligible. These activities capture and possibly delay fish, and on occasion kill a small number of fish, but the effect is small. The risk to the abundance and productivity VSP parameters (Section 2.2.6.2.1) of the DPS is negligible, given the essential nature of the RM&E activities in terms of: understanding the status of the species survival and recovery in the wild; making sure the programs comply with best management practices; providing information on the performance of the hatchery programs and their interactions with the natural population; and coordinating with RM&E programs elsewhere to provide much needed information on how to align Mitchell Act funding with the goals of reducing extinction risk and promoting recovery of target species, while not disadvantaging non-target species.

Our effects analysis showed that the ecological impact of the hatchery releases competing with and preying on natural-origin steelhead juvenile outmigrants produced in the basins, based on the most up-to-date interactions modeling available, is minor. At some point, densities can be expected to slow growth and perhaps affect survival of the naturally produced component of the population. This is a natural consequence of survival and recovery in the wild. NMFS will monitor whether increased productivity or abundance of natural-origin fish may necessitate more aggressive adult management, and/or reconsideration of hatchery program size in the future to limit impacts to these VSP parameters in this ESU (Section 2.2.6.2.1).

The Proposed Action will also contribute to marine-derived nutrient input in the Columbia River Basin by increasing the number of naturally-spawning salmon and steelhead carcasses over the level that would be present in the absence of the Mitchell Act-funded programs, and through distribution of hatchery-origin carcasses. Decaying carcasses of spawned adult hatchery-origin fish would contribute nutrients that increase the productivity VSP parameter (Section 2.2.6.2.1) in watershed areas, enhancing food resources for naturally-produced steelhead. Returning adults from the hatchery programs can also be expected to improve the condition of spawning gravel into the future, if they spawn naturally (Montgomery et al. 1996).

Recent information on the proportion of hatchery fish on the spawning grounds is limited for the Klickitat River summer and winter steelhead populations. Available data indicate that, during some periods of the year, adult hatchery- and natural-origin steelhead overlap in some areas of the Klickitat River basin. However, data also indicate that within this river, substantial spatial and temporal separation exists between hatchery- and natural-origin steelhead. This spatiotemporal separation likely limits gene flow from the summer steelhead hatchery program, which is unlikely to significantly and negatively affect the productivity and diversity VSP parameters (Section 2.2.6.2.1) of Klickitat River steelhead or the MCR Steelhead DPS.

Added to the Species' Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area, including those intended to reduce threats to listed species. For example, the recovery plan for the MCR Steelhead DPS (NMFS 2009a) describes the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to the DPS. Such actions are improving habitat conditions for the DPS in the Columbia River Basin and resulting in hatchery and harvest practices to protect MCR steelhead - such as those outlined in the HOF. NMFS expects this trend to continue.

2.7.6 Lower Columbia River (LCR) ESUs/DPS

2.7.6.1 LCR Chinook Salmon ESU

NMFS's recent 5-year review affirmed the status of this ESU as threatened due to a high risk of extinction (NMFS 2022b). Factors that limit the ESU have been, and continue to be, the combination of severe habitat loss and degradation, including the construction and operation of dams on tributary streams, and harvest and hatchery management, followed by the construction and operation of mainstem Columbia River hydropower dams and ecological factors including predation and environmental variability.

We conclude that the effects of facilities used for Mitchell Act production on the abundance, spatial structure, and diversity VSP parameters of the LCR Chinook Salmon ESU have recently been and will continue to be negligible for hatchery operations and small for broodstock collection and adult management. This is because only small numbers of natural-origin fish from this ESU will be impacted by broodstock collection for segregated programs, and for integrated programs, broodstock collection is limited to 2-33% of the natural-origin run. For the integrated programs, the impacts to the abundance, productivity, and diversity VSP parameters (Section

2.2.2.2.1) from the removal of natural-origin returning adults are actually less than 33%, and the reduction in abundance is partially mitigated by integrated hatchery Chinook salmon that spawn naturally. Furthermore, these hatchery programs serve as a genetic resource, supporting the diversity VSP parameter for the Toutle River and Washougal River fall Chinook salmon populations. In addition, water usage by facilities is a very small proportion of surface water flow, and facilities have NPDES permits for effluent discharge, if needed. Relatively few facilities in the LCR need upgrades, and these will be done in the near future to meet NMFS standards.

The risks from RM&E effects on the abundance, spatial structure, and diversity VSP parameters of the LCR Chinook Salmon ESU are also negligible. These activities capture and possibly delay fish, and on occasion kill a small number of fish, but the effect on the abundance and productivity VSP parameters (Section 2.2.2.2.1) of the LCR Chinook Salmon ESU is small. The risk to the species is negligible, given the essential nature of the RM&E activities in terms of: understanding the status of species survival and recovery in the wild; making sure the programs comply with best management practices; providing information on the performance of the hatchery programs and their interactions with the natural population; and coordinating with RM&E programs elsewhere to provide much needed information on how to align Mitchell Act funding with the goals of reducing extinction risk and promoting recovery of target species, while not disadvantaging non-target species. Moreover, the RM&E effects from the operation of the North Fork Toutle River Fish Collection Facility are mitigated by enabling passage to otherwise inaccessible habitat for LCR Chinook salmon.

Our effects analysis showed that the ecological impact of the hatchery releases competing with and preying on natural-origin LCR Chinook salmon juvenile outmigrants produced in the basins, based on the most up-to-date interactions modeling available, is minor. At some point, densities can be expected to slow growth and perhaps affect survival of the naturally produced component of the population. This is a natural consequence of survival and recovery in the wild. The programs have implemented reforms to minimize competition and predation effects to local natural-origin populations, and those measures will continue as a result of the Proposed Action. This represents an improved trend at the ESU level. NMFS will monitor this trend and whether increased productivity or abundance of natural-origin fish may necessitate more aggressive adult management, and/or reconsideration of hatchery program size in the future to limit impacts to these VSP parameters in this ESU (Section 2.2.2.2.1).

The Proposed Action will also contribute to marine-derived nutrient input in the Columbia River Basin by increasing the number of naturally-spawning salmon and steelhead carcasses over the level that would be present in the absence of Mitchell Act-funded programs, and through distribution of hatchery carcasses. Decaying carcasses of spawned adult hatchery-origin fish would contribute nutrients that increase the productivity VSP parameter (Section 2.2.2.2.1) in watershed areas, enhancing food resources for naturally-produced Chinook salmon. Returning adults from the hatchery programs can also be expected to improve the condition of spawning gravel into the future, if they spawn naturally (Montgomery et al. 1996).

Through the Proposed Action, new conservation hatchery programs will reintroduce or supplement fall Chinook salmon in critical habitats of the LCR Chinook Salmon ESU, thereby increasing the species abundance and distribution. The broodstock sources for these conservation programs have been carefully selected to safeguard and promote within- and among-ESU diversity. Associated monitoring efforts will evaluate the success and inform the management of new, limited-duration conservation hatchery programs in the LCR.

An important part of this Opinion is assessing the risk of genetic effects due to hatchery supplementation, which can reduce productivity and abundance at the population and ESU level. The Proposed Action involves numerous changes to hatchery management that will continue the trend of reducing genetic risks to LCR Chinook salmon populations directly impacted by the presence of hatchery fish. These changes build upon past actions that replaced exogenous (i.e., out-of-ESU) hatchery stocks of Chinook salmon with locally-derived stocks, installation of weirs to limit the proportion of hatchery-origin fish on spawning grounds, and major hatchery program reductions.

All of these measures were designed to, and continue to, significantly reduce genetic and ecological risks from Mitchell Act funded hatchery programs to LCR Chinook salmon. As described above, each hatchery program is required to control genetic effects as measured in each watershed where LCR Chinook spawn naturally. Evidence of the effects from changes made pursuant to the 2017 Mitchell Act Opinion shows that the hatchery management actions are reducing genetic risk. In some cases that evidence is unable to show the full picture, such as for new strategies instituted since 2017 that require more time to realize their full impact. Also, as described above, some actions were not fully implemented or required additional adjustments to reach their potential. Even with the measures implemented or underway, the genetic risk to LCR Chinook remains a significant threat to the species, and NMFS must monitor actions and results to assure that the Proposed Action is fully implemented and the positive trend continues. However, NMFS does feel that the genetic risks at the population and the cumulative risk at the ESU level is likely to continue trending downward.

Under the Proposed Action, existing weirs will continue to be operated and new weirs (or similar adult fish collection facilities) will be constructed and operated to limit genetic risks from stray hatchery-origin Chinook salmon, promote population productivity, and support the operation and success of conservation hatchery efforts aimed to increase the abundance and distribution of LCR Chinook salmon.

Over the past decade, production by several Mitchell Act funded hatchery programs has been drastically curtailed to reduce genetic risks to LCR Chinook salmon. Effects from these reductions continue to be realized and, through the Proposed Action, additional program reductions and release site changes (e.g., Deep River spring Chinook salmon and Kalama Hatchery Fall Chinook salmon programs) are expected to further reduce genetic effects from Mitchell Act funded programs. Moreover, planned termination of ODFW's Select Area Brights hatchery program, which has not received Mitchell Act funding, is expected to further reduce genetic risks to LCR Chinook Salmon (see Section 2.6, Cumulative Effects) and promote among-ESU diversity.

Altogether, through initiation of new conservation hatchery programs, key changes to existing hatchery programs, and installation of new and operation of existing weirs, the Proposed Action will not only reduce genetic risks from Mitchell Act funded hatchery programs, but also promote the productivity, abundance, spatial distribution, and diversity of LCR Chinook salmon populations. The Proposed Action also supports research that will inform the management of Mitchell Act funded hatchery programs, and allow these programs to adapt in a manner that best serves the conservation and recovery of LCR Chinook salmon amid a changing environment.

Fisheries that will occur as a consequence of the Proposed Action are likely to inadvertently and incidentally take LCR Chinook salmon. The ABM matrix approach has reduced the extinction risk of the LCR tule component of the LCR Chinook Salmon ESU by 4%, which is captured in the Environmental Baseline (Section 2.4). Additionally, placement of seasonal weirs that limit hatchery strays will continue with this Proposed Action. These weirs have resulted in decreased fishing pressure upstream of the weirs, resulting in decreased fishing impacts on LCR Chinook salmon.

Added to the Species' Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area, including those intended to reduce threats to listed species. For example, the Recovery Plan for the ESU (NMFS 2013e) describes the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed Chinook salmon. Such actions are improving habitat conditions for the ESU in the Columbia River Basin and resulting in hatchery and harvest practices designed to protect the LCR Chinook Salmon ESU - such as those outlined in the HOF. NMFS expects this trend to continue.

After taking into account the current viability status of the species, the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the effects of the Proposed Action added to the effects of all human activities in the Action Area will not appreciably reduce the likelihood of survival and recovery of the LCR Chinook Salmon ESU in the wild.

2.7.6.2 LCR Coho Salmon ESU

NMFS recent status review affirmed the status of this ESU as threatened due to a moderate risk of extinction (NMFS 2022b). Factors that limit the ESU have been, and continue to be, the combination of severe habitat loss and degradation, including the construction and operation of dams on tributary streams, and harvest and hatchery management, followed by the construction and operation of mainstem Columbia River hydropower dams and ecological factors including predation and environmental variability.

We conclude that the effects of facilities that are used for Mitchell Act productions on on the abundance, spatial structure, and diversity VSP parameters of LCR Coho Salmon ESU have recently been and will continue to be negligible for hatchery operations, and small for broodstock collection and adult management, because only small numbers of natural-origin fish from this ESU will be impacted by broodstock collection for segregated programs, and for integrated programs broodstock collection is limited to 33% of the natural-origin run, which limits impacts to the abundance and productivity VSP parameters (Section 2.2.3.1.1). Furthermore these integrated programs would act as a genetic resource, supporting the diversity VSP parameter (Section 2.2.3.1.1). In addition, water usage by facilities continues to be a very small proportion of surface water flow, and facilities have NPDES permits for effluent discharge, if needed. Relatively few facilities used for Mitchell Act productions need upgrades, and these will be done in the near future to meet NMFS standards.

The risks from RM&E effects to the abundance, spatial structure, and diversity VSP parameters of the LCR Coho Salmon ESU also continue to be negligible. These activities capture and possibly delay fish, and on occasion kill a small number of fish, but at a low level and frequency within populations, such that the effect on the abundance and productivity VSP parameters (Section 2.2.3.1.1) of the LCR Coho Salmon ESU is small. Furthermore, the net effect to the species is negligible, given the benefits to the ESU of the RM&E activities in terms of: understanding the status of species survival and recovery in the wild; making sure the program complies with best management practices; providing information on the performance of the hatchery program and its interactions with the natural population; and coordinating with RM&E programs elsewhere to provide much needed information on how to use hatchery programs to meet the goals of reducing extinction risk and promoting recovery of target species, while not disadvantaging non-target species. All of these measures assure that the risks to the species are appropriately understood and controlled, to prevent any changes. Moreover, the RM&E effects from the operation of the North Fork Toutle River Fish Collection Facility are mitigated by enabling passage to otherwise inaccessible habitat for the LCR coho salmon, a likely boost in abundance.

Our effects analysis showed that the ecological impact of the hatchery releases competing with and preying on natural-origin coho salmon juvenile outmigrants produced in the basins, based on the most up-to-date interactions modeling available, is minor. At some point, densities can be expected to slow growth and perhaps affect survival of the naturally produced component of the population. This is a natural consequence of survival and recovery in the wild. The programs have implemented reforms to minimize competition and predation effects to local natural-origin populations, and those measures will continue as a result of the Proposed Action. This represents an improved trend at the ESU level. NMFS will monitor whether increased productivity or abundance of natural-origin fish may necessitate more aggressive adult management, and/or reconsideration of hatchery program size in the future to limit impacts to these VSP parameters in this ESU (Section 2.2.3.1.1).

The Proposed Action will also contribute to marine-derived nutrient input in the Columbia River Basin by increasing the number of naturally-spawning salmon and steelhead carcasses over the level that would be present in the absence of the Proposed Action, and through distribution of hatchery carcasses. Decaying carcasses of spawned adult hatchery-origin fish would contribute nutrients that increase the productivity VSP parameter (Section 2.2.3.1.1) in watershed areas, enhancing food resources for naturally-produced coho salmon. Returning adults from the hatchery programs can also be expected to improve the condition of spawning gravel into the future, if they spawn naturally (Montgomery et al. 1996).

Through the Proposed Action, Mitchell Act funded hatchery programs will support reintroduction of LCR coho salmon to the upper reaches of the Toutle River, expanding the species' spatial distribution and increasing productivity. Risks to genetic diversity from this reintroduction effort are expected to be low, as target habitats are currently devoid of naturally-spawning coho salmon.

An important part of this Opinion is assessing the risk of genetic effects due to hatchery supplementation, which can reduce productivity and abundance at the population and ESU level. Many of the changes to hatchery operations from past conditions in the Proposed Action are aimed at continuing the trend of reducing the recent levels of genetic influence from Mitchell Act funded hatchery programs on LCR coho salmon populations directly impacted by hatchery fish.

As with LCR Chinook salmon, the Proposed Action continues to fund programs which have some level of genetic effect on the ESU, but the reduction of these effects through past and proposed changes is profound. As described in the proposed action, all Mitchell Act funded hatchery production of coho salmon within this ESU uses broodstock that has been sourced from within-ESU populations, thereby promoting among-ESU genetic diversity in the affected populations and across the ESU. There are ongoing genetic effects on naturally spawning populations that could continue to impact diversity and productivity, but each program is required to limit the extent of impacts in each affected population. Additional changes include discontinuing of the Deep River Netpen and moving the Grays River coho hatchery program to the Beaver Creek Hatchery, further reducing these risks.

In summary, the Proposed Action will, through hatchery program adjustments and terminations, weir operations to remove excess returning hatchery fish, use of appropriate broodstocks, and targeted reintroduction efforts, drastically reduce negative genetic effects from Mitchell Act funded hatchery production and effectively promote the productivity, abundance, diversity and distribution of LCR coho salmon. These actions will increase the ability of the populations to respond to improvements in habitat and other measures described in the recovery plan for the ESU. Lastly, the relative improvements to the productivity, abundance, distribution, and diversity VSP parameters (Section 2.2.3.1.1), brought about through implementation of the Proposed Action, are expected to collectively increase the resilience of the LCR Coho Salmon ESU to the challenges of climate change. Even with the measures implemented or underway, the genetic risk to LCR Chinook remains a significant threat to the species, and NMFS must monitor actions and results to assure that the Proposed Action is fully implemented and the positive trend continues. However, NMFS does feel that the genetic risks at the population and the cumulative risk at the ESU level are likely to continue trending downward.

Fisheries that will occur as a consequence of the Proposed Action are likely to inadvertently and incidentally take LCR coho salmon. The resulting escapements described in Section 2.2.3.1.1 are the result of any fisheries implemented at both preterminal and terminal levels, which is captured in the Environmental Baseline (Section 2.4). Additionally, placement of seasonal weirs that limit hatchery strays will continue with this Proposed Action. These weirs have resulted in decreased fishing pressure upstream of the weirs, resulting in decreased fishing impacts to LCR coho salmon.

Added to the Species' Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area, including those intended to reduce threats to listed species. The Recovery Plan for the ESU (NMFS 2013e) describes the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed coho salmon. Such actions are improving habitat conditions for the ESU in the Columbia River Basin and resulting in hatchery and harvest practices designed to protect the coho salmon - such as those outlined in the HOF. NMFS expects this trend to continue.

After taking into account the current viability status of the species, the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the effects of the Proposed Action added to the effects of all human activities in the Action Area will not appreciably reduce the likelihood of survival and recovery of the LCR Coho Salmon ESU in the wild.

2.7.6.3 Columbia River (CR) Chum Salmon ESU

NMFS recent status review affirmed the status of this ESU as threatened due to a moderate to high risk of extinction, though improvements in some populations were observed almost every year during the 2015-2019 interval (NMFS 2022b). Factors that limit the ESU have been, and continue to be, loss and degradation of spawning and rearing habitat including in the Columbia River estuary, impacts of main stem hydropower dams on upstream access and downstream habitats, and the legacy effects of historical harvest.

We conclude that the effects of facilities used for Mitchell Act production on the abundance, spatial structure, and diversity VSP parameters of the CR Chum Salmon ESU have recently been and will continue to be negligible for hatchery operations and small for broodstock collection and adult management activities. This is because the Big Creek chum program is a reintroduction program, where the hatchery-origin spawners offset the impacts to the abundance and productivity VSP parameters for the natural populations (Section 2.2.4.1.1). Also, the encounters at other hatchery facilities and weirs used for Mitchell Act production are low, with the expected maximum total salmon mortality to be no more than 3% of the encounters. In addition, water usage by facilities continues to be a very small proportion of surface water flow, and facilities have NPDES permits for effluent discharge, if needed. Relatively few facilities need upgrades, and these will be done in the near future to meet NMFS standards.

The risks from RM&E effects on the abundance, spatial structure, and diversity VSP parameters of the CR Chum Salmon ESU are also expected to remain negligible. These activities capture and possibly delay fish, and on occasion kill small numbers of fish, but at low levels and frequencies such that the effect on the abundance and productivity VSP parameters (Section 2.2.4.1.1) of the CR Chum Salmon ESU is small. The net effect to the species is negligible, given the beneficial nature of the RM&E activities in terms of: understanding the survival and recovery status of the species; making sure the program complies with best management practices; providing information on the performance of the hatchery program and its interactions with the natural population; and coordinating with RM&E programs elsewhere to provide much needed information on how to use hatchery programs to reduce extinction risk and promote recovery of target species, while not disadvantaging non-target species. All of these measures assure that the risks to the species are appropriately understood and controlled, to prevent any changes.

Our effects analysis showed that the ecological impact of the hatchery releases competing with and preying on natural-origin chum salmon juvenile outmigrants produced in the basins, based on the most up-to-date interactions modeling available, is minor. The programs have implemented reforms to minimize competition and predation effects to local natural-origin populations, and those measures will continue as a result of the Proposed Action. This represents an improved trend at the ESU level. NMFS will monitor whether increased productivity or abundance of natural-origin fish may necessitate more aggressive adult management, and/or reconsideration of hatchery program size in the future to limit impacts to these VSP parameters in this ESU (Section 2.2.4.1.1).

The Proposed Action will also contribute to marine-derived nutrient input in the Columbia River Basin by increasing the number of naturally-spawning salmon and steelhead carcasses over the level that would be present in the absence of the Mitchell Act funded programs, and through distribution of hatchery carcasses. Decaying carcasses of spawned adult hatchery-origin fish would contribute nutrients that increase the productivity VSP parameter (Section 2.2.4.1.1) in watershed areas, enhancing food resources for naturally-produced chum salmon. Returning adults from the hatchery programs can also be expected to improve the condition of spawning gravel into the future, if they spawn naturally (Montgomery et al. 1996).

The Mitchell Act funded chum salmon hatchery program supports conservation and recovery of the LCR Chum Salmon ESU through recolonization of vacant habitats *sensu* HSRG (2014). At this stage of population recovery, demographic benefits from the hatchery program outweigh any risk posed by artificial rearing and selection. Accordingly, pHOS/PNI standards are not applied at this time. As re-established populations become locally adapted, transition to PNI-based management may be warranted. But, currently, benefits of the hatchery program to population abundance and distribution far outweigh any potentially negative genetic effects to the productivity and diversity of naturally spawning LCR chum salmon.

Added to the Species' Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area, including those intended to reduce threats to listed species. For example, the

Recovery Plan for the ESU (NMFS 2013e) describes the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed chum salmon. Such actions are improving habitat conditions for CR chum in the Columbia River Basin and resulting in hatchery and harvest practices designed to protect CR chum salmon - such as those outlined in the HOF. NMFS expects this trend to continue.

After taking into account the current viability status of the species, the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the effects of the Proposed Action added to the effects of all human activities in the Action Area will not appreciably reduce the likelihood of survival and recovery of the CR Chum Salmon ESU in the wild.

2.7.6.4 LCR Steelhead DPS

NMFS' recent status review affirmed the status of this DPS as threatened due to a moderate risk of extinction (NMFS 2022b). Factors that limit the DPS have been, and continue to be, hydropower development on the Columbia River and its tributaries, habitat degradation, hatchery effects, fishery management and harvest decisions, and ecological factors including predation and environmental variability.

The effects of facilities used for Mitchell Act production on the abundance, spatial structure, and diversity VSP parameters of the LCR Steelhead DPS have recently been and will continue to be negligible for hatchery operations and small for broodstock collection and adult management activities. This is because only small numbers of natural-origin fish will be impacted by broodstock collection for segregated programs, and for integrated programs, effects to the abundance, productivity, and diversity VSP parameters are small (Section 2.2.6.1.1), as broodstock take is limited to 5-33% of the natural-origin run. In addition, water usage by facilities is a very small proportion of surface water flow, and facilities have NPDES permits for effluent discharge, if needed. Relatively few facilities need upgrades, and these will be done in the near future to meet NMFS standards.

The risks from RM&E effects to the abundance, spatial structure, and diversity VSP parameters of the LCR Steelhead DPS are also expected to continue to be negligible. These activities capture and possibly delay fish, and on occasion kill small numbers of fish, but at a low level and frequency within the affected populations such that the effect on the abundance and productivity VSP parameters (Section 2.2.6.1.1) of the LCR Steelhead DPS is small. The risk to the species is negligible, given the essential nature of the RM&E activities in terms of: understanding the survival and recovery status of the DPS; making sure the program complies with best management practices; providing information on the performance of the hatchery program and its interactions with the natural population; and coordinating with RM&E programs elsewhere to provide much needed information on how to use hatchery programs to reduce extinction risk and promote recovery of target species, while not disadvantaging non-target species.

Our effects analysis showed that the ecological impact of the hatchery releases competing with and preying on natural-origin steelhead juvenile outmigrants produced in the basins, based on the most up-to-date interactions modeling available, is minor. The programs have implemented reforms to minimize competition and predation effects to local natural-origin populations, and those measures will continue as a result of the Proposed Action. This represents an improved trend at the DPS level. NMFS will monitor whether increased productivity or abundance of natural-origin fish may necessitate more aggressive adult management, and/or reconsideration of hatchery program size in the future to limit impacts to these VSP parameters in this DPS (Section 2.2.6.1.1).

The Proposed Action will also contribute to marine-derived nutrient input in the Columbia River Basin by increasing the number of naturally-spawning salmon and steelhead carcasses over the level that would be present in the absence of the Mitchell Act programs, and through distribution of hatchery carcasses. Decaying carcasses of spawned adult hatchery-origin fish would contribute nutrients that increase the productivity VSP parameter (Section 2.2.6.1.1) in watershed areas, enhancing food resources for naturally-produced coho salmon. The programs can also be expected to improve the condition of spawning gravel into the future (Montgomery et al. 1996)

All Mitchell Act funded steelhead hatchery programs operating in the LCR currently use broodstock sourced from LCR steelhead populations. This practice will continue under the Proposed Action, thereby promoting conservation of among-DPS genetic diversity.

An important part of this Opinion is assessing the risk of genetic effects due to hatchery supplementation, which can reduce diversity, productivity and abundance at the population and DPS level. Through the Proposed Action, NMFS will continue to fund integrated broodstock hatchery programs, where the abundance of natural-origin steelhead and availability of adult collection facilities support this approach. Genetic effects from integrated hatchery programs are limited through management of geneflow and, under the Proposed Action, programs will continue to manage these effects within limits set for each affected watershed. The segregated programs funded by the proposed action will similarly control their impacts through strict limits on hatchery spawners in the wild.

Several of these limits were previously in place, and are either showing a reduction in gene flow risk or will require more time for the changes to program operation to realize their intended effect. The proposed action will carry over these management changes, as well as including additional risk reduction measures, such as the integration and size reduction of the Washougal winter steelhead hatchery program. Even with the measures implemented or underway, the genetic risk to LCR steelhead remains a significant threat to the DPS, and NMFS must monitor actions and results to assure that the Proposed Action is fully implemented and the positive trend continues. However, NMFS does feel that the genetic risks at the population and the cumulative risk at the DPS level is likely to continue trending downward.

In summary, the Proposed Action will, through support of hatchery steelhead programs, increase the abundance of LCR steelhead beyond baseline levels and reduce negative genetic effects on diversity and productivity through program size adjustments and improved broodstock management. Collectively, these actions represent improvements to LCR Steelhead VSP parameters (Section 2.2.6.1.1), brought about through implementation of the Proposed Action.

Added to the Species' Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area, including those intended to reduce threats to listed species. The Recovery Plan for the DPS (NMFS 2013e) describes the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed steelhead. Such actions are improving habitat conditions for the DPS in the Columbia River Basin and resulting in hatchery and harvest practices designed to protect the LCR Steelhead DPS - such as those described in the HOF. NMFS expects this trend to continue.

After taking into account the current viability status of the species, the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the effects of the Proposed Action added to the effects of all human activities in the Action Area will not appreciably reduce the likelihood of survival and recovery of the LCR Steelhead DPS in the wild.

2.7.7 Upper Willamette River (UWR) ESU/DPS

2.7.7.1 UWR Chinook Salmon ESU

NMFS recent status review affirmed the status of this ESU as threatened due to a moderate risk of extinction (NMFS 2024b). Factors that limit the ESU have been, and continue to be, dams that block access to major production areas, loss and degradation of accessible spawning and rearing habitat, and degraded water quality and increased water temperatures. No effect on this ESU is expected from RM&E activities associated with the Proposed Action.

The programs in the HOF will continue to pose a low risk to the diversity and productivity of UWR Chinook salmon populations through broodstock collection and adult management activities. The activities capture and possibly delay a small number of UWR Chinook salmon, and may on occasion kill a few of these fish, which may affect the spatial structure VSP parameter (Section 2.2.2.2.2), but the effect will be small with no more than 11 mortalities expected annually, which is offset by the conservation hatchery program.

In addition, water usage by facilities used for Mitchell Act production is a very small proportion of surface water flow, and facilities have NPDES permits for effluent discharge, if needed. Relatively few facilities need upgrades, and these will be done in the near future to meet NMFS standards.

Our effects analysis showed that the ecological impact of the hatchery releases competing with and preying on natural-origin Chinook salmon juvenile outmigrants produced in the basins, based on the most up-to-date interactions modeling available, is minor. NMFS will monitor whether increased productivity or abundance of natural-origin fish may necessitate more aggressive adult management, and/or reconsideration of hatchery program size in the future to limit impacts to these VSP parameters in this ESU (Section 2.2.2.2.2).

The Proposed Action will also contribute to marine-derived nutrient input in the Columbia River Basin by increasing the number of naturally-spawning salmon and steelhead carcasses over the level that would be present in the absence of the Mitchell Act programs, and through distribution of hatchery carcasses. Decaying carcasses of spawned adult hatchery-origin fish would contribute nutrients that increase the productivity VSP parameter (Section 2.2.2.2.2) in watershed areas, enhancing food resources for naturally-produced UWR Chinook salmon. Returning adults from the hatchery programs can also be expected to improve the condition of spawning gravel into the future, if they spawn naturally (Montgomery et al. 1996)

Based on current recovery standards for hatchery genetic influence, the Proposed Action poses little risk to the productivity and diversity VSP parameters (Section 2.2.2.2.2) for the Clackamas spring Chinook salmon population, or to the ESU. Estimated pHOS levels are under 10%, which is acceptably low for a primary population being affected by an integrated hatchery program. The Clackamas River is the only watershed within the ESU directly impacted by hatchery programs under the proposed action. Very little straying of hatchery fish from the proposed action occurs in any UWR watershed beyond the Clackamas River, further limiting the risks to productivity or diversity, beyond the baseline levels (which encompass other hatchery effects).

Added to the Species' Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area, including those intended to reduce threats to listed species. For example, the Recovery Plan for the ESU (ODFW and NMFS 2011) describes the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed Chinook salmon. Such actions are improving habitat conditions for the ESU in the Columbia River Basin and resulting in hatchery and harvest practices designed to protect the UWR Chinook Salmon ESU - such as those described in the HOF. NMFS expects this trend to continue.

After taking into account the current viability status of the species, the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the effects of the Proposed Action added to the effects of all human activities in the Action Area will not appreciably reduce the likelihood of survival and recovery of the UWR Chinook Salmon ESU in the wild.

2.7.7.2 UWR Steelhead DPS

NMFS's recent status review affirmed the status of this DPS as threatened due to a moderate-to-high risk of extinction (NMFS 2024b). Factors that limit the DPS have been, and continue to be, loss and degradation of spawning and rearing habitat, impacts of mainstem hydropower dams on upstream access and downstream habitats, and the legacy effects of historical harvest.

We conclude that the effects of facilities used for Mitchell Act production on the abundance, spatial structure, and diversity VSP parameters on the UWR Steelhead DPS will continue to be negligible for hatchery operations and small for broodstock collection and adult management. This is because only small numbers of natural-origin fish will be impacted by broodstock collection for segregated programs. In addition, water usage by facilities is a very small proportion of surface water flow, and facilities have NPDES permits for effluent discharge, if needed. Relatively few facilities need upgrades, and these will be done in the near future to meet NMFS standards.

The risks from RM&E effects on the abundance, spatial structure, and diversity VSP parameters of the UWR Steelhead DPS are also negligible. These activities capture and possibly delay fish, and on occasion kill small numbers of fish, but the effect on the abundance and productivity VSP parameters (Section 2.2.2.1.2) of the UWR Steelhead DPS is small. The risk to the species is negligible, given the essential nature of the RM&E activities in terms of: understanding the survival and recovery status of the DPS; making sure the program complies with best management practices; providing information on the performance of the hatchery program and its interactions with the natural population; and coordinating with RM&E programs elsewhere to provide much needed information on how to use hatchery programs to reduce extinction risk and promote recovery of target species, while not disadvantaging non-target species.

Our effects analysis showed that the ecological impact of the hatchery releases competing with and preying on natural-origin steelhead juvenile outmigrants produced in the basins, based on the most up-to-date interactions modeling available, is minor. No programs funded by the Proposed Action operate directly within the UWR Steelhead DPS, however, which limits the opportunities for ecological impacts from Mitchell Act-funded hatchery fish to the DPS's migration areas.[38] NMFS will monitor whether increased productivity or abundance of natural-origin fish may necessitate more aggressive adult management, and/or reconsideration of hatchery program size in the future to limit impacts to these VSP parameters in this DPS (Section 2.2.2.1.2).

The Proposed Action will also contribute to marine-derived nutrient input in the Columbia River Basin by increasing the number of naturally-spawning salmon and steelhead carcasses over the level that would be present in the absence of the Mitchell Act programs, and through distribution of hatchery carcasses. Decaying carcasses of spawned adult hatchery-origin fish would contribute nutrients that increase the productivity VSP parameter (Section 2.2.2.1.2) in watershed areas, enhancing food resources for naturally-produced UWR steelhead. The programs can also be expected to improve the condition of spawning gravel into the future (Montgomery et al. 1996)

Added to the Species' Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area, including those intended to reduce threats to listed species. The Recovery Plan for

[38] The Clackamas winter steelhead program and Clackamas River population are included within the LCR steelhead DPS, unlike Chinook, where the Clackamas programs and the river population are included in the UWR Chinook salmon ESU.

the DPS (ODFW and NMFS 2011) describes the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed steelhead. Such actions are improving habitat conditions for the DPS in the Columbia River Basin and resulting in hatchery and harvest practices designed to protect the UWR Steelhead DPS - such as those outlined in the HOF. NMFS expects this trend to continue.

After taking into account the current viability status of the species, the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the effects of the Proposed Action added to the effects of all human activities in the Action Area will not appreciably reduce the likelihood of survival and recovery of the UWR Steelhead DPS in the wild.

2.8 Conclusion

After reviewing and analyzing the current status of the listed species and the 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 cumulative effects, it is NMFS's biological opinion that the Proposed Action is not likely to jeopardize the continued existence of any of the species in Table 1: the Southern DPS of Pacific Eulachon, the LCR Chinook Salmon, UCR Chinook Salmon Spring-Run, Snake River Spring/Summer-Run Chinook Salmon, Snake River Fall-Run Chinook Salmon, UWR Chinook Salmon, Puget Sound Chinook Salmon, California Coastal Chinook Salmon, Central Valley Spring-Run Chinook Salmon, LCR Coho Salmon, CR Chum Salmon, and Snake River Sockeye Salmon ESUs, and the LCR Steelhead, UCR Steelhead, Snake River Basin Steelhead, MCR Steelhead, and UWR Steelhead DPS, or destroy or adversely modify their designated critical habitat.

2.9 Incidental Take Statement

Section 9 of the ESA and federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). "Harass" is further defined by 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.

NMFS has not yet promulgated an ESA section 4(d) rule prohibiting take of threatened eulachon. Anticipating that such a rule may be issued in the future, we have included a prospective incidental take statement for eulachon. The elements of this ITS for eulachon would become effective on the date on which any future 4(d) rule prohibiting take of eulachon becomes effective. Nevertheless, as specified in this statement, the amount and extent of eulachon incidental take will serve as one of the criteria for reinitiation of consultation pursuant to 50 C.F.R. §402.16(a), if exceeded.

2.9.1 Amount or Extent of Take

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

2.9.1.1 Pacific Eulachon Southern DPS

Under the HOF, incidental take of adult, juvenile, sub-adult, and larval eulachon will likely occur through predation by hatchery-produced and released salmon and steelhead throughout their life cycle.

Take caused by the production and release of hatchery-produced salmon and steelhead cannot be directly quantified because the distribution and abundance of eulachon that occur within the Action Area are affected by habitat quality, competition, predation, and the interaction of processes that influence genetic, population, and environmental characteristics. These biotic and environmental processes interact in ways that may be random or directional, and may operate across far broader temporal and spatial scales than are affected by the Proposed Action. Thus, the impacts to distribution and abundance of eulachon within the Action Area cannot be attributed entirely to predation caused by the production and release of hatchery-produced salmon and steelhead under the HOF. In such circumstances, NMFS uses a surrogate to describe the extent of take. Here, the best available indicator for the extent of take is the annual production and release as described in Table 124. This is a reasonable surrogate because the extent of take caused by the Proposed Action will vary with the overall number of hatchery fish released and therefore able to encounter eulachon. Whether the Mitchell Act-funded programs stay within the total limit on fish releases will be tracked by each operator and included in annual reports to NMFS.

Under the HOF, incidental take of adult eulachon will likely also occur from the juvenile migrant trapping activity associated with the Abernathy conservation hatchery program. For the purposes of this statement, NMFS proposes to administer funds in a way that the expected number of eulachon encounters and mortality to not exceed those numbers identified in the table below (Table 118).

Table 118. Maximum adult Pacific Eulachon Southern DPS expected to be annually encountered and killed as the result of RM&E activities under the Abernathy conservation hatchery program funded through the Proposed Action (NMFS 2024a)

Location	Adult Encounters	Adult Mortalities

Mill Creek	≤30	≤1
Abernathy Creek	≤30	≤1
Germany Creek	≤30	≤1

2.9.1.2 Salmon and Steelhead

For salmon and steelhead, incidental take is likely to occur under the Proposed Action for the factors described in Section 2.5.1. The following analysis describes the level of impacts anticipated for each applicable ESA-listed species per the factors.

2.9.1.2.1 The hatchery program does or does not remove fish from the natural population and use them for hatchery broodstock

Here, NMFS is not authorizing direct take of natural-origin ESA-listed fish for broodstock, as that is not part of the Proposed Action; however, collecting the natural-origin ESA-listed fish for broodstock is an incidental impact of the funding action, so the impacts are included here.

For the purposes of this statement, NMFS proposes to administer funds in a way that the expected number of natural-origin ESA-listed broodstock will not exceed those numbers identified in the table below (Table 119). This represents the quantified level of take associated with broodstock collection, including the operation of weirs, where these fish are lethally used as broodstock for the hatchery operation.

Table 119. Summary of broodstock needs for programs using ESA-listed salmon and steelhead species by ESU/DPS.

EESU/DPS	Program	Number of broodstock needed[1]
LCR Chinook Salmon ESU	North Fork Toutle fall Chinook salmon program	Maximum number of NOR broodstock (includes males, females and jacks) is 814; the maximum number of NORs that can be collected for broodstock is limited to 33% of the Toutle fall Chinook population annual NOR return.
	Washougal fall Chinook salmon program	Maximum number of NOR broodstock (includes males, females and jacks) is 978; the maximum number of NORs that can be collected for broodstock is limited to 33% of the Washougal fall Chinook population annual NOR return.
	Sandy River spring Chinook salmon	Maximum number of NOR broodstock (includes males, females and jacks) is 42; the maximum number of NORs that can be collected for broodstock is limited to 2% of the Sandy River spring Chinook population annual NOR return.
	Grays River fall Chinook Salmon Conservation Hatchery	A maximum of 154 NOR fall Chinook salmon collected from the Grays River; collection not to exceed 33% of the NOR return of fall Chinook salmon to the Grays River.
	Abernathy fall Chinook salmon Conservation Hatchery	A maximum of 48 NOR fall Chinook salmon collected from the Elochoman River; collection not to exceed 33% of the NOR return of fall Chinook salmon to the Elochoman River.
UWR Chinook Salmon	Clackamas spring Chinook salmon	Maximum number of broodstock (includes males, females and jacks) of is 120 NOR adults through 2025. Starting in 2026, broodstock will be collected on a sliding scale based on the number of NORs: 0 (< 1000 NOR), 21 total (1000-2500 NOR), and 45 total (>2500 NOR)
LCR Coho Salmon ESU	Beaver Creek (Elochoman) coho	Maximum number of NOR broodstock (includes males, females and jacks) is 337; the maximum number of NORs that can be collected for broodstock is limited to 33% of the Elochoman/Skamokawa coho population annual NOR return.
	North Fork Toutle coho	Maximum number of NOR broodstock (includes males, females and jacks) is 96; the maximum number of NORs that can be collected for broodstock is limited to 33% of the North Fork Toutle coho population annual NOR return.
	Washougal coho salmon	Maximum number of NOR broodstock (includes males, females and jacks) is 96; the maximum number of NORs that can be collected for broodstock is limited to 33% of the Washougal coho population annual NOR return.

EESU/DPS	Program	Number of broodstock needed[1]
CR Chum Salmon ESU	Big Creek Hatchery	Maximum number of NOR broodstock (includes males, females and jacks) is 1,352.
LCR Steelhead DPS	Clackamas River winter steelhead	Maximum number of broodstock (includes males, females and jacks) is 49; adults from this program will be live-spawned and released back into the Clackamas River to potentially spawn again. The maximum number of NORs that can be collected for broodstock is limited to 5% of the Clackamas winter steelhead population annual NOR return.
	Sandy River winter steelhead	Maximum number of broodstock (includes males, females and jacks) is 50; adults from this program will be live-spawned and released back into the Sandy River to potentially spawn again. The maximum number of NORs that can be collected for broodstock is limited to 5% of the Sandy winter steelhead population annual NOR return.
	Kalama River summer steelhead	Maximum number of NOR broodstock (includes males and females) is 90; the maximum number of NORs that can be collected for broodstock is limited to 33% of the Kalama summer steelhead population annual NOR return.
	Kalama River winter steelhead	Maximum number of NOR broodstock (includes males and females) is 45; the maximum number of NORs that can be collected for broodstock is limited to 33% of the Kalama winter steelhead population annual NOR return.
	Washougal winter steelhead	Maximum number of NOR broodstock (includes males and females) 42; the maximum number of NORs that can be collected for broodstock is limited to 33% of the Washougal winter steelhead population annual NOR return.

[1] The maximum number of NOR listed here assumes a scenario using 100% proportion of natural-origin broodstock (pNOB).

2.9.1.2.2 Hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities

Under this factor, take is likely to occur under three categories of effects: genetic effects of hatchery-origin fish interbreeding with natural spawners, ecological effects of adult hatchery-origin fish competing for spawning sites with natural-origin spawners or superimposing redds, and effects of adult collection facilities.

2.9.1.2.2.1 Genetic effects and adult ecological interactions (Interactions on the spawning grounds, including spawning site competition and redd superimposition)

When hatchery fish are not harvested or do not return to release locations, genetic interactions and adult ecological interactions (i.e., spawning site competition or redd superimposition) with listed fish on the spawning grounds can occur, and the result constitutes take of the natural populations. The exact amount of such take is always uncertain because it is typically impossible to observe or confidently measure effects from adult genetic and ecological interactions. NMFS will, therefore, rely on the surrogate variables pHOS, gene flow, PNI, or a combination of these to estimate this form of incidental take. Using pHOS as a surrogate indicator of take associated with genetic interactions is rational because it relates directly to the form of take – genetic interactions due to interbreeding – by measuring the relative abundance of hatchery fish available to interbreed with natural-origin fish. Using pHOS as a surrogate indicator of take associated with ecological interactions is also rational because the proportion of hatchery-origin fish on the spawning grounds serves to describe the amount of spawning site competition and redd superimposition that is likely to occur between hatchery and natural-origin fish. Where applicable and feasible, the surrogate indicator of PNI will be used instead of pHOS to estimate incidental take from genetic effects. Because minimum limits on PNI imply maximum limits for pHOS, PNI also serves as an appropriate surrogate for take that occurs through negative ecological interactions of adult hatchery- and natural-origin fish.

As described below, the pHOS and PNI estimates to be used are running arithmetic means, calculated over a three-year period for steelhead and coho salmon, and over a four-year period for Chinook salmon. If a better methodology to estimate genetic or adult ecological interactions is found or developed, it will be used rather than the methods described below.

2.9.1.2.2.1.1 ESA-listed salmon and steelhead populations affected by Mitchell Act funded hatchery programs for which genetic risk reduction measures are not required under the Proposed Action

Negative genetic effects from Mitchell Act funded hatchery programs are minor or non-existent for ESA-listed salmon and steelhead populations in the MCR Steelhead DPS and CR Chum Salmon ESU. Therefore, no additional genetic risk reduction measures are required through the Proposed Action for programs operating within this ESU and DPS, and no incidental take is expected to occur pursuant to this factor.

2.9.1.2.2.1.2 ESA-listed salmon and steelhead populations affected by Mitchell Act funded hatchery programs for which genetic risk reduction measures are required under the Proposed Action

Incidental take of ESA-listed salmon and steelhead is expected to occur in the form of genetic effects as a result of the proposed action, which results in harm to listed fish. This take cannot be readily observed or quantified, therefore NMFS will rely on a surrogate measure of take, in the form of the numeric limits described in Table 120. These limits can be reliably monitored and reported to NMFS in the required annual reports for each hatchery operator. The limits are described further below.

Although most Mitchell Act-funded hatchery programs are currently managed in a manner that adequately limits genetic effects on ESA-listed salmon and steelhead, several hatchery programs operating in the Lower Columbia River contribute to excessively high pHOS observed in ESA-listed steelhead, and Chinook and coho salmon populations. To address these issues, the Proposed Action requires various measures, described in the HOF, to be taken by the program operators to reduce pHOS or increase PNI for populations of LCR Chinook salmon, LCR coho salmon, and LCR steelhead affected by Mitchell Act funded hatchery programs, thereby reducing genetic risk from these programs. In some cases, the effects of these measures on pHOS or PNI will not be immediate, but will instead require one or more years to begin to manifest. For example, an immediate reduction to the size of a hatchery program would not be expected to reduce pHOS until fish released by the modified program return as adults. For such an action, the generational lag between broodstock collection and pHOS reduction would typically be three years for steelhead and coho salmon, and four years for Chinook salmon. On the other hand, installation and operation of a new weir could, in some cases, be expected to immediately reduce local pHOS.

Table 120 lists those measures required by the Proposed Action that are designed to reduce negative genetic effects from Mitchell Act funded hatchery programs (i.e., reduce pHOS or increase PNI), the years in which those measures are expected to be implemented, the first year in which effects are expected to occur, and the year by which mean pHOS or PNI is to be calculated and evaluated against expectations (i.e., limits). Calculation of arithmetic means for pHOS and PNI are to include values from the first year of expected effect, but are not to include values from previous or interim years. Estimates for mean pHOS and PNI are to be calculated over a three-year period for steelhead and coho salmon, and over a four-year period for Chinook salmon. Mean pHOS and PNI values will be evaluated against and subject to the limits presented in Table 120. For those populations not already meeting their expected pHOS levels, and for which genetic risk reduction measures are expected to have delayed effects on pHOS (e.g., program reductions), NMFS requires that mean pHOS does not exceed baseline levels (see Table 120), during the interim time period before the pHOS limit for a specific population is required to be met. During this interim period, mean pHOS is to be calculated as a three-year arithmetic mean of annual estimates. Where multiple measures are expected to affect pHOS for a given population, estimation of mean pHOS shall begin in the first year when effects from all measures affecting that population are expected to occur.

Where segregated hatchery populations are genetically distinct from local natural-origin populations, molecular genetic methods can sometimes be used to estimate gene flow. We have explored the relationship between pHOS and gene flow and have determined that over a fairly wide range of conditions, a census level pHOS of 0.05 serves as an adequately conservative proxy to the 2% gene flow surrogate. This means that any exceedance of the pHOS limit, where the gene flow limit has not been calculated, will exceed the allowable take under this Statement. In situations where gene flow is calculated, the gene flow limit will apply (and the limit of pHOS is relegated to limits established for ecological effects). For segregated and integrated programs, the same maximum pHOS levels are used as take surrogates for Chinook and coho salmon.

For natural populations influenced by integrated hatchery programs, and where PNI has been established as the appropriate measure of take, hatchery programs are expected to realize at least 67% mean PNI in accordance with the schedule indicated in Table 120.

Incidental take by interactions on the spawning grounds shall not exceed the limits identified Table Table 120.

NMFS understands that the running mean calculations will not result in measurements for a number of years after the implementation of the Proposed Action. However, since genetic and adult ecological effects result from returning hatchery-origin adults, the effects of the Proposed Action relating to genetic and adult ecological interactions will not take place any sooner than the average time frames described for each species' running mean (see Table 120). Moreover, the running mean will likely provide useful information, as the Mitchell Act grant program has been in effect for many years.

Table 120. Measures proposed to reduce or limit genetic effects from Mitchell Act-funded hatchery programs affecting UWR and LCR Chinook salmon, LCR coho salmon, and LCR steelhead. Years for implementation, first year of expected effect, and year for mean pHOS or PNI to meet expectations are provided. Beyond those measures specified here, *status quo* pHOS control may include effects from maintenance of program size, mark-selective fisheries, and other tacit measures.

Affected LCR population		Recent estimated pHOS or PNI (2020-2022)[a]	Expected pHOS or PNI	Genetic risk reduction measure	Year of measure implementation	First year of expected effect from measure[b]	Year for mean pHOS or PNI to meet expected value[c]
Chinook salmon	Grays/Chinook River Chinook salmon[d]	pHOS = 75%	pHOS ≤ 50%	Install and operate an improved weir in Grays River; conduct additional HOS removal when feasible.	2027	2027	2030
	Elochoman/Skamokawa River Chinook salmon	pHOS = 61%	pHOS ≤ 50%	Continue operation of Elochoman River weirs	2025	2025	2028
	MAG[e] Chinook salmon[d]	pHOS = 87%	pHOS ≤ 50%	Install and operate a weir in Germany Creek; conduct additional HOS removal when feasible.	2026	2026	2030*
	MAG Chinook salmon[d]	pHOS = 87%	pHOS ≤ 50%	Install and operate a weir in Abernathy Creek	2027	2027	2030
	Coweeman River Chinook salmon	pHOS = 7%	pHOS ≤ 10%	Continue operation of Coweeman River weir	2025	2025	2029
	Lower Cowlitz River Chinook salmon	pHOS = 12%	pHOS ≤ 30%	Continue *status quo* pHOS control	2025	2025	2029
	Toutle River fall Chinook salmon[f]	pHOS = 43%	pHOS ≤ 30%	Continue operation of South Fork Toutle River and Green River weirs	2025	2025	2029
	Lewis River Chinook salmon	pHOS = 40%	pHOS ≤ 10%	Continue operation of Cedar Creek weir and Grist Mill trap; remove HOS adults as feasible	2025	2025	2031*

	Lewis River Chinook salmon	pHOS = 40%	pHOS ≤ 10%	Reduce Fallert Creek release of fall Chinook salmon to 2 million smolts	2025	2028	2031
	Washougal River Chinook salmon	pHOS = 28%	pHOS ≤ 30%	Continue operation of Washougal River weir	2025	2025	2028
	Kalama River (spring) Chinook salmon	pHOS = 4%[g]	pHOS ≤ 10%	Continue operation of sorting facility at Kalama Falls Hatchery	2025	2025	2028
	Clackamas River Chinook salmon	pHOS = 3%	pHOS ≤ 10%	Continue integration and pHOS control	2025	2025	2028
Coho salmon	Grays/Chinook River coho salmon	pHOS = 42%	pHOS ≤ 10%	Discontinue Grays River coho salmon hatchery program	2025	2028	2032*
	Grays/Chinook River coho salmon	pHOS = 42%	pHOS ≤ 10%	Discontinue Deep River coho salmon netpen program	2027	2030	2032
	Elochoman/Skamokawa River coho salmon	pHOS = 25%	pHOS ≤ 30%	Continue operation of Elochoman River weir	2025	2025	2028
	Clatskanie River coho salmon	pHOS = 15%	pHOS ≤ 10%	Continue *status quo* pHOS control	2025	2025	2028
	Scappoose River coho salmon	pHOS = 2%	pHOS ≤ 10%	Continue *status quo* pHOS control	2025	2025	2028
	Lower Cowlitz River coho salmon	pHOS = 15%	pHOS ≤ 30%	Continue *status quo* pHOS control	2025	2025	2028
	Coweeman River coho salmon	pHOS = 13%	pHOS ≤ 10%	Continue operation of Coweeman River weir	2025	2025	2028
	South Fork Toutle River coho salmon	pHOS = 14%	pHOS ≤ 10%	Continue operation of South Fork Toutle River weir	2025	2025	2028
	North Fork Toutle River coho salmon	pHOS = 16%	pHOS ≤ 30%	Continue *status quo* pHOS control	2025	2025	2028
	East Fork Lewis River coho salmon	pHOS = 11%	pHOS ≤ 10%	Initiate consultation for the Lewis River coho program through HGMP submission	2027	2031	2034
	Washougal River coho salmon	pHOS = 27%	pHOS ≤ 30%	Continue operation of Washougal River weir	2025	2025	2028
	Sandy River coho salmon	pHOS = 3%	pHOS ≤ 10%	Continue *status quo* pHOS control	2025	2025	2028

	Clackamas River coho salmon	pHOS = 9%	pHOS ≤ 10%	Continue *status quo* pHOS control	2025	2025	2028
Steelhead	Clackamas River winter steelhead	pHOS = 0% from segregated summer steelhead	pHOS ≤ 5% from segregated summer steelhead	Continue pHOS control for Clackamas summer steelhead program	2025	2025	2028
	Sandy River winter steelhead	pHOS = 0% from segregated summer steelhead	pHOS ≤ 5% from segregated summer steelhead	Continue pHOS control for Sandy summer steelhead program	2025	2025	2028
	South Fork Toutle winter steelhead	pHOS = 0% from segregated summer steelhead	pHOS ≤ 5% from segregated summer steelhead	Continue pHOS control for summer steelhead program	2025	2025	2028
	Washougal River summer steelhead	pHOS = 1% from segregated summer steelhead	pHOS ≤ 5% from segregated summer steelhead	Continue pHOS control for summer steelhead program	2025	2025	2028
	Kalama River winter steelhead (segregated)	pHOS = 2% from segregated winter steelhead	pHOS ≤ 5% from segregated winter steelhead	Continue pHOS control for segregated winter steelhead program	2025	2025	2028
	Coweeman River winter steelhead	pHOS = 1% from segregated winter steelhead	pHOS ≤ 5% from segregated winter steelhead	Continue pHOS control for winter steelhead program	2025	2025	2028
	Kalama River summer steelhead	PNI = 0.76	PNI ≥ 0.67	Continue pHOS control; Continue NOR integration for summer steelhead program	2025	2025	2028
	Kalama River winter steelhead	PNI = 0.97	PNI ≥ 0.67	Continue pHOS control; Continue NOR integration for	2025	2025	2028

				integrated winter steelhead program			
	Clackamas River winter steelhead	PNI = 0.59	PNI ≥ 0.67	Continue pHOS control; Continue NOR integration for integrated winter steelhead	2025	2025	2028
	Sandy River winter steelhead	PNI = 0.90	PNI ≥ 0.67	Continue NOR integration and implementation of NMFS (2014)[h]	2025	2025	2028
	Washougal River steelhead	N/A New program	PNI ≥ 0.67	Terminate isolated winter steelhead hatchery program, conduct additional HOS removal when feasible. Initiate integrated winter steelhead hatchery program	2025	2027	2029

[a] Data source summarized in (NMFS 2024a)
[b] The first year in which effect from risk reduction measure is expected to occur; the first year to generate data for calculation of mean pHOS or PNI
[c] The first year in which mean pHOS or PNI shall be evaluated against expected values. For programs not already meeting pHOS goals, the 3-year mean pHOS is not to exceed baseline levels (i.e. recent estimated pHOS).
[d] Because the intention of the Grays River Fall Chinook Salmon Conservation Program, Abernathy Fall Chinook Salmon Conservation Program, and the Clatskanie River Fall Chinook Salmon Supplementation Programs is to produce naturally-spawning hatchery fish, returning adult fish from these programs will not be counted against the pHOS levels identified here.
[e] Mill, Abernathy, Germany population
*Year to meet mean pHOS limit defaults to the value for the last measure implemented for that population (i.e. measures fully implemented)
[f] The expected pHOS levels identified here only apply to river reaches below the Sediment Retention Structure (SRS) on the North Fork Toutle River because recovery efforts for spring and fall Chinook salmon above the SRS plan to use hatchery stocks during reintroduction. That is, because of these reintroduction efforts, NMFS expects pHOS levels to be as high as 100% above the SRS for a limited duration.
[g] This estimate is a median based on WDFW (unpublished) data from 2011-20 and 2023.
[h] Sandy River Hatchery Programs Biological Opinion WCR-2014-300

2.9.1.2.2.2 Encounters with natural-origin and hatchery-origin fish at adult collection facilities, including the operation of weirs

In the course of collecting hatchery-origin fish for hatchery broodstock, the Proposed Action will fund activities that result in the annual handling of adult natural-origin fish, by species, as described in Section 2.5.2.2.2.3 of the Opinion. This handling is a form of take by harm or harassment, and is quantified below.

For the purposes of this statement, NMFS proposes to administer funds in a way that the expected handling associated with the collection of hatchery broodstock will not exceed those numbers identified in the tables listed below (Table 121, Table 122, and Table 123). These numbers are a reasonable take surrogate for the level of take associated with broodstock collection and adult management activities, including the operation of weirs, for those programs where the fish can be identified as being part of a particular ESU or DPS because they encompass the maximum amount of impact on each ESU or DPS.

For other programs where the fish cannot be distinguished from hatchery-origin fish or other ESUs/DPSs (e.g., Snake River fall Chinook salmon at the Bonneville Hatchery), the numbers listed in Table 121, Table 122, and Table 123 are limits on the overall numbers of fish handled, including listed and non-listed fish. Because the precise quantification is not readily possible, we will rely on a surrogate which uses this combined number of fish handled. This is a rational surrogate because these numbers have a causal link to the amount of take expected from broodstock collection. That is, the ESA-listed fish are a subset of the number of fish identified in these tables. These fish return to and enter into the respective hatchery facility by watershed or are trapped at weirs located at the specified watershed. This number can be reliably monitored and reported to NMFS in annual reports.

Table 121. Maximum number of natural-origin adults and jacks for each species authorized to be handled at hatchery facilities that rear Mitchell Act-funded fish and the maximum authorized incidental mortalities resulting from handling at hatchery facilities (assumes a 3% incidental handling mortality)[1].

Watershed	Hatchery Facility	ESU/DPS from which fish are expected to be collected.	Expected maximum number that could be encountered	Estimated maximum mortalities (≤ 3%)[1]	Comment
Mainstem Columbia River	Bonneville Hatchery	LCR and SR Fall Chinook Salmon	2,600	≤78	Unmarked URB, fall Chinook salmon, could be from other non-listed populations or hatchery programs.
		LCR Coho Salmon	2,300	≤69	

Watershed	Hatchery Facility	ESU/DPS from which fish are expected to be collected.	Expected maximum number that could be encountered	Estimated maximum mortalities (≤ 3%)[1]	Comment
		CR Chum Salmon	100	≤3	
		LCR, MCR, UCR, and SR Steelhead	110	≤3	Could be from any these DPSs due to the proximity of the hatchery to the mainstem Columbia River
		SR Sockeye Salmon	<10	1	Sockeye could be from SR or from unlisted sockeye salmon populations
	Ringold Springs	UCR Steelhead	50	≤2	Handled during recycling activities.
Big Creek	Big Creek Hatchery	LCR Fall Chinook Salmon	200	≤6	
		LCR Coho Salmon	700	≤21	Passed above the hatchery.
		CR Chum Salmon	2,500	≤75	
Youngs Bay	Klaskanine Hatchery and SF Clatsop Co. Fisheries Hatchery	LCR Fall Chinook Salmon	20	1	
		LCR Coho Salmon	120	≤4	Released above the hatchery.
		CR Chum Salmon	50	≤3	
Clackamas River	Clackamas Hatchery	LCR Steelhead	200	≤6	
		UWR Spring Chinook Salmon	350	≤11	
		LCR Coho	100	≤3	
Sandy River	Sandy Hatchery	LCR Chinook Salmon	200	≤6	
		LCR Steelhead	400	≤12	
		LCR Coho	2000	≤60	
Elochoman River	Beaver Creek	LCR Fall Chinook Salmon	20	1	
		LCR Coho Salmon	500	≤15	

Watershed	Hatchery Facility	ESU/DPS from which fish are expected to be collected.	Expected maximum number that could be encountered	Estimated maximum mortalities (≤ 3%)[1]	Comment
		CR Chum Salmon	500	≤15	
Kalama River	Kalama Falls Hatchery and Fallert Creek Hatchery	LCR Fall Chinook Salmon	2,000	≤60	
		LCR Spring Chinook Salmon	500	≤15	
		LCR Coho Salmon	2,000	≤60	
		LCR Steelhead (summer)	1,000	≤30	
		LCR Steelhead (winter)	3,000	≤90	
		CR Chum Salmon	25	1	
Washougal River	Washougal Hatchery	LCR Fall Chinook Salmon	1,200	≤36	
		LCR Coho Salmon	1,000	≤30	
		CR Chum Salmon	25	1	
		LCR Steelhead (summer)	250	≤8	
		LCR Steelhead (winter)	50	≤2	
	Skamania Hatchery	LCR Fall Chinook Salmon	10	1	
		LCR Coho Salmon	25	1	
		CR Chum Salmon	10	1	
		LCR Steelhead (summer)	200	≤6	
		LCR Steelhead (winter)	200	≤6	
Klickitat River	Klickitat Hatchery	MCR Steelhead	10	1	
Wind River	Carson NFH	LCR Chinook Salmon	0	0	
		LCR Coho Salmon	≤5	≤2	

Watershed	Hatchery Facility	ESU/DPS from which fish are expected to be collected.	Expected maximum number that could be encountered	Estimated maximum mortalities (≤ 3%)[1]	Comment
		LCR Steelhead	≤5	≤2	
Little White Salmon	Little White NFH	LCR Chinook Salmon	≤50	≤2	
		LCR Coho Salmon	≤500	N/A[2]	
		Steelhead (incl. MCR, LCR, UCR, and Snake)	≤50	≤2	
		Snake River Sockeye	≤50	≤2	
Eagle Creek	Eagle Creek NFH	LCR Chinook Salmon	0	0	
		LCR Coho Salmon	≤100	≤3	
		LCR Steelhead	≤50	≤2	
Snake River	Lostine River	Snake River Fall Chinook Salmon	≤ 50	≤1	
		Snake River Steelhead	≤ 25	≤1	
		Snake River Sockeye Salmon	≤ 5	≤1	
	Wallowa Hatchery	Snake River Fall Chinook Salmon	≤ 50	≤1	
		Snake River Steelhead	≤ 25	≤1	
		Snake River Sockeye Salmon	≤ 5	≤1	

[1] Based on recent data (NMFS 2024g), the incidental mortality is expected to be no more than 3% of the numbers encountered at the trap.
[2] All fish encountered will be culled from the river; see discussion in Section 2.5.2.2.2.4

Table 122. Maximum number of natural-origin adults and jacks for each species authorized to be handled at weirs and the maximum mortality limits (assumes a 3% incidental handling mortality)*.

Watershed	Status	Species encountered	Number Adults & Jacks encountered	Estimated Adult & Jacks mortalities*	Number Juveniles Encountered	Estimated Juvenile mortalities*
Grays (MA)	In place	Fall Chinook	750	≤23	100	≤3
		Coho Salmon	800	≤24	100	≤3
		Chum Salmon	8,500	≤255	0	0
Elochoman (MA)	In place 2 locations: Foster Road and Beaver Creek Sill	Fall Chinook	750	≤23	100	≤3
		Coho Salmon	2000	≤60	100	≤3
		Chum Salmon	1,000	≤30	0	0
Abernathy Germany	New	Fall Chinook	750	≤23	100	≤3
		Coho Salmon	1,500	≤45	100	≤3
		Chum Salmon	250	≤8	0	0
South Fork Toutle	In place	Fall Chinook	350	≤11	50	≤2
		Spring Chinook	50	≤2	50	≤2
		Coho Salmon	5,500	≤165	100	≤3
		Chum Salmon	250	≤8	0	0
		Winter Steelhead	50	≤2	50	≤2
		Summer Steelhead	50	≤2	50	≤2
Coweeman (MA)	In place	Fall Chinook	1,600	≤48	100	≤3
		Coho Salmon	800	≤24	100	≤3
		Chum Salmon	100	≤3	0	0
		Winter Steelhead	50	≤2	100	≤

Watershed	Status	Species encountered	Number Adults & Jacks encountered	Estimated Adult & Jacks mortalities*	Number Juveniles Encountered	Estimated Juvenile mortalities*
		Summer Steelhead	10	1	0	0
Cedar Creek (Lewis River Tributary) (MA)	In place 2 locations: Lower Cedar Ck. and Grist Mill Fish Ladder	Fall Chinook	1200	≤36	100	≤3
		Coho Salmon	1200	≤36	100	≤3
		Chum Salmon	250	≤8	0	0
		Summer Steelhead	50	≤2	50	≤2
		Winter Steelhead	250	≤8	50	2
Washougal (MA)	In place	Fall Chinook	3000	≤90	100	≤3
		Coho Salmon	200	<6	100	≤3
		Chum Salmon	250	<8	0	0
		Summer Steelhead	200	<6	100	≤3
		Winter Steelhead	10	1	100	≤3
Kalama (Located at Modrow Rd.) (MA)	In place	Fall Chinook	7,200	≤216	50	≤2
		Spring Chinook	50	≤2	50	≤2
		Coho Salmon	1,150	≤35	100	≤3
		Chum Salmon	250	≤8	0	0
		Summer Steelhead	500	≤15	50	≤2
		Winter Steelhead	0	0	50	≤2

[1] May also be referred to as Adult Collection Facility (ACF) in the HOF
[2] Adult management activities include, but are not limited to, broodstock collection, biodata collection, genetic sampling, marking and or tagging.
[*] Based on recent data (NMFS 2024g), the incidental mortality is expected to be no more than 3% of the numbers encountered at the trap.

Table 123. Maximum number of natural-origin salmon and steelhead expected to be encountered through other adult collection methods (such as seining, angling, netting, or other new trapping techniques) outside of the hatchery facilities and weirs described above and associated maximum expected mortality levels[1].

Watershed	Species encountered	Number Adults & Jacks encountered	Estimated Adult & Jack mortalities	Number Juveniles Encountered	Estimated Juvenile mortalities
Grays	Fall Chinook	100	≤3	100	≤3
	Coho Salmon	250	≤8	100	≤3
	Chum Salmon	250	≤8	0	0
Abernathy	Fall Chinook	100	≤3	100	≤3
	Coho Salmon	250	≤8	100	≤3
Germany	Chum Salmon	50	≤2	0	0
South Fork Toutle	Fall Chinook	100	≤3	50	≤2
	Spring Chinook	10	1	50	≤2
	Coho Salmon	250	≤8	100	≤3
	Chum Salmon	10	1	0	0
	Winter Steelhead	10	1	50	≤2
	Summer Steelhead	10	1	50	≤2
Coweeman	Fall Chinook	100	≤3	100	≤3
	Coho Salmon	250	≤8	100	≤3
	Chum Salmon	10	1	0	0
	Winter Steelhead	10	1	100	≤3
	Summer Steelhead	10	1	0	0
Lewis River/Cedar Creek	Fall Chinook	600	≤12	200	≤6
	Coho Salmon	600	≤12	200	≤6
	Chum Salmon	50	≤2	0	0
	Summer Steelhead	50	≤2	100	≤3
	Winter Steelhead	10	1	100	≤3
Washougal	Fall Chinook	250	≤8	100	≤3
	Coho Salmon	250	≤8	100	≤3
	Chum Salmon	50	≤2	0	0
	Summer Steelhead	50	≤2	100	≤3
	Winter Steelhead	50	≤2	100	≤3
Kalama	Fall Chinook	500	≤16	50	≤2
	Spring Chinook	50	≤2	50	≤2
	Coho Salmon	250	≤8	100	≤3
	Chum Salmon	10	1	0	0
	Summer Steelhead	50	≤2	50	≤2
	Winter Steelhead	10	1	50	≤2
Toutle	Fall Chinook	250	≤8	100	≤3
	Spring Chinook	50	≤2	100	≤3

Watershed	Species encountered	Number Adults & Jacks encountered	Estimated Adult & Jack mortalities	Number Juveniles Encountered	Estimated Juvenile mortalities
	Coho Salmon	250	≤8	100	≤3
	Chum Salmon	10	1	0	0
	Winter Steelhead	10	1	100	≤3
	Summer Steelhead	10	1	0	0

[1] NMFS expects these fish to experience mortality after being released as a result of gear effects, capture, and handling. Such mortality will be estimated for each encounter using best available science associated with the method of removing hatchery-origin fish from the spawning grounds.

For the purposes of this Statement, mortalities during funded broodstock collection and adult management activities will not exceed those identified in Table 121, Table 122, and Table 123. For Table 123, the numbers are the limits such that when either the encounter or the mortality numbers are reached, the adult collection operation in that particular watershed will cease for the year. NMFS will report annually the number of adults handled at each funded location and any mortalities incidental to the operation of the facilities or weirs (see Section 2.9.42.9.3, Terms and Conditions).

The operation of weirs is expected to result in a separate form of take of ESA-listed salmon and steelhead due to associated factors such as weir rejection, migration delay, and delayed mortality after release due to collection at the weir (this is in addition to the incidental mortality from handling at the weirs that is identified in Table 122). It is not possible to accurately observe or quantify this take because reliable measurements cannot be made of such factors or their effects. NMFS will therefore rely on surrogate take indicators that attempt to measure the effects of weir rejection, migration delay, and delayed mortality due to handling adult salmon or steelhead at the weirs. These have a rational connection to the amount of take because they reflect operational delay and the effects of weir operation compared to pre-weir conditions. Furthermore, they can be reliably monitored through surveys and reported by the operators to NMFS.

In making the assessments described below, we note that there is a high level of variability in the natural environment and in the rivers and locations for each weir, as placements range from tributaries near the mouth of the Columbia River, upstream to tributaries near Bonneville Dam. Furthermore, even excluding the effects of these types of local environmental conditions coupled with weather events, there is natural variability due to factors outside each location that affect the survival and productivity of the natural-origin populations. These factors affect smolt-to-adult survival, as illustrated by the variations in survival reflected in the changes in the abundance of natural-origin adults returning across the years for each ESU or DPS (See Section 2.2). Variability is also seen in things like spawning distribution (Schroeder et al. 2013); (Whitman, Cannon, and Walker 2014), time of first spawning, and peak spawning (Whitman, Cannon, and Walker 2014) for any run of salmon or steelhead. Surrogate take indicators attempt to identify changes to the natural populations due to the operation of the weirs by comparing things such as redd distribution and pre-spawning mortality before and after the operation of weirs. Unfortunately, it is often difficult to determine if changes to distribution, spawn timing or population productivity are due to the operation of the weirs or due to changes in the natural environment.

To buffer against effects from natural, interannual variability, NMFS will base its evaluations on a three-year running mean for each of the surrogate take indicators described below, with the calculation of means beginning in 2025 or in the first year of weir operation. NMFS will also monitor annual reports (Section 2.9.4) to determine if the surrogate take indicators have been exceeded in a single year and whether that exceedance would preclude a three-year mean within limits, thereby requiring NMFS to determine whether the impact level analyzed in this Opinion has been exceeded.

2.9.1.2.2.2.1 Surrogate for Weir Rejection

As previously described, weir operations can sometimes affect the distribution and productivity of naturally-spawning salmon and steelhead, particularly when weir operations impede adult upstream migration and cause fish to spawn in lower-quality, downstream habitats (see Section 2.5.2.2). In most cases, such weir rejection cannot be directly observed and quantified, because it is typically impossible to track and predict how individual fish might move in the absence of a particular weir. However, effects from weir operations can often be detected through population-level changes to spawner distribution and productivity. Therefore, NMFS will use a surrogate which consists of either a 10% change in spawner distribution or a 10% change in productivity. In each basin, NMFS will use the metric which can be most reliably monitored and reported. In all cases, the incidental take will have been exceeded if a greater than 10% change of the average spawning distribution or productivity, using a three-year running average, is detected.

In basins where the spawning distribution change cannot be reliably estimated, NMFS will recognize reductions to population productivity as the primary surrogate take indicator for weir rejection, for ESA-listed steelhead, chum, coho, and Chinook salmon where and when weir operations, required by the Proposed Action, may affect the adult, upstream migration of these species. Determination and quantification of changes in population productivity is a reasonable surrogate for weir rejection, because weir rejection can be expected to reduce upstream spawning and thereby impact natural production in potentially suitable habitat. Importantly, it is unlikely that all changes to a population's productivity would be attributable to the operation of a new or existing weir. However, significant changes to productivity, beyond those which can be explained by natural variability, can be reasonably attributed to weir operations. Moreover, changes to population productivity can be observed and measured in a reasonably reliable manner. NMFS must therefore ensure that funding recipients monitor the productivity of naturally-spawning salmon and steelhead populations associated with each weir required by the Proposed Action. Population productivity will be determined using the methods described in the HOF (NMFS 2024h), including the use of stock-recruit models and integrated population models (e.g., (Buhle et al. 2018) or, at minimum, through estimates of spawner-to-spawner ratios.

Where the distribution of spawners can be surveyed above and below new or existing weir locations, NMFS will recognize changes to spawner distributions as a secondary surrogate take indicator for weir rejection. Not all change in distribution is attributable to the presence of weirs. However, a change beyond a certain level likely exceeds natural variability and, therefore, can be reasonably attributed to weirs. Additionally, changes in spawning distribution can be observed and measured in a reasonably reliable manner. NMFS must therefore ensure that funding recipients monitor spawner distributions above and below each weir required by the Proposed Action, wherever possible.

Implementation of the HOF is expected to result in no more than a 10% relative increase in the distribution of natural-origin spawners (NMFS 2014e). Methods to evaluate and detect changes to spawner distribution are described in the HOF (NMFS 2024h). The surrogate take indicator is based on estimated changes to the cumulative spawning distribution caused by the installation and operation of weirs, as it compares to the distribution of redds observed during the years prior to weir placement.

The level of incidental take described here, attributable to NMFS's funding of the implementation of the HOF, would be exceeded when a 3-year running mean of the relative change (δ) in spawning distribution is greater than 10% using the best available data before weir installation.

This surrogate indicator serves as a reasonable and reliable measure of incidental take because if the distribution of redds increases in areas now affected by the weirs, as compared to the average proportion observed (as a measure of distribution) under natural conditions before weir placement, then it is reasonable to conclude that the weirs are causing this change and that salmon or steelhead are spawning below the weir in greater-than-normal proportions and are doing so because they are having difficulty passing the weirs. Upon reaching such a threshold, NMFS would propose changes to the operation of the weirs to minimize their effects, and NMFS would likely require reinitiation of consultation (Section 2.11, Reinitation of Consultation). Where weirs are funded and operated, NMFS will continue to require operators to monitor redd distribution within the respective river, annually. As described above, a 3-year running mean will be used for this surrogate take indicator because this will allow for naturally occurring variations in the proportion of redds in the lower survey sections.

2.9.1.2.2.2.2 Surrogate for Migration Delay

Take in the form of migration delay due to weir operations cannot be reliably measured. Migration timing data are incomplete for some salmon and steelhead that spawn in the rivers where weir are to be (or have been) installed, and migration timing is highly variable and subject to change from natural environment effects. Moreover, when migration delay does occur, it is expected to impact spawning distribution, population productivity, or both, such that effects from migration delay can be expected to be captured by aforementioned surrogate take indicators. Therefore, NMFS will use the same take surrogates as described for weir rejection: population productivity for all weirs and spawner distribution for weirs that are located in places where spawner distribution can be reliably monitored. Exceedance of limits for either of these surrogates would compel NMFS to propose changes to the operation of the weirs to minimize the effects, and NMFS would likely require reinitiation of consultation (Section 2.11).

This surrogate indicator serves as a reasonable and reliable measure of incidental take because if the distribution of redds increases in areas now affected by the weirs, as compared to the average proportion observed (as a measure of distribution) under natural conditions before weir placement, then it is reasonable to conclude that the weirs are causing this change and that salmon or steelhead are spawning below the weir in greater-than-normal proportions and are doing so because they are having difficulty passing the weirs. Upon reaching such a threshold, NMFS would propose changes to the operation of the weirs to minimize their effects, and NMFS would likely require reinitiation of consultation (Section 2.11). Where weirs are funded and operated, NMFS will continue to require operators to monitor redd distribution within the respective river, annually. As described above, a 3-year running mean will be used for this surrogate take indicator because this will allow for naturally occurring variations in the distribution of redds.

2.9.1.2.2.2.3 Surrogate for Delayed Trapping and Handling Mortality

As discussed above, trapping and handling salmonids at weirs can result in impacts not manifested until after release. An indication of this delayed mortality is the level of pre-spawning mortality observed in salmonids following release. Generally, female pre-spawning mortality can be reliably detected and quantified during spawning ground surveys, where salmon and steelhead carcasses can be used to determine if spawning had occurred before death by examining carcasses for retained eggs. However, pre-spawning mortality can occur naturally as well, not solely as a result of trapping and handling.

It is not possible to directly accurately observe and quantify pre-spawning mortality that is attributed to implementation of the HOF, because where carcasses indicate pre-spawning mortality, there is no evidence as to the precise cause. This is in addition to incidental handling mortality identified in Table 121, Table 122, and Table 123. Therefore, NMFS will rely on a surrogate take indicator measuring the change in pre-spawning mortality from past years before weirs were installed or direct comparison of fish handled and not handled at weirs in years when weirs are installed. Specifically, the surrogate take indicator for delayed mortality after release is an increase in observed pre-spawning mortality. NMFS expects that the Proposed Action will result in an absolute increase of no more than 5% in pre-spawning mortality from what was measured during previous spawning ground surveys before the installation and operation of the weirs, or alternatively, between fish handled and not handled at weirs in years when weirs are installed To allow for natural variability, a running 3-year mean of greater than 5% increase in pre-spawning mortality would prompt NMFS to propose changes to the operation of the weirs to minimize the effects and consider reinitiation of consultation (Section 2.11).

This surrogate serves as a reasonable and reliable measure of incidental take because NMFS expects that the weirs have a minimal effect on pre-spawning mortality, and an absolute change of 5% using a 3-year running mean will allow for naturally occurring annual variability in pre-spawning mortality estimates while still providing protection to the ESA-listed salmon or steelhead. NMFS will ensure, as part of funded salmon or steelhead spawning ground surveys, that funding recipients will annually monitor and report pre-spawning mortality.

As a secondary surrogate in pre-spawning mortality in rivers where there are inadequate sample sizes to compare handled and not handled fish in years when weirs are installed and therefore no reliable measure for delayed trapping and handling mortality attributable to the operation of the weirs, NMFS will rely instead on the amount of take by handling at the respective weir described in Table 122. The number of fish handled is a good indicator of pre-spawning mortality because handling and delay can both contribute to pre-spawning mortality. Pre-spawning mortality will be monitored and compared to trends observed to determine if there are impacts from the operation of a specific weir. Pre-spawning mortality will be included as part of the annual report. As more data becomes available, NMFS may amend this section to rely on a pre-spawning mortality take indicator.

2.9.1.2.3 Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas, the migratory corridor, estuary, and ocean

Incidental take of ESA-listed salmon and steelhead are expected to occur in the form of interactions between juvenile hatchery and natural-origin fish in juvenile rearing and migratory areas. This form of take concerns interactions (predation, competition, or pathogen transmission, collectively referred to as ecological interactions) between juvenile salmon and steelhead and juvenile hatchery fish. This occurs as smolts emigrate from hatcheries and acclimation ponds and likely transit through the migratory fresh, brackish, and marine waters of the Action Area or as hatchery fish residualize and remain behind. However, it is difficult to quantify this take because ecological interactions cannot be observed directly. NMFS will, therefore, rely on a series of surrogate take indicators, each which will apply as described below. These surrogates all work in conjunction with each other.

Timing Surrogate: The first take surrogate is the date of release. This standard has a rational connection to the amount of take expected from ecological interactions, because the potential for adverse ecological interactions increases as more overlap occurs between hatchery and natural-origin fish, specifically hatchery-origin yearling fish, for the reasons discussed in Section 2.5.2.3. For this take surrogate, releases of salmon or steelhead yearling smolts should occur after most natural-origin salmon and steelhead have exited the system or have grown to a size in the estuary that they are less likely to be predated upon. NMFS considers, for this take surrogate, that the amount of incidental take associated with the release date will have been exceeded if hatchery yearling smolts are released before the last week of March, for release downstream of McNary Dam, unless the operator has first sought and obtained NMFS concurrence that an earlier smolt release will not increase the temporal overlap with natural-origin fish. The location of a release is associated with the travel time expected to reach the estuary. Absent NMFS concurrence, releases before the last week of March could result in take beyond the level of this estimate. If NMFS receives information that the emigration of most natural-origin juveniles has shifted to a later time, NMFS will revisit this take surrogate or its associated timing to determine whether the take levels analyzed in this Opinion have been exceeded.

Production Levels: The second take surrogate is the production levels. As the number of smolts released increases, so does the extent of potential interaction. The choice of location for the release also determines the extent of potential interaction. The limits imposed through these surrogates are as follows:

- Any single release of smolts in numbers that exceed the annual maximum release number identified below in Table 124 will be considered to have exceeded the expected incidental take through ecological interactions, unless NMFS has determined otherwise;
- Any five-year average calculation of smolt releases that exceed the five-year average production level identified in Table 124, below, will be considered to have exceeded the expected incidental take through ecological interactions

Table 124. Maximum number of annual and five-year average production levels for each Mitchell Act-funded program.

Mitchell Act Hatchery Program	Hatchery Program Operator	Five Year Average Production Level	Annual Maximum Production Level
Bonneville coho salmon	ODFW	255,000	262,500
Bonneville fall Chinook salmon (tule)	ODFW	6,120,000	6,300,000
Big Creek Chinook salmon (tule)	ODFW	1,428,000	1,470,000
Big Creek coho salmon	ODFW	749,700	771,750
Big Creek chum salmon	ODFW	1,723,800	1,774,500
Big Creek (combined with Gnat Creek and Klaskanine) winter steelhead	ODFW	149,940	154,350
Youngs Bay fall Chinook salmon (tule) (formerly Klaskanine, Big Creek Stock)	ODFW	2,346,000	2,415,000
Clackamas summer steelhead	ODFW	178,500	183,750
Clackamas winter steelhead	ODFW	270,300	278,250
Clackamas spring Chinook salmon	ODFW	1,122,000	1,155,000
Sandy River spring Chinook salmon	ODFW	306,000	315,000

Mitchell Act Hatchery Program	Hatchery Program Operator	Five Year Average Production Level	Annual Maximum Production Level
Sandy River winter steelhead	ODFW	173,400	178,500
Sandy River summer steelhead	ODFW	81,600	84,000
Sandy River coho salmon	ODFW	306,000	315,000
Clatskanie River Tule Fall Chinook Supplementation Program	ODFW	204,000	210,000
Umatilla River coho salmon	CTUIR/ODFW	550,000	550,000
Lostine River coho restoration project	NPT/ODFW	550,000	550,000
Clearwater River coho restoration project	NPT/USFWS	605,000	605,000
Carson National Fish Hatchery spring Chinook salmon	USFWS	1,550,400	1,596,000
Little White Salmon National Fish Hatchery Spring Chinook salmon	USFWS	1,836,000	1,890,000
Eagle Creek National Fish Hatchery coho salmon	USFWS	357,000	367,500
Willard National Fish Hatchery URB	USFWS	2,040,000	2,100,000
North Fork Toutle fall Chinook salmon (tule)	WDFW	1,122,000	1,155,000
North Fork Toutle coho salmon	WDFW	91,800	94,500
Kalama fall Chinook salmon (tule)	WDFW	2,040,000	2,100,000
Kalama coho salmon - Type N	WDFW	306,000	315,000
Kalama summer steelhead (integrated)	WDFW	91,800	94,500
Kalama winter steelhead (integrated)	WDFW	45,900	47,250
Kalama winter steelhead (KEWS)	WDFW	91,800	94,500
Washougal fall Chinook salmon (tule)	WDFW	1,224,000	1,260,000

Mitchell Act Hatchery Program	Hatchery Program Operator	Five Year Average Production Level	Annual Maximum Production Level
Washougal coho salmon	WDFW	110,160	113,400
Ringold Springs steelhead	WDFW	183,600	189,000
Ringold Springs coho salmon	WDFW	765,000	787,500
Beaver Creek summer steelhead	WDFW	30,600	31,500
Beaver Creek winter steelhead	WDFW	132,600	136,500
Beaver Creek (Elochoman R) coho salmon	WDFW	229,500	236,250
South Toutle summer steelhead	WDFW	25,500	26,250
Coweeman winter steelhead	WDFW	12,240	12,600
Klineline winter steelhead (Salmon Creek)	WDFW	40,800	42,000
Washougal summer steelhead (Skamania Hatchery)	WDFW	71,400	73,500
Washougal winter steelhead (Skamania Hatchery)	WDFW	61,200	63,000
Rock Creek winter steelhead	WDFW	20,400	21,000
Kalama Spring Chinook salmon	WDFW	765,000	787,500
Grays River Fall Chinook Conservation Hatchery Program	WDFW	368,220	379,050
Abernathy Fall Chinook Conservation Hatchery Program	WDFW	115,260	118,650
Klickitat upriver bright fall Chinook salmon	YN	4,080,000	4,200,000
Klickitat spring Chinook salmon	YN	816,000	840,000
Yakima River - Prosser coho (Eagle Creek stock)	YN	550,000	550,000
Klickitat coho salmon	YN/WDFW	3,570,000	3,675,000

Mitchell Act Hatchery Program	Hatchery Program Operator	Five Year Average Production Level	Annual Maximum Production Level
Klickitat Skamania summer steelhead	YN/WDFW	91,800	94,500

Residualism: Finally, take may occur through ecological interactions where hatchery fish residualize and remain in freshwater. This, too, cannot be reliably observed and quantified; therefore, NMFS will rely on a take surrogate consisting of the proportion of hatchery-origin fish that are visually identified as precocially mature prior to release by sampling a subset of the release. This standard has a rational connection to the amount of take expected from ecological interactions because precocious fish are more likely to residualize after release from the hatchery, which would place them in contact with natural-origin fish of a size that makes them vulnerable to predation. This take surrogate can be reliably measured and monitored by assessing precocious maturation rates before each proposed yearling release. While temperatures during the rearing of hatchery fish are known to affect the maturation and smolting rates, this take limit is also subject to variation similar to release size, given that hatchery survival varies with environmental conditions, which necessitates tracking both single-year changes as well as using a running average.

The incidental take through residualization will be exceeded if the percent of yearling releases that are determined to be precocially mature exceeds 5% in any one year or if the 5-year average exceeds 3% at any time. These are levels known to occur through a review of other yearling programs (IDFG 2003).

These surrogates can be reliably measured and monitored through the enumeration and tracking of release dates and numbers for hatchery salmon and steelhead. Each of these surrogates represents an independent threshold, meaning that exceedance of any one of these surrogates would result in the applicable program having exceeded the incidental take limits included in this Statement, necessitating the reinitiation of consultation.

2.9.1.2.4 Research, monitoring, and evaluation that exists because of the hatchery program

NMFS determined that the proposed RM&E activities resulting from the Proposed Action are expected to directly and incidentally take juvenile and adult ESA-listed anadromous fish (Section 2.5.2.4), which will negatively affect the populations encountered. The take associated with the proposed RM&E activities is necessary to verify the Opinion's analysis of effects, compliance with established terms and conditions, and to monitor the status of the natural-origin populations affected by the hatchery programs. The Opinion evaluated nine different RM&E activities as part of the Proposed Action, and each has specific details related to the take expected to occur.

NMFS expects that the Proposed Action will result in incidental take in the form of the expected encounters and mortalities associated with the following categories of RM&E:

a. Category: Columbia River Population Abundance and Spawning Composition Monitoring

NMFS shall administer funds for the programs associated with this category of RM&E in a way that the extent of incidental take through the expected encounters and mortalities will not exceed the limits identified in Table 125.

Table 125. Estimated levels of total capture, handle, sample, tag and release of ESA-listed, natural-origin adults and estimated levels of mortality from the activities.

ESU/DPS	MPG	Population	Species/Run	Adult Encounters	Adult Mortalities
LCR Steelhead	Cascade	Toutle SF & NF	Steelhead/winter	Up to 300	Up to 6
		Coweeman	Steelhead/winter	Up to 200	Up to 4
		Kalama	Included in Kalama Research Project (below)		
		EF Lewis	Steelhead/summer	Up to 200	Up to 4
			Steelhead/winter	Up to 200	Up to 4
		Salmon Creek	Steelhead/winter	Up to 100	Up to 2
		Washougal	Steelhead/summer	Up to 600	Up to 12
			Steelhead/winter	Up to 600	Up to 12
	Gorge	Upper Gorge	Steelhead/summer	Up to 600	Up to 12
		Lower Gorge	Steelhead/winter	Up to 200	Up to 4
		Upper Gorge	Steelhead/winter	Up to 200	Up to 4
MCR Steelhead	Gorge	White Salmon	Steelhead winter/summer	Up to 300	Up to 6

b. Category: Steelhead Genetic Monitoring Program

NMFS shall administer funds for the programs associated with this category of RM&E in a way that the extent of incidental take through the expected encounters and mortalities will not exceed the limits identified in Table 126.

Table 126. The maximum number of natural-origin juvenile fish handled or killed during activities associated with genetic monitoring activities to determine the efficacy of segregated steelhead programs funded through the Mitchell Act.

ESU/DPS	MPG	Population (State)	Number of Juveniles Encountered	Estimated Mortality*
	Cascade Spring	Toutle (WA)	2,000	≤80

ESU/DPS	MPG	Population (State)	Number of Juveniles Encountered	Estimated Mortality*
LCR Chinook		Kalama (WA)	2,000	≤80
	Gorge Spring	White Salmon (WA)	2,000	≤80
	Coastal Fall	Grays/Chinook (WA)	10,000	≤400
		Elochoman/Skamokawa (WA)	10,000	≤400
		Mill/Abernathy/Germany (WA)	10,000	≤400
	Cascade Fall	Toutle (WA)	20,000	≤800
		Coweeman (WA)	10,000	≤400
		Kalama (WA)	8,000	≤320
		Lewis (WA)	10,000	≤400
		Salmon (WA)	10,000	≤400
		Washougal (WA)	10,000	≤400
	Gorge Fall	Lower Gorge (WA)	10,000	≤400
		Upper Gorge (WA)	10,000	≤400
		White Salmon (WA)	10,000	≤400
CR Chum	Coast	Grays/Chinook (WA)	100	≤10
		Elochoman/Skamokawa (WA)	100	≤10
		Mill/Abernathy/Germany (WA)	100	≤10
	Cascade	Toutle (WA)	20	≤2
		Coweeman (WA)	20	≤2
		Kalama (WA)	20	≤2
		Lewis (WA)	20	≤2
		Salmon (WA)	20	≤2
		Washougal (WA)	20	≤2
	Gorge	Lower Gorge	100	≤10
		Upper Gorge/White Salmon	20	≤2
LCR Coho	Coast	Grays/Chinook (WA)	10,000	≤400
		Elochoman/ Skamokawa (WA)	10,000	≤400
		Mill/Abernathy/Germany (WA)	10,000	≤400
	Cascade	SF Toutle (WA)	10,000	≤400
		NF Toutle (WA)	10,000	≤400
		Coweeman (WA)	10,000	≤400
		Kalama (WA)	8,000	320
		NF Lewis (WA)	10,000	400

ESU/DPS	MPG	Population (State)	Number of Juveniles Encountered	Estimated Mortality*
		EF Lewis (WA)	10,000	400
		Salmon (WA)	7,400	104
		Washougal (WA)	10,000	400
	Gorge	Lower Gorge	10,000	400
		Upper Gorge/White Salmon	10,000	400
LCR Steelhead	Cascade Summer	Kalama (WA)	7,400	104
		NF Lewis (WA)	7,400	104
		EF Lewis (WA)	7,400	104
		Washougal (WA)	7,400	104
	Cascade Winter	SF Toutle (WA)	14,800	208
		NF Toutle (WA)	14,800	208
		Coweeman (WA)	14,800	208
		Kalama (WA)	7,400	104
		EF Lewis (WA)	7,400	104
		NF Lewis (WA)	7,400	104
		Salmon Creek (WA)	14,800	208
		Washougal (WA)	7,400	104
	Gorge Summer	Upper Gorge (WA)	7,400	104
	Gorge Winter	Lower Gorge	7,400	104
		Upper Gorge	7,400	104
MCR Steelhead	Gorge Summer/Winter	White Salmon (WA)	7,400	104

* Based on recent data (NMFS 2024g)

c. Category: Kalama River Research Program.

NMFS shall administer funds for the programs associated with this category of RM&E in a way that the extent of incidental take through the expected encounters and mortalities will not exceed those identified in Table 127.

Table 127. The maximum number of natural-origin juvenile and adult fish encounters and mortalities during activities associated with the Kalama River Research activities funded through the Mitchell Act. Note: wild winter and summer juvenile encounters are managed as a combined total because of the inability to distinguish run type at the juvenile stage.

Species	# Adults - Trapped, handled, sampled, tagged, released	Estimated mortalities	# Juveniles (smolts) - Trapped, handled, sampled,	Estimated mortalities	# Juveniles (egg/fry) - Trapped, handled, sampled,	Estimated mortalities

			tagged, released		tagged, released	
Wild winter steelhead	Up to 1,552	Up to 21	Up to 6,500	Up to 445 (includes some intentional lethal sampling)	Up to 1,500	Up to 115 (includes some intentional lethal sampling)
Wild Summer steelhead	Up to 1,012	Up to 16	Up to 6,500	Up to 445 (includes some intentional lethal sampling)	Up to 1,500	Up to 115 (includes some intentional lethal sampling)
Wild Spring Chinook salmon	Up to 502	Up to 13	Up to 1,300	Up to 65	Up to 300	Up to 15
Wild coho salmon	-	-	Up to 1,300	Up to 65	Up to 200	Up to 10

d. Category: Operation of the North Fork Toutle River Fish Collection Facility

NMFS shall administer funds for the programs associated with this category of RM&E in a way that the extent of incidental take through the expected encounters and mortalities will not exceed those identified in Table 128.

Table 128. The maximum number of natural-origin adult fish encounters and mortalities during activities associated with the operation of the North Fork Toutle River Fish Collection Facility funded through the Mitchell Act.

Species	# Adults - Trapped, handled, sampled, tagged, released	Estimated mortalities
Wild winter steelhead – adult	Up to 1000	10
Wild summer steelhead – adult	Up to 40	1
Wild coho salmon – adult & jack	Up to 600	6
Wild fall Chinook salmon – adult & jack	Up to 50	2
Wild chum salmon	Up to 20	1

e. Category: Klickitat River monitoring activities (Lyle Falls fishway and adult trap, smolt trapping, and other sampling)

NMFS shall administer funds for this program associated with this category of RM&E in a way that the extent of incidental take through the expected encounters and mortalities will not exceed those identified in Table 129.

Table 129. The maximum number of natural-origin juvenile and adult fish encountered and mortality during activities associated with the Klickitat River fishway and other monitoring activities funded through the Mitchell Act.

Population (DPS)	Juvenile Encounters	Juvenile Mortality	Adult Encounters	Adult Mortality
Mid-C steelhead	Up to 10,000	Up to 100	Up to 1,005	Up to 26
Snake River steelhead	0	0	Up to 50	Up to 2

f. Category: Juvenile salmonid migrant monitoring programs on the Grays and Elochoman rivers and Mill, Abernathy, and Germany (MAG) creeks

Juvenile salmonid migrant monitoring programs are needed to evaluate the newly proposed Chinook salmon conservation hatchery programs. Juvenile salmonid migrant monitoring is currently in place on the Grays River and MAG creeks and is proposed for initiation on the Elochoman River in the spring of 2025. Incidental take needs for these programs are presented in Table 130 and Table 131.

Table 130. Estimated adult, jack, and juvenile salmonid encounters and incidental mortality during juvenile migrant trapping are associated with assessing the newly proposed Abernathy conservation hatchery program. (MAG = Mill/Abernathy/Germany Creek population; CR = Columbia River; LCR = Lower Columbia River)

ESU/DPS	MPG	Species	Population	Juvenile Encounters	Juvenile Mortalities	Adult & Jack Encounters	Adult & Jack Mortalities
LCR	Coast	Fall Chinook	MAG - Mill Ck.	≤4,000	≤60	≤5	1
			MAG - Abernathy Ck.	≤4,000	≤60	≤5	1

ESU/DPS	MPG	Species	Population	Juvenile Encounters	Juvenile Mortalities	Adult & Jack Encounters	Adult & Jack Mortalities
			MAG - Germany Ck.	≤4,000	≤60	≤5	1
LCR	Coast	Coho	MAG - Mill Ck.	≤14,000	≤140	≤15	1
			MAG - Abernathy Ck.	≤22,000	≤187	≤15	1
			MAG - Germany Ck.	≤10,000	≤100	≤15	1
CR	Coast	Chum	MAG - Mill Ck.	≤1,000	≤10	≤15	1
			MAG - Abernathy Ck.	≤15,000	≤150	≤15	1
			MAG - Germany Ck.	≤15,000	≤150	≤15	1
Southern DPS		Eulachon	CR- Mill Ck.	0	0	≤30	1
			CR – Abernathy Ck.	0	0	≤30	1
			CR- Germany Ck.	0	0	≤30	1
LCR	Coast	Fall Chinook	Elochoman/ Skamokawa	≤24,000	≤720	≤5	1
LCR	Coast	Coho	Elochoman/ Skamokawa	≤9,200	≤92	≤15	1
CR	Coast	Chum	Elochoman/ Skamokawa	≤93,600	≤2808	≤5	1
Southern DPS		Eulachon	CR	0	0	≤30	1

Table 131. Estimated adult, jack, and juvenile salmonid encounters and incidental mortality during juvenile migrant trapping are associated with assessing the newly proposed Grays conservation hatchery program. (CR = Columbia River; LCR = Lower Columbia River)

ESU/DPS	MPG	Species	Population	Juvenile Encounters	Juvenile Mortalities	Adult & Jack Encounters	Adult & Jack Mortalities
LCR	Coast	Fall Chinook	Grays/ Chinook	≤24,000	≤720	≤5	1

ESU/DPS	MPG	Species	Population	Juvenile Encounters	Juvenile Mortalities	Adult & Jack Encounters	Adult & Jack Mortalities
LCR	Coast	Coho	Grays/ Chinook	≤15,000	≤150	≤15	1
CR	Coast	Chum	Grays/ Chinook	≤833,000	≤20,000	≤15	1
Southern DPS		Eulachon	CR	0	0	≤30	1

g. Category: Juvenile salmonid migrant monitoring programs on the Claskanie River

Juvenile salmonid migrant monitoring programs are needed to evaluate the newly proposed Clatskanie River Tule Fall Chinook Supplementation Program and the ongoing Big Creek Chum program. Juvenile salmonid migrant monitoring is currently in place on the Claskanie River, with expanding effort. Incidental take needs for these programs are presented in Table 132.

Table 132. Estimated adult and juvenile salmonid encounters and incidental mortality during juvenile migrant trapping are associated with assessing the newly proposed Clatskanie River Tule Fall Chinook Supplementation Program and the Big Creek Chum Program. (CR = Columbia River; LCR = Lower Columbia River)

ESU/DPS	Juvenile Encounters	Juvenile Mortalities	Adult Encounters	Adult Mortalities
LCR Chinook	50,000	1500	5	≤1
Columbia Chum	50,000	3,250	5	≤1
LCR Coho	150,000	4,150	5	≤1

h. Category: Juvenile salmonid migrant monitoring programs for the Sandy River hatchery program

Table 133 provides a summary table of the anticipated juvenile encounters and mortality as part of the RM&E activities conducted as part of the Sandy Hatchery Screw Trap.

Table 133. Estimated juvenile encounters and mortality expected through RM&E activities in the Clatskanie River Tule Fall Chinook Supplementation Program.

ESU/DPS	MPG	Population	Juvenile Encounters	Juvenile Mortalities
LCR Chinook	Cascade	Sandy (OR)	1,000	30
LCR Steelhead	Cascade	Sandy (OR)	3,600	38
LCR Coho	Cascade	Sandy (OR)	6,000	80

2.9.1.2.5 Construction, operation, and maintenance of facilities that exist because of the hatchery program

NMFS determined that hatchery facility operations, resulting in water withdrawals as the result of the operation of individual hatcheries, acclimation facilities, and intake structures, is expected to cause incidental take of ESA-listed anadromous fish, primarily through water withdrawals, where harm can occur when stream flows are reduced by water withdrawals, which can reduce the quality and quantity of rearing habitat and inhibit migration (See Section 2.5.2.5)

It would not be possible to accurately assign take of ESA-listed species to facility effects, when facilities are operated consistent with the HOF, since the minimal change in water quality and quantity would be just one factor facing anadromous fish in the river. Nor would it be possible to quantify such take, since the effects of water withdrawals on individual fish cannot be detected and counted. Therefore, NMFS will rely on surrogate take indicators for the water quality and quantity take pathways.

Regarding water quantity and take resulting from water withdrawals, the surrogate take indicator is that water withdrawals will not exceed the currently established surface water right, during any time a hatchery facility is in operation. This level has a rational connection to the amount of take because either taking more water than is described in a water right, or reducing instream flows to levels that inhibit fish passage and habitat, reflects potential changes to the hydrograph of the river where a hatchery facility is located that are likely to result in a greater amount of salmonids being taken, or affect the designated critical habitat in a manner greater than what is expected to occur under the HOF. Hatchery operators will measure this surrogate by monitoring surface water withdrawal amounts and compliance with their water rights. These metrics will be reported by month, as measured in cubic feet per second (cfs).

Regarding water quality and the potential take through the effects of effluent discharges from hatchery programs, the surrogate take indicator is any effluent discharge that exceeds any applicable water quality standard or any term of a NPDES permit issued. Any concurrent effluent discharge NPDES permit violations, or more than two non-concurrent violations, that occur during any five-year timespan following the issuance of this Opinion would exceed the incidental take from this pathway. This standard has a rational connection to the amount of take because water quality standards are designed to limit discharges into waterways which would result in harm to fish, wildlife, and other beneficial uses, and the established effluent limits represent the effects and related take levels expected to result from the Proposed Action.

These surrogates serve as reasonable and reliable measures of incidental take because the water withdrawals directly cause the take at issue and are measurable because the hatchery facilities that receive funds as part of the Proposed Action will be required to record and report annual water usage in terms of their percentage withdrawn from their sources, and NPDES permit compliance, as part of its reporting requirements to NMFS.

NMFS has also determined that the intake structure at the North Fork Toutle Hatchery will cause take through entrapment of juvenile coho until the intake structure meets NMFS's screening criteria. Because juvenile natural-origin coho cannot be distinguished from hatchery-origin coho, a surrogate take indicator of the number of total coho found in the hatchery pond for fall Chinook salmon will be used to measure the overall take levels of natural-origin juvenile coho through the intake pipes. Take is deemed to be exceeded when 1,000 natural-origin juvenile coho are discovered in the fall Chinook salmon pond, with handling mortality of no more than 30. This limit can be reliably measured and monitored, and will be included in annual reports.

2.9.2 Effect of the Take

In the biological opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the Proposed Action, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

2.9.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" refer to those actions the Director considers necessary or appropriate to minimize the impact of the incidental take on the species (50 CFR 402.02).

NMFS concludes that the following reasonable and prudent measures are necessary and appropriate to minimize incidental take. This Opinion requires that Action Agencies, NMFS to:

1. Administer Mitchell Act funds for implementing the hatchery programs and operating the hatchery facilities as described in the Proposed Action (Section 1.3), and in the Biological Assessment.

2. Ensure that interactions on the spawning grounds with natural-origin fish from hatchery-origin fish produced through Mitchell Act funded hatchery programs are kept to the lowest feasible levels.

3. Ensure that broodstock practices result in no out-of-MPG broodstock fish produced through Mitchell Act funded hatchery programs being released in areas of LCR ESA-listed conspecific fish.

4. Limit the co-occurrence and any resulting competition and predation caused by hatchery fish to lowest feasible levels. This includes assuring compliance with the specific release size, locations, and timing.

5. Ensure that take resulting from encounters through broodstock collection and adult management activities in each tributary basin is minimized.

6. Ensure that hatchery facility water withdrawal screening and facility operations minimize effects on ESA-listed fish and designated critical habitat.

7. Annually assemble a document containing any reported data and information from all Mitchell Act-funded programs required to ensure ESA take exemptions do not exceed compliance.

8. Comply with all of the ESA requirements and provisions in the Incidental Take Statement.

2.9.4 Terms and Conditions

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

1) Administer Mitchell Act funds for implementing the hatchery programs and operating the hatchery facilities as described in the Proposed Action and the HOF (Section 1.3) and in the Biological Assessment:
    a) NMFS shall ensure that the funding grantees notify NMFS's Sustainable Fisheries Division (SFD), 30 days in advance of any changes in funding administration that result in changes to the Proposed Action.
    b) NMFS shall ensure that the funding grantees notify NMFS's SFD 30 days before implementing any change to programs described in the HOF.

2) Ensure that interactions on the spawning grounds with natural-origin fish from hatchery-origin fish produced through Mitchell Act-funded hatchery programs are kept to the lowest feasible levels:

    a) NMFS shall ensure that the funding grantee submits pHOS survey protocols, gene flow monitoring methods, and RM&E protocols and statements of work on or before January 1 of each year for NMFS concurrence on or before March 1 of each year, if such protocols and methods deviate from methods used in the analysis of this Opinion.

    b) NMFS shall ensure administration of funds through the Mitchell Act results in adherence to pHOS, PNI, and gene flow levels in Table 120, weir and facility trapping and handling levels in Table 121, Table 122, and Table 123, and RM&E take at levels specified in Section 2.9.1.2.4 of the ITS.

        i) NMFS shall require funding grantees to complete a report prior to 2026 that describes methods and models used to estimate and predict pHOS for LCR coho and Chinook salmon. If funding grantees modify these methods or models, they shall be required to notify NMFS of any changes within one calendar year of performing the modification.

        ii) NMFS shall require funding grantees to conduct annual surveys or other acceptable methods to determine the timing, abundance, origin, and distribution of Chinook, coho, and chum salmon and summer and winter steelhead that spawn naturally and report the findings to NMFS.

    c) NMFS shall require, unless otherwise specified in the *U.S. v. Oregon* management agreement, that all juvenile hatchery fish released from Mitchell Act-funded hatchery programs be visually marked or other methods of identification used and that operators report annually on the proportion of unmarked fish released from each Mitchell Act program.

3) Ensure administration of funds through the Mitchell Act results in the following broodstock practices:

    a) No future funding is awarded for rearing and releasing Chambers Creek steelhead for hatchery programs where ESA-listed steelhead co-occur.

    b) No future funding is awarded for any Chinook and coho salmon hatchery programs that rear or release out-of-MPG hatchery fish in areas of LCR ESA-listed conspecific fish.

4) Limit the co-occurrence and any resulting competition and predation caused by hatchery fish to the lowest feasible levels. This includes assuring compliance with the specific release size, locations, and timing:

a) NMFS shall require funding grantees to report to NMFS the estimated number, size, release location, and proposed release date for all programs funded through the Proposed Action.

b) NMFS shall require funding grantees to report to NMFS the estimated proportion of precocial male smolts released annually from each program.

c) NMFS shall require funding grantees to notify NMFS when the situation may warrant the early release of hatchery fish and/or consideration of options for the handling of infected/diseased fish. In such cases, funding grantees shall notify NMFS prior to release if feasible, but may notify NMFS after release if the release is an emergency that prohibits such notification.

5) Ensure that take resulting from encounters at broodstock collection facilities and from the operation of weirs in each tributary basin is minimized:

a) NMFS shall require funding grantees to not exceed the number of ESA-listed adults encountered and associated incidental mortalities during broodstock collection and adult management activities and to not exceed those numbers provided in Table 121, Table 122, and Table 123, subject to term and condition 1, described above.

b) NMFS shall require WDFW to provide details of any change in weir operation by April 30th, if weir operation will deviate from the plan described in the HOF that year.

c) NMFS shall require funding grantees to estimate changes in spawner distribution at weirs, where applicable, and population productivity and handling mortalities, by species, for each weir, as part of RM&E.

6) Ensure that hatchery facility water withdrawal screening and facility operations minimize effects on ESA-listed fish and designated critical habitat. NMFS shall require funding grantees to:

a) Operate surface water withdrawal structures not to exceed established water rights for that facility.

b) Operate and maintain intake screening structures to meet NMFS screening criteria. For intake screens that are not in compliance with current NMFS screening criteria, by January 1, 2027, develop and submit, for NMFS concurrence, plans for upgrading the facility to meet the criteria.

c) Minimize passage delay for natural-origin adult salmonids that encounter hatchery facility passage barriers.

d) Minimize the operation of intake structures that do not currently meet NMFS criteria until facilities are upgraded.

7) NMFS shall annually assemble a document containing any reported data and information from all Mitchell Act-funded programs required to ensure ESA take exemptions do not exceed compliance. All Mitchell Act-funded programs must report the following data and/or information on or before the end of each federal fiscal year. The reported data and information will include the prior fiscal year, starting in 2025, for FY2024. NMFS may adjust the reporting timeframe and duration based on the best fit for biological data synthesis, which typically does not coincide with any fiscal year deadline. NMFS shall require funding grantees to submit the following information:

a) Numbers of fish released, release dates and locations, average size of fish released, and tag/mark information for each program.

b) Estimates of the spawning distribution among populations, origin, survival, and contribution to fisheries and escapements for fish released for each brood year, for each program.

c) Estimates of pHOS and/or gene flow for all natural ESA-listed salmonid populations that are affected by straying from Mitchell Act-funded hatchery programs.

d) Provide tables for all Mitchell Act-funded facilities combined, grouped by operators, that include the pathogens that were detected annually and the frequency of pathogen related epizootics at facilities producing fish funded by the Mitchell Act.

e) Annual water withdrawals for each hatchery/acclimation facility under the HOF, including monthly estimates of the quantity (in cfs) of surface water withdrawal for the facility operations and the ratio of that withdrawal to the maximum water rights permit.

f) Compliance records with NPDES permitting requirements.

g) The number of fish encountered and killed at each weir, during HOS removal activities, and broodstock collection location, including the species, origin (hatchery or natural-origin), life stage, and release condition (unharmed, injured, killed).

h) Estimates of population productivity and spawner distribution, where applicable, at weirs, and handling-related mortality by species for each of the weirs operated under the HOF.

i) Results of RM&E, including important findings, for:

(1) The Kalama River Research Program;

(2) Operation of the North Fork Toutle River Fish Collection Facility;

(3) Reintroduction of spring and fall Chinook and coho salmon above SRS;

(4) LCR fall Chinook salmon conservation programs;

(5) Lower Columbia River and tributary fishery monitoring;

(6) Monitoring of the Nez Perce Tribe's Snake River coho salmon Restoration Program;

(7) Klickitat River Fishway (Lyle Falls); and

(8) USFWS Hatchery Monitoring Program.

All reports, as well as all other notifications required by this Opinion, shall be submitted electronically to the SFD point of contact on this program:

James Archibald, (james.Archibald@noaa.gov)

Written materials may also be submitted to:

ATTN: James Archibald
NMFS – West Coast Region
Sustainable Fisheries Division
Anadromous Hatcheries South
1201 NE Lloyd Blvd #1100,
Portland, OR 97232

8) Comply with all of the ESA requirements and provisions in the Incidental Take Statement;

NMFS shall require funding grantees to submit letters concurring to the ESA requirements and provisions in the Incidental Take Statement.

2.10 Conservation Recommendations

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

- ODFW to develop adult upstream passage criteria for the Big Creek weir to inform management of fall Chinook salmon intercepted at the Big Creek weir.
- ODFW to assist with or lead development of a model to forecast pHOS from LCR Chinook and coho hatchery programs, similar to or as expanded versions of the Chinook Assessment and Coho Assessment models currently in use.

- WDFW and the Yakama Nation to conduct additional research to better understand contemporary levels of gene flow from the Skamania summer steelhead stock into the naturally spawning population of Klickitat River steelhead, and evaluate the potential benefits, risks, and feasibility of developing an integrated hatchery program from the native steelhead population.

- NMFS recommends that operators return stray hatchery-origin fish to their hatchery of origin or, alternatively, use the fish for human consumption, stream fertilization, or to support tribal or recreational harvest in areas not accessible to anadromous salmonids.

- Mitchell Act grantees and co-managers continue to work with NMFS to align Mitchell Act hatchery program management strategies with NMFS's Recovery Plans for species under the Endangered Species Act.

2.11 Reinitiation of Consultation

This concludes formal consultation for NMFS's administration of appropriated funds established by the Mitchell Act in the Columbia River Basin as described in Section 1.3.

Under 50 CFR 402.16(a): "Reinitiation of consultation is required and shall be requested by the federal agency, where discretionary federal involvement or control over the action has been retained or is authorized by law and: (1) 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."

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 § 402.16(a)(2) and/or (a)(3) will have been met.

2.12 "Not Likely to Adversely Affect" Determinations

NMFS does not anticipate the Proposed Action will adversely affect the species in Table 2, or their critical habitat. NMFS has determined that, while the Proposed Action may affect these ESA-listed species, due to their presence in the Columbia River Basin, the Proposed Action is not likely to adversely affect them. This determination was made pursuant to Section 7(a)(2) of the ESA implementing regulations at 50 CFR 402.

When evaluating whether the Proposed Action is "not likely to adversely affect" ESA listed species or critical habitat, NMFS considers whether the effects of the action are expected to be completely beneficial, insignificant, or discountable. Completely beneficial effects are contemporaneous, positive effects without any adverse effects on the species or critical habitat.

Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Effects are considered discountable if they are extremely unlikely to occur.

2.12.1 Marine Mammals

We assessed potential effects to ESA-listed marine mammals from the Proposed Action. In this assessment the following DPS was determined to incur beneficial effects as a result of the Proposed Action. The following DPS is affected by the Proposed Action in marine waters, as the species does not occur in freshwater areas.

2.12.1.1 Southern Resident Killer Whales

2.12.1.1.1 Status and Occurrence

The Southern Resident Killer Whale (SRKW) DPS was listed as endangered under the ESA in 2005 (70 FR 69903, November 18, 2005) and the final recovery plan was completed in 2008 (NMFS 2008i). Several factors identified in the recovery plan for SRKWs may be limiting their recovery. The primary threats include quantity and quality of prey, toxic chemicals that accumulate in top predators, and disturbance from sound and vessels. It is likely that multiple threats are acting together to impact the whales. Although it is not clear which threat or threats are most significant to the survival and recovery of SRKWs, all of the threats identified are potential limiting factors in their population dynamics (NMFS 2008i). 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 2021g).

The SRKW DPS consists of three pods (J, K, and L) that inhabit coastal waters off Washington, Oregon, and Vancouver Island, Canada, and are known to travel as far south as central California and as far north as Southeast Alaska (NMFS 2008i) ; (Hanson et al. 2013.) ; (Carretta, Oleson, et al. 2023). Seasonal movements are likely tied to migration of their primary prey, salmon. During the spring, summer, and fall months, SRKWs spend a substantial amount of time in the inland waterways of the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound (Bigg 1982) ; (Ford, Ellis, and Balcomb 2000) ; (Krahn et al. 2002) ; (Hauser et al. 2007) ; (Olson et al. 2018) ; (NMFS 2021h) ; (Ettinger et al. 2022) ; (Thornton et al. 2022)). During fall and early winter, SRKWs, and J pod in particular, expand their routine movements into Puget Sound, likely to take advantage of chum, coho, and Chinook salmon runs ((Osborne 1999) ; (Hanson et al. 2010); (Ford, Hempelmann, et al. 2016) ; (Olson et al. 2018)). Although seasonal movements are somewhat predictable, there can be large inter-annual variability in arrival time and days present in inland waters from spring through fall, with late arrivals and fewer days present in recent years ((NMFS 2021g); (Ettinger et al. 2022)).

Land- and vessel-based opportunistic and survey-based visual sightings, satellite tracking, and passive acoustic research have provided an updated estimate of the whales' coastal range. In recent years, several sightings and acoustic detections of SRKWs have been obtained off the Washington, Oregon, and California coasts in the winter and spring ((Hanson et al. 2010) ;

(Hanson et al. 2013); (Hanson et al. 2017); (Emmons, Hanson, and Lammers 2021); (NMFS 2021g)). Satellite-linked tag deployments in the winter indicate that K and L pods use the coastal waters along Washington, Oregon, and California during non-summer months ((Hanson et al. 2017); (NMFS 2021g), while J pod occurred frequently near the western entrance of the Strait of Juan de Fuca but spent relatively little time in other outer coastal areas. A full description of the geographic area occupied by SRKW can be found in the biological report that accompanies the final critical habitat rule ((NMFS 2021g)).

SRKWs consume a variety of fish species (22 species) and one species of squid ((Ford et al. 1998); (Ford, Ellis, and Balcomb 2000); (Ford and Ellis 2006); (Hanson et al. 2010); (Ford, Hempelmann, 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, Murdoch, et al. 2016)). Chinook salmon, including hatchery salmon, is their primary prey despite the much lower abundance in comparison to other salmonids in some areas and during certain time periods. Scale and tissue sampling from May to September in inland waters of Washington and British Columbia, Canada, indicate that their diet consists of a high percentage of Chinook salmon (monthly proportions as high as >90%) (Hanson et al. 2010); (Ford et al. 2016). Ford et al. (2016) confirmed the importance of Chinook salmon to SRKWs in the summer months using DNA sequencing from whale feces. Salmon and steelhead made up to 98% of the inferred diet, of which almost 80% were Chinook salmon. Coho salmon and steelhead are also found in the diet in inland waters in spring and fall months when Chinook salmon are less abundant ((Ford et al. 1998) ; (Ford, Murdoch, et al. 2016); (Hanson et al. 2010) ; (Ford, Hempelmann, et al. 2016)).

Prey remains and fecal samples collected in inland and coastal waters during October through May indicate Chinook salmon and chum salmon, including hatchery salmon, are primary contributors of the whale’s diet during the fall, winter, and spring months as well (Hanson et al. 2021). Analysis of prey remains and fecal samples sampled during the winter and spring in coastal waters indicated the majority of prey samples were Chinook salmon (approximately 80% of prey remains and 67% of fecal samples were Chinook salmon), with a smaller number of steelhead, chum salmon, and halibut detected in prey remain samples and foraging on coho, chum, steelhead, big skate, and lingcod detected in fecal samples (Hanson et al. 2021). The occurrence of K and L pods off the Columbia River in March suggests the importance of Columbia River spring runs of Chinook salmon in their diet (Hanson et al. 2013). Chinook salmon genetic stock identification from samples collected in winter and spring in coastal waters included 12 U.S. west coast stocks, and over half the Chinook salmon consumed originated in the Columbia River (Hanson et al. 2021).

At the time of the 2024 population census, there were 73 SRKWs counted in the population,[39] with a new calf born in L pod since the census came out but that has presumably died, and another adult male who has died, bringing the population to 72 whales. The abundance estimate for this stock of killer whales is a direct count of individually identifiable animals, and as such

[39] https://www.whaleresearch.com/orca-population

serves as both a best estimate of abundance and a minimum estimate of abundance. The NWFSC continues to evaluate changes in fecundity and mortality rates. Population projections using survival and fecundity rates from a recent five-year period (2017–2021) project a downward trend over the next 25 years (NMFS 2021h). Recent genomic analyses indicate that the SRKW population has greater inbreeding and carries a higher load of deleterious mutations than do Alaska resident or transient killer whales, and that inbreeding depression is likely impacting the survival and growth of the population (Kardos et al. 2023). These factors, including the anthropogenic threats listed above, likely contribute to the SRKW population's poor status. Here, we focus on the prey threat as the primary pathway of effects to SRKWs due to the Proposed Action. Although clear relationships between prey abundance and SRKW population demographics, survival, and reproduction have been difficult to consistently statistically identify over time (varying results across (Ford, Ellis, and Olesiuk 2005) ; (Ford et al. 2009) ; (Ward, Holmes, and Balcomb 2009) ; (Hilborn et al. 2012); (Ward et al. 2013) ; (Lacy 2017) ; (PFMC 2020a) ; (Murray et al. 2021)), several recent studies support the widely accepted notion that prey availability is currently still a limiting factor for SRKW recovery ((Stewart et al. 2021); (Couture et al. 2022); (Nelson et al. 2024); (Williams et al. 2024).

The most recent potential biological removal[40] (PBR) level for this stock is 0.13 whales per year, which was based on the minimum population size of 74 whales from the 2021 July census. A recent examination of all killer whale ecotype strandings found that three whales, including one SRKW (L98 who was habituated to humans) died from vessel strikes (Raverty et al. 2020). The cause of death of another SRKW, L112, was determined to be blunt force trauma to the head, however the source of the trauma (vessel strike, intraspecific aggression, or other unknown source) could not be established (Carretta, Greenman, et al. 2023). Total observed fishery mortality and serious injury for this stock is zero; however, recovery of a SRKW carcass is rare and undetected mortality and serious injury may occur.

2.12.1.1.2 Critical Habitat

In November 2006, NMFS designated critical habitat for the SRKW DPS (71 FR 69054, November 29, 2006). This designation includes approximately 2,500 square miles of Puget Sound, including three specific areas: 1) the Summer Core Area in Haro Strait and waters around the San Juan Islands; 2) Puget Sound; and 3) the Strait of Juan de Fuca. Areas with water less than 20 feet deep are not included in the designation. Three physical or biological essential features were identified: (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality and availability to support individual growth, reproduction and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging.

[40] Under the Marine Mammal Protection Act (MMPA), the PBR for a stock is defined as the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population size.

In September 2021, NMFS revised the critical habitat designation for the SRKW DPS by designating six additional coastal critical habitat areas along the U.S. West Coast (86 FR 41668, August 2, 2021). The revision added to the existing critical habitat approximately 15,910 square miles of marine waters between the 6.1-meter and 200-meter depth contours from the U.S.-Canada border to Point Sur, California. The same physical or biological essential features listed above were identified for coastal critical habitat, and each coastal area contains all three physical or biological essential features identified in the 2006 designation.

2.12.1.1.3 Potential for Proposed Action Effects

The Proposed Action is expected to increase the amount of Chinook salmon prey available to SRKWs in their critical habitat, which would positively affect the whales and their critical habitat. We do not expect any impacts to SRKWs via other effects pathways, such as vessel or noise disturbance, or water quality impacts.

As described in detail in the Environmental Baseline for salmon and steelhead (Section 2.4), hatchery production of salmonids has occurred for over a hundred years. There are over 300 hatchery programs in Washington, Oregon, California, and Idaho that produce and release juvenile salmon that migrate through coastal and inland waters of the Action Area. Many of these fish contribute to both fisheries and the SRKW prey base in coastal and inland waters of the Action Area.

NMFS has completed Section 7(a)(2) consultations on more than two hundred hatchery programs (Doremus and Friedman 2021); refer to Appendix B of NMFS (2024c)). A detailed description of the effects of these hatchery programs can be found in the site-specific ESA and NEPA documents for programs referenced in NMFS (NMFS 2024c). These effects are further described in Appendix C of NMFS (NMFS 2018c), which is incorporated here by reference. Additionally, a description of the effects of hatchery production implemented with federal funds to increase SRKW prey is described in (NMFS 2024c), as well as in Alternative 2 of the prey program FEIS (NMFS 2024f). Currently, hatchery production is a significant component of the salmon prey base within the range of SRKWs (Barnett-Johnson et al. 2007) ; (NMFS 2008j)). Prey availability has been identified as a threat to SRKW recovery, and we expect the existing hatchery programs referenced above to continue benefiting SRKWs by contributing to their prey base.

As described in the Proposed Action, Congress enacted the Mitchell Act in 1938 for the conservation of anadromous fishery resources, including hatchery programs, in the Columbia River Basin (Section 1.2.3). Since 1946, Congress has continued to appropriate Mitchell Act funds on an annual basis. These programs encompass a major proportion, roughly one third, of the total salmonid hatchery production in the Columbia River. Columbia River Chinook salmon make up several high- and medium-priority stock groups for SRKW prey, based on fecal samples, diet studies, and the known spatial and seasonal distribution of SRKWs. For example, LCR fall Chinook salmon rank 2nd on the SRKW priority prey list[41], being identified both in the diet and with strong spatiotemporal overlap. UCR and Snake River fall Chinook salmon, and LCR spring Chinook salmon are tied for 3rd on the priority list. For a list of the programs funded by the Mitchell Act funds, see Table 3.

The associated benefits to the SRKW prey base are expected to occur 3–5 years following implementation of each year of funding and production as those fish that have been released age into the SRKW prey base (age 3+). For this analysis, we estimate Chinook salmon abundance increases in the Action Area by modeling hatchery production estimated to occur as part of the Proposed Action. For a description of the methods used to estimate annual regional prey abundance increases as a result of Mitchell Act hatchery production, please see Appendix B. The annual projected benefit to the SRKW prey base is presented below in Figure 70, based on the proposed number of annual releases by facility (Table 3), and this benefit is included in the analysis and expected to occur for at least three years following the release of fish each year as the fish mature into the SRKW prey base.

While increases in prey abundance from all areas in the SRKW range are of interest, we focus our attention on hatchery production benefits during times and places along the continental shelf that are most likely to be important for SRKW foraging. Specifically, the Southwest Coast of Vancouver Island (SWCVI) (which includes Swiftsure Bank) are important foraging areas during the May–June and July–September time steps, and the Salish Sea is important during July-September. The NOF region (Figure 63) is an important area during the October–April time step, though in recent years this region is becoming more important in the summer months (see Status and Occurrence above). SRKWs are also known to occupy and forage along the Oregon and California coasts during the winter and early spring months.

Based on the proposed hatchery production, SRKW prey is expected to increase in various regions and seasons across their range, and at varying times throughout the year, for the next few years. As shown in Figure 70, during the October–April time step, SRKW prey is expected to increase by approximately 10%, on average, in the NOF region. During the May–June time step, SRKW prey is expected to increase by approximately 4% on average, in the SWCVI region, and in the July–September time step, prey is expected to increase by nearly 1% and over 2% in the SWCVI and in the Salish Sea, respectively, on average (Figure 70).

[41] https://media.fisheries.noaa.gov/dam-migration/srkw_priority_chinook_stocks_conceptual_model_report___list_22june2018.pdf

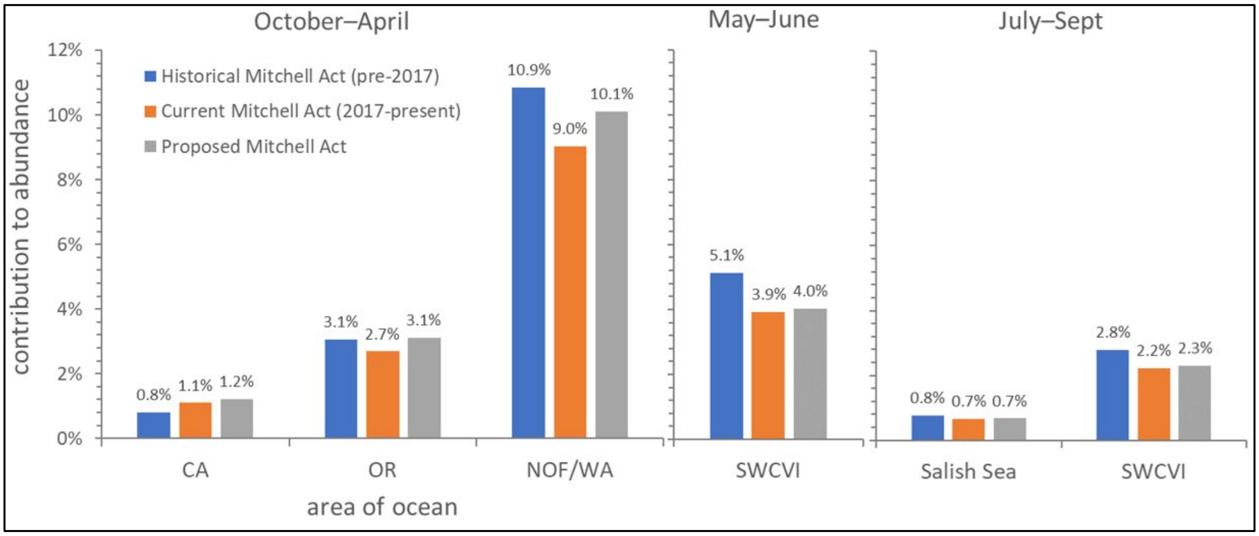

Figure 70. Contribution of Mitchell Act Chinook salmon (ages 3-5 years) to overall Chinook salmon abundance for select marine areas and time periods important for SRKW foraging. Estimates are based on FRAM-Shelton model results, as detailed in Appendix B, and are relative to the 2009-2018 base period.

While the ranges of estimated prey increases presented in Figure 70 are estimates based on the proposed hatchery production, the actual percent prey increases depend on the overall abundance of Chinook salmon observed in that year. For example, variable ocean conditions are a major driver of ocean salmon abundances which can vary widely from year to year (see Figure 71). As such, percent prey increases due to the hatchery program may be smaller in years when ocean abundance is high (i.e., marine survival is high for salmon across all stocks). Accordingly, the benefits of Mitchell Act hatchery production to SRKW (i.e., percent prey increases) may be much higher in low abundance years.

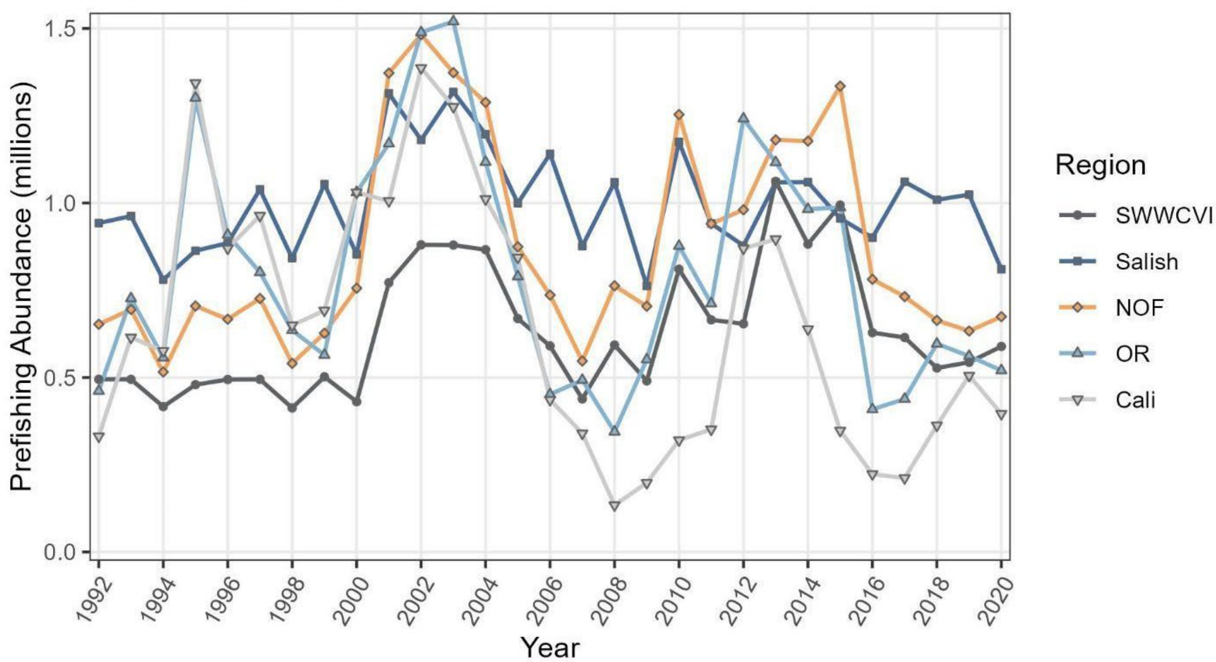

Figure 71. October pre-fishing Chinook salmon abundances by region in a retrospective analysis from 1992–2020.

Under the Proposed Action, the Mitchell Act hatchery funding provides benefits to SRKWs through improving the abundance and availability of prey in various regions and seasons, and is expected to occur year-round.

Chinook salmon aged 3+ are the preferred prey of SRKWs year-round (Ford et al. 1998) ; (Ford and Ellis 2006) ; (Hanson et al. 2010) ; (Ford, Hempelmann, et al. 2016) ; (Hanson et al. 2021)). Genetic studies from fecal and predation event remains have identified Chinook salmon stocks consumed by SRKWs during different seasons in inland and coastal portions of their range (Hanson et al. 2010); (Ford, Hempelmann, et al. 2016); (Hanson et al. 2021)). These studies have informed a list of priority prey stocks that are important to SRKWs (NOAA Fisheries and WDFW 2018). While these studies have not assessed whether the fish consumed come from wild or hatchery populations, all available evidence suggests that SRKWs consume both wild and hatchery Chinook salmon given the high proportion of hatchery-origin fish in the priority stocks that were identified. The abundance of the Puget Sound Chinook Salmon ESU, the top priority prey stocks for SRKW, comprises a minimum[42] of 77% hatchery produced fish, on average (Appendix C). In the Columbia River, a minimum of 50% of the abundance is made up of

[42] These percentages are based on the percentage of marked versus unmarked fish from FRAM validation runs 2009-2020. While mass marking is largely in effect in these areas, there are several unclipped hatchery programs (and a couple wild marking programs in the Columbia), leading these percentages to be underestimates of the proportion of hatchery fish.

hatchery fish (Appendix C). Based on the contribution of hatchery fish to these preferred prey stock groups, it is extremely likely that hatchery fish are a main component of the SRKW diet.

Chinook salmon have the highest value of total energy content compared to other salmonids because of their larger body size and higher energy density (O'Neill, Ylitalo, and West 2014), likely the reason for their preference in the SRKW diet. Studies have identified a trend in declining body size and age structure in Chinook salmon along the west coast ((Ohlberger et al. 2018) ; (Ohlberger et al. 2019)). This trend is evident in both hatchery- and natural-origin fish, and is evident even in natural Chinook salmon populations that are not exposed to hatchery fish, such as in western Alaska (Ohlberger et al. 2018). Given that smaller fish have a lower total energy value than larger ones (O'Neill, Ylitalo, and West 2014), this trend suggests that SRKWs may need to eat more Chinook salmon – hatchery- and natural-origin – to meet their daily metabolic needs as compared to historically. The cause of this trend is uncertain, but several hypotheses include climate change, size-selective removals from predation or fishing practices, or evolutionary shifts. Given all of this information, we do not expect any negative effects to SRKWs from the Proposed Action in terms of changes to the proportion of hatchery- and natural-origin fish or priority prey stock composition, or the size of Chinook salmon available as prey.

Importantly, as concluded in Section 2.8, the expected Mitchell Act production is not expected to jeopardize listed Chinook salmon ESUs. The risks to natural-origin salmon assessed include the six factors described in Section 2.5.1: removal of natural-origin fish for broodstock, hatchery fish and their progeny on natural spawning grounds and encounters at adult collection facilities, hatchery fish and their progeny in juvenile rearing areas, migratory corridors, estuary, and ocean, RM&E due to the hatchery programs, operation, maintenance, and construction of facilities, and fisheries that exist because of the hatchery programs. Please see Section 2.7 for a summary of the factors leading to take of each Chinook salmon ESU as well as hatchery operation practices that minimize risks to natural-origin salmon. At the ESU scale for Chinook salmon, anywhere from negligible effects to low risk of effects is expected for all factors analyzed. In the ocean, effects to non-listed Chinook salmon are expected to be similar to those described in Section 2.5.2.3 for listed Chinook salmon. In the ocean, effects are from competition, which can reasonably be expected to affect listed and unlisted fish equally at the broad spatiotemporal scale considered in the evaluation (limitations of available data and information prohibit a finer-scale evaluation). Where the distributions of non-ESA listed fish occur as described in Appendix B, those effects are reasonably expected to affect non-listed fish in a similar manner to those explained and evaluated in Section 2.5.2.3. This evaluation concluded that the Proposed Action presents a low risk to listed Chinook salmon in the ocean.

We therefore confer this finding to unlisted Chinook salmon. Our assessment of these risks at the program and site-specific levels support our conclusion that the effects of the Proposed Action to natural-origin Chinook salmon are sufficiently low that no adverse effects to SRKW in terms of reduced quantity or quality of Chinook prey over the long term are expected.

In summary, given that the Proposed Action is beneficial to SRKWs in that more prey is expected to be available throughout the range of SRKWs, including in important times and areas for foraging, there are no negative effects expected to SRKWs, and listed Chinook salmon ESUs are not jeopardized, the Proposed Action is not likely to adversely affect SRKWs.

2.12.1.1.3.1 Critical Habitat

In addition to the effects to the DPS discussed above, the Proposed Action affects critical habitat designated for SRKWs. We do not expect the Proposed Action to impact the water quality or passage features of critical habitat because hatchery production occurs in-river and does not affect the water quality or passage conditions within SRKW critical habitat. The Proposed Action has the potential to affect the quantity and availability of prey in critical habitat, however. The expected prey increases due to the Proposed Action are shown in Figure 70. The percent prey increases presented are estimates based on the proposed hatchery production by facility, but depend on the level of Chinook salmon observed in that year. For example, variable ocean conditions are a major driver of ocean salmon abundances which can vary widely from year to year. As such, percent prey increases due to the hatchery program may be smaller in years when ocean abundance is high (i.e., marine survival is high for salmon across all stocks). Accordingly, the benefits of the hatchery production (i.e., percent prey increases) may be much higher in low abundance years.

We would not expect any impacts from the Proposed Action on prey quality with respect to levels of harmful contaminants. We also do not expect any impacts on prey quality with respect to the size of Chinook salmon. As discussed above, size and age structure of Chinook salmon has substantially changed across the Northeast Pacific Ocean since the 1970s (Ohlberger et al. 2018). Therefore, SRKWs would need to consume more salmon in order to meet their caloric needs as a result of a decrease in average size of older Chinook salmon, as compared to previous years when Chinook salmon were larger. Across most of the west coast, adult Chinook salmon (ocean ages 4 and 5) are becoming smaller, the size of age 2 fish are generally increasing, and most of the Chinook salmon populations from Oregon to Alaska have shown declines in the proportions of age 4- and 5-year-olds and an increase in the proportion of 2-year-olds (i.e., the mean age in populations has declined over time) (Ohlberger et al. 2018). Strength of trends varied by region. Ohlberger et al. (2019) found that reasons for this shift may be largely due to direct effects from size-selective removal by resident killer whales and fisheries, followed by evolutionary changes toward these smaller sizes and early maturation. Therefore, we would not expect the current level of hatchery production to appreciably decrease Chinook salmon size (i.e., quality) thereby reducing the conservation value of the prey feature.

As described above and in Section 2.8, the increase in Chinook salmon abundance due to the Proposed Action is not expected to jeopardize listed Chinook salmon ESUs. There are also no negative effects to SRKW critical habitat expected due to the Proposed Action. As such, the Proposed Action is beneficial to SRKW prey in both coastal and inland (Salish Sea) critical habitat, and therefore is not likely to adversely affect SRKW critical habitat.

2.12.2 Other Salmon and Steelhead Species

The entirety of the Action Area described for salmon and steelhead in Section 2.3 (see Figure 57) was assessed in order to determine potential effects to ESA-listed salmon and steelhead. In this assessment the following ESUs and DPSs were determined to incur discountable or insignificant effects as a result of the Proposed Action within the Action Area. All of the following ESUs and DPSs are only affected by the Proposed Action in the marine waters portion of the Action Area, as they are outside the impacted freshwater areas described in Section 2.3.

2.12.2.1 Coho Salmon (Oregon Coast, Southern Oregon/Northern California Coast, and North-Central California Coast Recovery Domains)

Coho salmon from the Oregon Coast Coho Salmon ESU occur in the Action Area from the Oregon coast to the west coast of Vancouver during April–June, and from Oregon to Alaska later in the year ((Fisher et al. 2007); (Beacham et al. 2016)). Van Doornik et al. (2007) determined the origin of 2,344 juvenile coho salmon collected along the Washington and Oregon coasts during June and September, 1998–2005. Oregon coast coho were found in approximately equivalent abundances along both coasts in both months. Subadult and adult Oregon coast coho salmon are known to occur from northern Oregon to Vancouver Island, although higher proportions are likely to occur in more southerly areas (Weitkamp and Neely 2002). Coho salmon from ESA-listed California ESUs in the Southern Oregon/Northern California Coast and North-Central California Coast Recovery Domains—including the Southern Oregon/Northern California Coast Coho Salmon ESU, and the Central California Coast Coho Salmon ESU—very rarely occur in the Action Area ((Weitkamp and Neely 2002) ; (Van Doornik et al. 2007.) ; (Beacham et al. 2016)).

At a broad scale, Chinook and coho salmon utilize somewhat similar habitat and forage resources in marine areas, including along the Washington and Oregon coast. Similarities in general spatial distribution (e.g., Bi et al. (2008)) and depth selection (e.g., Fisher, 2007)) have been observed. Though data are limited, there is evidence that Chinook and coho salmon occur in loose aggregations or patches at large spatial scales (e.g., Peterson et al. (2010) ; (Berdahl et al. 2016)). Pearcy and Fisher (1990) evaluated the distribution and abundance of juvenile salmonids along Washington and Oregon coastal areas during May–September, 1981–1985. They observed a high degree of co-occurrence of juvenile Chinook and coho salmon. That is, the two species were frequently captured in the same purse seine sets. The number of sets with both species was significantly greater than the expected number if co-occurrence was random ($p < 0.05$). Conversely, Pool et al. Pool, Reese, and Brodeur (2012) observed that juvenile Chinook and coho salmon along the Oregon coast selected different habitat types. Studies have documented a moderate to high degree of dietary overlap between coho and Chinook salmon juveniles (e.g., Peterson et al. (1982); Brodeur and Pearcy (1990); Schabetsberger et al. (2003); Brodeur et al. (2007); (Miller and Brodeur 2007); (Weitkamp and Sturdevant 2008); Daly et al. (2009); Brodeur et al. (2013)) and adults (e.g., Brodeur et al. ; Brodeur et al. (2014)) along the west coast of North America, including coastal Washington and Oregon and the Columbia River plume. However, the current limited evidence is insufficient to determine that coho salmon suffer from density dependence within the oceanic portion of Action Area (Beamish 2018b). For these reasons, it is unlikely that hatchery salmon from the Proposed Action will affect the growth and survival of coho salmon within the Action Area.

Adult, immature, and large juvenile Chinook and coho salmon in marine waters feed heavily on fish, particularly forage fish, and are large enough to prey on younger juvenile salmonids ((Beamish 2018b); (Riddell et al. 2018)). However, there is substantial available information showing that predation on juvenile salmonids by Chinook and coho salmon in marine waters is rare. Many diet studies of adult, immature, and large juvenile Chinook and coho salmon in marine waters only identify specific taxa that made up more than about 1–5% of the diet (i.e., "common" prey taxa), and do not mention specific taxa that were consumed at lower levels (e.g., Silliman (1941); Beacham (1986) ; Daly et al. (2009); Daly et al. (2012); Brodeur et al.; Thayer et al. (2014); Hertz et al. (2015);Osgood et al. (2016); Daly et al. (2017); Hertz et al. (2017)). Juvenile salmonids are not identified as common prey taxa in these studies. Of studies that have identified all consumed taxa regardless of their prevalence in the diet, the substantial majority have found no juvenile salmonids in Chinook or coho salmon stomach contents ((Prakash 1962); (Brodeur, Lorz, and Pearcy 1987); (Brodeur and Pearcy 1990); (Landingham, Sturdevant, and Brodeur 1998); (Hunt, Mulligan, and Komori 1999); (Kaeriyama et al. 2004); (Wainwright et al. 2008); (Chamberlin 2021); (Weitkamp et al. 2022)). Where juvenile salmonids have been consumed by Chinook or coho salmon ((Reid 1961);(Fresh, Cardwell, and Koons 1981); (Wing 1985); (Duffy et al. 2010); (Orsi et al. 2012);(Daly et al. 2019); (Beauchamp et al. 2020)), they have been a rare component of the diet, and they have been consumed almost exclusively at times and in places where large densities of juvenile salmonids are present (i.e., in Puget Sound, near the mouth of the Columbia River, and in inside areas of southeast Alaska during early summer after large pulses of small juvenile fish have entered these areas). Outside of these areas, predation by Chinook or coho salmon on salmonids in marine waters is exceedingly rare. These findings indicate that predation by Chinook and coho salmon on salmonids in marine waters is extraordinarily rare, particularly outside of times and places where large densities of recent marine-entrant juveniles are present.

ESA-listed juvenile coho salmon are expected to occur in very low abundances relative to preferred prey taxa and other juvenile salmonids in the broad spatial areas where they may overlap with Mitchell Act fish. Numerous diet surveys have demonstrated the extreme rarity of predation on juvenile salmonids by Chinook and coho salmon in marine waters, particularly in coastal areas. For these reasons, we conclude that predation by Mitchell Act fish on coho salmon from the ESUs listed above is extremely unlikely to occur, and is therefore discountable.

Designated critical habitat for the ESA-listed coho salmon ESUs listed above includes specified freshwater areas and the adjacent estuaries. These are all located outside of the Action Area. Therefore, no effects to critical habitat are expected as part of the Proposed Action.

2.12.2.2 Lake Ozette Sockeye Salmon

There is very little stock-specific information available for Lake Ozette sockeye salmon. Distribution and migration patterns for Lake Ozette sockeye salmon are not well understood, and no marine harvest data for Lake Ozette sockeye salmon exist (Haggerty et al. 2009). However, juvenile sockeye from neighboring Puget Sound and the Columbia River migrate north on the continental shelf during the summer ((Tucker et al. 2009); (Beacham et al. 2014)), where they may overlap with juvenile hatchery salmon released as part of the Proposed Action ((Tucker et al. 2011) ;(Tucker et al. 2012)). Researchers have found very little overlap in diet between juvenile sockeye salmon and Chinook and coho salmon in these areas ((Brodeur 1990a); (Landingham, Sturdevant, and Brodeur 1998); (Brodeur et al. 2007)). These studies found that juvenile Chinook salmon feed at a higher trophic level than sockeye salmon. That is, juvenile Chinook and coho salmon in the ocean are primarily piscivores, whereas juvenile sockeye salmon are largely planktivores (NMFS 2009b). Given the extent of information available, and for these aforementioned reasons, we've determined that any potential competitive effects during this time are discountable.

Adult, immature, and large juvenile Chinook and coho salmon in marine waters feed heavily on fish, particularly forage fish, and are large enough to prey on younger juvenile salmonids ((Beamish 2018a); (Riddell et al. 2018)). However, there is substantial available information showing that predation on juvenile salmonids by Chinook and coho salmon in marine waters is rare. Many diet studies of adult, immature, and large juvenile Chinook and coho salmon in marine waters only identify specific taxa that made up more than about 1–5% of the diet (i.e., "common" prey taxa), and do not mention specific taxa that were consumed at lower levels (e.g., Silliman (1941); Beacham (1986); Daly et al. (2009); Daly et al. (2012); Brodeur et al. (2014); Thayer et al. (2014); Hertz et al. (2015); Osgood et al. (2016); Daly et al. (2017); Hertz et al. (2017)). Juvenile salmonids are not identified as common prey taxa in these studies. Of studies that have identified all consumed taxa regardless of their prevalence in the diet, the substantial majority have found no juvenile salmonids in Chinook or coho salmon stomach contents ((Prakash 1962); (Brodeur, Lorz, and Pearcy 1987); (Brodeur 1990a); (Landingham, Sturdevant, and Brodeur 1998); (Hunt, Mulligan, and Komori 1999); (Kaeriyama et al. 2004); (Wainwright et al. 2008); (Chamberlin 2021); (Weitkamp et al. 2022)). Where juvenile salmonids have been consumed by Chinook or coho salmon ((Reid 1961); (Fresh, Cardwell, and Koons 1981); (Wing 1985); (Duffy et al. 2010); (Orsi et al. 2012); (Daly et al. 2019); (Beauchamp et al. 2020)), they have been a rare component of the diet, and they have been consumed almost exclusively at times and in places where large densities of juvenile salmonids are present (i.e., in Puget Sound, near the mouth of the Columbia River, and in inside areas of southeast Alaska during early summer after large pulses of small juvenile fish have entered these areas). Outside of these areas, predation by Chinook or coho salmon on salmonids in marine waters is exceedingly rare. These findings indicate that predation by Chinook and coho salmon on salmonids in marine waters is extraordinarily rare, particularly outside of times and places where large densities of recent marine-entrant juveniles are present.

Lake Ozette sockeye salmon are expected to occur in very low abundances relative to preferred prey taxa and other juvenile salmonids in the broad spatial areas where they may overlap with Mitchell Act fish. Numerous diet surveys have demonstrated the extreme rarity of predation on juvenile salmonids by Chinook and coho salmon in marine waters, particularly in coastal areas. For these reasons, we conclude that predation by Mitchell Act fish on Lake Ozette Sockeye salmon is extremely unlikely to occur, and is therefore discountable.

Critical habitat for Lake Ozette sockeye salmon does not exist within the Action Area for the Proposed Action and there is therefore no effect to Lake Ozette sockeye salmon critical habitat.

2.12.2.3 Steelhead (Puget Sound, North-Central California Coast, Central Valley, and South-Central/Southern California Coast Recovery Domains)

Risk from competition to all Interior Columbia and Willamette/Lower Columbia Recovery Domain steelhead DPSs in the Pacific Ocean is negligible. Columbia River Basin steelhead migrate rapidly from the river mouth to the outer edge of the continental shelf. Based on 13–14 years of sampling along the Washington and northern Oregon coast, including the Columbia River plume, Daly et al. (2014) determined that juvenile steelhead from the Columbia River Basin reached the western edge of the continental shelf in just a few days, and spent about 10 days in continental shelf waters before moving to open ocean areas off the shelf. Juvenile steelhead presence along the coast of Washington and Oregon diminishes during the summer and becomes very rare by September ((Brodeur and Pearcy 1990); (Daly et al. 2014)). When juvenile steelhead are present, they are mostly found farther from shore in deeper water than other juvenile salmon, similar to the observations of Hayes et al. (2016) along the California coast. Most juvenile steelhead along Washington and Oregon are in waters greater than 100 m deep ((Daly et al. 2014); (Gavery et al. 2019)). Conversely, juvenile Chinook salmon, for example, are typically closer to shore in waters less than 70 m deep ((Arterburn et al. 2007); (Peterson et al. 2010)), except for yearlings in the immediate vicinity of the Columbia River plume which tend to extend into deeper water (Sagar et al. 2015). For these reasons, any competitive effects to juvenile steelhead in the Action Area are expected to be extremely small, undetectable, and therefore insignificant.

Steelhead from ESA-listed California DPSs in the North-Central California Coast, Central Valley, and South-Central/Southern California Coast Recovery Domains—including Northern California steelhead, Central California Coast steelhead, South-Central California steelhead, Southern California steelhead, and California Central Valley steelhead—rarely occur in the Action Area. A very small but indeterminate proportion of juvenile steelhead from ESA-listed California DPSs may remain near the outer edge of the continental shelf as they move northward to common steelhead open ocean ranges (Myers 2018). For example, Van Doornik et al. Van Doornik et al. (2019) identified 1 California-origin (Central Valley) juvenile steelhead among 490 juvenile steelhead captured along the Washington and northern Oregon coast during sampling in May, 2006–2012. Other findings also demonstrate that some steelhead individuals from stocks south of the Columbia River migrate north along the continental shelf as they move west toward the open ocean. For example, Brodeur et al. (2014) estimated that 28% of steelhead captured during June and August, 2000, along the southern Oregon coast (south of Newport, Oregon) were of California origin, with 3% originating from the Central and South California Coast. Similarly, 2% of juvenile steelhead (11 of 490 individuals) captured by (Van Doornik et al. 2019) along the Washington and northern Oregon coast were from Oregon stocks south of the sampling area, some potentially as far as 300 km. Because the catch per unit effort (CPUE) of those southern stocks was very low, the authors speculated that the majority of fish originating from those areas were already in the open ocean outside the sample area by the time they reached the sample area latitude. The presence of any juvenile steelhead from ESA-listed California DPSs along within the Action Area is expected to be very small, transitory, and farther from shore than most Mitchell Act fish.

Adult, immature, and large juvenile Chinook and coho salmon in marine waters feed heavily on fish, particularly forage fish, and are large enough to prey on younger juvenile salmonids ((Beamish 2018b); (Riddell et al. 2018)). However, there is substantial available information showing that predation on juvenile salmonids by Chinook and coho salmon in marine waters is rare. Many diet studies of adult, immature, and large juvenile Chinook and coho salmon in marine waters only identify specific taxa that made up more than about 1–5% of the diet (i.e., “common” prey taxa), and do not mention specific taxa that were consumed at lower levels (e.g., Silliman (1941); Beacham (1986); Daly et al. (2009); Daly et al.(2012); Brodeur et al. (2014); Thayer et al. (2014); Hertz et al. (2015); Osgood et al. (2016); Daly et al. (2017); Hertz et al. (2017)). Juvenile salmonids are not identified as common prey taxa in these studies. Of studies that have identified all consumed taxa regardless of their prevalence in the diet, the substantial majority have found no juvenile salmonids in Chinook or coho salmon stomach contents ((Prakash 1962); (Brodeur, Lorz, and Pearcy 1987); (Brodeur 1990a); (Landingham, Sturdevant, and Brodeur 1998); (Hunt, Mulligan, and Komori 1999); (Kaeriyama et al. 2004); (Wainwright et al. 2008); (Chamberlin 2021); (Weitkamp et al. 2022)). Where juvenile salmonids have been consumed by Chinook or coho salmon ((Reid 1961); (Fresh, Cardwell, and Koons 1981); (Wing 1985); (Duffy et al. 2010); (Orsi et al. 2012); (Daly et al. 2019); (Beauchamp et al. 2020)), they have been a rare component of the diet, and they have been consumed almost exclusively at times and in places where large densities of juvenile salmonids are present (i.e., in Puget Sound, near the mouth of the Columbia River, and in inside areas of southeast Alaska during early summer after large pulses of small juvenile fish have entered these areas). Outside of these areas, predation by Chinook or coho salmon on salmonids in marine waters is exceedingly rare. These findings indicate that predation by Chinook and coho salmon on salmonids in marine waters is extraordinarily rare, particularly outside of times and places where large densities of recent marine-entrant juveniles are present.

Steelhead from these DPSs are expected to occur in very low abundances relative to preferred prey taxa and other juvenile salmonids in the broad spatial areas where they may overlap with Mitchell Act fish. Numerous diet surveys have demonstrated the extreme rarity of predation on juvenile salmonids by Chinook and coho salmon in marine waters, particularly in coastal areas. For these reasons, we conclude that predation by Mitchell Act fish on steelhead from these DPSs is extremely unlikely to occur, and is therefore discountable.

There is no designated critical habitat in the oceanic part of the Action Area for any of the ESA-listed steelhead DPSs. Therefore, ecological interactions in the ocean will have no effects on any steelhead designated critical habitat.

2.12.2.4 Hood Canal Summer Chum Salmon ESU

Risk from competition to Hood Canal summer chum in the Pacific Ocean is negligible. Juvenile Chinook and coho salmon are typically found in shallower water than juvenile chum salmon during their first ocean year on the continental shelf ((Fisher et al. 2007); (Beamish 2018b); (Riddell et al. 2018); (Urawa et al. 2018)). In addition, juvenile chum salmon typically feed at a lower trophic level than juvenile Chinook and coho salmon during this time, with the former consuming mostly zooplankton while the latter transitions to a mostly fish-based diet ((Brodeur et al. 2007); (Beamish 2018a); (Riddell et al. 2018); (Urawa et al. 2018)). Similar to juveniles, dietary overlap between chum salmon and Chinook and coho salmon at their subadults and adult stages is minimal, with Chinook and coho salmon continuing to feed at higher trophic levels than chum salmon (e.g., Johnson and Schindler (2009); Beamish (2018b); Riddell et al. (2018); Urawa et al. (2018)).

Adult, immature, and large juvenile Chinook and coho salmon in marine waters feed heavily on fish, particularly forage fish, and are large enough to prey on younger juvenile salmonids ((Beamish 2018a); (Riddell et al. 2018)). However, there is substantial available information showing that predation on juvenile salmonids by Chinook and coho salmon in marine waters is rare. Many diet studies of adult, immature, and large juvenile Chinook and coho salmon in marine waters only identify specific taxa that made up more than about 1–5% of the diet (i.e., "common" prey taxa), and do not mention specific taxa that were consumed at lower levels (e.g., Silliman (1941); Beacham (1986); Daly, Brodeur, and Weitkamp (2009); Daly et al. (2012); Brodeur et al. (2014); Thayer et al. (2014); Hertz et al. (2015); Osgood et al. (2016); Daly et al. (2017); Hertz et al. (2017). Juvenile salmonids are not identified as common prey taxa in these studies. Of studies that have identified all consumed taxa regardless of their prevalence in the diet, the substantial majority have found no juvenile salmonids in Chinook or coho salmon stomach contents ((Prakash 1962); (Brodeur, Lorz, and Pearcy 1987); (Brodeur 1990a); (Landingham, Sturdevant, and Brodeur 1998); (Hunt, Mulligan, and Komori 1999); (Kaeriyama et al. 2004); (Wainwright et al. 2008); (Chamberlin 2021); (Weitkamp et al. 2022)). Where juvenile salmonids have been consumed by Chinook or coho salmon ((Reid 1961); (Fresh, Cardwell, and Koons 1981); (Wing 1985); (Duffy et al. 2010); (Orsi et al. 2012); (Daly et al. 2019); (Beauchamp et al. 2020)), they have been a rare component of the diet, and they have been consumed almost exclusively at times and in places where large densities of juvenile salmonids are present (i.e., in Puget Sound, near the mouth of the Columbia River, and in inside areas of southeast Alaska during early summer after large pulses of small juvenile fish have entered these areas). Outside of these areas, predation by Chinook or coho salmon on salmonids in marine waters is exceedingly rare. These findings indicate that predation by Chinook and coho salmon on salmonids in marine waters is extraordinarily rare, particularly outside of times and places where large densities of recent marine-entrant juveniles are present.

Hood Canal summer chum are expected to occur in very low abundances relative to preferred prey taxa and other juvenile salmonids in the broad spatial areas where they may overlap with Mitchell Act fish. Numerous diet surveys have demonstrated the extreme rarity of predation on juvenile salmonids by Chinook and coho salmon in marine waters, particularly in coastal areas. For these reasons, we conclude that predation by Mitchell Act fish on Hood Canal summer chum is extremely unlikely to occur, and is therefore discountable.

The combined risk from competition and predation to Hood Canal summer chum salmon in the Pacific Ocean is negligible because risk from competition is negligible and risk of predation is negligible, as described above.

2.12.3 Green Sturgeon Southern DPS

The anadromous green sturgeon occurs throughout the West Coast of North America from El Socorro Bay, Baja California (Rosales-Casián and Almeda-Jáuregui 2009) to the Bering Sea, Alaska (Colway and Stevenson 2007). Green sturgeon inhabit coastal bays and estuaries and spawn in cool, deep freshwater rivers. Juveniles rear in their natal rivers for two to three years before migrating to the ocean. Two DPSs are recognized based on spawning site fidelity and genetic analyses (71 FR 17757; April 7, 2006): a Southern DPS consisting of populations originating from coastal watersheds south of the Eel River (with confirmed spawning in the Sacramento River system) (Adamski and Witkowski 2007); (Seesholtz, Manuel, and Eenennaam 2015) ; (Beccio 2018); (Beccio 2019) and a Northern DPS consisting of populations originating from coastal watersheds northward of and including the Eel River (with confirmed spawning in the Eel, Klamath, and Rogue Rivers} ; (Adamski and Witkowski 2007); (Stillwater Sciences and Wiyot Tribe Natural Resources Department 2017).

In 2006, NMFS listed the Southern DPS as threatened and the Northern DPS as a NMFS Species of Concern (71 FR 17757; April 7, 2006). The population size of the Southern DPS is estimated to be smaller than the Northern DPS (NMFS 2015f); (Dudley et al. 2024). Major threats to the Southern DPS include alterations to freshwater habitat such as barriers to migration, insufficient flows, increased temperatures, and pollution (Waples et al. 2007) . For example, historical spawning grounds in the Upper Sacramento River are currently blocked by the Shasta and Keswick Dams (Thomas et al. 2013) and green sturgeon have been found stranded in flood diversions in the Sacramento River, in numbers that could potentially impact population viability (Thomas et al. 2013). Green sturgeon are also encountered as bycatch in freshwater and coastal marine fisheries (Waples et al. 2007). While freshwater release mortalities are low, saltwater release mortalities may be as high as 18% (Doukakis et al. 2020) and could impede recovery (Dudley et al. 2024).

Critical habitat for Southern DPS Green Sturgeon was designated on October 9, 2009 (74 FR 52300). Critical habitat was designated in coastal bays and estuaries in California, Oregon, and Washington, including the Columbia River estuary, as well as in the Sacramento River system in California and in coastal marine waters from Monterey Bay, CA to Cape Flattery, WA.

Beginning in 1938, Congress appropriated funding for NMFS to distribute to hatcheries in the Columbia River Basin pursuant to the Mitchell Act. As a consequence of the Proposed Action, we expect approximately 39 million salmon and steelhead to be released per year by the hatcheries receiving this funding. The release of hatchery fish has not been identified as a threat to the survival or persistence of Southern DPS Green Sturgeon. An in-depth literature search has revealed no documented interactions between green sturgeon and hatchery released salmon and steelhead even though both Northern and Southern DPS Green Sturgeon occur in the Columbia River estuary and the Columbia River up to Bonneville Dam, including in areas where hatchery released fish occur.

Another consequence of the Proposed Action is continued funding of hatchery operations that include water withdrawals and the use of temporary weirs, both of which could adversely affect green sturgeon. Water withdrawal can reduce streamflow, impede migration, or impinge juvenile green sturgeon, and weirs could create migration barriers for green sturgeon. However, we do not expect green sturgeon to be exposed to these aspects of hatchery operations because the hatchery facilities and weirs are located in freshwater tributaries and not in the LCR (mainstem) or Columbia River estuary, where green sturgeon occur. Although it is possible, green sturgeon do not appear to enter or occupy the tributaries on a regular basis, based on available acoustic tracking data (Hansel, Romine, and Perry 2017); (Heironimus, Sturza, and Schade 2024). Thus, we consider the effects of hatchery operations on green sturgeon to be unlikely to occur and discountable. In addition, the proposed hatchery programs include designs to minimize effects from water withdrawals and the use of temporary weirs, which could further reduce potential effects on green sturgeon. For example, minimum flows will be maintained for juvenile and adult migration, and best management practices will be applied to the operation of weirs, including the use of removable weir structures only when needed and continuous surveillance of some weirs to ensure proper operation. Taken together, these measures would reduce any potential effects of water withdrawals and weirs on green sturgeon to insignificant levels.

One additional potential (but not observed) effect of Mitchell Act funded hatchery programs on green sturgeon is increased competition for resources between hatchery salmonids and green sturgeon. This may be a concern for large releases of hatchery salmonids in natal rivers. There is preliminary evidence of green sturgeon spawning in the Columbia River based on the collection of five young-of-year green sturgeon below Bonneville Dam in 2011 and 2017 (Schreier et al. 2016) ; (Schreier and Stevens 2020). Genetic analysis assigned these individuals to the Northern DPS (Schreier et al. 2016) ; (Schreier and Stevens 2020); thus, this research indicates that any increased competition for resources would affect Northern DPS Green Sturgeon but not Southern DPS Green Sturgeon. There may be some overlap in prey resources between salmonids and larval green sturgeon, which primarily feed on zooplankton and transition to benthic macroinvertebrates as they increase in size (Zarri and Palkovacs 2019). However, spatial separation between salmonids, which tend to feed in the upper water column, and green sturgeon, which tend to feed along the bottom, reduces the potential for competition (Zarri and Palkovacs 2019) ; (Thomas et al. 2019) ; (Poytress et al. 2013). Thus, we do not expect the Proposed Action to result in an increase in competition for resources between hatchery salmonids and larval or juvenile green sturgeon.

The green sturgeon found in the Columbia River estuary are primarily subadults and adults (Moser and Lindley 2007) and do not occupy the same foraging habitats as salmonids, making the potential increase in competition unlikely and therefore inconsequential for subadult and adult green sturgeon. Overall, we conclude that the effects of the Proposed Action on food resources for Southern DPS Green Sturgeon would be insignificant.

Other potential effects include the effects of hatchery effluent on water quality and the potential for hatchery fish to introduce pathogens into the environment. We concluded that the effects of hatchery effluent on water quality would be insignificant as treatment of effluent mitigates that impact on water quality. We are not aware of any transmission of pathogens from hatchery salmonids to sturgeon in the wild and concluded that this risk is very unlikely and discountable.

2.12.3.1 Conclusion

Based on this analysis, NMFS concludes that all effects of the Proposed Action are not likely to adversely affect the ESA-listed Southern DPS Green Sturgeon and their designated critical habitat.

2.12.4 Eulachon Critical Habitat

2.12.4.1 Background

Critical habitat was designated for the Southern DPS of Eulachon in 2011 under section 4(a)(3)(A) of the ESA ((NMFS 2011c)). The physical or biological features of eulachon habitat identified as essential to conservation are: (1) freshwater spawning and incubation sites with water flow, quality and temperature conditions and substrate supporting spawning and incubation, and with migratory access for adults; (2) Freshwater and estuarine migration corridors associated with spawning and incubation sites that are free of obstruction and with water flow, quality and temperature conditions supporting larval and adult mobility, and with abundant prey items supporting larval feeding after the yolk sac is depleted; and (3) Nearshore and offshore marine foraging habitat with water quality and available prey, supporting juveniles and adult survival.

Under the Proposed Action, critical habitat includes portions of 9 (Table 134) rivers and streams in Oregon, and Washington (NMFS 2011c). We designated all of these areas as migration and spawning habitat for this species

Table 134. Rivers and streams designated as critical habitat for the southern DPS of eulachon.

Specific Area	River Miles Containing Features
Umpqua River	24.2
Tenmile Creek	0.2
Sandy River	12.4
Columbia River	143.2
Grays River	4.8
Skamokawa Creek	11.1
Elochoman River	5.2
Cowlitz River	50.2
Toutle River	6.6
Kalama River	7.8
Lewis River	19.3
East Fork	5.7
Quinalt River	3.0
Elwha River	4.7

2.12.4.2 Effects to Critical Habitat

The Proposed Action has the potential to affect designated critical habitat for the southern DPS of eulachon within the following areas: Tenmile Creek, Sandy River, Columbia River, Skamokawa Creek, Elochoman River, Cowlitz River, Toutle River, Kalama River, Lewis River, East Fork Lewis River. Thus, the hatchery-produced salmon and steelhead released under the Proposed Action may affect designated critical habitat for eulachon.

Designated critical habitat contains the essential features for eulachon in freshwater and estuarine areas: (1) spawning and incubation sites (with water flow, quality and temperature conditions and substrate supporting spawning and incubation); and (2) migration corridors (free of obstruction and with water flow, quality and temperature conditions supporting larval and adult mobility, and with abundant prey items supporting larval feeding). Although they are separate features, spawning and incubation sites for eulachon cannot functionally exist without a migratory corridor to access them.

We do not expect the increase in hatchery-produced and released salmon and steelhead to have measurable or detectable effects on these essential features based on the following considerations:

Spawning and Incubation Sites

- We do not expect the increase in hatchery-produced and released salmon and steelhead to have a measurable effect on eulachon spawning and incubation sites in critical habitat as there is limited spatial and temporal overlap in spawn timing, and location — eulachon typically spawn in the lower reaches of rivers, and eulachon spawning habitat primarily consists of sand or pea-sized gravel; whereas Chinook salmon spawning, especially stream-type Chinook salmon, occurs further up-river, and spawning substrates primarily consists of gravel and cobble sized rock. As such, we do not expect hatchery-produced and released Chinook salmon that return to inland rivers to spawn to affect eulachon critical habitat for spawning and incubation (via competition for space) given these differences in spawn timing, location, and substrate preferences. Furthermore, the release of hatchery-produced fish into the environment will have no measurable or detectable effect on water flow, quality and temperature conditions and substrate supporting spawning and incubation as the release of hatchery-produced fish into the environment will have no physical impact on water flow, quality and temperature, and substrate.

Migration Corridors

- The increase in hatchery-produced and released Chinook salmon will not obstruct eulachon migration corridors as the release of hatchery-produced fish into the environment will have no physical effects on aquatic habitats or create in-water barriers that would obstruct the mobility of larval or adult eulachon.

- We do not expect the increase in hatchery-produced and released Chinook salmon to have any physical effects on migration corridors for adult eulachon that would obstruct their migration as there is limited spatial and temporal overlap of these two species in freshwater environments as adults (Table 3, Table 4, and Table 77).

- Even though there is an overlap in the timing of eulachon larvae as they drift downriver and juvenile/smolt Chinook salmon out-migration (Table 3, Table 4, and Table 77), we do not expect the increase in hatchery-produced and released hatchery fish to impede larval eulachon as they drift downriver through estuaries to the ocean. Eulachon larvae tend to be distributed throughout the water column, whereas juvenile/smolt salmon and steelhead tend to be distributed in the upper portion of the water column. Additionally, while there is overlap with the timing of larval eulachon and juvenile/smolt Chinook and Coho salmon, peak abundance of eulachon larval tends to occur in January through April, whereas peak abundance of juvenile/smolt salmon tends to occur in May through early August (stock-dependent). Therefore, we do not expect the release of hatchery-produced salmon to have any physical effects on migration corridors for larval eulachon that would obstruct their migration (passive drift) to the Pacific Ocean based on these spatial and temporal differences in migration patterns. Winter steelhead programs in the Kalama, Elochoman, and Coweeman Rivers would interact with eulachon in spawning areas due to temporal overlap. However, these hatchery steelhead rapidly migrate out of freshwater subbasins where they are released to minimize spatial overlap with eulachon and limit any effects to the migration corridor from their release.

- The release of hatchery-produced fish into the environment will have no measurable or detectable effect on water flow, quality, and temperature conditions that support eulachon larval and adult mobility as the release of hatchery-produced fish into the environment will have no physical impact on water flow, quality and temperature, and substrate.

- There is limited overlap in the prey species consumed by salmon and steelhead and eulachon. Salmon and steelhead, especially smolts, primarily feed on aquatic and terrestrial insects, amphipods, mysids, copepods, krill, freshwater crustaceans, and larval and juvenile fish in tidal fresh, brackish, and estuarine waters. Adult salmon and steelhead feed primarily on other fishes, e.g., herring, whiting, and mackerel. Eulachon larvae and post-larvae eulachon eat a variety of prey items, including phytoplankton, copepods, copepod eggs, mysids, barnacle larvae, and worm larvae (NMFS 2011c). Eulachon adults feed on zooplankton, chiefly eating crustaceans such as copepods and euphausiids (NMFS 2011c). Therefore, we do not expect the increase in hatchery-produced and released salmon and steelhead to measurably reduce food resources for eulachon given these differences in prey species.

- Hatchery operations could potentially reduce streamflow and may affect critical migration habitat available for larval eulachon. However, hatchery operations will not obstruct the migration corridor or result in no passage due the minimum flow requirements for salmon as part of the proposed action. Therefore we do not expect hatchery operations and water withdrawals to have discernible effects on the migration corridor.

- Fish weirs could also obstruct the migration corridor for adult eulachon. Most fish weirs allow for eulachon passage. The most likely effect from fish weirs in the migration corridor would be a delay in migration as they pass through the weir. However, these effects are likely to be discountable as there would only be weirs in 3 rivers (Grays, Elochoman, and Kalama) with major eulachon spawning grounds, and the weir operations would have limited overlap with eulachon spawning.

Overall, we expect the likelihood of effects on critical habitat PBFs for eulachon, to the extent they occur, would be too small to meaningfully measure, detect or evaluate and therefore are insignificant. Therefore, we conclude the proposed increase in hatchery production and release of Chinook salmon under the Proposed Action would not adversely affect designated critical habitat for Southern DPS of Eulachon.

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

Section 305(b) of the MSA directs federal agencies to consult with NMFS on all actions or Proposed Actions that may adversely affect EFH. Under the MSA, this consultation is intended to promote the conservation of EFH as necessary to support sustainable fisheries and the managed species' contribution to a healthy ecosystem. For the purposes of the MSA, EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." (50 CFR 600.10). Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include direct, indirect, site-specific or habitat-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 avoid, minimize, mitigate, or otherwise offset the adverse effects of the action on EFH. Such recommendations may include measures to avoid, minimize, mitigate, or otherwise offset the adverse effects of the action on EFH (50 CFR 600.905(b)).

The effects of hatchery programs funded by the Proposed Action can occur within EFH that is described for the following federally managed fish species within fishery management plans (FMPs) developed by the Pacific Fisheries Management Council (PFMC), and approved by the Secretary of Commerce: Pacific Coast salmon (PFMC 2024b), Pacific Coast groundfish (PFMC 2023c), coastal pelagic species (CPS) (PFMC 2023a), and highly migratory species (HMS)(PFMC 2023b).

3.1 Essential Fish Habitat Affected by the Project

For this EFH consultation, the Proposed Action and Action Area are described in detail above in Sections 1.3 and 2.3 (Proposed Action and Action Area). Briefly, the Proposed Action is the continued implementation of a policy direction that NMFS follows when funding hatchery programs in the Columbia River Basin. The Action Area includes rivers, streams, and hatchery facilities where hatchery-origin salmon and steelhead occur or are anticipated to occur in the Columbia River Basin, and the Columbia River estuary and plume, including within the Snake River and all other tributaries of the Columbia River in the United States (U.S.), and in the Pacific Ocean on the continental shelf between Yakutat Bay, Alaska and Cape Falcon, Oregon, where the hatchery-origin fish are expected to occur. The freshwater, estuarine and marine waters included in the Action Area overlap with designated EFH for various life stages of Pacific Coast salmon, Pacific Coast groundfish, coastal pelagic species, and highly migratory species managed by the PFMC (2024b).

Pursuant to the MSA, NMFS's approval of the most recent FMPs includes designated EFH for three species of Pacific salmon (PFMC 2024b)- Chinook salmon (*O. tshawytscha*); coho salmon (*O. kisutch*); and Puget Sound pink salmon (*O. gorbuscha*)—six coastal pelagic taxa (PFMC 2023a), 11 highly migratory species (PFMC 2023b), and over 90 species of groundfish (PFMC 2023c). Assessment of potential adverse effects to these species' EFH from the Proposed Action is based, in part, on the information described below. Federal waters are not managed for chum salmon (*O. keta*) or steelhead (*O. mykiss*). Therefore, EFH has not been designated for these species.

Marine EFH for Chinook, coho, and Puget Sound pink salmon in Washington and Oregon includes all estuarine, nearshore, and marine waters, from the extreme high tide line in the nearshore and tidal submerged environments within State territorial waters out to the full extent of the exclusive economic zone (EEZ), out to 200 miles offshore (PFMC 2014) ; (PFMC 2024b). Freshwater EFH for Pacific salmon includes all those streams, lakes, ponds, wetlands, and other water bodies currently, or historically accessible to Chinook, coho, and Puget Sound pink salmon in Washington, Oregon, and Idaho, except areas upstream of certain impassible man-made barriers, and longstanding, naturally-impassable barriers (i.e., natural waterfalls in existence for several hundred years). Freshwater EFH for Chinook and coho salmon consists of four major components, (1) spawning and incubation; (2) juvenile rearing; (3) juvenile migration corridors; and (4) adult migration corridors and adult holding habitat. Marine EFH for Chinook and coho salmon consists of three components, (1) estuarine rearing; (2) ocean rearing; and (3) juvenile and adult migration. Freshwater EFH for pink salmon consists of three components, (1) spawning and incubation; (2) juvenile migration corridors; and (3) adult migration corridors and adult holding habitat. Marine EFH for pink salmon consists of three components, (1) estuarine rearing; (2) early ocean rearing; and (3) juvenile and adult migration. A more detailed description and identification of EFH for salmon is found in Appendix A of the Pacific Coast Salmon Fishery Management Plan (PFMC 2024b).

EFH for coastal pelagic species includes all marine and estuarine waters from the shoreline along the coasts of California, Oregon, and Washington offshore to the limits of the EEZ and above the thermocline where sea surface temperatures range between 10 °C to 26 °C. A more detailed description and identification of EFH for coastal pelagic species is found in Appendix D of the Coastal Pelagic Species Fishery Management Plan, as amended by Amendment 20 (PFMC 2023a).

EFH for highly migratory species range from vertical habitat within the upper ocean water column from the surface to depths generally not exceeding 200 m to vertical habitat within the mid-depth ocean water column, from depths between 200 and 1000 m (PFMC 2023b). These range from coastal waters primarily over the continental shelf; generally over bottom depths equal to or less than 183 m to the open sea, beyond continental and insular shelves. A more detailed description and identification of EFH for highly migratory species in Section 7.2 and Appendix F of the Fishery Management Plan for U.S. West Coast Fisheries for Highly Migratory Species Amended Through Amendment 7(PFMC 2023b).

EFH for groundfish includes all waters and substrate from the mean higher high-water line, or the upriver extent of saltwater intrusion in river mouths, seaward to the 3,500 m depth contour plus specified areas of interest such as seamounts. A more detailed description and identification of EFH for groundfish is found in the Appendix B of the Pacific Coast Groundfish Management Plan (PFMC).

3.2 Adverse Effects on Essential Fish Habitat

The Proposed Action is likely to affect marine EFH for salmon through ecological interactions between hatchery and wild salmonids, as described by PFMC (2014). Ecological interactions in marine areas are described in considerable detail in the Biological Opinion (see Section 2.5). Additional detail on possible effects of hatchery programs can be found in Appendix A. In marine areas, predation by salmon on salmon is extremely rare. Adverse effects from competition will be experienced by Chinook salmon, but not coho or Puget Sound pink salmon. The Biological Opinion indicates that effects of ecological interactions from the Proposed Action in marine areas are minor and low risk, mainly because the Proposed Action will contribute to Chinook salmon ocean abundance by a relatively minor amount, and because available evidence indicates that Chinook salmon make up a very small proportion of competitors in marine areas.

The Proposed Action is likely to have an effect on freshwater EFH for Chinook, coho and Puget Sound pink salmon. Potential effects on freshwater EFH by the Proposed Action (particularly through water withdrawal, effluent discharge, temporary weir operation, and increased competition for spawning and rearing sites) are only likely to occur in areas that Chinook, coho, and Puget Sound pink salmon spawn naturally and within the migration corridor.

The Proposed Action is not likely to have adverse effects on EFH for the coastal pelagic species and highly migratory species. The Proposed Action is also not likely to have adverse effects on EFH for groundfish. Of the potential adverse effects listed in related fishery management plans (PFMC 2023a);(PFMC 2023b); 2023c); (PFMC 2024b), effects of hatchery operations are most similar to aquaculture of the potential effects listed, due to release of hatchery-produced waste and impacts to water quality.

The direct discharge of hatchery facility effluent is regulated by the EPA under the CWA through NPDES permits. For discharges from hatcheries not located on federal or tribal lands within Washington, the EPA has delegated its regulatory oversight to the State. Washington

Department of Ecology is responsible for issuing and enforcing NPDES permits that ensure water quality standards for surface and marine waters remain consistent with public health and enjoyment, and the propagation and protection of fish, shellfish, and wildlife (WAC 173-201A). In Oregon, the Oregon Department of Environmental Quality (DEQ) is the agency responsible for issuing and enforcing NPDES, while in Idaho the Idaho Department of Environmental Quality (IDEQ) is the authority for issuing and enforcing NPDES. NPDES permits are not required for hatchery facilities that release less than 20,000 pounds of fish per year or that feed less than 5,000 pounds of fish food during any calendar month. Additionally, Native American tribes may adopt their own water quality standards for permits on tribal lands (i.e., tribal wastewater plans).

Hatchery discharge volumes are typically a relatively small proportion of the receiving waterbody's flow. Thus, hatchery effluent is often rapidly diluted near the point of discharge to the receiving waterbody. The likelihood of injury to listed salmonids from exposure to effluent is related to the frequency of occurrence, length of time they are exposed (e.g., how long they remain in the immediate vicinity of the effluent discharge points), and concentration of substances within the effluent water. Due to the periodic nature of chemical and chemotherapeutic use, and the low concentrations that are commonly achieved at or very near the point of discharge, we do not expect any deleterious effects to ESA-listed salmon and steelhead.

Compliance with NPDES requirements is not an assurance that effects on ESA-listed salmonids will not occur. However, the hatchery facilities use water specifically for the purpose of incubating and rearing juvenile salmon. Survival of eggs and juveniles in hatcheries are typically much higher than those in the natural environment. Egg and juvenile survival of the programs included in this consultation are indicative of generally good water quality.

Other potential adverse effects listed in the related fishery management plans for pelagic, highly migratory and groundfish species, on EFH are not applicable to hatchery operations. Altering natural flows and the process associated with flow rates is not a concern associated with hatchery operations because the hatcheries are not altering the flow rate of the Columbia River enough for the effects to be detectable in the EFH for pelagic, highly migratory and groundfish species. Affecting prey base and entrapping fish, both from withdrawal of water, is not a potential adverse effect of hatchery operations because water is not withdrawn within the EFH, so these effects would not occur from hatchery operations. Finally, adverse effects associated with dams are not relevant to hatchery operations because hatchery operations do not affect how dams are operated.

The Proposed Action is likely to affect freshwater EFH for Chinook, coho, and Puget Sound pink salmon through the continued funding of hatchery facilities that will withdraw streamflow at hatchery facilities. As described in Section 2.5.2.5, water withdrawal for hatchery operations can adversely affect salmon by reducing streamflow, impeding migration, or reducing other stream-dwelling organisms that could serve as prey for juvenile salmonids. Water withdrawals can also kill or injure juvenile salmonids through impingement upon inadequately designed intake screens or by entrainment of juvenile fish into the water diversion structures. The proposed hatchery programs include designs to minimize each of these effects; the minimum flows will be maintained to provide for juvenile and adult migration through the sections of stream from the point of withdrawal to the hatchery outfall, and the intakes are screened in compliance with NMFS criteria.

The Proposed Action is likely to affect freshwater EFH for Chinook, coho, and Puget Sound pink salmon through the effluent discharge from the hatchery facilities. As described in Section 2.5.2.5, effluent discharge from hatchery facilities can adversely affect water quality mainly by raising temperatures and total suspended solids (TSS) concentrations. The proposed hatchery programs minimize each of these effects through compliance with the NPDES permits, where applicable.

The Proposed Action is likely to affect freshwater EFH for Chinook, coho, and Puget Sound pink salmon through the use of temporary weirs, as described in Section 2.5.2.2. The effects of the installation and operation of the weirs potentially include displaced spawning, migration delay, and increased mortality from handling of fish at the trap. Any effects on EFH associated with weirs would be minimized through implementation of best management practices, including: use of a removable weir structure that rests on the river bottom and banks with minimal disruption of riverine habitat; placement and operation of removable weirs for only when they are needed; continuous surveillance of some weirs by staff residing on-site to ensure proper operation and to safeguard fish trapped; frequent sorting of fish from the trap to minimize trap holding times; and implementation of fish capture and handling methods that protect the health of fish retained as broodstock or released back into the river.

The Proposed Action is likely to affect freshwater EFH for Chinook, coho, and Puget Sound pink salmon through increased competition for spawning and rearing sites and predation. The (PFMC 2024a) recognized that these effects pertain to EFH because of the concerns about "genetic and ecological interactions of hatchery and wild fish … [which have] been identified as risk factors for wild populations." The Opinion describes in considerable detail the impacts hatchery programs might have on natural populations (see Section 2.4.1.4 above); greater detail on possible effects of hatchery programs can be found in Section 2.5.2. A small proportion of hatchery fish returning to the natal rivers is expected to spawn and may compete for space with Chinook or coho salmon. Some hatchery-origin fish may stray into non-natal rivers but not in numbers that would cause the carrying capacities of natural production areas to be exceeded, or that would result in increased incidence of disease or increases in predators. Predation by adult hatchery-origin fish on juvenile natural-origin salmonids will be limited because of timing differences, because adult salmon stop feeding by the time they reach spawning areas, and because predation by juvenile offspring of hatchery-origin fish on juvenile natural-origin salmonids would not occur for reasons discussed in Section 2.5.2.

3.3 Essential Fish Habitat Conservation Recommendations

For each of the potential adverse effects by the Proposed Action on EFH for Chinook and coho salmon, NMFS believes that the Proposed Action, as described in Section 1.3 and the ITS (Section 2.9, above) includes the best approaches to avoid or minimize those adverse effects. The Reasonable and Prudent Measures and Terms and Conditions included in the ITS constitute NMFS's recommendations to address potential EFH effects. NMFS does not have any EFH additional Conservation Recommendations.

3.4 Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, NMFS must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS's EFH Conservation Recommendations unless NMFS and the Federal agency have agreed to use alternative time frames for the Federal agency response. The response must include a description of measures proposed by the agency for avoiding, minimizing, mitigating, or otherwise offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the Conservation Recommendations, the Federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects (50 CFR 600.920(k)(1)).

In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency.

3.5 Supplemental Consultation

The NMFS 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 [*name of federal action agency(ies)*]. Other interested users could include [*e.g., permit or license applicants, citizens of affected areas, others interested in the conservation of the affected ESUs/DPS*]. Individual copies of this opinion were provided to the [*name of action agency(ies)*]. The document will be available within 2 weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. The format and naming adhere to conventional standards for style.

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 part 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*,* 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 MSA implementation, and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

5 References

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1. APPENDIX A: EFFECTS OF HATCHERY PROGRAMS ON SALMON AND STEELHEAD POPULATIONS: REFERENCE DOCUMENT FOR NMFS ESA HATCHERY CONSULTATIONS (REVISED MAY 2023)[1]

NMFS applies available scientific information, identifies the types of circumstances and conditions that are unique to individual hatchery programs, then refines the range in effects for a specific hatchery program. Our analysis of a Proposed Action addresses six factors:

(1) The hatchery program does or does not remove fish from the natural population and use them for hatchery broodstock
(2) Hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities
(3) Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas, the migration corridor, estuary, and ocean
(4) Research, monitoring, and evaluation (RM&E) that exist because of the hatchery program
(5) Operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program
(6) Fisheries that would not exist but for the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds

Because the purpose of biological opinions is to evaluate whether proposed actions pose unacceptable risk (jeopardy) to listed species, much of the language in this appendix addresses risk. However, we also consider that hatcheries can be valuable tools for conservation or recovery, for example when used to prevent extinction or conserve genetic diversity in a small population, or to produce fish for reintroduction.

The following sections describe each factor in detail, including as appropriate, the scientific basis for and our analytical approach to assessment of effects. The material presented in this Appendix is only scientific support for our approach; social, cultural, and economic considerations are not included. The scientific literature on effects of salmonid hatcheries is large and growing rapidly. This appendix is thus not intended to be a comprehensive literature review, but rather a periodically updated overview of key relevant literature we use to guide our approach to effects analysis. Because this appendix can be updated only periodically, it may sometimes omit very recent findings, but should always reflect the scientific basis for our analyses. Relevant new information not cited in the appendix will be cited in the other sections of the opinion that detail our analyses of effects.

In choosing the literature we cite in this Appendix, our overriding concern is our mandate to use "best available science". Generally, "best available science" means recent peer-reviewed journal articles and books. However, as appropriate we cite older peer-reviewed literature that is still relevant, as well as "gray" literature. Although peer-review is typically considered the "gold standard" for scientific information, occasionally there are well-known and popular papers in the peer-reviewed literature we do not cite because we question the methodology, results, or conclusions. In citing sources, we also consider availability, and try to avoid sources that are

[1] This version of the appendix supersedes all earlier dated versions and the NMFS (2012) standalone document of the same name.

difficult to access. For this reason, we generally avoid citing master's theses and doctoral dissertations, unless they provide unique information.

1.1. Factor 1. The hatchery program does or does not remove fish from the natural population and use them for hatchery broodstock

A primary consideration in analyzing and assessing effects for broodstock collection is the origin and number of fish collected. The analysis considers whether broodstock are of local origin and the biological benefits and risks of using ESA-listed fish (natural or hatchery-origin) for hatchery broodstock. It considers the maximum number of fish proposed for collection and the proportion of the donor population collected for hatchery broodstock. "Mining" a natural population to supply hatchery broodstock can reduce population abundance and spatial structure

1.2. Factor 2. Hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural and hatchery fish at adult collection facilities.

There are three aspects to the analysis of this factor: genetic effects, ecological effects, and encounters at adult collection facilities. We present genetic effects first. For the sake of simplicity, we discuss genetic effects on all life stages under factor 2.

1.2.1. Genetic effects

1.2.1.1. Overview

Based on currently available scientific information, we generally view the genetic effects of hatchery programs as detrimental to the ability of a salmon population's ability to sustain itself in the wild. We believe that artificial breeding and rearing is likely to result in some degree of change of genetic diversity and fitness reduction in hatchery-origin. Hatchery-origin fish can thus pose a risk to diversity and to salmon population rebuilding and recovery when they interbreed with natural-origin fish. However, conservation hatchery programs may prevent extinction or accelerate recovery of a target population by increasing abundance faster than may occur naturally (Waples 1999). Hatchery programs can also be used to create genetic reserves for a population to prevent the loss of its unique traits due to catastrophes (Ford et al. 2011).

We recognize that there is considerable debate regarding aspects of genetic risk. The extent and duration of genetic change and fitness loss and the short- and long-term implications and consequences for different species (i.e., for species with multiple life-history types and species subjected to different hatchery practices and protocols) remain unclear and should be the subject of further scientific investigation. As a result, we believe that hatchery intervention is a legitimate and useful tool to alleviate short-term extinction risk, but otherwise managers should seek to limit interactions between hatchery and natural-origin fish and implement hatchery practices that harmonize conservation with the implementation of treaty Indian fishing rights and other applicable laws and policies (NMFS 2011). We expect the scientific uncertainty surrounding genetic risks to be reduced considerably in the next decade due to the rapidly increasing power of genomic analysis (Waples et al. 2020).

Four general processes determine the genetic composition of populations of any plant or animal species (e.g., Falconer and MacKay 1996):

- Selection- changes in genetic composition over time due to some genotypes being more successful at survival or reproduction (i.e., more fit) than others
- Migration- individuals, and thus their genes, moving from one population to another
- Genetic drift- random loss of genetic material due to finite population size
- Mutation- generation of new genetic diversity through changes in DNA

Mutations are changes in DNA sequences that are generally so rare[2] that they can be ignored for relatively short-term evaluation of genetic change, but the other three processes are considerations in evaluating the effects of hatchery programs on the productivity and genetic diversity of natural salmon and steelhead populations. Although there is considerable biological interdependence among them, we consider three major areas of genetic effects of hatchery programs in our analyses (Figure 1):

- Within-population genetic diversity
- Among-population genetic diversity/outbreeding
- Hatchery-influenced selection

The first two areas are well-known major concerns of conservation biology (e.g., Frankham et al. 2010; Allendorf et al. 2013), but our emphasis on hatchery-influenced selection— what conservation geneticists would likely call “adaptation to captivity” (Allendorf et al. 2013, pp. 408-409)— reflects the fairly unique position of salmon and steelhead among ESA-listed species. In the case of ESA-listed Pacific salmon and steelhead, artificial propagation in hatcheries has been used as a routine management tool for many decades, and in some cases the size and scope of hatchery programs has been a factor in listing decisions.

In the sections below we discuss these three major areas of risk, but preface this with an explanation of some key terms relevant to genetic risk. Although these terms may also be listed in a glossary in the biological opinion to which this appendix accompanies, we felt that it was important to include them here, as this appendix may at times be used as a stand-alone document.

[2] For example, the probability of a random base substitution in a DNA molecule in coho salmon is .000000008 (Rougemont et al. 2020).

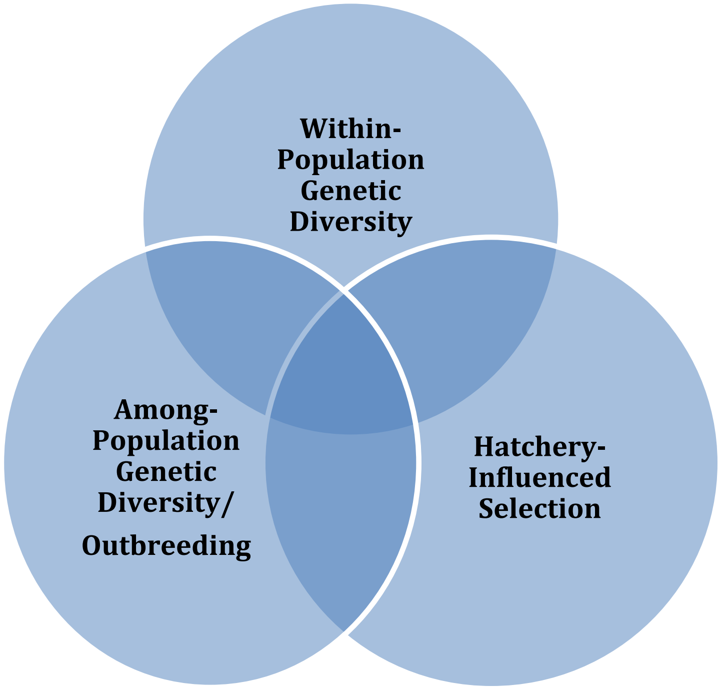

Figure 1. Major categories of hatchery program genetic effects analyzed by NMFS

1.2.1.1.1. Key Terms

The terms "wild fish" and "hatchery fish" are commonly used by the public, management biologists, and regulatory biologists, but their meaning can vary depending on context. For genetic risk assessment, more precise terminology is needed. Much of this terminology, and further derivatives of it, is commonly attributed to the Hatchery Scientific Review Group (HSRG), but were developed in 2004 technical discussions between the HSRG and scientists from the Washington Department of Fish and Wildlife (WDFW) and the Northwest Indian Fisheries Commission (HSRG 2009a).

- **Hatchery-origin (HO)**- refers to fish that have been reared and released by a hatchery program, regardless of the origin (i.e., from a hatchery or from spawning in nature) of their parents. A series of acronyms has been developed for subclasses of HO fish:
    - **Hatchery-origin recruits (HOR)** – HO fish returning to freshwater as adults or jacks. Usage varies, but typically the term refers to post-harvest fish that will either spawn in nature, used for hatchery broodstock, or surplused.
    - **Hatchery-origin spawners (HOS)**- hatchery-origin fish spawning in nature. A very important derivative term, used both in genetic and ecological risk, is **pHOS,** the proportion of fish on the spawning grounds of a population consisting of HO fish. pHOS is the expected maximum genetic contribution of HO spawners to the naturally spawning population.
    - **Hatchery-origin broodstock (HOB)**- hatchery-origin fish that are spawned in the hatchery (i.e., are used as broodstock). This term is rarely used.

- **Natural-origin (NO)**- refers to fish that have resulted from spawning in nature, regardless of the origin of their parents. A series of acronyms parallel to those for HO fish has been developed for subclasses of NO fish:
    - **Natural-origin recruits (NOR)** – NO fish returning to freshwater as adults or jacks. Usage varies, but typically the term refers to post-harvest fish that will either spawn in nature or used for hatchery broodstock.
    - **Natural-origin spawners (NOS)**- natural-origin fish spawning in nature.
    - **Natural-origin broodstock (NOB)**- natural-origin fish that are spawned in the hatchery (i.e., are used as broodstock). An important derivative term is **pNOB**, the proportion of a hatchery program's broodstock consisting of NO fish.

Hatchery programs are designated as either as "integrated" or "segregated". In the past these terms have been described in various ways, based on purpose (e.g., conservation or harvest) or intent with respect to the genetic relationship between the hatchery fish and the natural population they interact with. For purposes of genetic risk, we use simple functional definitions based on use of natural-origin broodstock:

- **Integrated hatchery programs**- programs that intentionally incorporate natural-origin fish into the broodstock at some level (i.e., pNOB > 0)
- **Segregated hatchery programs**- programs that do not intentionally incorporate natural-origin fish into the broodstock (i.e., pNOB = 0)

1.2.1.2. Within-population diversity effects

Within-population genetic diversity is a general term for the quantity, variety, and combinations of genetic material in a population (Busack and Currens 1995). Within-population diversity is gained through mutations or gene flow from other populations (described below under outbreeding effects) and is lost primarily due to genetic drift. In hatchery programs diversity may also be lost through biased or nonrepresentational sampling incurred during hatchery operations, particularly broodstock collection and spawning protocols.

1.2.1.2.1. Genetic drift

Genetic drift is random loss of diversity due to population size. The rate of drift is determined not by the census population size (N_c), but rather by the effective population size (N_e). The effective size of a population is the size of a genetically "ideal" population (i.e., equal numbers of males and females, each with equal opportunity to contribute to the next generation) that will display as much genetic drift as the population being examined (e.g., Falconer and MacKay 1996; Allendorf et al. 2013)[3].

[3] There are technically two subcategories of N_e: inbreeding effective size and variance effective size. The distinction between them is usually not a concern in our application of the concept.

This definition can be baffling, so an example is useful. A commonly used effective-size equation is $Ne = 4 * N_m * N_f / (N_m + N_f)$, where N_m and N_f are the number of male and female parents, respectively. Suppose a steelhead hatchery operation spawns 5 males with 29 females. According to the equation, although 34 fish were spawned, the skewed sex ratio made this equivalent to spawning 17 fish (half male and half female) in terms of conserving genetic diversity because half of the genetic material in the offspring came from only 5 fish.

Various guidelines have been proposed for what levels of N_e should be for conservation of genetic diversity. A long-standing guideline is the 50/500 rule (Franklin 1980; Lande and Barrowclough 1987): 50 for a few generations is sufficient to avoid inbreeding depression, and 500 is adequate to conserve diversity over the longer term. One recent review (Jamieson and Allendorf 2012) concluded the rule still provided valuable guidance; another (Frankham et al. 2014) concluded that larger values are more appropriate, basically suggesting a 100/1000 rule. See Frankham et al. (2010) for a more thorough discussion of these guidelines.

Although Ne can be estimated from genetic or demographic data, often-insufficient information is available to do this, so for conservation purposes it is useful to estimate effective size from census size. As illustrated by the example above, N_e can be considerably smaller than N_c. This is typically the case. Frankham et al. (2014) suggested a N_e/N_c range of ~0.1-0.2 based on a large review of the literature on effective size. For Pacific salmon populations over a generation, Waples (2004) arrived at a similar range of 0.05-0.3.

In salmon and steelhead management, effective size concerns are typically dealt with using the term effective number of breeders (N_b) in a single spawning season, with per-generation N_e equal to the generation time (average age of spawners) times the average N_b (Waples 2004). We will use N_b rather than N_e where appropriate in the following discussion.

Hatchery programs, simply by virtue of being able to create more progeny than natural spawners are able to, can increase N_b in a fish population. In very small populations, this increase can be a benefit, making selection more effective and reducing other small-population risks (e.g., Lacy 1987; Whitlock 2000; Willi et al. 2006). Conservation hatchery programs can thus serve to protect genetic diversity; several programs, such as the Snake River sockeye salmon program, are important genetic reserves. However, hatchery programs can also directly depress N_b by three principal pathways:

- Removal of fish from the naturally spawning population for use as hatchery broodstock. If a substantial portion of the population is taken into a hatchery, the hatchery becomes responsible for that portion of the effective size, and if the operation fails, the effective size of the population will be reduced (Waples and Do 1994).

- Mating strategy used in the hatchery. N_b is reduced considerably below the census number of broodstock by using a skewed sex ratio, spawning males multiple times (Busack 2007), and by pooling gametes. Pooling milt is especially problematic because when milt of several males is mixed and applied to eggs, a large portion of the eggs may be fertilized by a single male (Gharrett and Shirley 1985; Withler 1988). This problem can be avoided by more structured mating schemes such as 1-to-1 mating. Factorial mating schemes, in which fish are systematically mated multiple times, can be used to increase N_b (Fiumera et al. 2004; Busack and Knudsen 2007) over what would be achievable with less structured designs. Considerable benefit in N_b increase over what is achievable by 1-to-1 mating can be achieved through a factorial design as simple as a 2 x 2 (Busack and Knudsen 2007).

- Ryman-Laikre effect. On a per-capita basis, a hatchery broodstock fish can often contribute many more progeny to a naturally spawning population than a naturally spawning fish can contribute This difference in reproductive contribution causes the composite N_b to be reduced, which is called a Ryman-Laikre (R-L) effect (Ryman and Laikre 1991; Ryman et al. 1995). The key factors determining the magnitude of the effect are the numbers of hatchery and natural spawners, and the proportion of natural spawners consisting of hatchery returnees.

The initial papers on the R-L effect required knowledge of N_b in the two spawning components of the population. Waples et al. (2016) have developed R-L equations suitable for a wide variety of situations in terms of knowledge base. A serious limitation of any R-L calculation however, is that it is a snapshot in time. What happens in subsequent generations depends on gene flow between the hatchery broodstock and the natural spawners. If a substantial portion of the broodstock are NO fish, the long-term effective size depression can be considerably less than would be expected from the calculated per-generation N_b.

Duchesne and Bernatchez (2002), Tufto and Hindar (2003), and Wang and Ryman (2001) have developed analytical approaches to deal with the effective-size consequences of multiple generations of interbreeding between HO and NO fish. One interesting result of these models is that effective size reductions caused by a hatchery program can easily be countered by low levels of gene flow from other populations. Tufto (2017) recently provided us with R code (R Core Team 2019) updates to the Tufto and Hindar (2003) method that yield identical answers to the Duchesne and Bernatchez (2002) method, and we use an R (R Core Team 2019) program incorporating them to analyze the effects of hatchery programs on effective size.

Inbreeding depression, another N_e-related phenomenon, is a reduction in fitness and survival caused by the mating of closely related individuals (e.g., siblings, half-siblings, cousins). Related individuals are genetically similar and produce offspring characterized by low genetic variation, low heterozygosity, lower survival, and increased expression of recessive deleterious mutations (Frankham et al. 2010; Allendorf et al. 2013; Rollinson et al. 2014; Hedrick and Garcia-Dorado 2016). Lowered fitness due to inbreeding depression exacerbates genetic risk relating to small population size and low genetic variation which further shifts a small population toward extinction (Nonaka et al. 2019). The protective hatchery environment masks the effects of inbreeding which becomes apparent when fish are released into the natural environment and experience decreased survival (Thrower and Hard 2009). Inbreeding concerns in salmonids related to hatcheries have been reviewed by Wang et al. (2002) and Naish et al. (2007).

N_e affects the level of inbreeding in a population, as the likelihood of matings between close relatives is increased in populations with low numbers of spawners. Populations exhibiting high levels of inbreeding are generally found to have low N_e (Dowell Beer et al. 2019). Small populations are at increased risk of both inbreeding depression and genetic drift (e.g., Willi et al. 2006). Genetic drift is the stochastic loss of genetic variation, which is most often observed in populations with low numbers of breeders. Inbreeding exacerbates the loss of genetic variation by increasing genetic drift when related individuals with similar allelic diversity interbreed (Willoughby et al. 2015).

Hatchery populations should be managed to avoid inbreeding depression. If hatcheries produce inbred fish which return to spawn in natural spawning areas the low genetic variation and increased deleterious mutations can lower the fitness, productivity, and survival of the natural population (Christie et al. 2014). A captive population, which has been managed so genetic variation is maximized and inbreeding is minimized, may be used for a genetic rescue of a natural population characterized by low genetic variation and low Ne.

1.2.1.2.2. Biased/nonrepresentational sampling

Even if effective size is large, the genetic diversity of a population can be negatively affected by hatchery operations. Although many operations aspire to randomly use fish for spawning with respect to size, age, and other characteristics, this is difficult to do. For example, male Chinook salmon that mature precociously in freshwater are rarely if ever used as broodstock because they are not captured at hatchery weirs. Pressure to meet egg take goals is likely responsible for advancing run/spawn timing in at least some coho and Chinook salmon hatcheries (Quinn et al. 2002; Ford et al. 2006). Ironically, random mating, a common spawning guideline for conservation of genetic diversity has been hypothesized to be effectively selecting for younger, smaller fish (Hankin et al. 2009).

The sampling examples mentioned thus far are more or less unintentional actions. There are also established hatchery practices with possible diversity consequences that are clearly intentional. A classic example is use of jacks in spawning, where carefully considered guidelines range from random usage to near exclusion of jacks (e.g., Seidel 1983; IDFG et al. 2020). Another is the deliberate artificial selection in the hatchery of summer and winter steelhead to smolt at one year of age, which has resulted in early spawning stocks of both ecotypes (Crawford 1979).

Another source of biased sampling is non-inclusion of precocious males in broodstock. Precociousness, or early male maturation, is an alternative reproductive tactic employed by Atlantic salmon (Baglinière and Maisse 1985; Myers et al. 1986), Chinook salmon (Bernier et al. 1993; Larsen et al. 2004), coho salmon (Iwamoto et al. 1984; Silverstein and Hershberger 1992), steelhead (Schmidt and House 1979; McMillan et al. 2012) , sockeye salmon (Ricker 1959), as well as several salmonid species in Asia and Europe (Dellefors and Faremo 1988; Kato 1991; Munakata et al. 2001; Morita et al. 2009).

Unlike anadromous males and females that migrate to the ocean to grow for a year or more before returning to their natal stream, precocious males generally stay in headwater reaches or migrate shorter distances downstream (Larsen et al. 2010) before spawning. They are orders of magnitude smaller than anadromous adults and use a ‘sneaker’ strategy to spawn with full size anadromous females (Fleming 1996). Precocious males are typically not subject to collection as broodstock, because of either size or location. Thus, to the extent this life history is genetically determined, hatchery programs culturing species that display precociousness unintentionally select against it.

The examples above illustrate the overlap between diversity effects and selection. Selection, natural or artificial, affects diversity, so could be regarded as a subcategory of within-population diversity. Analytically, here we consider specific effects of sampling or selection on genetic diversity. Broodstock collection or spawning guidelines that include specifications about non-random use of fish with respect to age or size, spawn timing, etc. (e.g., Crawford 1979) are of special interest. We consider general non-specific effects of unintentional selection due to the hatchery that are not related to individual traits in Section 1.2.1.4.

1.2.1.3. Among-population diversity/ Outbreeding effects

Outbreeding effects result from gene flow from other populations into the population of interest. Gene flow occurs naturally among salmon and steelhead populations, a process referred to as straying (Quinn 1997; Keefer and Caudill 2012; Westley et al. 2013). Natural straying serves a valuable function in preserving diversity that would otherwise be lost through genetic drift and in re-colonizing vacant habitat, and straying is considered a risk only when it occurs at unnatural levels or from unnatural sources.

Hatchery fish may exhibit reduced homing fidelity relative to NO fish (Grant 1997; Quinn 1997; Jonsson et al. 2003; Goodman 2005), resulting in unnatural levels of gene flow into recipient populations from strays, either in terms of sources or rates. Based on thousands of coded-wire tag (CWT) recoveries, Westley et al. (2013) concluded that species propagated in hatcheries vary in terms of straying tendency: Chinook salmon > coho salmon > steelhead. Also, within Chinook salmon, “ocean-type” fish stray more than “stream-type” fish. However, even if hatchery fish home at the same level of fidelity as NO fish, their higher abundance relative to NO fish can cause unnaturally high gene flow into recipient populations.

Rearing and release practices and ancestral origin of the hatchery fish can all play a role in straying (Quinn 1997). Based on fundamental population genetic principles, a 1995 scientific workgroup convened by NMFS concluded that aggregate gene flow from non-native HO fish from all programs combined should be kept below 5 percent (Grant 1997), and this is the recommendation NMFS uses as a reference in hatchery consultations. It is important to note that this 5% criterion was developed independently and for a different purpose than the HSRG’s 5% pHOS criterion that is presented in Section 1.2.1.4.

Gene flow from other populations can increase genetic diversity (e.g., Ayllon et al. 2006), which can be a benefit in small populations, but it can also alter established allele frequencies (and co-adapted gene complexes) and reduce the population’s level of adaptation, a phenomenon called outbreeding depression (Edmands 2007; McClelland and Naish 2007). In general, the greater the geographic separation between the source or origin of hatchery fish and the recipient natural population, the greater the genetic difference between the two populations (ICTRT 2007), and the greater potential for outbreeding depression. For this reason, NMFS advises hatchery action agencies to develop locally derived hatchery broodstock.

In addition, unusual high rates of straying into other populations within or beyond the population's MPG, salmon ESU, or a steelhead DPS, can have a homogenizing effect, decreasing intra-population genetic variability (e.g., Vasemagi et al. 2005), and increasing risk to population diversity, one of the four attributes measured to determine population viability (McElhany et al. 2000). The practice of backfilling — using eggs collected at one hatchery to compensate for egg shortages at another—has historically a key source of intentional large-scale "straying". Although it now is generally considered an unwise practice, it still is common.

There is a growing appreciation of the extent to which among-population diversity contributes to a "portfolio" effect (Schindler et al. 2010), and lack of among-population genetic diversity is considered a contributing factor to the depressed status of California Chinook salmon populations (Carlson et al. 2011; Satterthwaite and Carlson 2015). Eldridge et al. (2009) found that among-population genetic diversity had decreased in Puget Sound coho salmon populations during several decades of intensive hatchery culture.

As discussed in Section 1.2.1.4, pHOS[4] is often used as a surrogate measure of gene flow. Appropriate cautions and qualifications should be considered when using this proportion to analyze outbreeding effects.

- Adult salmon may wander on their return migration, entering and then leaving tributary streams before spawning (Pastor 2004). These "dip-in" fish may be detected and counted as strays, but may eventually spawn in other areas, resulting in an overestimate of the number of strays that potentially interbreed with the natural population (Keefer et al. 2008). On the other hand, "dip-ins" can also be captured by hatchery traps and become part of the broodstock.

- Strays may not contribute genetically in proportion to their abundance. Several studies demonstrate little genetic impact from straying despite a considerable presence of strays in the spawning population (e.g., Saisa et al. 2003; Blankenship et al. 2007). The causes of poor reproductive success of strays are likely similar to those responsible for reduced productivity of HO fish in general, e.g., differences in run and spawn timing, spawning in less productive habitats, and reduced survival of their progeny (Reisenbichler and McIntyre 1977; Leider et al. 1990; Williamson et al. 2010).

1.2.1.4. Hatchery-influenced selection effects

Hatchery-influenced selection (often called domestication[5]), the third major area of genetic effects of hatchery programs that NMFS analyses, occurs when selection pressures imposed by

[4] It is important to reiterate that as NMFS analyzes them, outbreeding effects are a risk only when the HO fish are from a *different* population than the NO fish.

[5] We prefer the term "hatchery-influenced selection" or "adaptation to captivity" (Fisch et al. 2015) to "domestication" because in discussions of genetic risk in salmon "domestication" is often taken as equivalence to species that have been under human management for thousands of years; e.g., perhaps 30,000 yrs for dogs (Larson and Fuller 2014), and show evidence of large-scale genetic change (e.g., Freedman et al. 2016). By this standard, the only domesticated fish species is the carp (*Cyprinus carpio*) (Larson and Fuller 2014). "Adaptation to captivity", a term commonly used in conservation biology (e.g., Frankham 2008), and becoming more common in the fish literature (Christie et al. 2011; Allendorf et al. 2013; Fisch et al. 2015) is more precise for species that have been

hatchery spawning and rearing differ greatly from those imposed by the natural environment and causes genetic change that is passed on to natural populations through interbreeding with HO fish. These differing selection pressures can be a result of differences in environments or a consequence of protocols and practices used by a hatchery program.

Hatchery-influenced selection can range from relaxation of selection that would normally occur in nature, to selection for different characteristics in the hatchery and natural environments, to intentional selection for desired characteristics (Waples 1999), but in this section, for the most part, we consider hatchery-influenced selection effects that are general and unintentional. Concerns about these effects, often noted as performance differences between HO and NO fish have been recorded in the scientific literature for more than 60 years (Vincent 1960, and references therein).

Genetic change and fitness reduction in natural salmon and steelhead due to hatchery-influenced selection depends on:

- The difference in selection pressures presented by the hatchery and natural environments. Hatchery environments differ from natural environments in many ways (e.g., Thorpe 2004) Some obvious ones are food, density, flows, environmental complexity, and protection from predation.

- How long the fish are reared in the hatchery environment. This varies by species, program type, and by program objective. Steelhead, coho and "stream-type" Chinook salmon are usually released as yearlings, while "ocean-type" Chinook, pink, and chum salmon are usually released at younger ages.

- The rate of gene flow between HO and NO fish, which is usually expressed as pHOS for segregated programs and PNI for integrated programs.

All three factors should be considered in evaluating risks of hatchery programs. However, because gene flow is generally more readily managed than the selection strength of the hatchery environment, current efforts to control and evaluate the risk of hatchery-influenced selection are currently largely focused on gene flow between NO and HO fish[6]. Strong selective fish culture with low hatchery-wild interbreeding can pose less risk than relatively weaker selective fish culture with high levels of interbreeding.

subjected to semi-captive rearing for a few decades. We feel "hatchery-influenced selection" is even more precise, and less subject to confusion.

[6] Gene flow between NO and HO fish is often interpreted as meaning actual matings between NO and HO fish. In some contexts, it can mean that. However, in this document, unless otherwise specified, gene flow means contributing to the same progeny population. For example, HO spawners in the wild will either spawn with other HO fish or with NO fish. NO spawners in the wild will either spawn with other NO fish or with HO fish. But all these matings, to the extent they are successful, will generate the next generation of NO fish. In other words, all will contribute to the NO gene pool.

1.2.1.4.1. Relative Reproductive Success Research

Although hundreds of papers in the scientific literature document behavioral, morphological and physiological differences between NO and HO fish, the most frequently cited research has focused on RRS of HO fish compared to NO fish determined through pedigree analysis. The influence of this type of research derives from the fact that it addresses fitness, the ability of the fish to produce progeny that will then return to sustain the population. The RRS study method is simple: genotyped NO and HO fish are released upstream to spawn, and their progeny (juveniles, adults, or both) are sampled genetically and matched with the genotyped parents. In some cases, multiple-generation pedigrees are possible.

RRS studies can be easy to misinterpret (Christie et al. 2014) for at least three reasons:

- RRS studies often have little experimental power because of limited sample sizes and enormous variation among individual fish in reproductive success (most fish leave no offspring and a few leave many). This can lead to lack of statistical significance for HO:NO comparisons even if a true difference does exist. Kalinowski and Taper (2005) provide a method for developing confidence intervals around RRS estimates that can shed light on statistical power.

- An observed difference in RRS may not be genetic. For example, Williamson et al. (2010) found that much of the observed difference in reproductive success between HO and NO fish was due to spawning location; the HO fish tended to spawn closer to the hatchery. Genetic differences in reproductive success require a multiple generation design, and only a handful of these studies are available.

- The history of the natural population in terms of hatchery ancestry can bias RRS results. Only a small difference in reproductive success of HO and NO fish might be expected if the population had been subjected to many generations of high pHOS (Willoughby and Christie 2017).

For several years, the bulk of the empirical evidence of fitness depression due to hatchery-influenced selection came from studies of species that are reared in the hatchery environment for an extended period— one to two years—before release (Berejikian and Ford 2004). Researchers and managers wondered if these results were applicable to species and life-history types with shorter hatchery residence, as it seemed reasonable that the selective effect of the hatchery environment would be less on species with shorter hatchery residence times (e.g., RIST 2009). Especially lacking was RRS information on “ocean-type” Chinook. Recent RRS work on Alaskan pink salmon, the species with the shortest hatchery residence time has found very large differences in reproductive success between HO and NO fish (Lescak et al. 2019; Shedd et al. 2022). The RRS was 0.42 for females and 0.28 for males (Lescak et al. 2019). This research suggests the “less residence time, less effect” paradigm should be revisited.

Collectively, some RRS results are now available for all eastern Pacific salmon species except sockeye salmon. Note that this is not an exhaustive list of references:

- Coho salmon (Theriault et al. 2011; Neff et al. 2015)

- Chum salmon (Berejikian et al. 2009)
- "Ocean-type" Chinook salmon (Anderson et al. 2012; Sard et al. 2015; Evans et al. 2019)
- "Stream-type" Chinook salmon (Ford et al. 2009; Williamson et al. 2010; Ford et al. 2012; Hess et al. 2012; Ford et al. 2015; Janowitz-Koch et al. 2018)
- Steelhead (Araki et al. 2007; Araki et al. 2009; Berntson et al. 2011; Christie et al. 2011)
- Pink salmon (Lescak et al. 2019; Shedd et al. 2022)

Although the size of the effect may vary, and there may be year-to-year variation and lack of statistical significance, the general pattern is clear: HO fish have lower reproductive success than NO fish.

As mentioned above, few studies have been designed to detect unambiguously a genetic component in RRS. Two such studies have been conducted with steelhead and both detected a statistically significant genetic component in steelhead (Araki et al. 2007; Christie et al. 2011; Ford et al. 2016), but the two conducted with "stream-type" Chinook salmon (Ford et al. 2012; Janowitz-Koch et al. 2018) have not detected a statistically significant genetic component.

Detecting a genetic component of fitness loss in one species and not another suggests that perhaps the impacts of hatchery-influenced selection on fitness differs between Chinook salmon and steelhead.[7] The possibility that steelhead may be more affected by hatchery-influenced selection than Chinook salmon by no means suggest that effects on Chinook are trivial, however. A small decrement in fitness per generation can lead to large fitness loss.

1.2.1.4.2. Hatchery Scientific Review Group (HSRG) Guidelines

Key concepts concerning the relationship of gene flow to hatchery-influenced selection were developed and promulgated throughout the Pacific Northwest by the Hatchery Scientific Review Group (HSRG), a congressionally funded group of federal, state, tribal, academic, and unaffiliated scientists that existed from 2000 to 2020. Because HSRG concepts have been so influential regionally, we devote the next few paragraphs to them.

The HSRG developed gene-flow guidelines based on mathematical models developed by Ford (2002) and by Lynch and O'Hely (2001). Guidelines for segregated programs are based on pHOS, but guidelines for integrated programs also include PNI, which is a function of pHOS and pNOB. PNI is, in theory, a reflection of the relative strength of selection in the hatchery and natural environments; a PNI value greater than 0.5 indicates dominance of natural selective forces.

The HSRG guidelines (HSRG 2009b) vary according to type of program and conservation importance of the population. The HSRG used conservation importance classifications that were developed by the Willamette/Lower Columbia Technical Recovery Team (McElhany et al.

[7] This would not be surprising. Although steelhead are thought of as being quite similar to the "other" species of salmon, genetic evidence suggests the two groups diverged well over 10 million years ago (Crête-Lafrenière et al. 2012).

2003).[8] (Table 1). In considering the guidelines, we equate “primary” with a recovery goal of “viable” or “highly viable”, and “contributing” with a recovery goal of “maintain”. We disregard the guidelines for “stabilizing”, because we feel they are inadequate for conservation guidance.

Table 1. HSRG gene flow guidelines (HSRG 2009b).

	Program classification	
Population conservation importance	Integrated	Segregated
Primary	PNI $\geq$ 0.67 and pHOS $\leq$ 0.30	pHOS $\leq$ 0.05
Contributing	PNI $\geq$ 0.50 and pHOS $\leq$ 0.30	pHOS $\leq$ 0.10
Stabilizing	Existing conditions	Existing conditions

Although they are controversial, the HSRG gene flow guidelines have achieved a considerable level of regional acceptance. They were adopted as policy by the Washington Fish and Wildlife Commission (WDFW 2009), and were recently reviewed and endorsed by a WDFW scientific panel, who noted that the “…HSRG is the primary, perhaps only entity providing guidance for operating hatcheries in a scientifically defensible manner…” (Anderson et al. 2020). In addition, HSRG principles have been adopted by the Canadian Department of Fisheries and Oceans, with very similar gene-flow guidelines for some situations (Withler et al. 2018)[9].

The gene flow guidelines developed by the HSRG have been implemented in areas of the Pacific Northwest for at most 15 years, so there has been insufficient time to judge their effect. They have also not been applied consistently, which complicates evaluation. However, the benefits of high pNOB (in the following cases, 100 percent) has been credited with limiting genetic change and fitness loss in supplemented Chinook populations in the Yakima (Washington) (Waters et al. 2015) and Salmon (Idaho) (Hess et al. 2012; Janowitz-Koch et al. 2018) basins.

Little work toward developing guidelines beyond the HSRG work has taken place. The only notable effort along these lines has been the work of Baskett and Waples (2013), who developed a model very similar to that of Ford (2002), but added the ability to impose density-dependent survival and selection at different life stages. Their qualitative results were similar to Ford’s, but the model would require some revision to be used to develop guidelines comparable to the HSRG’s.

NMFS has not adopted the HSRG gene flow guidelines per se. However, at present the HSRG guidelines are the only scientifically based quantitative gene flow guidelines available for reducing the risk of hatchery-influenced selection. NMFS has considerable experience with the HSRG guidelines. They are based on a model (Ford 2002) developed by a NMFS geneticist, they have been evaluated by a NMFS-lead scientific team (RIST 2009), and NMFS scientists have extended the Ford model for more flexible application of the guidelines to complex situations (Busack 2015) (Section 1.2.1.4.3).

[8] Development of conservation importance classifications varied among technical recovery teams (TRTs); for more information, documents produced by the individual TRT’s should be consulted.
[9] Withler et al. (2018) noted a non-genetic biological significance to a pHOS level of 30%. Assuming mating is random with respect to origin (HO or NO) in a spawning aggregation of HO and NO fish, NOxNO matings will comprise the majority of matings only if pHOS is less than 30%.

At minimum, we consider the HSRG guidelines a useful screening tool. For a particular program, based on specifics of the program, broodstock composition, and environment, we may consider a pHOS or PNI level to be a lower risk than the HSRG would but, generally, if a program meets HSRG guidelines, we will typically consider the risk levels to be acceptable. However, our approach to application of HSRG concepts varies somewhat from what is found in HSRG documents or in typical application of HSRG concepts. Key aspects of our approach warrant discussion here.

1.2.1.4.2.1. **PNI and segregated hatchery programs**

The PNI concept has created considerable confusion. Because it is usually estimated by a simple equation that is applicable to integrated programs, and applied in HSRG guidelines only to integrated programs, PNI is typically considered to be a concept that is relevant only to integrated programs. This in turn has caused a false distinction between segregated and integrated programs in terms of perceptions of risk. The simple equation for PNI is:

$PNI \approx pNOB / (pNOB + pHOS)$.

In a segregated program, pNOB equals zero, so by this equation PNI would also be zero. You could easily infer that PNI is zero in segregated programs, but this would be incorrect. The error comes from applying the equation to segregated programs. In integrated programs, PNI can be estimated accurately by the simple equation, and the simplicity of the equation makes it very easy to use. In segregated programs, however, a more complicated equation must be used to estimate PNI. A PNI equation applicable to both integrated and segregated programs was developed over a decade ago by the HSRG (HSRG 2009a, equation 9), but has been nearly completed ignored by parties dealing with the gene flow guidelines:

$$PNI \approx \frac{h^2 + (1.0 - h^2 + \omega^2) * pNOB}{h^2 + (1.0 - h^2 + \omega^2) * (pNOB + pHOS)},$$

where h^2 is heritability and ω^2 is the strength of selection in standard deviation units, squared. Ford (2002) used a range of values for the latter two variables. Substituting those values that created the strongest selection scenarios in his simulations (h^2 of 0.5 and ω^2 of 10), which is appropriate for risk assessment, results in:

$$PNI \approx \frac{0.5 + 10.5 * pNOB}{0.5 + 10.5 * (pNOB + pHOS)}$$

HSRG (2004) offered additional guidance regarding isolated programs, stating that risk increases dramatically as the level of divergence increases, especially if the hatchery stock has been selected directly or indirectly for characteristics that differ from the natural population. More recently, the HSRG concluded that the guidelines for isolated programs may not provide as much protection from fitness loss as the corresponding guidelines for integrated programs (HSRG 2014). This can be easily demonstrated using the equation presented in the previous paragraph: a pHOS of 0.05, the standard for a primary population affected by a segregated program, yields a

PNI of 0.49, whereas a pHOS of 0.024 yields a PNI of 0.66, virtually the same as the standard for a primary population affected by an integrated program.

1.2.1.4.2.2. **The effective pHOS concept**

The HSRG recognized that HO fish spawning naturally may on average produce fewer adult progeny than NO spawners, as described above. To account for this difference, the HSRG (2014) defined *effective* pHOS as:

$$pHOS_{eff} = (RRS * HOS_{census}) / (NOS + RRS * HOS_{census}),$$

where RRS is the reproductive success of HO fish relative to that of NO fish. They then recommend using this value in place of $pHOS_{census}$ in PNI calculations.

We feel that adjustment of census pHOS by RRS for this purpose should be done not nearly as freely as the HSRG document would suggest because the Ford (2002) model, which is the foundation of the HSRG gene-flow guidelines, implicitly includes a genetic component of RRS. In that model, hatchery fish are expected to have RRS < 1 (compared to natural fish) due to selection in the hatchery. A component of reduced RRS of hatchery fish is therefore already incorporated in the model and by extension the calculation of PNI. Therefore, reducing pHOS values by multiplying by RRS will result in underestimating the relevant pHOS and therefore overestimating PNI. Such adjustments would be particularly inappropriate for hatchery programs with low pNOB, as these programs may well have a substantial reduction in RRS due to genetic factors already incorporated in the model.

In some cases, adjusting pHOS downward may be appropriate, particularly if there is strong evidence of a non-genetic component to RRS. Wenatchee spring Chinook salmon (Williamson et al. 2010) is an example case with potentially justified adjustment by RRS, where the spatial distribution of NO and HO spawners differs, and the HO fish tend to spawn in poorer habitat. However, even in a situation like the Wenatchee spring Chinook salmon, it is unclear how much of an adjustment would be appropriate.

By the same logic, it might also be appropriate to adjust pNOB in some circumstances. For example, if hatchery juveniles produced from NO broodstock tend to mature early and residualize (due to non-genetic effects of rearing), as has been documented in some spring Chinook salmon and steelhead programs, the “effective” pNOB might be much lower than the census pNOB.

It is important to recognize that PNI is only an approximation of relative trait value, based on a model that is itself very simplistic. To the degree that PNI fails to capture important biological information, it would be better to work to include this biological information in the underlying models rather than make ad hoc adjustments to a statistic that was only intended to be a rough guideline to managers. We look forward to seeing this issue further clarified in the near future. In the meantime, except for cases in which an adjustment for RRS has strong justification, we feel that census pHOS, rather than effective pHOS, is the appropriate metric to use for genetic risk evaluation.

1.2.1.4.2.3. Gene flow guidelines in phases of recovery

In 2012 the HSRG expanded on the original gene flow guidelines/standards by introducing the concept of recovery phases for natural populations (HSRG 2012), and then refined the concept in later documents (HSRG 2014; 2015; 2017). They defined and described four phases:

1. Preservation
2. Re-colonization
3. Local adaptation
4. Fully restored

The HSRG provided guidance on development of quantitative "triggers" for determining when a population had moved (up or down) from one phase to another. As explained in HSRG (2015), in the preservation and re-colonization phase, no PNI levels were specified for integrated programs (Table 1). The emphasis in these phases was to "Retain genetic diversity and identity of the existing population". In the local adaptation phase, when PNI standards were to be applied, the emphasis shifted to "Increase fitness, reproductive success and life history diversity through local adaptation (e.g., by reducing hatchery influence by maximizing *PNI*)". The HSRG provided additional guidance in HSRG (2017), which encouraged managers to use pNOB to "…the extent possible…" during the preservation and recolonization phases.

Table 2. HSRG gene flow guidelines/standards for conservation and harvest programs, based on recovery phase of impacted population (Table 2 from HSRG 2015).

Natural Population		Hatchery Broodstock Management	
Designation	Status	Segregated	Integrated
Primary	Fully Restored	pHOS<5%	PNI>0.67
	Local Adaptation	pHOS<5%	PNI>0.67
	Re-colonization	pHOS<5%	Not Specified
	Preservation	pHOS<5%	Not Specified
Contributing	Fully Restored	pHOS<10%	PNI>0.50
	Local Adaptation	pHOS<10%	PNI>0.50
	Re-colonization	pHOS<10%	Not Specified
	Preservation	pHOS<10%	Not Specified
Stabilizing	Fully Restored	Current Condition	Current Condition
	Local Adaptation	Current Condition	Current Condition
	Re-colonization	Current Condition	Current Condition
	Preservation	Current Condition	Current Condition

We have two concerns regarding the phases of recovery approach. First, although the phase structure is intuitively appealing, no scientific evidence was presented the HSRG for existence of the phases. Second, while we agree that conservation of populations at perilously low abundance may require prioritization of demographic over genetic concerns, we are concerned that high pHOS/low PNI regimes imposed on small recovering populations may prevent them from advancing to higher recovery phases[10]. A WDFW scientific panel reviewing HSRG principles and guidelines reached the same conclusion (Anderson et al. 2020). In response, the HSRG in issued revised guidance for the preservation and recolonization phases (HSRG 2020):

1. *Preservation – No specific pHOS or PNI recommendations, but hatchery managers are encouraged to use as many NOR brood as possible. In some cases (e.g., very low R/S values at low spawner abundances or low intrinsic productivity), it may be preferable to use all available NORs in the hatchery brood and allow only extra hatchery-origin recruits (HORs) to spawn naturally.*

2. *Recolonization – No specific pHOS or PNI recommendations, but managers are encouraged to continue to use some NOR in broodstock (perhaps 10%-30% of NORs), while allowing the majority of NORs to spawn naturally.*

1.2.1.4.3. Extension of PNI modeling to more than two population components

The Ford (2002) model considered a single population affected by a single hatchery program—basically two population units connected by gene flow—but the recursion equations underlying the model are easily expanded to more than two populations (Busack 2015). This has resulted in tremendous flexibility in applying the PNI concept to hatchery consultations.

A good example is a system of genetically linked hatchery programs, an integrated program in which in which returnees from a (typically smaller) integrated hatchery program are used as broodstock for a larger segregated program, and both programs contribute to pHOS (Figure 3). It seems logical that this would result in less impact to the natural population than if the segregated program used only its own returnees as broodstock, but because the two-population implementation of the Ford model did not apply, there was no way to calculate PNI for this system.

Extending Ford's recursion equations (equations 5 and 6) to three populations allowed us to calculate PNI for a system of this type. We successfully applied this approach to link two spring Chinook salmon hatchery programs: Winthrop NFH (segregated) and Methow FH (integrated). By using some level of Methow returnees as broodstock for the Winthrop program, PNI for the natural population could be increased significantly[11](Busack 2015). We have since used the multi-population PNI model in numerous hatchery program consultations in Puget Sound and the Columbia basin, and have extended to it to include as many as ten hatchery programs and natural production areas.

[10] According to Andy Appleby, past HSRG co-chair, the HSRG never intended this guidance to be interpreted as total disregard for pHOS/PNI standards in the preservation and recovery phases (Appleby 2020).
[11] Such programs can lower the effective size of the system, but the model of Tufto (Section 1.2.1.4) can easily be applied to estimate this impact.

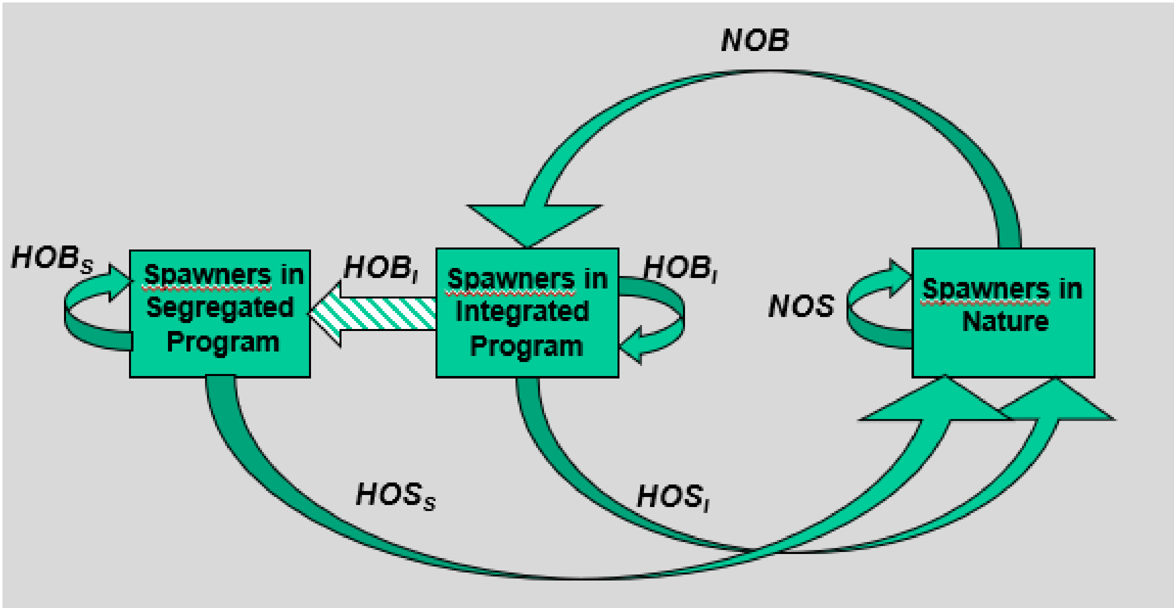

Figure 2. Example of genetically linked hatchery programs. The natural population is influenced by hatchery-origin spawners from an integrated (HOS_I) and a segregated program (HOS_S). The integrated program uses a mix of natural-origin (NOB) and its own returnees (HOB_I) as broodstock, but the segregated uses returnees from the integrated program (HOB_I above striped arrow) as all or part of its broodstock, genetically linking the two programs. The system illustrated here is functionally equivalent to the HSRG's (HSRG 2014)"stepping stone" concept.

1.2.1.4.4. California HSRG

Another scientific team was assembled to review hatchery programs in California and this group developed guidelines that differed somewhat from those developed by the "Northwest" HSRG (California HSRG 2012). The California team:

- Felt that truly isolated programs in which no HO returnees interact genetically with natural populations were impossible in California, and was "generally unsupportive" of the concept of segregated programs. However, if programs were to be managed as isolated, they recommend a pHOS of less than 5 percent.

- Rejected development of overall pHOS guidelines for integrated programs because the optimal pHOS will depend upon multiple factors, such as "the amount of spawning by NO fish in areas integrated with the hatchery, the value of pNOB, the importance of the integrated population to the larger stock, the fitness differences between HO and NO fish, and societal values, such as angling opportunity."

- Recommended that program-specific plans be developed with corresponding population-specific targets and thresholds for pHOS, pNOB, and PNI that reflect these factors. However, they did state that PNI should exceed 50 percent in most cases, although in supplementation or reintroduction programs the acceptable pHOS could be much higher than 5 percent, even approaching 100 percent at times.

- Recommended for conservation programs that pNOB approach 100 percent, but pNOB levels should not be so high they pose demographic risk to the natural population by taking too large a proportion of the population for broodstock.

1.2.2. Ecological effects

Ecological effects for this factor (i.e., hatchery fish and the progeny of naturally spawning hatchery fish on the spawning grounds) refer to effects from competition for spawning sites and redd superimposition, contributions to marine-derived nutrients, and the removal of fine sediments from spawning gravels. Ecological effects on the spawning grounds may be positive or negative.

To the extent that hatcheries contribute added fish to the ecosystem, there can be positive effects. For example, when anadromous salmonids return to spawn, hatchery-origin and natural-origin alike, they transport marine-derived nutrients stored in their bodies to freshwater and terrestrial ecosystems. Their carcasses provide a direct food source for juvenile salmonids and other fish, aquatic invertebrates, and terrestrial animals, and their decomposition supplies nutrients that may increase primary and secondary production (Kline et al. 1990; Piorkowski 1995; Larkin and Slaney 1996; Gresh et al. 2000; Murota 2003; Quamme and Slaney 2003; Wipfli et al. 2003). As a result, the growth and survival of juvenile salmonids may increase (Hager and Noble 1976; Bilton et al. 1982; Holtby 1988; Ward and Slaney 1988; Hartman and Scrivener 1990; Johnston et al. 1990; Larkin and Slaney 1996; Quinn and Peterson 1996; Bradford et al. 2000; Bell 2001; Brakensiek 2002).

Additionally, studies have demonstrated that perturbation of spawning gravels by spawning salmonids loosens cemented (compacted) gravel areas used by spawning salmon (e.g., (Montgomery et al. 1996). The act of spawning also coarsens gravel in spawning reaches, removing fine material that blocks interstitial gravel flow and reduces the survival of incubating eggs in egg pockets of redds.

The added spawner density resulting from hatchery-origin fish spawning in the wild can have negative consequences, such as increased competition, and potential for redd superimposition. Although males compete for access to females, female spawners compete for spawning sites. Essington et al. (2000) found that aggression of both sexes increases with spawner density, and is most intense with conspecifics. However, females tended to act aggressively towards heterospecifics as well. In particular, when there is spatial overlap between natural-and hatchery-origin spawners, the potential exists for hatchery-derived fish to superimpose or destroy the eggs and embryos of ESA-listed species. Redd superimposition has been shown to be a cause of egg loss in pink salmon and other species (e.g., Fukushima et al. 1998).

1.2.3. Adult Collection Facilities

The analysis also considers the effects from encounters with natural-origin fish that are incidental to broodstock collection. Here, NMFS analyzes effects from sorting, holding, and handling natural-origin fish in the course of broodstock collection. Some programs collect their broodstock from fish voluntarily entering the hatchery, typically into a ladder and holding pond, while others sort through the run at large, usually at a weir, ladder, or sampling facility. The more a hatchery program accesses the run at large for hatchery broodstock – that is, the more fish that are handled or delayed during migration – the greater the negative effect on natural- and hatchery-origin fish that are intended to spawn naturally and on ESA-listed species. The information NMFS uses for this analysis includes a description of the facilities, practices, and protocols for collecting broodstock, the environmental conditions under which broodstock collection is conducted, and the encounter rate for ESA-listed fish.

NMFS also analyzes the effects of structures, either temporary or permanent, that are used to collect hatchery broodstock, and remove hatchery fish from the river or stream and prevent them from spawning naturally, on juvenile and adult fish from encounters with these structures. NMFS determines through the analysis, for example, whether the spatial structure, productivity, or abundance of a natural population is affected when fish encounter a structure used for broodstock collection, usually a weir or ladder.

1.3. Factor 3. Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas, the migratory corridor, estuary, and ocean (Revised June 1, 2020)

NMFS also analyzes the potential for competition, predation, and disease when the progeny of naturally spawning hatchery fish and hatchery releases share juvenile rearing areas.

1.3.1. Competition

Competition and a corresponding reduction in productivity and survival may result from direct or indirect interactions. Direct interactions occur when hatchery-origin fish interfere with the accessibility to limited resources by natural-origin fish, and indirect interactions occur when the utilization of a limited resource by hatchery fish reduces the amount available for fish from the natural population (Rensel et al. 1984). Natural-origin fish may be competitively displaced by hatchery fish early in life, especially when hatchery fish are more numerous, are of equal or greater size, take up residency before natural-origin fry emerge from redds, and residualize. Hatchery fish might alter natural-origin salmon behavioral patterns and habitat use, making natural-origin fish more susceptible to predators (Hillman and Mullan 1989; Steward and Bjornn 1990). Hatchery-origin fish may also alter natural-origin salmonid migratory responses or movement patterns, leading to a decrease in foraging success by the natural-origin fish (Hillman and Mullan 1989; Steward and Bjornn 1990). Actual impacts on natural-origin fish thus depend on the degree of dietary overlap, food availability, size-related differences in prey selection, foraging tactics, and differences in microhabitat use (Steward and Bjornn 1990).

Several studies suggest that salmonid species and migratory forms that spend longer periods of time in stream habitats (e.g., coho salmon and steelhead) are more aggressive than those that outmigrate at an earlier stage (Hutchison and Iwata 1997). The three least aggressive species generally outmigrate to marine (chum salmon) or lake (kokanee and sockeye salmon) habitats as post-emergent fry. The remaining (i.e., more aggressive) species all spend one year or more in stream habitats before outmigrating. Similarly, Hoar (1951) did not observe aggression or territoriality in fry of early migrants (chum and pink salmon), in contrast to fry of a later migrating species (coho salmon) which displayed high levels of both behaviors. Hoar (1954) rarely observed aggression in sockeye salmon fry, and observed considerably less aggression in sockeye than coho salmon smolts. Taylor (1990) found that Chinook salmon populations that outmigrate as fry are less aggressive than those that outmigrate as parr, which in turn are less aggressive than those that outmigrate as yearlings.

Although *intraspecific* interactions are expected to be more frequent/intense than *interspecific* interactions (e.g., Hartman 1965; Tatara and Berejikian 2012), this apparent relationship between aggression and stream residence appears to apply to *interspecific* interactions as well. For example, juvenile coho salmon are known to be highly aggressive toward other species (e.g., Stein et al. 1972; Taylor 1991). Taylor (1991) found that coho salmon were much more aggressive toward size-matched *ocean*-type Chinook salmon (early outmigrants), but only moderately more aggressive toward size-matched *stream*-type Chinook salmon (later outmigrants). Similarly, the findings of Hasegawa et al. (2014) indicate that masu salmon (*O. masou*) , which spend 1 to 2 years in streams before outmigrating, dominate and outcompete the early-migrating chum salmon.

A few exceptions to this general stream residence-aggression pattern have been observed (e.g., Lahti et al. 2001; Young 2003; Hasegawa et al. 2004; Young 2004), but all the species and migratory forms evaluated in these studies spend one year or more in stream habitat before outmigrating. Other than the Taylor (1991) and Hasegawa et al. (2014) papers noted above, we are not aware of any other studies that have looked specifically at interspecific interactions between early-outmigrating species (e.g., sockeye, chum, and pink salmon) and those that rear longer in streams.

En masse hatchery salmon and steelhead smolt releases may cause displacement of rearing natural-origin juvenile salmonids from occupied stream areas, leading to abandonment of advantageous feeding stations, or to premature out-migration by natural-origin juveniles. Pearsons et al. (1994) reported small-scale displacement of naturally produced juvenile rainbow trout from stream sections by hatchery steelhead. Small-scale displacements and agonistic interactions observed between hatchery steelhead and natural-origin juvenile trout were most likely a result of size differences and not something inherently different about hatchery fish, such as behavior.

A proportion of the smolts released from a hatchery may not migrate to the ocean but rather reside for a time near the release point. These non-migratory smolts (residuals) may compete for food and space with natural-origin juvenile salmonids of similar age (Bachman 1984; Tatara and Berejikian 2012). Although this behavior has been studied and observed most frequently in hatchery steelhead, residualism has been reported as a potential issue for hatchery coho and Chinook salmon as well (Parkinson et al. 2017). Adverse impacts of residual hatchery Chinook and coho salmon on natural-origin salmonids can occur, especially given that the number of smolts per release is generally higher than for steelhead; however, residualism in these species has not been as widely investigated as it has in steelhead. Therefore, for all species, monitoring of natural stream areas near hatchery release points may be necessary to determine the potential effects of hatchery smolt residualism on natural-origin juvenile salmonids.

The risk of adverse competitive interactions between hatchery- and natural-origin fish can be minimized by:

- Releasing hatchery smolts that are physiologically ready to migrate. Hatchery fish released as smolts emigrate seaward soon after liberation, minimizing the potential for competition with juvenile natural-origin fish in freshwater (Steward and Bjornn 1990; California HSRG 2012)
- Rearing hatchery fish to a size sufficient to ensure that smoltification occurs
- Releasing hatchery smolts in lower river areas, below rearing areas used by natural-origin juveniles
- Monitoring the incidence of non-migratory smolts (residuals) after release and adjusting rearing strategies, release location, and release timing if substantial competition with natural-origin juveniles is likely

Critical information for analyzing competition risk is quality and quantity of spawning and rearing habitat in the action area,[12] including the distribution of spawning and rearing habitat by quality, and best estimates for spawning and rearing habitat capacity. Additional important information includes the abundance, distribution, and timing for naturally spawning hatchery fish and natural-origin fish; the timing of emergence; the distribution and estimated abundance for progeny from both hatchery and natural-origin natural spawners; the abundance, size, distribution, and timing for juvenile hatchery fish in the action area; and the size of hatchery fish relative to co-occurring natural-origin fish.

1.3.2. Predation

Predation is another potential ecological effect of hatchery releases. Predation, either direct (consumption by hatchery fish) or indirect (increases in predation by other predator species due to enhanced attraction), can result from hatchery fish released into the wild. Here we consider predation by hatchery-origin fish, by the progeny of naturally spawning hatchery fish, and by birds and other non-piscine predators attracted to the area by an abundance of hatchery fish.

Hatchery fish originating from egg boxes and fish planted as non-migrant fry or fingerlings can prey upon fish from the local natural population during juvenile rearing. Hatchery fish released at a later stage that are more likely to migrate quickly to the ocean, can still prey on fry and fingerlings that are encountered during the downstream migration. Some of these hatchery fish do not emigrate and instead take up residence in the stream where they can prey on stream-rearing juveniles over a more prolonged period, as discussed above. The progeny of naturally spawning hatchery fish also can prey on fish from a natural population and pose a threat.

Predation may be greatest when large numbers of hatchery smolts encounter newly emerged fry or fingerlings, or when hatchery fish are large relative to natural-origin fish (Rensel et al. 1984). Due to their location in the stream, size, and time of emergence, newly emerged salmonid fry are likely to be the most vulnerable to predation. Their vulnerability is greatest immediately upon emergence from the gravel and then decreases as they move into shallow, shoreline areas

[12] “Action area,” in ESA section 7 analysis documents, means all areas to be affected directly or indirectly by the action in which the effects of the action can be meaningfully detected and evaluated.

(USFWS 1994). Emigration out of important rearing areas and foraging inefficiency of newly released hatchery smolts may reduce the degree of predation on salmonid fry (USFWS 1994).

Some reports suggest that hatchery fish can prey on fish that are as large as 1/2 their length (Hargreaves and LeBrasseur 1986; Pearsons and Fritts 1999; HSRG 2004 and references therein), but other studies have concluded that salmonid predators prey on fish up to 1/3 their length (Horner 1978; Hillman and Mullan 1989; Beauchamp 1990; Cannamela 1992; CBFWA 1996; Daly et al. 2009). Hatchery fish may also be less efficient predators as compared to their natural-origin conspecifics, reducing the potential for predation impacts (Sosiak et al. 1979; Bachman 1984; Olla et al. 1998).

Size is an important determinant of how piscivorous hatchery-origin fish are. Keeley and Grant (2001) reviewed 93 reports detailing the relationship between size and piscivory in 17 species of stream-dwelling salmonids. *O. mykiss* and Pacific salmon were well represented in the reviewed reports. Although there is some variation between species, stream-dwelling salmonids become piscivorous at about 100 mm FL, and then piscivory rate increases with increasing size. For example:

- For 140 mm fish, 15% would be expected to have fish in their diet but would not be primarily piscivorous; 2% would be expected to be primarily piscivorous (> 60% fish in diet).
- For 200 mm fish, those figures go to 32% (fish in diet) and 11% (primarily piscivorous).

The implication for hatchery-origin fish is pretty clear: larger hatchery-origin fish present a greater predation risk because more of them eat fish, and more of them eat primarily fish.

There are two key measures that hatchery programs can implement to reduce or avoid the threat of predation:

- Ensuring that a high proportion of the hatchery fish are fully smolted. Juvenile salmon tend to migrate seaward rapidly when fully smolted, limiting the duration of interaction between hatchery- and natural-origin fish present within and downstream of release areas.
- Releasing hatchery smolts in lower river areas near river mouths and below upstream areas used for stream-rearing young-of-the-year naturally produced salmon fry, thereby reducing the likelihood for interaction between the hatchery and naturally produced fish.

The two measures just mentioned will reduce minimize residualism as well as predation. The following measures can also help minimize residualism:

- Allowing smolts to exit the hatchery facility volitionally rather than forcing them out
- Ensuring that hatchery rearing regimes and growth rates produce fish that meet the minimum size needed for smolting, but are not so large as to induce desmoltification or early maturation

- Removing potential residuals based on size or appearance before release. This is likely impractical in most cases

1.3.3. Disease

The release of hatchery fish, as well as hatchery effluent, into juvenile rearing areas can lead to pathogen transmission; and contact with chemicals, or altering environmental conditions (e.g., dissolved oxygen) can result in disease outbreaks. Fish diseases can be subdivided into two main categories:

- Infectious diseases are those caused by pathogens such as viruses, bacteria, and parasites.
- Noninfectious diseases are those that cannot be transmitted between fish and are typically caused by environmental factors (e.g., low dissolved oxygen), but can also have genetic causes.

Pathogens can be categorized as exotic or endemic. For our purposes, exotic pathogens are those that have little to no history of occurrence within the boundaries of the state where the hatchery program is located. For example, *Oncorhynchus masou* virus (OMV) would be considered an exotic pathogen if identified anywhere in Washington state because it is not known to occur there. Endemic pathogens are native to a state, but may not be present in all watersheds.

In natural fish populations, the risk of disease associated with hatchery programs may increase through a variety of mechanisms (Naish et al. 2007), discussed below:

- Introduction of exotic pathogens
- Introduction of endemic pathogens to a new watershed
- Intentional release of infected fish or fish carcasses
- Continual pathogen reservoir
- Pathogen amplification

The last two terms above require some explanation. A continual pathogen reservoir is created when a standing crop of susceptible hosts keeps the pathogen from burning itself out. For example, stocking certain susceptible strains of trout can ensure that the pathogen is always present. Pathogen amplification occurs when densities of pathogens that are already present increase beyond baseline levels due to hatchery activities. A good example is sea lice in British Columbia (e.g., Krkošek 2010). The pathogen is endemic to the area and is normally present in wild populations, but salmon net pens potentially allow for a whole lot more pathogen to be produced and added to the natural environment.

Continual pathogen reservoir and pathogen amplification can exist at the same time. For example, stocked rainbow trout can amplify a naturally occurring pathogen if they become infected, and if stocking occurs every year, the stocked animals also can act as a continual pathogen reservoir.

Pathogen transmission between hatchery and natural fish can occur indirectly through hatchery water influent/effluent or directly via contact with infected fish. Within a hatchery, the likelihood of transmission leading to an epizootic (i.e., disease outbreak) is increased compared to the natural environment because hatchery fish are reared at higher densities and closer proximity than would naturally occur. During an epizootic, hatchery fish can shed relatively large amounts of pathogen into the hatchery effluent and ultimately, the environment, amplifying pathogen numbers. However, few, if any, examples of hatcheries contributing to an increase in disease in natural populations have been reported (Steward and Bjornn 1990; Naish et al. 2007). This lack of reporting is because both hatchery and natural-origin salmon and trout are susceptible to the same pathogens (Noakes et al. 2000), which are often endemic and ubiquitous (e.g., *Renibacterium salmoninarum,* the cause of Bacterial Kidney Disease).

Several state, federal, and tribal fish health policies, in some cases combined with state law, limit the disease risks associated with hatchery programs (IHOT 1995; ODFW 2003; USFWS 2004; WWTIT and WDFW 2006). Specifically, the policies govern the transfer of fish, eggs, carcasses, and water to prevent the spread of exotic and endemic pathogens. For example, the policy for Washington (WWTIT and WDFW 2006) divides the state into 14 Fish Health Management Zones[13] (FHMZs), and specifies requirements for transfers within and across FHMZs. Washington state law lists pathogens for which monitoring and reporting is required (regulated pathogens), and the Washington Department of Fish and Wildlife typically requires monitoring and reporting for additional pathogens. Reportable pathogen occurrence at a Washington hatchery is communicated to the state veterinarian, but also to fish health personnel at a variety of levels: local, tribal, state, and federal.

For all pathogens, both reportable and non-reportable, pathogen spread and amplification are minimized through regular monitoring (typically monthly) removing mortalities, and disinfecting all eggs. Vaccines may provide additional protection from certain pathogens when available (e.g., *Vibrio anguillarum*). If a pathogen is determined to be the cause of fish mortality, treatments (e.g., antibiotics) will be used to limit further pathogen transmission and amplification. Some pathogens, such as *infectious hematopoietic necrosis virus* (IHNV), have no known treatment. Thus, if an epizootic occurs for those pathogens, the only way to control pathogen amplification is to cull infected individuals or terminate all susceptible fish. In addition, current hatchery operations often rear hatchery fish on a timeline that mimics their natural life history, which limits the presence of fish susceptible to pathogen infection and prevents hatchery fish from becoming a pathogen reservoir when no natural fish hosts are present.

In addition to the state, federal, and tribal fish health policies, disease risks can be further minimized by preventing pathogens from entering the hatchery through the treatment of incoming water (e.g., by using ozone), or by leaving the hatchery through hatchery effluent (Naish et al. 2007). Although preventing the exposure of fish to any pathogens before their release into the natural environment may make the hatchery fish more susceptible to infection after release into the natural environment, reduced fish densities in the natural environment

[13] Puget Sound consists of five FHMZs, the Columbia basin only 1.

compared to hatcheries likely reduces the risk of fish encountering pathogens at infectious levels (Naish et al. 2007).

Treating the hatchery effluent reduces pathogen amplification, but does not reduce disease outbreaks within the hatchery caused by pathogens present in the incoming water supply. Another challenge with treating hatchery effluent is the lack of reliable, standardized guidelines for testing or a consistent practice of controlling pathogens in effluent (LaPatra 2003). However, hatchery facilities located near marine waters likely limit freshwater pathogen amplification downstream of the hatchery without human intervention because the pathogens are killed before transmission to fish when the effluent mixes with saltwater.

Noninfectious diseases are typically caused by environmental factors (e.g., low dissolved oxygen). Hatchery facilities routinely use a variety of chemicals for treatment and sanitation purposes. Chlorine levels in the hatchery effluent, specifically, are monitored with a National Pollutant Discharge Elimination System (NPDES) permit administered by the Environmental Protection Agency. Other chemicals are discharged in accordance with manufacturer instructions. The NPDES permit also requires regular monitoring of settleable and unsettleable solids, temperature, and dissolved oxygen in the hatchery effluent to ensure compliance with environmental standards and to prevent fish mortality.

In contrast to infectious diseases, which typically are manifest by a limited number of life stages and over a protracted time period, non-infectious diseases caused by environmental factors typically affect all life stages of fish indiscriminately and over a relatively short time period. Because of the vast literature available on rearing of salmon and trout in aquaculture, one group of non-infectious diseases that are expected to occur rarely in current hatchery operations are those caused by nutritional deficiencies

1.3.4. Ecological Modeling

While competition, predation, and disease are important effects to consider, they are events which can rarely, if ever, be observed and directly measured. However, these behaviors have been established to the point where NMFS can model these potential effects to the species based on known factors that lead to competition or predation occurring. In our Biological Opinions, we use the Predation, Competition, and Delayed Mortality (PCD) Risk model version 4.1.0 based on Pearsons and Busack (2012). PCD Risk is an individual-based model that simulates the potential number of ESA-listed natural-origin juveniles lost to competition, predation, and delayed mortality (from disease, starvation, etc.) due to the release of hatchery-origin juveniles in the freshwater environment.

The PCD Risk model has undergone considerable modification since 2012 to increase supportability, reliability, transparency, and ease of use. Notably, the current version no longer operates as a compiled FORTRAN program in a Windows environment. The current version of the PCD Risk model (Version 4.1.0) is an R package (R Core Team 2019). A macro-enabled Excel workbook is included as an interface to the model that is used as a template for creating model scenarios, running the model, and reporting results. Users with knowledge of the R programming language have flexibility to develop and run more complex scenarios than can be created by the Excel template. The current model version no longer has a probabilistic mode for defining input parameter values. We also further refined the model by allowing for multiple hatchery release groups of the same species to be included in a single run.

There have also been a few recent modifications to the logic and parameterization of the model. The first was the elimination of competition equivalents and replacement of the disease function with a delayed mortality parameter. The rationale behind this change was to make the model more realistic; competition rarely directly results in death in the model because it takes many competitive interactions to suffer enough weight loss to kill a fish. Weight loss is how adverse competitive interactions are captured in the model. However, fish that lose competitive interactions and suffer some degree of weight loss are likely more vulnerable to mortality from other factors such as disease or predation by other fauna such as birds or bull trout. Now, at the end of each run, the competitive impacts for each fish are assessed, and the fish has a probability of delayed mortality based on the competitive impacts. This function will be subject to refinement based on research. For now, the probability of delayed mortality is equal to the proportion of a fish's weight loss. For example, if a fish has lost 10% of its body weight due to competition and a 50% weight loss kills a fish, then it has a 20% probability of delayed death, (0.2 = 0.1/0.5).

Another change in logic was to the habitat segregation parameter to make it size-independent or size-dependent based on hatchery species. Some species, such as coho salmon, are more aggressive competitors than other species, such as chum and sockeye salmon. To represent this difference in behavior more accurately in the model, for less aggressive species such as chum and sockeye salmon, hatchery fish segregation is random, whereas for more aggressive species, segregation occurs based on size, with the largest fish eliminated from the model preferentially.

1.3.5. Acclimation

One factor that can affect hatchery fish distribution and the potential to spatially overlap with natural-origin spawners, and thus the potential for genetic and ecological impacts, is the acclimation (the process of allowing fish to adjust to the environment in which they will be released) of hatchery juveniles before release. Acclimation of hatchery juveniles before release increases the probability that hatchery adults will home back to the release location, reducing their potential to stray into natural spawning areas.

Acclimating fish for a time also allows them to recover from the stress caused by the transportation of the fish to the release location and by handling. Dittman and Quinn (2008) provide an extensive literature review and introduction to homing of Pacific salmon. They note that, as early as the 19th century, marking studies had shown that salmonids would home to the stream, or even the specific reach, where they originated. The ability to home to their home or "natal" stream is thought to be due to odors to which the juvenile salmonids were exposed while living in the stream (olfactory imprinting) and migrating from it years earlier (Dittman and Quinn 2008; Keefer and Caudill 2014). Fisheries managers use this innate ability of salmon and steelhead to home to specific streams by using acclimation ponds to support the reintroduction of species into newly accessible habitat or into areas where they have been extirpated (Quinn 1997; Dunnigan 1999; YKFP 2008).

Dittman and Quinn (2008) reference numerous experiments that indicated that a critical period for olfactory imprinting is during the parr-smolt transformation, which is the period when the salmonids go through changes in physiology, morphology, and behavior in preparation for transitioning from fresh water to the ocean (Hoar 1976; Beckman et al. 2000). Salmon species with more complex life histories (e.g., sockeye salmon) may imprint at multiple times from emergence to early migration (Dittman et al. 2010). Imprinting to a particular location, be it the hatchery, or an acclimation pond, through the acclimation and release of hatchery salmon and steelhead is employed by fisheries managers with the goal that the hatchery fish released from these locations will return to that particular site and not stray into other areas (Fulton and Pearson 1981; Quinn 1997; Hard and Heard 1999; Bentzen et al. 2001; Kostow 2009; Westley et al. 2013). However, this strategy may result in varying levels of success in regards to the proportion of the returning fish that stray outside of their natal stream. (e.g., (Kenaston et al. 2001; Clarke et al. 2011).

Increasing the likelihood that hatchery salmon and steelhead home to a particular location is one measure that can be taken to reduce the proportion of hatchery fish in the naturally spawning population. When the hatchery fish home to a particular location, those fish can be removed (e.g., through fisheries, use of a weir) or they can be isolated from primary spawning areas. Factors that can affect the success of acclimation as a tool to improve homing include:

- Timing acclimation so that a majority of the hatchery juveniles are going through the parr-smolt transformation during acclimation
- A water source distinct enough to attract returning adults
- Whether hatchery fish can access the stream reach where they were released
- Whether the water quantity and quality are such that returning hatchery fish will hold in that area before removal and/or their harvest in fisheries.

1.4. Factor 4. Research, monitoring, and evaluation that exists because of the hatchery program

NMFS analyzes proposed research, monitoring, and evaluation (RM&E) activities associated with proposed hatchery programs for their effects on listed species and designated critical habitat. Such activities include, but are not limited to, the following:

- Observation during surveying (in-water or from the bank)
- Collecting and handling (purposeful or inadvertent)
- Sampling (e.g., the removal of scales and tissues)
- Tagging and fin-clipping, and observing the fish (in-water or from the bank)

Some RM&E actions may capture fish, induce injury, cause behavioral changes, and affect redds. Any negative effects from RM&E are weighed against the value of new information, particularly information that tests key assumptions and that reduces uncertainty. NMFS also considers the overall effectiveness of the RM&E program. There are five factors that we consider when assessing the beneficial and negative effects of hatchery RM&E:

- Status of the affected species and effects of the proposed RM&E on the species and on designated critical habitat
- Critical uncertainties concerning effects on the species

- Performance monitoring to determine the effectiveness of the hatchery program at achieving its goals and objectives
- Identifying and quantifying collateral effects
- Tracking compliance of the hatchery program with the terms and conditions for implementing the program.

After assessing the proposed hatchery RM&E, and before making any recommendations to the action agency(s), NMFS considers the benefit or usefulness of new or additional information, whether the desired information is available from another source, the effects on ESA-listed species, and cost. The following subsections describe effects to listed fish species associated with typical RM&E activities and risk mitigation measures.

1.4.1. Observing

For some activities, listed fish and redds of listed fish are observed in-water (e.g., by snorkel surveys, wading surveys, or observation from the banks). Direct observation is the least disruptive method for determining a species' presence/absence and estimating its relative numbers. Effects of direct observation 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 fish behavior and causing minimal to no disturbance to redds. Fish frightened by the turbulence and sound created by observers are likely to seek temporary refuge in deeper water, or behind/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. These avoidance behaviors are expected to be in the range of normal predator and disturbance behaviors, and are typically not expected to significantly disrupt normal behavioral patterns or create the likelihood of injury.

Redds may be observed or encountered during some RM&E activities. Trained and knowledgeable surveyors are typically aware of risk reduction measures, such as not walking on redds, avoiding disturbance to nearby sediments and gravel, affording disturbed fish time and space to reach cover, and minimizing time present.

1.4.2. Capturing/handling

Any physical handling or psychological disturbance is known to be stressful to fish (Sharpe et al. 1998). Primary contributing factors to stress and death from handling are excessive doses of anesthetic, differences in water temperatures (between the river and holding vessel), dissolved oxygen conditions, the amount of time fish are held out of the water, and physical trauma. Stress increases rapidly if the water temperature exceeds 18ºC or dissolved oxygen is below saturation. Fish transferred to holding tanks can experience trauma if care is not taken in the transfer process, and fish can experience stress and injury from overcrowding in traps if the traps are not emptied regularly. Decreased survival can result from high stress levels, and may also increase the potential for vulnerability to subsequent challenges (Sharpe et al. 1998).

NMFS has developed general guidelines to reduce impacts when collecting listed adult and juvenile salmonids (NMFS 2000; 2008) that have been incorporated as terms and conditions into section 7 opinions and section 10 permits for research and enhancement. Additional monitoring principles for supplementation programs have been developed by Galbreath et al. (2008).

1.4.3. Fin clipping and tagging

Many studies have examined the effects of fin clips on fish growth, survival, and behavior. Although the results of these studies vary somewhat, it appears that generally fin clips do not alter fish growth (Brynildson and Brynildson 1967; Gjerde and Refstie 1988). Mortality among fin-clipped fish is variable, but can be as high as 80 percent (Nicola and Cordone 1973). In some cases, though, no significant difference in mortality was found between clipped and un-clipped fish (Gjerde and Refstie 1988; Vincent-Lang 1993). The mortality rate typically depends on which fin is clipped. Recovery rates are generally higher for adipose- and pelvic-fin-clipped fish than for those that have clipped pectoral, dorsal, or anal fins (Nicola and Cordone 1973), probably because the adipose and pelvic fins are not as important as other fins for movement or balance (McNeil and Crossman 1979). However, some work has shown that fish without an adipose fin may have a more difficult time swimming through turbulent water (Reimchen and Temple 2003; Buckland-Nicks et al. 2011).

In addition to fin clipping, two commonly available tags are available to differentially mark fish: passive integrated transponder (PIT) tags, and coded-wire tags (CWTs). PIT tags consist of small radio transponders that transmit an ID number when interrogated by a reader device.[14] CWTs are small pieces of wire that are detected magnetically and may contain codes[15] that can be read visually once the tag is excised from the fish.

PIT tags are 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. Thus, tagging needs to take place where there is cold water of high quality, a carefully controlled environment for administering anesthesia, sanitary conditions, quality control checking, and a recovery tank.

Most studies have concluded that PIT tags generally have very little effect on growth, mortality, or behavior. Early studies of PIT tags showed no long-term effect on growth or survival (Prentice and Park 1984; Prentice et al. 1987; Rondorf and Miller 1994). 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 orally or surgically implanted sham radio tags or PIT tags. However, (Knudsen et al. 2009) found that, over several brood years, PIT tag induced smolt-adult mortality in Yakima River spring Chinook salmon averaged 10.3 percent and was at times as high as 33.3 percent.

CWTs are made of magnetized, stainless-steel wire and are injected into the nasal cartilage of a salmon and thus cause little direct tissue damage (Bergman et al. 1968; Bordner et al. 1990). The conditions under which CWTs should be inserted are similar to those required for PIT tags. A major advantage to using CWTs is that they have a negligible effect on the biological condition or response of tagged salmon (Vander Haegen et al. 2005); however, if the tag is placed too

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[14] The same technology, more commonly called RFID (radio frequency identification), is widely used in inventory control and to tag pets.
[15] Tags without codes are called blank wire tags (BWTs).

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).

Mortality from tagging 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. 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.

1.4.4. Masking

Hatchery actions also must be assessed for risk caused by masking effects, defined as when hatchery fish included in the Proposed Action are not distinguishable from other fish. Masking undermines and confuses RM&E, and status and trends monitoring. Both adult and juvenile hatchery fish can have masking effects. When presented with a proposed hatchery action, NMFS analyzes the nature and level of uncertainties caused by masking, and whether and to what extent listed salmon and steelhead are at increased risk as a result of misidentification in status evaluations. The analysis also takes into account the role of the affected salmon and steelhead population(s) in recovery and whether unidentifiable hatchery fish compromise important RM&E.

1.5. Factor 5. Construction, operation, and maintenance, of facilities that exist because of the hatchery program

The construction/installation, operation, and maintenance of hatchery facilities can alter fish behavior and can injure or kill eggs, juveniles, and adults. These actions can also degrade habitat function and reduce or block access to spawning and rearing habitats altogether. Here, NMFS analyzes changes to: riparian habitat, channel morphology, habitat complexity, in-stream substrates, and water quantity and quality attributable to operation, maintenance, and construction activities. NMFS also confirms whether water diversions and fish passage facilities are constructed and operated consistent with NMFS criteria.

1.6. Factor 6. Fisheries that exist because of the hatchery program

There are two aspects of fisheries that are potentially relevant to NMFS' analysis:

1) Fisheries that would not exist but for the program that is the subject of the Proposed Action, and listed species are inadvertently and incidentally taken in those fisheries.
2) Fisheries that are used as a tool to prevent the hatchery fish associated with the HGMP, including hatchery fish included in an ESA-listed salmon ESU or steelhead DPS, from spawning naturally.

"Many hatchery programs are capable of producing more fish than are immediately useful in the conservation and recovery of an ESU and can play an important role in fulfilling trust and treaty obligations with regard to harvest of some Pacific salmon and steelhead populations. For ESUs listed as threatened, NMFS will, where appropriate, exercise its authority under section 4(d) of the ESA to allow the harvest of listed hatchery fish that are surplus to the conservation and recovery needs of the ESU, in accordance with approved harvest plans" (NMFS 2005). In any event, fisheries must be carefully evaluated and monitored based on the take, including catch and release effects, of ESA-listed species.

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Appendix B

Chinook Modeling for Mitchell Act Biological Opinion

October 11, 2024

Modeling the Mitchell Act Production

The purpose of this assessment is to evaluate the effects of proposed changes to Mitchell Act funded Chinook production on the estimated abundances of Chinook in the ocean and on projected adult returns of Chinook to the Columbia River (CR). To accomplish this we used the Fishery Regulation Assessment Model (FRAM) to simulate the projected changes in abundance, based off 2009 – 2018 postseason model runs that had fisheries modified to represent current international and domestic management frameworks (see Scenario 2 from NMFS (2024)).

Scenario descriptions

To assess the effects of the proposed Mitchell Act production, we ran three model scenarios:

1. *Scenario 1 - No Mitchell Act:* this scenario represents projected Chinook abundances in the absence of any Mitchell Act Chinook production. We used the average 2015-2016 Chinook releases from Table 1 in NMFS (2017) to represent the average Mitchell Act Chinook production that produced the abundances of Chinook in the ocean between 2009 and 2018.

2. *Scenario 2 - Current Mitchell Act:* this scenario represents projected Chinook abundances under current levels of Mitchell Act Chinook production, as represented by the end of Phase 2 in Table 1 of NMFS (2017).

3. *Scenario 3 -Proposed Mitchell Act:* this scenario represents projected Chinook abundances under the proposed levels of Mitchell Act Chinook production being addressed in this biological opinion.

Approach

Table 1 presents the levels of Chinook production modeled under each scenario, summarized by FRAM stock. For more detail on these releases, see Appendix A1. Note that the production levels for scenarios 2 and 3 include an additional five percent buffer to account for typical variables associated with rearing live fish (e.g., individual female salmon fecundity, in-hatchery egg-to-smolt survival, etc.). Regional changes in abundance resulting from the different levels of production in each scenario were estimated by comparing the abundances at the end of each time period between two sets of FRAM runs, one with and one without the starting abundances modified to account for the relevant production changes. Regional ocean abundance estimates were derived using the 'FRAM-Shelton' approach developed by the Pacific Fishery Management Council's (PFMC) ad-hoc Southern Resident Killer Whale (SRKW) Workgroup (PFMC 2020) with modifications described in NMFS (2023). For all analyses in this document, we used distribution parameters from Shelton et al. (2021). The base model runs used in this assessment (i.e., unadjusted postseason abundances) used the FRAM Round 7.1.1 base period calibration and were from the "2019 PST" scenario completed for NMFS (2024).

Table 1: Mitchell Act Chinook production associated with each of the three modeling scenarios by FRAM stock.

	SCENARIO 1	SCENARIO 2	SCENARIO 3
FRAM STOCK	NO MITCHELL ACT	CURRENT MITCHELL ACT	PROPOSED MITCHELL ACT
COLUMBIA RIVER			
CR Oregon Hatchery Tule	-8,091,500	9,360,250	10,436,500
CR Washington Hatchery Tule	-10,074,000	5,145,000	5,012,700
CR Upriver Bright	-4,424,038	6,300,000	6,300,000
Cowlitz River Spring	-639,591	787,500	787,500
Willamette River Spring	-768,000	1,241,100	1,470,000
CR Upriver Spring (Non-FRAM)	-2,941,000	3,118,500	4,336,500

To estimate the abundances that would have occurred given the production levels associated with each scenario, we developed a set of stock/brood year specific adjustment factors to apply to the existing starting cohorts in the base model runs. To derive the adjustment factors, we first needed to know the level of total hatchery production that actually occurred for each stock. To determine this we conducted a series of queries of the Regional Mark Information System that returned the number of adipose fin-clipped (marked) and adipose-intact (unmarked) Chinook released by brood year for each relevant FRAM stock (Appendix A2). These are the releases that produced the subsequent age-specific cohorts contained in the postseason model runs; for example, the brood year 2010 marked releases of a given stock would produce the age 3 marked starting cohort in the 2013 postseason FRAM run and the age 4 marked starting cohort in the 2014 FRAM run.

For scenario 1 (no Mitchell Act production), the intent was to remove Chinook that were produced with Mitchell Act funds from the model runs. The stock and brood year-specific adjustment factors were calculated as $1 - \left(Prod_{x,S_1}/TotProd_{x,y}\right)$, where $Prod_{x,S_i}$ is the Mitchell Act production from Table 1 for stock x and scenario i and $TotProd_{x,y}$ is the marked production from Appendix A2 for stock x and brood year y. These expansions were then applied to the respective stock/age-specific starting cohort sizes in each model run to simulate the proportional decreases in abundance that would be expected if the levels of Mitchell Act production for Scenario 1 in Table 1 had not occurred. In some instances early in the time series when mass-marking had not yet been fully implemented, the scenario 1 production from Table 1 for the OR and WA hatchery Tule stocks exceeded the total marked hatchery production. In these situations the marked and unmarked total production were summed together to calculate the adjustment factors, which were then applied to both the marked and unmarked starting cohorts in the respective model runs. Any adjustment factors that were negative (i.e., average Mitchell Act production exceeded the total production in that year) were rounded up to zero.

For scenarios 2 and 3, we add the production associated with each of these scenarios back into the abundances resulting from scenario 1. Adjustment factors for these scenarios were calculated for each stock/brood year as $1-\left(\left(Prod_{x,S_i}-Prod_{x,S_1}\right)/TotProd_{x,y}\right)$, where $Prod_{x,S_i}$ is the stock x and scenario i specific production from Table 1 and $TotProd_{x,y}$ is the total marked hatchery production for stock x in brood year y from Appendix A2. The fishery inputs in the model runs for all three scenarios were converted to effort scalars to allow for different catches that would be expected to occur with the same levels of effort applied to different abundances.

For this exercise, with the exceptions noted above for OR and WA Tules, we focused only on the marked components of each stock because we know the number of releases that produced the estimated starting cohorts, whereas the total production that produced the un-clipped cohorts is generally unknown for stocks with natural components due to uncertainty regarding the number of naturally-produced Chinook. Consequently, we limited this analysis to a time frame that began with return year 2009, as mass-marking became less consistent for brood years that contributed to prior return years. Once these models with the simulated hatchery production levels were run, we calculated the pre- and post-fishing abundances by region using the FRAM-Shelton approach outlined in PFMC (2020) with the modifications described in NMFS (2023). For each region/year combination we calculated percent changes in abundance by subtracting the post-fishing abundances in the original runs without the modified production from the runs with the modified production then dividing by the starting abundance of the original runs.

Note that changes to the production of CR Upriver spring Chinook are not accounted for in the results of the FRAM modeling scenarios because there is not a representative model stock for these fish in Chinook FRAM. Instead, the abundances for CR Upriver spring Chinook (defined here as all mid- and upper-Columbia River spring Chinook in addition to Snake River spring/summer Chinook) are processed using methods external to FRAM (PFMC 2020). To account for the production changes in each model scenario for these fish, we calculated an adjustment factor for each scenario that was consistent across all years.

The adjustment factors for CR Upriver spring Chinook were based on (1) the scenario-specific production changes ($Prod_{S_i}$) for CR Upriver spring Chinook in Table 1, (2) an assumption that the proportion hatchery-origin ($pHat$) of the total CR Upriver spring return is equal to 75%, and (3) the mean total hatchery production ($TotProd$) of CR Upriver spring Chinook for the brood years that contributed to 2009 – 2018 ocean abundances (22.46M; Appendix A2). For scenario 1, the adjustment factor was calculated as $1-\left(Prod_{S_1}/TotProd * pHat\right)$. For scenarios 2 and 3, the adjustment factors were calculated as $1-\left(\left(Prod_{S_1}-Prod_{S_i}\right)/TotProd * pHat\right)$. Annual estimates of pre- and post-fishing abundances for Upper CR spring Chinook were then calculated for each scenario by multiplying the original unadjusted CR Upriver spring abundances by the scenario-specific adjustment factors.

Effects on Abundance

A summary of the percent changes in abundance resulting from each modeling scenario by region and time period is presented in Table 2 and Figure 1, with additional detail provided in Appendix A3. All percent changes are relative to the respective starting abundances in the base model runs.

Table 2: Estimated mean 2009-2018 percent increases in adult (age 3-5) Chinook abundance under each Mitchell Act production scenario, by region and time step.

	SCENARIO 1	SCENARIO 2	SCENARIO 3
TIME STEP	NO MITCHELL ACT	CURENT MITCHELL ACT	PROPOSED MITCHELL ACT
SALISH			
Oct_Apr	-1.33%	-0.33%	-0.29%
May_Jun	-1.73%	-0.47%	-0.44%
Jul_Sep	-0.77%	-0.11%	-0.10%
SWWCVI			
Oct_Apr	-8.33%	-1.19%	-0.99%
May_Jun	-5.12%	-1.20%	-1.09%
Jul_Sep	-2.79%	-0.56%	-0.50%
NOF			
Oct_Apr	-10.85%	-1.81%	-0.75%
May_Jun	-4.46%	-1.21%	-1.12%
Jul_Sep	-9.04%	-0.85%	-0.73%
OR			
Oct_Apr	-3.07%	-0.38%	0.05%
May_Jun	-1.09%	-0.26%	-0.24%
Jul_Sep	-1.03%	-0.16%	-0.14%
CALI			
Oct_Apr	-0.80%	0.30%	0.41%
May_Jun	-0.14%	-0.02%	-0.01%
Jul_Sep	-0.06%	0.01%	0.01%

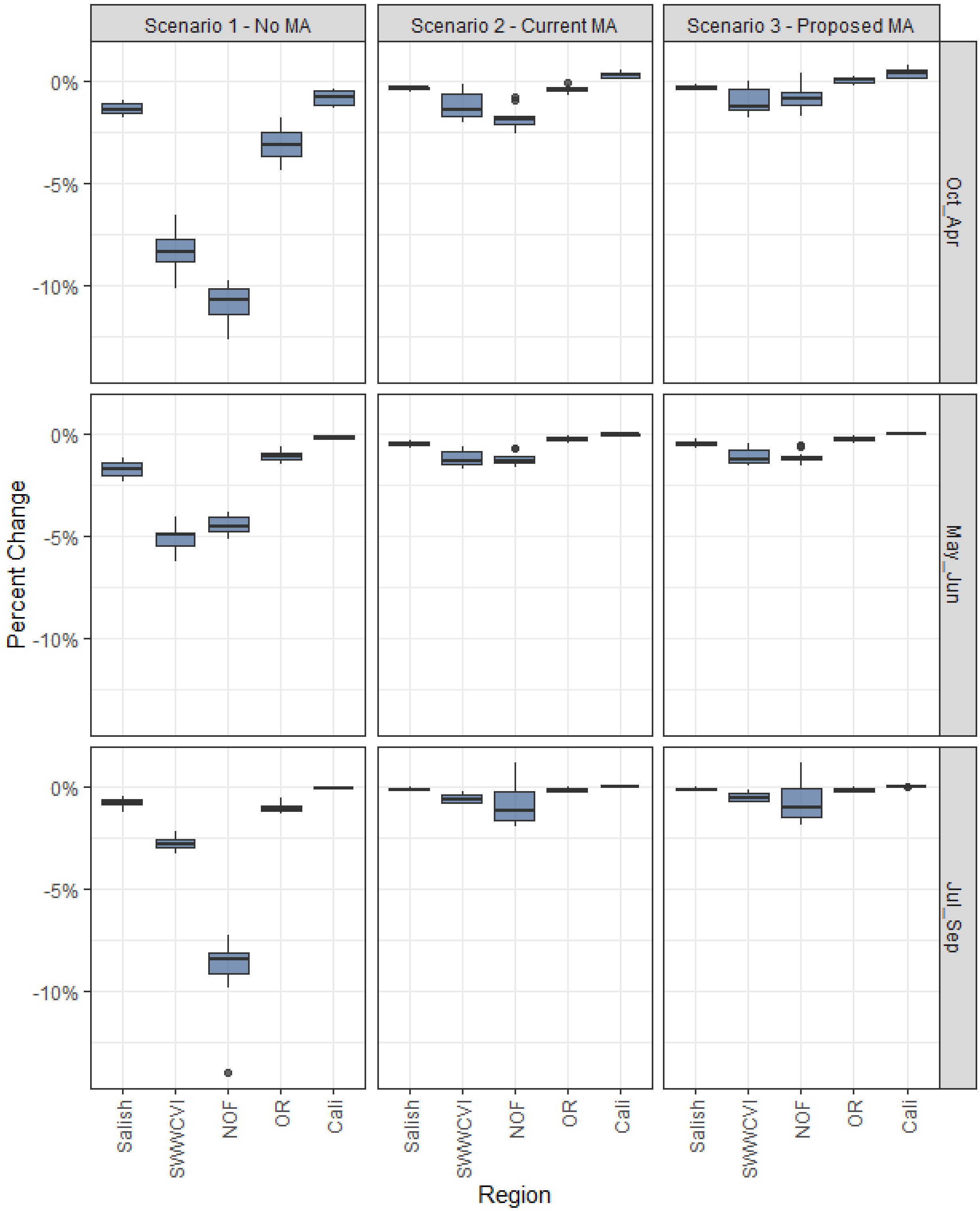

Figure 1: *Summary of estimated 2009-2018 percent increases in Chinook abundance for each Mitchell Act production scenario, by region and time step.*

Effects on Escapement

Table 3 shows the estimated mean annual change in numbers of fish expected to return to the river under each Mitchell Act production scenario, where negative values represent a decrease relative to the base model runs. Table 4 shows the percentage change in abundance relative to the original abundances in the base model runs. For all stocks with the exception of White River Spring, these are assumed to be 100% ad-clipped and the percentage increase is relative to only the ad-clipped component of the stock. It is important to note here that the numbers of fish reported represent returns to the river mouth, not fish on the spawning grounds. Of these additional fish returning to the river, some would be caught in freshwater fisheries and some would return to hatchery racks, while others would ultimately end up on the spawning grounds. All ocean fisheries in these model scenarios were modeled to maintain the existing effort levels (i.e., if the abundance of a given stock doubled, then the fishery would catch twice as many of that stock). This is an important caveat to be aware of, and may not be a valid assumption in some cases, as the changes to expected returns would likely be captured in annual forecasts, and some fisheries might be shaped differently as a result. Given this, it might be best to instead look at the percent changes and consider them an approximation for the potential proportional change in ad-clipped HOR spawners, acknowledging that changes in fishery structure would affect these values.

Table 3: Estimated mean annual difference in returns to the mouth of the Columbia River by FRAM stock resulting from each Mitchell Act production scenario.

FRAM STOCK	MEAN ANNUAL DIFFERENCE IN RETURNS		
	SCENARIO 1 - NO MA	SCENARIO 2 - CURRENT MA	SCENARIO 3 - PROPOSED MA
CR Oregon Hatchery Tule	-16,277	3,022	5,586
CR Washington Hatchery Tule	-40,465	-19,795	-20,326
Columbia R Upriver Bright	-43,625	18,497	18,498
Cowlitz River Spring	-6,278	1,452	1,452
Willamette River Spring	-9,626	5,930	8,798

Table 4: Estimated mean annual percent difference in returns to the mouth of the Columbia River by FRAM stock resulting from each Mitchell Act production scenario.

FRAM STOCK	MEAN PERCENT DIFFERENCE IN RETURNS		
	SCENARIO 1 - NO MA	SCENARIO 2 - CURRENT MA	SCENARIO 3 - PROPOSED MA
CR Oregon Hatchery Tule	-92%	17%	32%
CR Washington Hatchery Tule	-61%	-30%	-31%
Columbia R Upriver Bright	-33%	14%	14%
Cowlitz River Spring	-22%	5%	5%
Willamette River Spring	-10%	6%	9%

Figure 2 and Table 5 provide information on the amount of year-to-year variability in the number of fish returning to the river for the marked component of each FRAM stock with Mitchell Act funded production. Note that these values represent expected returns under the base model runs, not the model runs that include the modified abundances for each scenario.

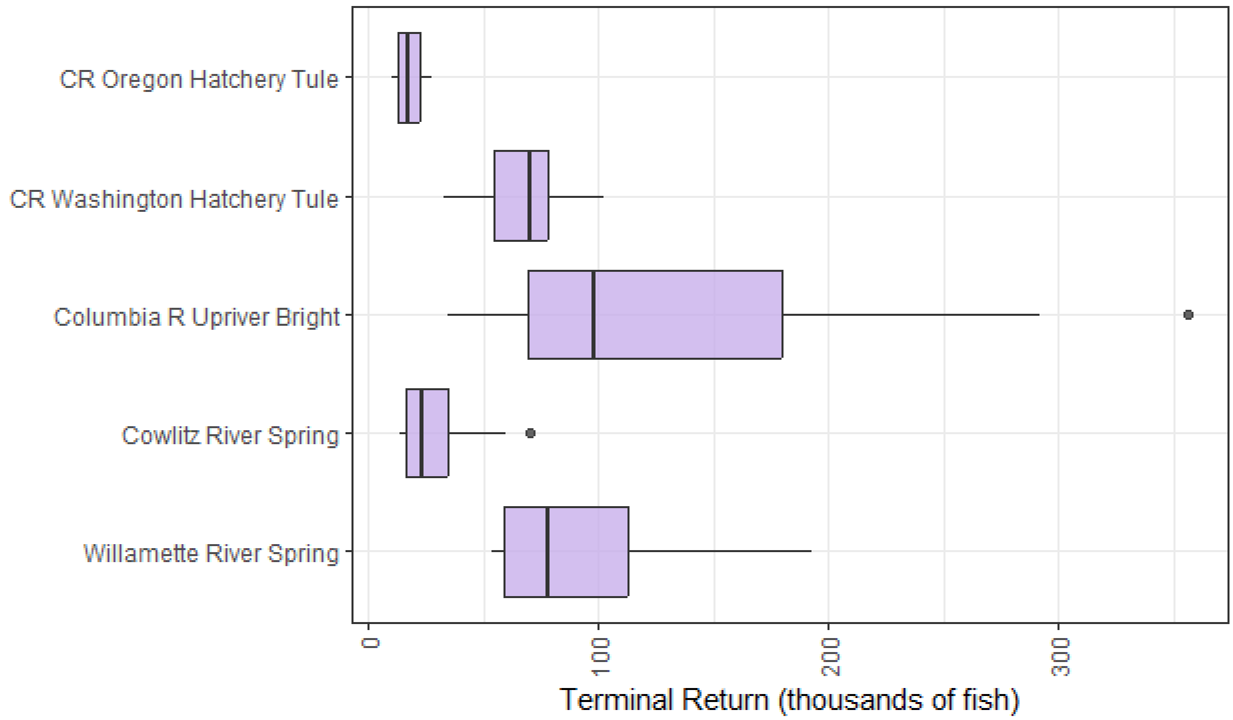

Figure 2: *Summary of projected 2009-2018 returns to the river for FRAM stocks with Mitchell Act funded production. These projections are from the base '2019 PST' model runs without modified hatchery production and, with the exception of White River spring, represent only the marked component of each stock.*

Table 5: Minimum, maximum, mean, and standard deviation of projected returns to the river between 2009 and 2018 for FRAM stocks with Mitchell Act funded production. These projections are from the base '2019 PST' model runs withouth modified hatchery production and, with the exception of the OR and WA hatchery tule stocks, represent only the marked component of each stock.

FRAM STOCK	2009-2018 RETURNS TO THE RIVER MOUTH			
	MINIMUM	MAXIMUM	MEAN	STANDARD DEVIATION
CR Oregon Hatchery Tule	10,327	27,194	17,641	5,959
CR Washington Hatchery Tule	32,728	102,393	67,356	20,243
Columbia R Upriver Bright	34,562	356,733	139,309	108,550
Cowlitz River Spring	13,254	70,506	30,659	19,755
Willamette River Spring	53,924	192,467	94,142	45,529

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APPENDIX A

Appendix A1: Chinook production by facility under each model scenario.

MITCHELL ACT HACTHERY PROGRAM	FRAM STOCK	S1_PRODUCTION	S2_PRODUCTION	S3_PRODUCTION
Bonneville fall Chinook salmon (tule)	CR Oregon Hatchery Tule	2,519,000	5,250,000	6,300,000
Big Creek Chinook salmon (tule)	CR Oregon Hatchery Tule	3,106,000	1,470,000	1,470,000
Klaskanine fall Chinook salmon (tule)	CR Oregon Hatchery Tule	2,425,000	2,598,750	2,415,000
Clackamas spring Chinook salmon	Willamette River Spring	636,000	1,102,500	1,155,000
North Fork Toutle fall Chinook salmon (tule)	CR Washington Hatchery Tule	1,394,000	1,155,000	1,155,000
Kalama fall Chinook salmon (tule)	CR Washington Hatchery Tule	5,801,000	2,730,000	2,100,000
Washougal fall Chinook salmon (tule)	CR Washington Hatchery Tule	1,976,000	1,260,000	1,260,000
Walla Walla spring Chinook salmon	CR Upriver Spring (Non-FRAM)	250,000	NA	NA
Klickitat upriver bright fall Chinook salmon	Columbia R Upriver Bright	2,742,000	4,200,000	4,200,000
Klickitat spring Chinook salmon	CR Upriver Spring (Non-FRAM)	521,000	840,000	840,000
Deep River fall Chinook salmon	CR Washington Hatchery Tule	903,000	NA	NA
Cathlamet/Deep R Net-pen spring Chinook salmon	Cowlitz River Spring	124,000	262,500	0
Kalama Spring Chinook salmon	Cowlitz River Spring	515,591	525,000	787,500
Sandy River spring Chinook salmon	Willamette River Spring	132,000	138,600	315,000
Carson National Fish Hatchery spring Chinook salmon	CR Upriver Spring (Non-FRAM)	1,170,000	1,228,500	1,606,500
Little White Salmon National Fish Hatchery Spring Chinook salmon	CR Upriver Spring (Non-FRAM)	1,000,000	1,050,000	1,890,000
Willard National Fish Hatchery URB	Columbia R Upriver Bright	1,682,038	2,100,000	2,100,000
Astoria High School Salmon and Trout Enhancement Program (STEP) fall Chinook salmon (tule)	CR Oregon Hatchery Tule	25,000	25,000	25,000
Warrenton High School STEP fall Chinook salmon (tule)	CR Oregon Hatchery Tule	16,500	16,500	16,500
NEW: Grays River (at Big Creek Hatchery) Tule Conservation Program	CR Washington Hatchery Tule	NA	NA	379,050
NEW: Abernathy (Elochoman and Beavercreek stock) Tule Conservation Program	CR Washington Hatchery Tule	NA	NA	118,650
NEW: Clatskanie River Tule Fall Chinook Supplementation Program	CR Oregon Hatchery Tule	NA	NA	210,000

Appendix A2: RMIS query results for marked and unmarked hatchery releases by Columbia River FRAM stock for brood years that contributed to the 2009-2018 return years.

BROOD YEAR	COWLITZ SPRING	WILLAMETTE SPRING	COLUMBIA UPRIVER BRIGHT	COLUMBIA OR TULE	COLUMBIA WA TULE	COLUMBIA UPRIVER SPRING
MARKED						
2004	2,164,087	7,327,150	5,660,272	268,564	750,578	20,272,244
2005	2,530,768	7,109,765	11,015,277	234,079	6,099,266	17,699,546
2006	2,109,163	7,795,601	5,625,472	4,210,265	17,507,015	17,562,393
2007	2,651,585	6,990,827	11,565,752	4,018,254	17,068,578	17,784,775
2008	2,622,600	8,290,048	14,637,321	7,960,365	15,693,560	20,257,062
2009	2,268,888	8,130,635	15,880,918	8,573,093	17,635,783	17,849,736
2010	2,933,697	7,966,999	14,601,170	7,715,779	16,020,986	18,132,048
2011	2,999,836	7,792,413	15,455,031	7,901,326	16,731,195	19,265,603
2012	3,606,838	7,452,389	16,537,660	7,428,683	15,376,062	20,183,061
2013	3,713,648	7,080,269	16,418,912	8,644,922	15,573,320	19,065,845
2014	3,677,188	6,727,818	16,813,047	9,252,691	13,681,109	20,650,992
2015	3,043,928	6,799,252	15,657,840	9,096,236	11,176,862	21,022,450
2016	3,065,965	6,673,263	16,882,494	5,379,154	13,818,279	21,315,715
UNMARKED						
2004	422,582	538,710	17,352,872	5,639,679	17,373,918	2,818,554
2005	466,714	374,244	10,300,032	5,621,477	10,341,792	1,497,479
2006	421,570	180,315	23,253,363	256,751	443,050	2,733,477
2007	473,872	96,545	7,036,860	328,315	211,653	1,825,221
2008	465,591	241,231	9,288,597	198,605	180,956	3,838,086
2009	467,729	103,943	7,237,527	352,930	194,963	4,118,085
2010	569,790	22,119	7,975,873	269,451	118,474	4,828,072
2011	220,685	239,439	6,247,286	376,740	123,816	3,483,921
2012	160,645	184,396	5,155,559	298,839	82,181	3,616,719
2013	246,433	88,342	4,348,361	318,676	101,961	3,415,500
2014	198,223	35,449	5,613,344	20,707	96,681	2,864,049
2015	126,315	21,116	4,249,359	28,726	170,816	3,048,610
2016	230,057	21,573	6,085,095	20,114	78,581	2,837,940

Appendix A3: Annual estimates of percent change in abundance for each Mitchell Act production scenario, by region and time step.

TIMESTEP	REGION	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	MEAN	MEDIAN
SCENARIO 1: NO MITCHELL ACT PRODUCTION													
Oct_Apr	Salish	-1.27%	-1.46%	-1.59%	-1.36%	-1.61%	-1.34%	-1.79%	-1.01%	-1.02%	-0.91%	-1.33%	-1.35%
Oct_Apr	NOF	-11.24%	-11.60%	-12.63%	-10.13%	-10.23%	-9.73%	-10.67%	-10.14%	-11.41%	-10.73%	-10.85%	-10.70%
Oct_Apr	OR	-3.10%	-3.65%	-3.55%	-1.75%	-2.13%	-2.50%	-3.15%	-4.34%	-3.98%	-2.51%	-3.07%	-3.12%
Oct_Apr	Cali	-0.83%	-1.30%	-0.76%	-0.35%	-0.33%	-0.42%	-1.27%	-1.19%	-1.10%	-0.43%	-0.80%	-0.79%
Oct_Apr	SWWCVI	-8.64%	-9.34%	-10.13%	-8.62%	-8.87%	-8.13%	-8.08%	-6.56%	-7.58%	-7.37%	-8.33%	-8.38%
May_Jun	Salish	-1.67%	-1.87%	-2.02%	-1.74%	-2.09%	-1.73%	-2.34%	-1.30%	-1.33%	-1.19%	-1.73%	-1.73%
May_Jun	NOF	-4.60%	-4.49%	-5.14%	-3.98%	-4.79%	-3.96%	-4.29%	-3.84%	-4.91%	-4.59%	-4.46%	-4.54%
May_Jun	OR	-1.08%	-1.17%	-1.26%	-0.59%	-1.03%	-0.93%	-1.09%	-1.36%	-1.49%	-0.92%	-1.09%	-1.08%
May_Jun	Cali	-0.18%	-0.20%	-0.15%	-0.05%	-0.08%	-0.09%	-0.20%	-0.16%	-0.18%	-0.09%	-0.14%	-0.15%
May_Jun	SWWCVI	-5.57%	-5.87%	-6.21%	-5.16%	-4.89%	-4.71%	-4.98%	-4.08%	-4.90%	-4.82%	-5.12%	-4.94%
Jul_Sep	Salish	-0.68%	-0.78%	-0.85%	-0.76%	-1.21%	-0.83%	-1.07%	-0.55%	-0.53%	-0.47%	-0.77%	-0.77%
Jul_Sep	NOF	-8.20%	-8.31%	-9.83%	-8.05%	-14.02%	-9.18%	-9.08%	-7.28%	-8.65%	-7.85%	-9.04%	-8.48%
Jul_Sep	OR	-0.95%	-1.07%	-1.15%	-0.55%	-1.21%	-0.93%	-1.07%	-1.24%	-1.32%	-0.80%	-1.03%	-1.07%
Jul_Sep	Cali	-0.07%	-0.09%	-0.07%	-0.03%	-0.05%	-0.04%	-0.10%	-0.07%	-0.08%	-0.03%	-0.06%	-0.07%
Jul_Sep	SWWCVI	-2.94%	-3.19%	-3.30%	-2.75%	-2.97%	-2.55%	-2.80%	-2.19%	-2.62%	-2.54%	-2.79%	-2.77%
SCENARIO 2: CURRENT MITCHELL ACT PRODUCTION													
Oct_Apr	Salish	-0.40%	-0.40%	-0.38%	-0.20%	-0.32%	-0.20%	-0.50%	-0.30%	-0.32%	-0.25%	-0.33%	-0.32%
Oct_Apr	NOF	-2.42%	-1.87%	-2.03%	-0.76%	-1.67%	-0.93%	-1.89%	-1.84%	-2.54%	-2.12%	-1.81%	-1.88%
Oct_Apr	OR	-0.50%	-0.38%	-0.41%	-0.07%	-0.30%	-0.16%	-0.39%	-0.53%	-0.67%	-0.38%	-0.38%	-0.38%
Oct_Apr	Cali	0.28%	0.58%	0.31%	0.13%	0.12%	0.16%	0.47%	0.39%	0.39%	0.16%	0.30%	0.30%
Oct_Apr	SWWCVI	-1.99%	-1.76%	-1.49%	-0.39%	-0.12%	-0.16%	-1.29%	-1.30%	-1.82%	-1.61%	-1.19%	-1.40%
May_Jun	Salish	-0.55%	-0.57%	-0.53%	-0.30%	-0.47%	-0.31%	-0.72%	-0.43%	-0.45%	-0.36%	-0.47%	-0.46%
May_Jun	NOF	-1.50%	-1.33%	-1.33%	-0.67%	-1.04%	-0.69%	-1.29%	-1.25%	-1.62%	-1.36%	-1.21%	-1.31%
May_Jun	OR	-0.32%	-0.32%	-0.28%	-0.08%	-0.13%	-0.11%	-0.28%	-0.39%	-0.46%	-0.26%	-0.26%	-0.28%
May_Jun	Cali	-0.03%	-0.02%	-0.02%	-0.00%	-0.00%	-0.00%	-0.02%	-0.03%	-0.04%	-0.02%	-0.02%	-0.02%
May_Jun	SWWCVI	-1.67%	-1.58%	-1.41%	-0.69%	-0.71%	-0.58%	-1.29%	-1.19%	-1.51%	-1.35%	-1.20%	-1.32%
Jul_Sep	Salish	-0.17%	-0.17%	-0.13%	-0.04%	0.01%	-0.01%	-0.17%	-0.12%	-0.14%	-0.11%	-0.11%	-0.13%
Jul_Sep	NOF	-1.74%	-1.46%	-1.07%	-0.04%	1.15%	0.44%	-0.91%	-1.23%	-1.98%	-1.65%	-0.85%	-1.15%
Jul_Sep	OR	-0.23%	-0.22%	-0.17%	-0.02%	0.03%	0.00%	-0.16%	-0.26%	-0.34%	-0.19%	-0.16%	-0.18%
Jul_Sep	Cali	0.00%	0.01%	0.01%	0.00%	0.01%	0.01%	0.01%	0.00%	0.00%	0.00%	0.01%	0.01%
Jul_Sep	SWWCVI	-0.84%	-0.78%	-0.66%	-0.28%	-0.22%	-0.20%	-0.59%	-0.57%	-0.76%	-0.67%	-0.56%	-0.63%
SCENARIO 3: PROPOSED MITCHELL ACT PRODUCTION													
Oct_Apr	Salish	-0.37%	-0.34%	-0.33%	-0.14%	-0.30%	-0.16%	-0.47%	-0.29%	-0.30%	-0.23%	-0.29%	-0.30%
Oct_Apr	NOF	-1.26%	-0.44%	-0.71%	0.43%	-1.17%	0.14%	-0.87%	-0.79%	-1.68%	-1.16%	-0.75%	-0.83%
Oct_Apr	OR	-0.04%	0.23%	0.11%	0.21%	-0.13%	0.23%	0.06%	0.12%	-0.24%	-0.06%	0.05%	0.08%
Oct_Apr	Cali	0.39%	0.83%	0.44%	0.17%	0.15%	0.21%	0.63%	0.50%	0.55%	0.23%	0.41%	0.42%
Oct_Apr	SWWCVI	-1.81%	-1.40%	-1.18%	-0.05%	-0.07%	0.05%	-1.17%	-1.22%	-1.67%	-1.42%	-0.99%	-1.20%
May_Jun	Salish	-0.52%	-0.52%	-0.48%	-0.24%	-0.46%	-0.26%	-0.70%	-0.42%	-0.43%	-0.33%	-0.44%	-0.44%
May_Jun	NOF	-1.41%	-1.18%	-1.18%	-0.51%	-1.02%	-0.58%	-1.24%	-1.22%	-1.55%	-1.26%	-1.12%	-1.20%
May_Jun	OR	-0.30%	-0.28%	-0.25%	-0.06%	-0.13%	-0.08%	-0.27%	-0.38%	-0.44%	-0.24%	-0.24%	-0.26%
May_Jun	Cali	-0.03%	-0.01%	-0.01%	0.00%	-0.00%	0.00%	-0.02%	-0.02%	-0.03%	-0.01%	-0.01%	-0.01%
May_Jun	SWWCVI	-1.57%	-1.40%	-1.24%	-0.50%	-0.68%	-0.46%	-1.24%	-1.16%	-1.44%	-1.24%	-1.09%	-1.24%
Jul_Sep	Salish	-0.16%	-0.15%	-0.12%	-0.02%	0.01%	0.00%	-0.17%	-0.12%	-0.14%	-0.10%	-0.10%	-0.12%
Jul_Sep	NOF	-1.63%	-1.27%	-0.88%	0.17%	1.18%	0.58%	-0.86%	-1.19%	-1.90%	-1.51%	-0.73%	-1.03%
Jul_Sep	OR	-0.22%	-0.20%	-0.15%	-0.01%	0.04%	0.02%	-0.15%	-0.25%	-0.32%	-0.17%	-0.14%	-0.16%
Jul_Sep	Cali	0.00%	0.02%	0.01%	0.01%	0.01%	0.01%	0.02%	0.01%	0.01%	0.00%	0.01%	0.01%
Jul_Sep	SWWCVI	-0.79%	-0.69%	-0.58%	-0.18%	-0.21%	-0.14%	-0.57%	-0.55%	-0.72%	-0.61%	-0.50%	-0.57%

Appendix C
Estimating Hatchery-Wild Composition of Puget Sound and Columbia River Chinook

2024-06-07

Approach

To provide a rough estimate the hatchery/wild composition of Puget Sound and Columbia River Chinook during the retrospective time frame used to evaluate the prey program (2009–2018), we can examine the mark-rate (adipose fin-clipped vs. adipose intact) of mature fish returning to their natal rivers from post-season Chinook FRAM model runs. These are years in which mass-marking (adipose fin clipping of all hatchery fish) was in place for most Chinook hatchery production in Puget Sound and the Columbia River, thus the mark-rate of overall returns can provide a rough estimate of the hatchery/wild composition. Here we used Chinook FRAM post-season validation runs based on base period calibration Round 7.1.1, and summarized the returns to the river for all Chinook FRAM model stocks originating from Puget Sound of the Columbia River.

There are some exceptions to the assumption that the mark rate of returning Chinook represents a suitable surrogate for the hatchery/wild composition, however, as not all hatchery production is entirely mass marked. For some stocks, including White River spring Chinook, Nooksack River spring Chinook, and Dungeness and Elwha Chinook, large portions or even all of the hatchery production was unclipped in the years being assessed. For other stocks, there are double index tag programs, which require releasing a number of unclipped CWT hatchery fish commensurate with the number of clipped CWT fish. As a result of this, not all unclipped returns can be considered to be hatchery fish. Conversely, there are also some stocks where wild fish get clipped and a CWT, including Lewis River Wild and Hanford Upriver Brights in the Columbia River, although the magnitude of these clipped wild fish being released is much less than the magnitude of unclipped hatchery fish being released.

One other consideration to note, if there is a desire to use these estimated mark-rates of returning fish as a surrogate for the mark rate or hatchery/wild composition of ocean abundances for these stocks, is that some stocks (particularly those from Puget Sound) are exposed to mark-selective fisheries in marine waters, where retention of adipose clipped Chinook is permitted, but unclipped Chinook must be released. This results in clipped fish being removed from the system at a higher rate than unclipped fish, so the mark-rate of Chinook in the ocean prior to exposure to these fisheries would be even higher. For all these reasons, it would be best to treat the mark-rate as a lower bound of an estimate of the hatchery proportion.

Table 1: Annual returns of unmarked and marked Chinook, in addition to the proportion marked for Columbia River and Puget Sound Chinook FRAM stocks.

	COLUMBIA RIVER			PUGET SOUND		
RETURN YEAR	UNMARKED	MARKED	% MARKED	UNMARKED	MARKED	% MARKED
2009	293,044	268,448	48%	41,448	122,531	75%
2010	408,631	561,661	58%	35,046	154,053	81%
2011	387,128	462,160	54%	32,582	164,621	83%
2012	303,143	420,193	58%	46,819	191,654	80%
2013	751,888	666,284	47%	43,427	174,670	80%
2014	693,572	649,907	48%	33,131	88,299	73%
2015	902,927	757,571	46%	41,766	115,661	73%
2016	496,745	361,734	42%	52,939	180,209	77%
2017	332,850	336,076	50%	61,945	246,981	80%
2018	198,355	223,685	53%	54,242	182,126	77%
2019	261,687	204,178	44%	45,068	149,468	77%
2020	372,892	372,531	50%	39,285	101,867	72%