Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation

Select Area Fisheries Enhancement (SAFE) Spring Chinook Salmon and Coho Salmon Programs

NMFS Consultation Number: WCRO-2020-02145

Action Agencies: Bonneville Power Administration (BPA)
National Marine Fisheries Service (NMFS)
U.S. Fish and Wildlife Service (USFWS)

Program Operators: Oregon Department of Fish and Wildlife (ODFW)
Washington Department of Fish and Wildlife (WDFW)
Clatsop County Fisheries (CCF)

Affected Species and Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species or Critical Habitat?	Is Action Likely To Jeopardize the Species?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Lower Columbia River coho salmon (*Oncorhynchus kisutch*)	T	Yes	No	No
Lower Columbia River steelhead (*O. mykiss*)	T	Yes	No	No
Lower Columbia River Chinook salmon *(O. tshawytscha)*	T	Yes	No	No
Columbia River chum salmon (*O. keta*)	T	Yes	No	No
Upper Willamette Spring Chinook Salmon *(O. tshawytscha)*	T	Yes	No	No
Upper Willamette Winter Steelhead (*O. mykiss*)	T	No	No	No
Upper Columbia River spring-run Chinook salmon *(O. tshawytscha)*	E	No	No	No
Snake River spring/summer run Chinook salmon *(O. tshawytscha)*	T	Yes	No	No

Snake River fall-run Chinook salmon *(O. tshawytscha)*	T	No	No	No
Middle Columbia River steelhead (*O. mykiss*)	T	No	No	No
Upper Columbia River steelhead (*O. mykiss*)	T	No	No	No
Snake River Basin steelhead (*O. mykiss*)	T	No	No	No
Snake River sockeye salmon (*O. nerka*)	E	No	No	No
Eulachon (*Thaleichthys pacificus*)	T	No	No	No
Southern green sturgeon (*Acipenser medirostris*)	T	No	No	No
Southern Resident killer whale (*Orcinus orca*)	E	No	No	No

Fishery Management Plan That Describes Essential Fish Habitat (EFH) in the Project Area	**Does the Action Have an Adverse Effect on EFH?**	**Are EFH Conservation Recommendations Provided?**
Pacific Coast Salmon	No	No
Pacific Coast Groundfish	No	No
Coastal Pelagic Species	No	No

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

Issued By:

Barry A. Thom, Regional Administrator
West Coast Region
National Marine Fisheries Service

Date: May 3, 2021

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1. INTRODUCTION

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

The underlying activities that drive the proposed action are the funding, operation and maintenance, and monitoring and evaluation of three hatchery programs for spring Chinook salmon and coho salmon in the Select Area Fisheries Enhancement (SAFE) project, which are produced (i.e., collected and reared) at various hatchery facilities in the Lower Columbia River and its tributaries, and acclimated and released from SAFE hatchery and net pen facilities (SAFE facilities) in the Lower Columbia River estuary. These three SAFE hatchery programs and SAFE facility operation and maintenance activities are collectively funded by the Bonneville Power Administration (BPA), National Marine Fisheries Service (NMFS), Oregon Department of Fish and Wildlife (ODFW), Washington Department of Fish and Wildlife (WDFW), Clatsop County Fisheries (CCF), and U.S. Fish and Wildlife Service (USFWS). The hatchery facilities are primarily operated by ODFW, WDFW, and CCF. Each program is described in detail in a Hatchery and Genetic Management Plan (HGMP), which were submitted to the National Marine Fisheries Service (NMFS) for review. NMFS is evaluating these programs here under section 7 of the ESA.

The three SAFE programs that are the subject of this consultation are isolated harvest programs. The operation and management of every hatchery program is unique in time, and specific to an identifiable stock and its native habitat (Flagg et al. 2004). NMFS defines integrated hatchery programs as those that are reproductively connected or “integrated” with a natural population, promote natural selection over hatchery-influenced selection, contain genetic resources that represent the ecological and genetic diversity of a species, and are included in a salmon ESU or steelhead DPS. When a hatchery program actively maintains distinctions or promotes differentiation between hatchery fish and fish from a native population, then NMFS refers to the program as “isolated” (also referred to as segregated). Isolated programs promote domestication or selection in the hatchery over selection in the wild and may culture a stock of fish with phenotypes (e.g., different ocean migrations and spatial and temporal spawning distribution) different from the natural population.

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 ESA of 1973, as amended (16 U.S.C. 1531, et seq.), and implementing regulations at 50 CFR 402. The opinion documents consultation on the actions proposed by the action agencies and operators.

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

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available through NMFS' Environmental Consultation Organizer (ECO). A complete record of this consultation is on file at the Sustainable Fisheries Division (SFD) of NMFS in Portland, Oregon.

1.2. Consultation History

The first hatchery consultations in the Columbia Basin followed the first listings of Columbia Basin salmon under the Endangered Species Act (ESA). Snake River sockeye salmon were listed as an endangered species on November 20, 1991, Snake River spring/summer Chinook salmon and Snake River fall Chinook salmon were listed as threatened species on April 22, 1992, and the first hatchery consultation and opinion were completed on April 7, 1994 (NMFS 1994). The 1994 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 1995). This opinion determined that hatchery actions jeopardize listed Snake River salmon and required implementation of reasonable and prudent alternatives (RPAs) to avoid jeopardy.

A new opinion was completed on March 29, 1999, after Upper Columbia River (UCR) steelhead were listed under the ESA (62 FR 43937, August 18, 1997) and following the expiration of the previous opinion on December 31, 1998 (NMFS 1999). That opinion concluded that Federal and non-Federal hatchery programs jeopardize Lower Columbia River (LCR) steelhead and Snake River steelhead protected under the ESA and described RPAs necessary to avoid jeopardy. Those measures and conditions included restricting the use of non-endemic steelhead for hatchery broodstock and limiting stray rates of non-endemic salmon and steelhead to less than 5% of the annual natural population in the receiving stream. Soon after, NMFS reinitiated consultation when LCR Chinook salmon, UCR spring Chinook salmon, Upper Willamette Chinook salmon, Upper Willamette steelhead, Columbia River chum salmon, and Middle Columbia 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 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 opinions "instead of writing one biological opinion on all hatchery programs in the Columbia River Basin" (Smith 1999). Opinions would be issued for hatchery programs in the (1) Upper Willamette, (2) Middle Columbia River (MCR), (3) LCR, (4) Snake River, and (5) UCR, with the UCR NMFS' 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 opinion, and distributed it to hatchery operators and to funding agencies for review on January 4, 2001, but completion of consultation was put on hold pending several important basin-wide review and planning processes.

The increase in 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 Federal funded hatchery programs ordered by Congress was underway at about the same time that the 2000

Federal Columbia River Power System (FCRPS) opinion was issued by NMFS (NMFS 2000). The Northwest Power and Conservation Council (Council) was asked to develop a set of coordinated policies to guide the future use of artificial propagation, and RPA 169 of the FCRPS opinion called for the completion of NMFS-approved hatchery operating plans (i.e., HGMPs) by the end of 2003. 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. Also at this time, a new *U.S. v. Oregon* Columbia River Fisheries Management Plan (CRFMP), 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 under the FCRPS opinion was undertaken in cooperation with the Council's Artificial Production Review and Evaluation process, with CRFMP negotiations, and with ESA recovery planning (Foster 2004; Jones Jr. 2002). 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 an opinion were completed in 2007 for nine hatchery programs that produce a substantial proportion of the total number of salmon and steelhead released into the Columbia River annually. These programs are located in the LCR and MCR and are operated by the USFWS and by the Washington Department of Fish and Wildlife (WDFW). NMFS' opinion (NMFS 2007a) determined that operation of the programs would not jeopardize salmon and steelhead protected under the ESA.

On May 5, 2008, NMFS published a Supplemental Comprehensive Analysis (SCA) (NMFS 2008e) and an opinion and RPAs for the FCRPS to avoid jeopardizing ESA-listed salmon and steelhead in the Columbia Basin (NMFS 2008c). The SCA environmental baseline included "the past effects of hatchery operations in the Columbia River Basin. Where hatchery consultations have expired or where hatchery operations have yet to undergo ESA section 7 consultation, the effects of future operations cannot be included in the baseline. In some instances, effects are ongoing (e.g., returning adults from past hatchery practices) and included in this analysis despite the fact that future operations cannot be included in the baseline. The Proposed Action does not encompass hatchery operations per se, and therefore no incidental take coverage is offered through this biological opinion to hatcheries operating in the region. Instead, we expect the operators of each hatchery to address its obligations under the ESA in separate consultations, as required" (see NMFS 2008e, p. 5-40).

Because it was aware of the scope and complexity of ESA consultations facing the co-managers and hatchery operators, 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 Jr. 2008). NMFS also "promised to share key considerations in analyzing HGMPs" and provided those materials to interested parties in February 2009 (Jones Jr. 2009).

On April 28, 2010 (Walton 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.” 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 “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 place for developing hatchery and harvest plans for ESA review…."

Beginning in 1991, listing of various Evolutionarily Significant Unit (ESUs) under the ESA complicated harvest management and severely limited execution of mixed-stock fisheries in the mainstem Columbia River. Regarding the SAFE Program, BPA, NMFS, ODFW, CCF, and WDFW have been focused on maximizing the commercial and recreational salmon fisheries potential of the Columbia River while minimizing impact on the recovering ESA-listed stocks. The SAFE project was originally conceived as part of the 1993 Strategy for Salmon, the Northwest Power Planning Council (NPPC, currently Northwest Power and Conservation Council, NPCC) recommended terminal-fishing sites be developed to allow harvest of known hatchery production while minimizing incidental harvest of weak stocks ("[f]und a study to evaluate potential terminal fishery sites and opportunities. This study should include: general requirements for developing those sites (*e.g.*, construction of acclimation/release facilities for hatchery smolts so that adult salmon would return to the area for harvest); the potential number of harvesters that might be accommodated; type of gear to be used; and other relevant information needed to determine the feasibility and magnitude of the program.") NMFS, in the Snake River Salmon Recovery Team and in the Proposed Recovery Plan for Snake River Salmon, also recommended terminal area fishing and selective fishing as the best harvest schemes for meaningful fishing opportunity where mixed-stock fisheries include weak, depressed, or endangered stocks. The SAFE Project was subsequently initiated and funded by BPA in 1993 to mitigate fisheries by providing the opportunity to harvest locally-produced salmon stocks in off-channel areas of the Columbia River.

In 1993, BPA completed an Environmental Assessment (EA) of Youngs Bay Salmon Rearing and Release Program under the National Environmental Policy Act (NEPA), and in 1994, prepared a categorical exclusion for research activities to identify and evaluate potential sites for expansion of the SAFE Project. In 1995, BPA completed an EA for expansion of the SAFE Project to include net pens in new sites, including Deep River, and issued a Finding of No Significant Impact (FONSI). On March 24, 1998, BPA and NMFS began informal ESA Section 7(a)(2) consultation. On July 23, 1998, BPA initiated formal Section 7 consultation with NMFS by submitting its Biological Assessment proposing to fund WDFW, ODFW, and CCF to investigate the feasibility of expanding the numbers of terminal fisheries sites in the Lower Columbia River in the study area downstream of river mile 49.

The first section 7 biological opinion was issued in 1998 while five species upriver of the SAFE project were proposed for listing: Upper Willamette steelhead, Mid-Columbia steelhead, Columbia River chum, Upper Willamette Spring Chinook, and Lower Columbia Fall Chinook. The re-initiation of formal consultation occurred in 1999 once those species were officially listed (64 CFR 14308). NMFS determined that the description of the SAFE project activities considered in the original 1998 opinion remained applicable. The opinion evaluated the effects of SAFE project operations for the first two phases: 2 years of initial research and investigation of potential sites, salmon stocks, and methodologies (including different net pen rearing regimes and harvest options), followed by roughly 8 years of expansion, and data monitoring. The final phase includes(d) the establishment of terminal fisheries operating at full capacity at all acceptable sites; however, this has been constrained by stock availability and funding limitations. BPA conducted a Supplemental Analysis to the 1995 EA/FONSI in 2010, for the increase of spring chinook and coho smolts released from the single, consolidated Deep River net pen site. In the time since its launch as a pilot study, the SAFE project, including these three SAFE programs, has evolved to include multiple funding and operating entities and complexities.

Non-treaty ocean, commercial, and recreational fishing of SAFE fish from SAFE areas (Buoy 10 to Bonneville Dam) was reported on in subsequent SAFE Reports (ODFW 2009, ODFW 2013, ODFW 2017c). Harvest of SAFE fish from select areas is covered over the years by the interim Management Agreement, the 2008-2017 *U.S. v. Oregon* Management Agreement, and the 2018-2027 *U.S. v. Oregon* Management Agreement (NMFS 2018b). Consultation with NOAA Fisheries regarding the 2008-2017 *U.S. v. Oregon* Management Agreement resulted in a biological opinion dated May 5, 2008 (NMFS 2008) with a finding of no significant impact (FONSI) for all activities described in the Management Agreement (including Select Area fisheries and test fishing research) (ODFW 2017c), and more recently resulted in an updated *U.S. v. Oregon* biological opinion (NMFS 2018a). Harvest-related production of SAFE fish is also a related activity partially covered in other opinions, including NMFS' biological opinion covering Mitchell Act funding (NMFS 2017b) and the Upper Willamette River hatchery programs (NMFS 2019).

Between the years 2005-2017, co-managers submitted HGMPs for the Oregon Coho salmon and Oregon Chinook salmon, and the Washington Coho salmon SAFE Programs. Final HGMPs were submitted for formal review in 2017. The HGMPs were found to be sufficient for NMFS consideration in 2018.

This opinion on the funding, operation and maintenance, and monitoring and evaluation of these three SAFE hatchery programs is based on latest HGMPs (ODFW 2021a; ODFW 2021b; WDFW 2018) submitted to NMFS by the operators.

1.3. Proposed Action

"Action," as applied under the ESA, means all activities, of any kind, authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR 402.02). For EFH consultation, "Federal action" means any on-going or proposed action authorized, funded, or undertaken by a Federal Agency (50 CFR 600.910). Because the actions of the Federal agencies are subsumed within the effects of the hatchery program, and any associated research, monitoring and evaluation, the details of each hatchery program are summarized in this section.

The proposed action is to fund the operators to: (1) acclimate and release juveniles from the three SAFE spring Chinook salmon and coho salmon hatchery programs in the Lower Columbia River estuary at SAFE facilities, (2) monitor and evaluate these programs, and (3) operate and maintain the SAFE facilities. The federal funding provided by BPA, NMFS, and USFWS (Action Agencies) to the operators/co-managers for these activities helps support full implementation of these hatchery programs, as described, in brief, below and in ODFW (2021a), ODFW (2021b), and WDFW (2018)(Table 1; Figure 1) in their entirety.

The USFWS provides funding through their Sport Fish Restoration Act (SFR Act, 16 U.S.C. §§ 777 to 777-k), to ODFW, to support the Salmon and Trout Enhancement Program (STEP) grant and other WSFR grants or activities. Thus, a portion of ODFW funded activities, as mentioned below, may be through annual grants administered by the USFWS. BPA provides funding under the Pacific Northwest Electric Power Planning and Conservation Act (Northwest Power Act). NMFS provides funding through the Mitchell Act and the Pacific Salmon Treaty. Non-federal funding is also provided by ODFW, WDFW, and CCF. All of these combined funding sources are necessary in order for the operators to fully implement the three SAFE hatchery programs. Other funding may also support the production of SAFE hatchery fish since a variety of hatchery facilities are used throughout the Lower Columbia River and tributaries to implement the SAFE program, but this funding is ancillary to the funding specified above, and governed by ESA consultations as described below.

The operators' implementation of the three SAFE programs in their entirety includes: (1) the use of hatchery facilities throughout the Lower Columbia River and its tributaries for the collection and rearing of juvenile SAFE spring Chinook salmon and coho salmon, (2) transport of juveniles to SAFE facilities in the estuary, (3) acclimation and release of juveniles from SAFE facilities, (4) operation and maintenance of SAFE hatchery facilities and net pens, and (5) associated SAFE monitoring and evaluation activities. The details for the operators' production of SAFE hatchery fish is specified below and in Appendix A. Of these activities necessary for full implementation of the three SAFE programs, the operators' use of various hatchery facilities throughout the Lower Columbia River and tributaries to collect broodstock, take eggs, and rear juvenile salmon is necessary for the proposed action to occur, but not part of the proposed action covered in this opinion. ESA consultation has already been completed for the operation and funding of these hatchery facilities by NMFS (2017b) and NMFS (2019). The operation of these hatchery facilities is governed by those consultations; they are also used for the production of SAFE hatchery fish. The end result is the acclimation and release of hatchery fish from the SAFE facilities specified in Figure 1. The full details of the production of SAFE fish is further described below.

Table 1. Programs included in the Proposed Action.

Program	HGMP Date	Program Operator(s)	Funding Agencies	Program Type
SAFE Coho Salmon Program	October 19, 2017 May, 2021	ODFW, CCF	BPA, NMFS, ODFW, CCF	Isolated harvest for fisheries supplementation
SAFE Spring Chinook Salmon Program	March 31, 2017 May 2021	ODFW, CCF	BPA, NMFS, USFWS, ODFW, CCF	
SAFE Type-N Coho Salmon Program	Deep River Type-N July 24, 2018; Elochoman Type-N June 28, 2019	WDFW	NMFS, WDFW	

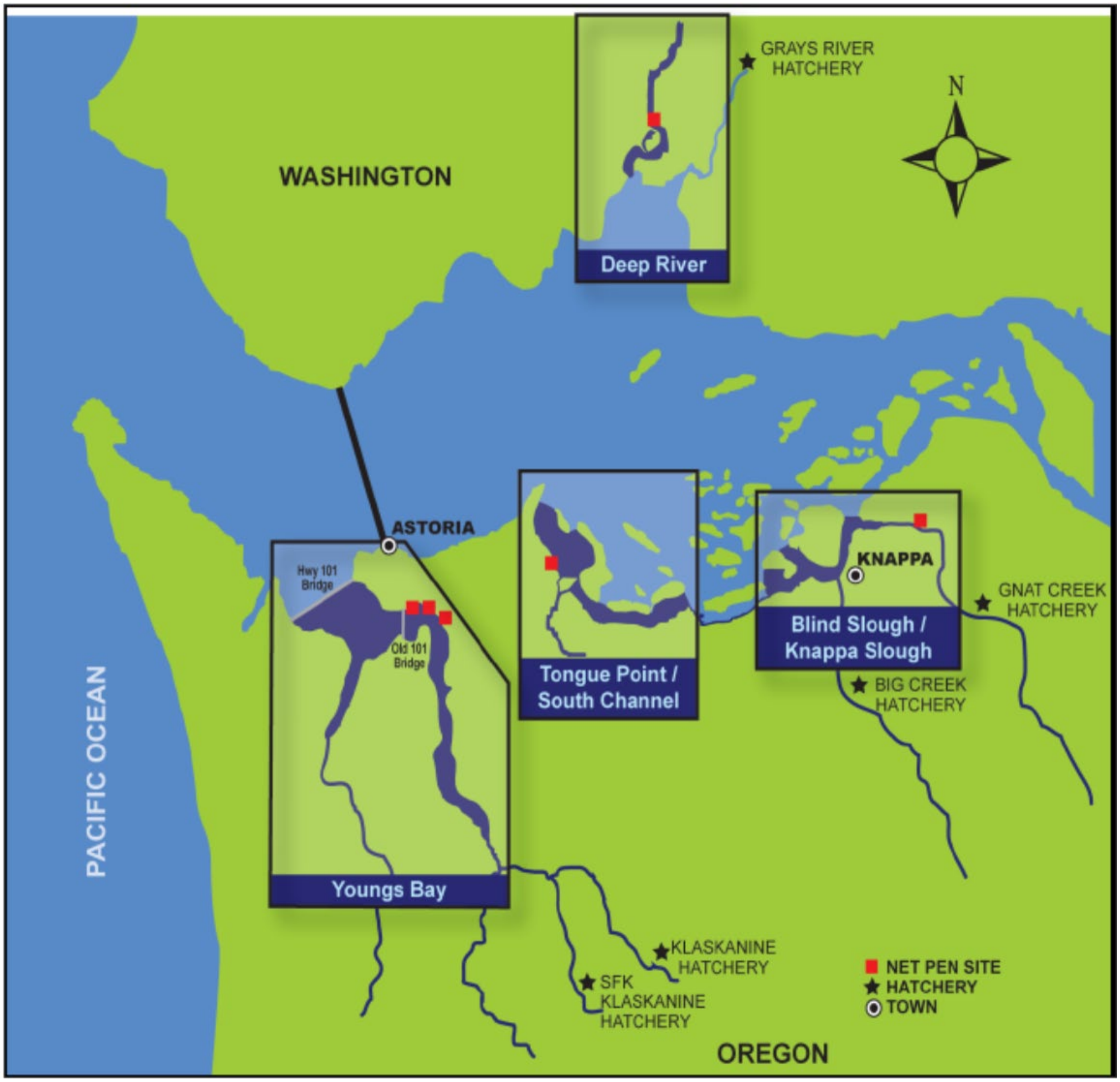

Figure 1. Locations where SAFE hatchery spring Chinook salmon and coho salmon are acclimated and released from net pens and other hatchery facilities in the Lower Columbia River estuary.

We considered, under the ESA, whether or not the proposed action would cause any other activities. This is not a simple or straightforward consideration for hatchery programs in the Columbia Basin, as such programs typically interact in various aspects of their operations, and most programs, including the SAFE programs considered here, are explicitly intended to provide fish for harvest. The primary purpose of the proposed action is to assist operators/co-managers with the full implementation of the SAFE programs (by funding acclimation and release at SAFE facilities, monitoring and evaluation, and SAFE facility O&M) such that SAFE hatchery salmon returning to the Lower Columbia River estuary are available for harvest. These commercial and recreational fisheries are an explicitly intended outcome of the production of SAFE hatchery fish. However, management of these fisheries is not entirely under the jurisdiction of the action agencies, and is subject to other management agreements among other co-managers responsible for fisheries management. Since ESA consultation has already been completed on the fisheries targeting SAFE returning salmon, these other opinions govern the allowable impacts (NMFS 2018a; NMFS 2018b) and are included in the Environmental Baseline section of the opinion below.

1.3.1. Proposed hatchery production and juvenile acclimation and release

To fully implement the SAFE programs, the operators and co-managers (CCF, ODFW, WDFW) propose to produce and release up to 4.25 million spring Chinook salmon smolts and up to 4.3 million coho salmon smolts annually as described in the three HGMPs (ODFW 2021a; ODFW 2021b; WDFW 2018)(where “production” includes collection and rearing and is an interrelated and interdependent action covered in other ESA consultations) for acclimation and release at the SAFE facilities that will continue to occur at the locations specified in those documents and shown in Figure 1. The operators’ production proposal for the full implementation of the SAFE programs includes a 10% variability in actual smolt production releases due to variability in survival, growth, and other factors outside the control of the hatchery operators.

Broodstock to produce the hatchery smolt production specified above will all be hatchery-origin salmon collected at several ODFW- and WDFW-operated facilities (Table 2). The total return of hatchery salmon to these facilities is typically greater than the need and therefore allows for eggs to be taken from surplus returns for the SAFE program. As described above, the actual operation of these broodstock collection facilities, including interrelated and interdependent broodstock and egg collection and rearing actions, have already undergone ESA consultation for effects on ESA-listed salmon and steelhead and is currently governed by NMFS (2017b) and NMFS (2019). This information is included here for clarity because it is an intended component of the action necessary for the full implementation of the SAFE program, and contextualizes the proposed action for acclimation and release activities covered by this opinion. For spring Chinook salmon production, broodstock is collected from the Clackamas, North Santiam River, and South Santiam River at hatchery facilities operated by ODFW. For coho salmon production, broodstock is collected from Big Creek, Beaver Creek, and Washington Cascade strata hatcheries (Cowlitz, Kalama, Lewis, Washougal) by ODFW and WDFW. NMFS (2017b) and NMFS (2019) ESA biological opinions and corresponding incidental take statements cover the operations of these facilities and are included as part of the environmental baseline below. Therefore, for the operation and maintenance of the three SAFE hatchery programs addressed by this opinion, only the acclimation and release components occurring at SAFE facilities needs to be evaluated and authorized under the ESA (in addition to monitoring and evaluation and SAFE facility O&M), and thus is the subject of this opinion.

Table 2. Broodstock collection locations for the ODFW and WDFW SAFE programs.

Program	**Stock**	**Collection Location**
Spring Chinook Salmon (OR)	Clackamas River (ODFW Stock 19)	Clackamas Hatchery; North Fork Dam[1]
	North Fork Santiam River (ODFW Stock 21)	Minto Fish Collection Facility[2]
	South Fork Santiam River (ODFW Stock 24)	Foster Fish Collection Facility[2]
Coho Salmon (OR)	Big Creek (ODFW Stock 13)[5]	Big Creek Hatchery[1]
Coho Salmon (WA)	Elochoman. Backup: Cowlitz, Kalama, Lewis, Washougal River Type N	Beaver Creek Hatchery. Backup: Cowlitz Hatchery, Kalama Falls Hatchery, Lewis River Hatchery, Washougal Hatchery

[1] The take associated with collecting brood at these facilities is governed by NMFS (2017b).
[2] The take associated with collecting brood at these facilities are governed by NMFS (2019).
[5] Klaskanine and South Fork Klaskanine hatcheries functions include providing backup coho broodstock to Big Creek (Stock 13). Since these broodstock collection facilities will be used as a backup in the event of a brood stock collection shortage at Big Creek Hatchery, there is no definitive number of adults that will be collected for the program. To satisfy the proposed smolt production goal for the broodstock portion of the coho salmon program, about 3,000 pairs are needed.

For the production of spring Chinook salmon, as described above, NMFS and ODFW will coordinate through other hatchery production and harvest forums and consultations (NMFS (2017b) for Clackamas stock, NMFS (2018a) for *U.S. v. Oregon* harvest, NMFS (2019) for Willamette hatcheries) to appropriately adjust broodstock sources, annual production levels, and incorporation of harvest-related tools to avoid or decrease effects on ESA-listed fish from spring Chinook SAFE hatchery production. For the acclimation and release of spring Chinook salmon at SAFE facilities, as described in Section 1.3 above, NMFS proposes to continue providing Pacific Salmon Treaty funding, (currently supporting operator production and release of up to 1.5 million smolts), BPA proposes to continue providing Northwest Power Act funding (which currently supports operator production and release of up to 900,000 smolts), and USFWS proposes to continue providing Sport Fish Restoration Act funding. ODFW will continue to fund production and release of the remaining smolts, up to 1.9 million smolts. As described both above and below, the production activities in the Willamette River Basin (broodstock/egg collection and rearing activities) are covered by other consultations (NMFS 2017b, NMFS 2019).

For the production of coho salmon, as described above, NMFS, WDFW, and ODFW will coordinate through other hatchery production and harvest forums and consultations (NMFS

2017b and 2018b) to appropriately adjust broodstock sources, annual production levels, and incorporation of harvest-related tools to avoid or decrease effects on ESA-listed fish from coho SAFE hatchery production. For the acclimation and release of coho salmon at SAFE facilities, as described in Section 1.3 above, BPA proposes to continue providing Northwest Power Act funding, and NMFS proposes to continue providing Mitchell Act funding (NMFS) to ODFW and WDFW. The specific production groups are further specified in Appendix A.

Fish health staff monitor the fish throughout their rearing cycle for signs of disease. Mortalities are checked daily and live grab samples are taken monthly. Fish are also tested prior to transfer to acclimation sites and before release. Spring Chinook salmon are also vaccinated at Gnat Creek Hatchery prior to arriving at net pens to help prevent vibriosis outbreaks. Coho salmon are vaccinated at approximately 100/lb for vibriosis and furunculosis once they are in the net pens. Sampling, testing, and treatment/control procedures are outlined in multiple documents (IHOT 1995; Pacific Northwest Fish Health Protection Committee (PNFHPC) 1989).

In the net pens, fish health is monitored daily and any mortalities are examined for signs of disease. If an outbreak occurs, pathology staff will take fish back to the lab for necropsy and gram stains, then recommend a treatment as needed, typically with medicated feed (TM-200). Usually, ODFW pathologist will receive samples to confirm the diagnosis. If significant losses occur in any of the net pens, mortalities are bagged, frozen, and put in the facility dumpster. No exchange of nets is made between different rearing sites, to minimize risk of disease transfer. All coho salmon are released volitionally. Spring Chinook salmon smolt are released from net pens once they show signs of wanting to leave (i.e., circling the pens) using methods which promote rapid emigration. Large high tides in late evening are preferred by CCF for releasing smolts as Ledgerwood et al. (1997) found that fish released near high tide emigrated out of Youngs Bay within one tidal cycle.

1.3.2. Proposed research, monitoring, and evaluation

Monitoring and evaluation (M&E) activities performed for these programs is funded by BPA through the SAFE project in Oregon and Washington (BPA Project #1993-06000). Additional monitoring elements necessary for evaluating the program effects are funded through the Coded Wire Tag recovery project in Oregon (NOAA – Mitchell Act). The following requirements of the SAFE programs to monitor and evaluate risks have been put in place:

- 100% adipose fin clips, with 6.8% CWT of coho salmon in Oregon and 45,000 coho salmon CWT in Washington.
- Spawning ground surveys along with CWT analysis will be conducted in SAFE drainage streams to determine the extent of natural spawning of program fish.
- Local area streams will be monitored for natural and hatchery-origin coho escapement based on adipose fin clip identification and CWT will be collected for evaluation.
- Hatchery fish will be monitored through standard fish health production monitoring and reporting.
- Juvenile fish will be monitored monthly by a fish health expert and disposal of affected fish or eggs will be disposed of following IHOT policy.
- Wild fish data will be obtained from juvenile and adult surveys by ODFW and WDFW and other affiliates.

1.3.3. Proposed operation, maintenance, and construction of hatchery facilities

Several routine maintenance activities occur in or near water that could impact fish in the area including: sediment/gravel removal/relocation from intake and/or outfall structures, pond cleaning, pump maintenance, debris removal from intake and outfall structures, and maintenance and stabilization of existing bank protection. All in-water maintenance activities considered "routine" for the purposes of this action will occur within existing structures or the footprint of areas that have already been impacted. When maintenance activities occur within water, they will comply with the following guidance:

- In-water work will:
    - Be done during the allowable freshwater work times established for each location, or comply with an approved variance of the allowable freshwater work times with the appropriate state agencies
    - Follow a pollution and erosion control plan that addresses equipment and material storage sites, fueling operations, staging areas, cement mortars and bonding agents, hazardous materials, spill containment and notification, and debris management
    - Cease if fish are observed in distress at any time as a result of the activities
    - Include notification of NMFS staff
- Equipment will:
    - Be inspected daily, and be free of leaks before leaving the vehicle staging area
    - Work above ordinary high water or in the dry whenever possible
    - Be sized correctly for the work to be performed and have approved oils / lubricants when working below the ordinary high water mark
    - Be staged and fueled in appropriate areas 150 feet from any water body
    - Be cleaned and free of vegetation before they are brought to the site and prior to removal from the project area net pens

Both the ODFW spring Chinook salmon and the coho salmon programs use net pens for some of the over-winter or two-week acclimation. These net pens are located in Youngs Bay, Tongue Point, and Blind Slough (Figure 1). Net pens at each rearing/acclimation/release site consist of two to four individual 6.1 m^2 inside dimension frames of high-density polyethylene pipe (33 cm) filled with Styrofoam. A wooden walkway of 2" x 12" lumber is bolted to the plastic frame for access. A 3.1 m deep net hung within each frame confines the fish during rearing and acclimation. Mesh sizes of 3.2-19.0 mm (0.125-0.750") are utilized and adjusted depending on fish size. Vertical plastic standpipes are submerged around the perimeter of each pen to maintain the shape of the net. Actual rearing area of each net is approximately 91 m^3 (3,200 ft^3). There are currently 76 pens at Youngs Bay, 37 at Tongue Point, and 15 at Blind Slough. Fish are grown and released from these pens under varying management and grow-out regimes including 2-week acclimation, over-winter, and full-term net-pen rearing (ODFW 2021a; ODFW 2021b). The WDFW Coho salmon program uses Deep River net pens for acclimation starting in November through smoltification in March/April. The 40 net pens in Deep River each have a volume of 147 m^3 and mesh sizes used are appropriate to retain the fish until smolt stage is reached without premature escape. Predator measures of cover nettings and electrical grid fences are used to minimize predation impact (WDFW 2018).

No major catastrophic disasters related to net-pen rearing or related operational activities have occurred in the past, though several minor incidences, such as floating debris, have torn holes in nets allowing early escapement for a small number of fish. Net pens are checked for holes during regular washing schedules to prevent accidental releases, and net pen complexes are sufficiently constructed to avoid accidents due to adverse weather.

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

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

NMFS has determined the proposed action is not likely to adversely affect many ESA-listed species or their critical habitat. Our concurrence is documented in the "Not Likely to Adversely Affect" Determinations section (Section 2.12, below). These include the following species: Upper Willamette winter steelhead, Middle Columbia steelhead, Upper Columbia spring Chinook salmon and steelhead, Snake River fall Chinook and sockeye salmon and steelhead, eulachon, Southern green sturgeon, and Southern Resident killer whales.

2.1. Analytical Approach

This biological opinion includes both a jeopardy analysis and an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "jeopardize the continued existence of" a listed species, which is "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

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

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

The 2019 regulations define effects of the action using the term "consequences" (50 CFR 402.02). As explained in the preamble to the regulations (84 FR 44977), that definition does not change the scope of our analysis and in this opinion we use the terms "effects" and "consequences" interchangeably.

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

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

Range-wide status of the species and critical habitat

This section describes the status of species and critical habitat that are the subject of this opinion. The status review starts with a description of the general life history characteristics and the population structure of the ESU/DPS, including the strata or major population groups (MPG) where they occur. NMFS has developed specific guidance for analyzing the status of salmon and steelhead populations in a “Viable Salmonid Population” (VSP) paper (McElhany et al. 2000). The VSP approach considers four attributes, the abundance, productivity, spatial structure, and diversity of each population (natural-origin fish only), as part of the overall review of a species’ status. For salmon and steelhead protected under the ESA, the VSP criteria therefore encompass the species’ “reproduction, numbers, or distribution” (50 CFR 402.02). In describing the range-wide status of listed species, NMFS reviews available information on the VSP parameters including abundance, productivity trends (information on trends, supplements the assessment of abundance and productivity parameters), spatial structure, and diversity. We also summarize available estimates of extinction risk that are used to characterize the viability of the populations and ESU/DPS, and the limiting factors and threats. To source this information, NMFS relies on viability assessments and criteria in technical recovery team documents, ESA Status Review updates, and recovery plans. We determine the status of critical habitat by examining its physical and biological features (also called “primary constituent elements” or PCEs). Status of the species and critical habitat are discussed in Section 2.2.

Description of the environmental baseline

The environmental baseline includes the past and present impacts of Federal, state, or private actions and other human activities in the Action Area on ESA-listed species. 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. The environmental baseline is discussed in Section 2.4 of this opinion.

Cumulative effects

Cumulative effects, as defined in NMFS' implementing regulations (50 CFR 402.02), 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 considered in Section 2.6 of this opinion.

Integration and synthesis

Integration and synthesis occurs in Section 2.7 of this opinion. In this step, NMFS adds the effects of the Proposed Action (Section 1.3) to the status of ESA protected populations in the Action Area under the environmental baseline (Section 2.4) and to cumulative effects (Section 2.6). Impacts on individuals within the affected populations are analyzed to determine their effects on the VSP parameters for the affected populations, and these are combined with the overall status of the strata/MGP to determine the effects on the ESA-listed species (ESU/DPS) which will be used to formulate the agency's opinion as to whether the hatchery action is likely to: (1) result in appreciable reductions in the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat.

Jeopardy and adverse modification

Based on the Integration and Synthesis analysis in Section 2.7, the opinion determines whether the proposed action is likely to jeopardize the survival and recovery of ESA-listed species or destroy or adversely modify designated critical habitat in Section 2.7.

Reasonable and prudent alternative(s) (RPAs) to the Proposed Action

If NMFS determines that the action under consultation is likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat, NMFS must identify an RPA or RPAs to the Proposed Action.

2.2. Range-wide Status of Species and Critical Habitat

This opinion examines the status of each species that would be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the function of the PBFs that are essential for the conservation of the species.

An example of some PBFs are listed below. These are often similar among listed salmon and steelhead; specific differences can be found in the critical habitat designation for each species (Section 2.2).

(1) Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development;
(2) Freshwater rearing sites with: (i) Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; (ii) Water quality and forage supporting juvenile development; and (iii) Natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks;
(3) Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival;
(4) Estuarine areas free of obstruction and excessive predation with: (i) Water quality, water quantity, salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; (ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels; and (iii) Juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation;
(5) Near-shore marine areas free of obstruction and excessive predation with: (i) Water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and (ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels;
(6) Offshore marine areas with water-quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.

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 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.

2.2.1. Status of Listed Species

For Pacific salmon and steelhead, 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 parameters or 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) produced per naturally spawning parental pair. 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, on habitat quality and spatial configuration, and on the dynamics and dispersal characteristics of individuals in the population.

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

In describing the range-wide status of listed species, we rely on viability assessments and criteria in TRT documents and recovery plans, when available, that describe VSP parameters at the population, major population group (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 have 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).

Within an ESU or DPS, independent populations fall into larger groups based on ecological preference and dominant life history strategy and expressed run timing (that is, the time of year when the salmon or steelhead return to spawn). These major population groups, or strata, share similar genetic characteristics, geographic distribution, and habitat requirements. Strata are largely isolated from one another over a longer time scale than that defining individual populations, but they retain a degree of connectivity greater than that between different ESUs or

DPSs. Figure 2 shows the relationship between ESU/DPS, strata, and independent populations. In the case of LCR salmon and steelhead, strata are defined by a combination of ecological zone – Coast, Cascade, or Gorge – and dominant life history strategy, such as spring, fall, or late fall run timing. For example, Gorge fall Chinook salmon and Gorge spring Chinook salmon are separate strata.

NMFS (2013) in their LCR Recovery Plan identified what is necessary for a viable ESU/DPS:

- Every stratum should have a high probability of persistence.
- Within each stratum, there should be at least two populations that have at least a 95% probability of persistence over a 100-year time frame.
- Within each stratum, the average viability of the populations should be 2.25 or higher, using the McElhany et al. (2007b) scoring system (see discussion below). Functionally, this is equivalent to half of the populations in the stratum being viable; a viable population is one whose probability of persistence is high or very high.
- Populations targeted for viability should include those within the ESU that historically were the most productive ("core" populations) and those that best represent the historical genetic diversity of the ESU ("genetic legacy" populations). In addition, viable populations should be geographically dispersed in a way that protects against the effects of catastrophic events.

Viable populations should meet specific criteria for abundance, productivity, spatial structure, and diversity population attributes.

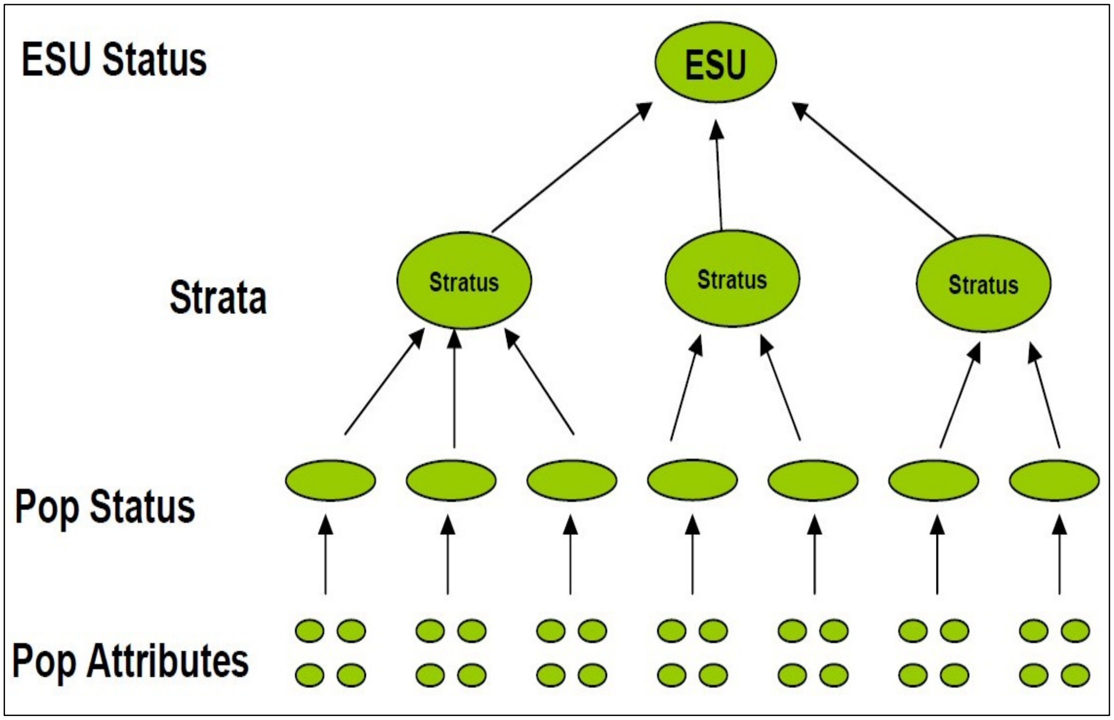

Figure 2. Hierarchical approach for ESU/DPS viability criteria.

In describing the range-wide status of listed species, we rely on viability assessments and criteria in TRT documents and recovery plans, when available, that describe VSP parameters at the population, major population group (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 have 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).

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 April 14, 2014. Critical Habitat for LCR Chinook salmon was designated on September 2, 2005 (70 FR 52706).

Within the geographic range of this ESU, 27 hatchery Chinook salmon programs are currently operational. Fourteen of these hatchery programs are included in the ESU, while the Mitchell Act funding remaining 13 programs are excluded (Jones Jr. 2015). Willamette River Chinook salmon are listed within the Willamette River Chinook Salmon ESU, but they are not listed within the LCR Chinook Salmon ESU. Genetic resources that represent the ecological and genetic diversity of a species can reside in a hatchery program. "Hatchery programs with a level of genetic divergence relative to the local natural population(s) that is no more than what occurs within the ESU are considered part of the ESU and will be included in any listing of the ESU" (NMFS 2005c). For a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS (NMFS 2005c).

Table 3. LCR Chinook Salmon ESU description and MPGs.

ESU Description[1]	
Threatened	Listed under ESA in 1999, updated in 2014
6 major population groups	32 historical populations
Major Population Group	***Populations***
Cascade Spring	Upper Cowlitz (C,G), Cispus (C), Tilton, 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 the ESU (14)	Big Creek Tule Fall Chinook, Astoria High School (STEP), Tule Fall Chinook, Warrenton High School (STEP), Tule Fall Chinook, Cowlitz Tule Fall Chinook Salmon Program, North

	Fork Toutle Tule Fall Chinook, Kalama Tule Fall Chinook, Washougal River Tule Fall Chinook, Spring Creek National Fish Hatchery (NFH) Tule Chinook, Cowlitz spring Chinook salmon (2 programs), Friends of Cowlitz spring Chinook, Kalama River Spring Chinook, Lewis River Spring Chinook, Fish First Spring Chinook, Sandy River Hatchery Spring Chinook salmon (ODFW stock #11)
Hatchery programs *not* included in the ESU (13)	Deep River Net-Pens Spring Chinook, 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, 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

[1] The designation (C) and (G) identify Core and Genetic Legacy populations, respectively

Thirty-two historical populations within six MPGs comprise the LCR Chinook Salmon ESU. These are distributed through three ecological zones, whereby through a combination of life history types based on run timing and ecological zones result in the six MPGs, some of which are considered extirpated or nearly so. The run timing distributions across the 32 historical populations are: nine spring populations, 21 early-fall populations, and two late-fall populations.

Table 4. Current status for LCR Chinook salmon populations and recommended status under the recovery scenario (NMFS 2013).

Major Population Group	**Population (State)**	**Status Assessment**		**Recovery Scenario**	
		Baseline Persistence Probability[1]	**Contribution[2]**	**Target Persistence Probability**	**Abundance Target[3]**
Cascade Spring	Upper Cowlitz (WA)	VL	Primary	H+	1,800
	Cispus (WA)	VL	Primary	H+	1,800
	Tilton (WA)	VL	Stabilizing	VL	100
	Toutle (WA)	VL	Contributing	M	1,100
	Kalama (WA)	VL	Contributing	L	300
	North Fork Lewis (WA)	VL	Primary	H	1,500
	Sandy (OR)	M	Primary	H	1,230
Gorge Spring	White Salmon (WA)	VL	Contributing	L+	500
	Hood (OR)	VL	Primary[4]	VH[4]	1,493
Coast Fall	Youngs Bay (OR)	L	Stabilizing	L	505
	Grays/Chinook (WA)	VL	Contributing	M+	1,000
	Big Creek (OR)	VL	Contributing	L	577
	Elochoman/Skamokawa (WA)	VL	Primary	H	1,500
	Clatskanie (OR)	VL	Primary	H	1,277
	Mill/Aber/Germ (WA)	VL	Primary	H	900
	Scappoose (OR)	L	Primary	H	1,222
Cascade Fall	Lower Cowlitz (WA)	VL	Contributing	M+	3,000
	Upper Cowlitz (WA)	VL	Stabilizing	VL	--
	Toutle (WA)	VL	Primary	H+	4,000
	Coweeman (WA)	VL	Primary	H+	900
	Kalama (WA)	VL	Contributing	M	500
	Lewis (WA)	VL	Primary	H+	1,500
	Salmon (WA)	VL	Stabilizing	VL	--
	Clackamas (OR)	VL	Contributing	M	1,551
	Sandy (OR)	VL	Contributing	M	1,031
	Washougal (WA)	VL	Primary	H+	1,200
Gorge Fall	Lower Gorge (WA/OR)	VL	Contributing	M	1,200
	Upper Gorge (WA/OR)	VL	Contributing	M	1,200
	White Salmon (WA)	VL	Contributing	M	500
	Hood (OR)	VL	Primary[4]	H[4]	1,245
Cascade Late Fall	North Fork Lewis (WA)	VH	Primary	VH	7,300
	Sandy (OR)	H	Primary	VH	3,561

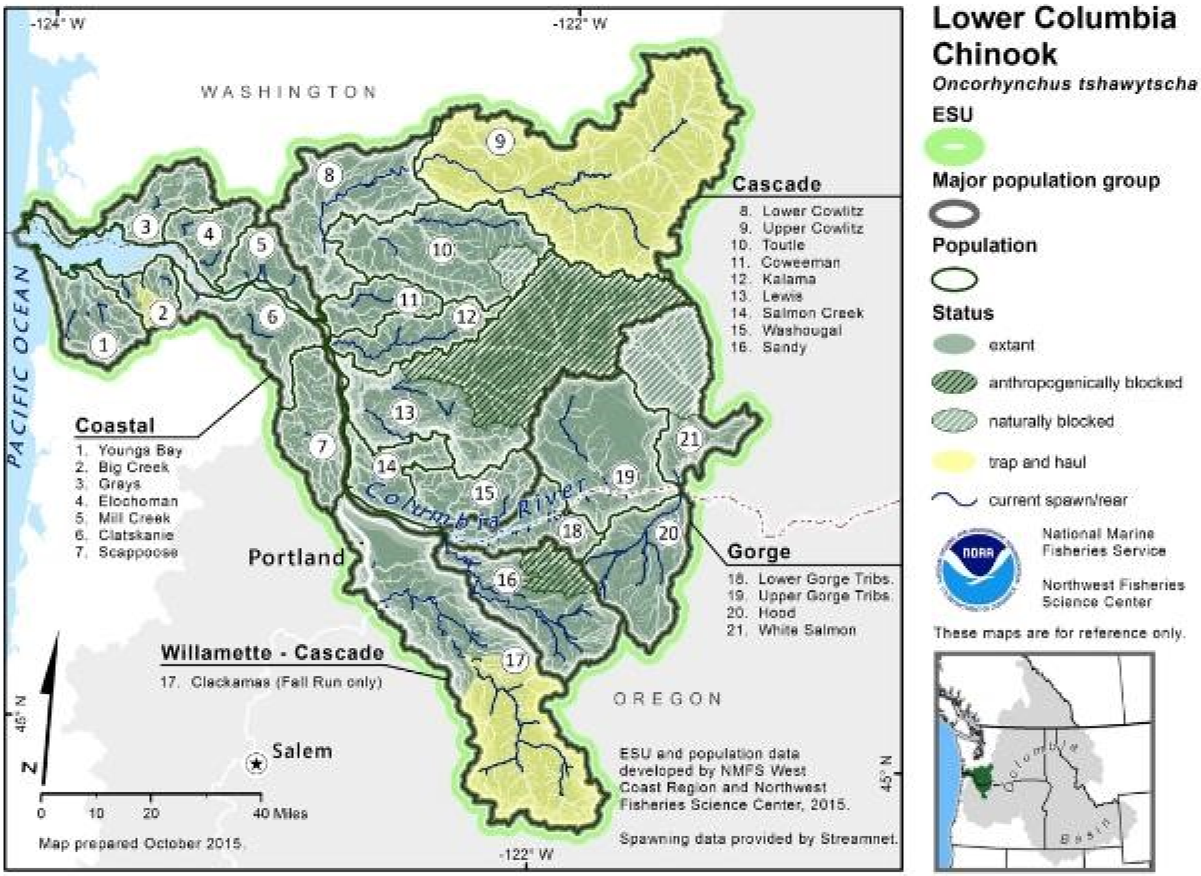

Figure 3. Map of the LCR Chinook Salmon ESU spawning and rearing areas, illustrating populations and major population groups (NWFSC 2015).

LCR 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 5). LCR spring Chinook salmon are stream-type, while LCR 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 main stem Columbia (NMFS 2013). Stream characteristics determine the distribution of run types among LCR streams. Depending on run type, Chinook salmon may rear for 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 LCR fish occasionally reach sizes up to 25 kilograms (55 lbs). Chinook salmon require clean gravels for spawning and pool and side-channel habitats for rearing. All Chinook salmon die after spawning once (NMFS 2013).

Table 5. Life-history and population characteristics of LCR Chinook salmon.

Characteristic	**Life-History Features**		
	Spring	**Early-fall (tule)**	**Late-fall (bright)**
Number of extant population	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	Main stem large tributaries	Main stem 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 main stem	Main stem, tributaries, sloughs, estuary	Main stem, 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

All LCR Chinook salmon runs have been designated as part of a LCR Chinook Salmon ESU that includes natural populations in Oregon and Washington from the ocean upstream to and including the White Salmon River in Washington and Hood River in Oregon. 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) (LCFRB 2010b). 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 LCR spring or tule Chinook salmon, and have a more northerly oceanic distribution. Currently, the abundance of all fall Chinook salmon greatly exceeds that of the spring component (NWFSC 2015).

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 Chinook Salmon ESU, is at high risk and remains at threatened status. Each LCR Chinook salmon natural population baseline and target persistence probability level is summarized in Table 13, 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%).

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 for Gorge spring and Gorge fall Chinook salmon would not meet WLC TRT criteria because, within each MPG, the scenario targets only one population (the Hood) for high persistence probability. Exceeding the WLC TRT criteria, particularly in the Cascade fall and Cascade spring Chinook salmon MPG, was intentional on the part of local 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 because of 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 to provide a safety factor 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.

Based on the information provided by the WLC TRT and the management unit recovery planners, NMFS concluded in the recovery plan that the recovery scenario in 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.

Cascade Spring MPG

LCR spring Chinook salmon natural populations occur in both the Gorge and Cascade MPGs (Table 12). There are seven LCR spring Chinook salmon populations in the Cascade MPG. The most recent estimates of minimum inriver run size, catch, and escapement totals for LCR spring Chinook salmon is provided in Table 15. The combined hatchery-origin and natural-origin LCR spring Chinook salmon run sizes for the Cowlitz, Kalama, and Lewis river populations in Washington have all numbered in the thousands in recent years (Table 15). Estimated total spawner abundances for Washington populations are provided in Table 16. The Cowlitz and Lewis populations are currently managed for hatchery production since most of the historical spawning habitat has been inaccessible due to hydro development in the upper basin (LCFRB 2010). The hatcheries' escapement objectives have been met in recent years with few exceptions (Table 17).

Table 6. Total annual run size of LCR spring Chinook salmon populations (PFMC 2016, Table B-12).

Year or Average	Cowlitz River[1]	Kalama River	Lewis River[1]	Sandy River
1997	1,877	505	2,196	4,410
1998	1,055	407	1,611	3,577
1999	2,069	977	1,753	3,585
2000	2,199	1,418	2,515	3,641
2001	1,609	1,796	3,777	5,329
2002	5,215	2,912	3,514	5,905
2003	15,954	4,556	5,040	5,615
2004	16,511	4,286	7,475	12,680
2005	9,379	3,367	3,512	7,668
2006	6,963	5,458	7,301	4,382
2007	3,975	8,030	7,596	2,813
2008	2,986	1,623	2,215	5,994
2009	5,977	404	1,493	2,429
2010	8,830	918	2,337	7,652
2011	5,834	778	1,311	5,721
2012	12,617	862	1,895	5,038
2013	9,536	1,014	1,597	5,700
2014	10,461	1,013	1,482	5,971
2015	23,931	3,149	1,006	4,000

[1] Includes hatchery escapement, tributary recreational catch, and natural spawning escapement from 1975-present.

Table 7. Spring Chinook salmon total natural spawner abundance estimates in LCR tributaries, 1997-2014 (from WDFW Salmon Conservation and Reporting Engine (SCORE)[1])*.

Year	Cowlitz[2]	Kalama	NF Lewis
1997	437	39	410
1998	262	42	211
1999	235	215	240
2000	264	33	439
2001	315	555	642
2002	781	886	483
2003	2,485	766	679
2004	2,048	352	494
2005	539	380	116
2006	816	292	847
2007	144	2,144	264
2008	484	363	25

2009	549	26	58
2010	286	0	157
2011	191	200	120
2012	321	28	318
2013	409	158	60
2014	227	187	428

[1] Online at: https://fortress.wa.gov/dfw/score/score/species/chinook.jsp?species=Chinook
*Date Accessed: April 12, 2016.
[2] Cowlitz River numbers include both the Lower, Upper, and Cispus portions of the Cowlitz River. Only natural spawner abundance estimates are shown. Estimates have been provided in the hatchery origin and natural origin forms for the Lower, Upper, and Cispus portions of the Cowlitz River from 2010-2014, 1996-2014, and 1996-2014, respectively.

Table 8. Cowlitz, Lewis River, and Kalama Falls Hatchery rack escapements for LCR Spring Chinook salmon (From WDFW Final Hatchery Escapement Reports, 1996-1997 through 2009-2010). These are numbers of fish returning to the hatchery, with each hatchery's goal.

Year	**Cowlitz Salmon Hatchery**[1]	**Lewis River Hatchery**[2]	**Kalama Falls Hatchery**[3]
	Goal: 1,337	**Goal: 1,380**	**Goal: 300**
1997	1,298	2,245	576
1998	812	1,148	408
1999	1,321	845	794
2000	1,408	776	1,256
2001	1,306	1,193	952
2002	2,713	1,865	1,374
2003	10,481	3,056	3,802
2004	12,596	4,235	3,421
2005	7,503	2,219	2,825
2006	5,379	4,130	4,313
2007	3,089	3,897	4,748
2008	1,895	1,386	940
2009	3,604	1,068	170
2010	5,920	1,896	467
2011	1,992	1,101	275
2012	5,589	1,294	285
2013	3,762	1,785	732
2014	4,591	1,009	709
2015	17,600	908	2,642

[1] Cowlitz River Spring Chinook salmon brood origin hatchery returns are collected on-station at the Cowlitz Salmon Hatchery. Goal is from Cowlitz River Spring Chinook HGMP online at: http://wdfw.wa.gov/hatcheries/hgmp/pdf/lower_columbia/cowlitz_sping_chinook_2014.pdf last accessed June 18, 2016.
[2] Lewis River Spring Chinook salmon brood origin hatchery returns are collected at the Merwin Dam Fish Collection Facility, and on-station at the Lewis River Hatchery. Goal is from Lewis River Spring Chinook HGMP online at: http://wdfw.wa.gov/hatcheries/hgmp/pdf/lower_columbia/lewisr_sp_chin_2014_draft.pdf last accessed June 18, 2016.

[3] Kalama River Spring Chinook salmon brood origin hatchery returns are collected on-station at the Kalama Falls Hatchery.

A reintroduction program is now being implemented on the Cowlitz River that involves trap and haul of adults and juveniles. The reintroduction program for the upper Cowlitz and Cispus Rivers above Cowlitz Falls Dam is consistent with the recommendations of the recovery plan and constitutes the initial steps in a more comprehensive recovery strategy. However, the program is currently limited by low collection efficiency of out-migrating juveniles at Cowlitz Falls Dam and by lack of productivity in the Tilton basin because of relatively poor habitat quality. Some unmarked adults, meaning unknown origin (hatchery or natural), return voluntarily to the hatchery intake, but for the time being, the reintroduction program relies primarily on the use of surplus hatchery adults. (Information on the hatchery program and associated Settlement Agreement with Tacoma Power can be found at: https://www.mytpu.org/tacomapower/fish-wildlife-environment/cowlitz-river-project/cowlitz-fisheries-programs/). The reintroduction program facilitates the use of otherwise vacant habitat, but cannot be self-sustaining until low juvenile collection problems are solved, and other limiting factors are addressed. Efforts are underway to improve juvenile collection facilities Given the current circumstances, populations are managed to achieve the hatchery escapement goals and thereby preserve the genetic heritage of the population; this preservation of genetic heritage continues the viability of the reintroduction program should the passage problems continue, and eventual recovery of the Cowlitz population.

A reintroduction program is also in place for the Lewis River as described in the Lewis River Hatchery and Supplementation Plan (Jones & Stokes Associates 2009). Out planting of hatchery spring Chinook salmon adults began in 2012 after completion of downstream passage facilities.

The Cowlitz, Lewis, and Kalama river systems have all met their hatcheries escapement objectives in recent years, with few exceptions based on the goals established in their respective HGMPs, and are expected to do so for the foreseeable future (Table 8), thus ensuring that what remains of the genetic legacy is preserved and can be used to advance recovery. The existence of the hatchery programs mitigates the risk to these populations; the Cowlitz and Lewis populations would be extinct but for the hatchery programs.

The historical significance of the Kalama population to the overall LCR Chinook Salmon ESU was likely limited because habitat there was probably not as productive for spring Chinook salmon compared to the other spring Chinook salmon populations in the ESU (NMFS 2013). In the recovery scenario, the Kalama spring Chinook salmon population is designated as a contributing population targeted for low persistence probability because habitat there was probably not as productive historically for spring Chinook salmon and because of the intent to maintain a fishery enhancement hatchery program there (NMFS 2013).

Legacy effects of the 1980 Mount St. Helens eruption are still a fundamental limiting factor for the Toutle spring Chinook salmon population (NMFS 2013). The North Fork Toutle was dramatically affected by sedimentation from the eruption. Because of the eruption, a sediment retention structure (SRS) was constructed to manage the ongoing input of fine sediments into the lower river. Nonetheless, the SRS is a continuing source of fine sediments and blocks passage to the upper river. A trap and haul system was implemented and operates annually from September to May to transport adult fish above the SRS. The transport program provides access to 50 miles of anadromous fish habitat located above the structure (NMFS 2013). There is relatively little known about current natural spring Chinook salmon production in this basin. The Toutle population has been designated a contributing population targeted for medium persistence probability under the recovery scenario.

The baseline persistence probability of the Sandy River spring population is currently medium. The Sandy River spring Chinook salmon population is designated as a primary population targeted for high persistence probability and thus is likely to be important to the overall recovery of the ESU. Marmot Dam was used as a counting and sorting site in prior years, but the Dam was removed in October 2007. The abundance component of the persistence probability goal for Sandy River spring Chinook salmon is 1,230, and the return of natural-origin fish has exceeded this goal in recent years. The total return of spring Chinook salmon to the Sandy River including listed hatchery fish has averaged more than 5,500 since 2000. Although the abundance criterion has been exceeded in recent years, other aspects of the VSP criteria would have to improve for the population to achieve the higher persistence probability level that is targeted.

Gorge Spring MPG

The Hood River and White Salmon populations are the only populations in the Gorge Spring MPG. The 2005 BRT described the Hood River spring run as “extirpated or nearly so” (Good et al. 2005) and the 2005 ODFW Native Fish Status report describes the population as extinct (ODFW 2005). NMFS reaffirmed its conclusion that Hood River spring Chinook salmon are in the Gorge Spring MPG in the most recent status review (NWFSC 2016). Additonally, the White Salmon River population is considered extirpated (NMFS 2013, Appendix C).

Most of the habitat that was historically available to spring Chinook salmon in the Hood River is still accessible, but the basin was likely not highly productive for spring Chinook salmon due to the character of the basin. Because of the apparent extirpation of the population, Oregon initiated a reintroduction program using spring Chinook salmon from the Deschutes River. The Deschutes River is the nearest source for broodstock, but the population is from the MCR Chinook Salmon ESU. Although the reintroduction program has been underway since the mid-90s, it has not met its original goals for smolt-to-adult survival rates. Deficiencies are attributed to production practices (CTWSR 2009; ISRP 2008; NMFS 2013). The Confederated Tribes of Warm Springs Reservation (CTWSR) conducted a Hood River Production Program (HRPP) monitoring and evaluation project through 2010, and their estimates of natural spring Chinook salmon returning to the Powerdale trap prior to removal of the Powerdale Dam in 2010 are in Table 9. The delisting persistence probability target is listed as very high, but NMFS (2013) indicates the prospects for meeting that target are uncertain.

Table 9. Hood River Spring Chinook salmon actual returns to the Powerdale adult trap generated by CTWSR for the HRPP (from CTWSR 2011).

Year	Hatchery Origin Returns	Natural Origin Returns
1997	280	72

1998	18	80
1999	88	21
2000	20	66
2001	597	42
2002	1,304	71
2003	344	100
2004	148	131
2005	633	110
2006	920	297
2007	401	143
2008	974	60
2009	1,395	66
2010[a]	850	213

[a] Run data for 2010 is an expanded estimate based on counts at Powerdale Dam made before the fish trap was abandoned on June 30, 2010 as a result of the Dam decommissioning.

The White Salmon River population is also considered extirpated. Condit Dam was completed in 1913 with no juvenile or adult passage, thus precluding access to all essential habitat. The breaching of Condit Dam in 2011 provided an option for recovery planning in the White River. The recovery plan calls for monitoring escapement into the basin for four to five years to see if natural recolonization occurs (abundance estimates prior to 2012 reflected fish spawning below Condit Dam during the spring run temporal spawning window) (NWFSC 2016). Sometime during or at the end of the interim monitoring program, a decision will be made about whether to proceed with a reintroduction program using hatchery fish; however, there is not enough data available yet to evaluate that action. The recovery scenario described in the recovery plan identifies the White Salmon spring population as a contributing population with a low plus persistence probability target.

Coast Fall MPG

There are seven populations in the Coast Fall MPG. None are considered genetic legacy populations. The baseline persistence probability of five of the seven populations in this MPG is listed as very low, whereas the remaining two populations are listed as low (Youngs Bay and Scappoose). All of the populations are targeted for improved persistence probability in the recovery scenario. Elochoman/Skamokawa, Clatskanie, Mill/Abernathy/Germany (M/A/G), and Scappoose populations are targeted for high persistence, while the Grays River is targeted for medium plus persistence probability. The Big Creek and Youngs Bay populations are targeted for low persistence probability.

Populations in this MPG are subject to significant levels of hatchery straying (Beamesderfer et al. 2011). There was a Chinook salmon hatchery on the Grays River, but that program was closed in 1997 with final returns coming back a few years later. A temporary weir was installed for the first time on the Grays River in 2008 to quantify escapement and to help control the number of hatchery strays that might still be returning to the system. A significant number of out-of-ESU Rogue River "brights" from the Youngs Bay net pen programs were observed at the weir, and by 2010 the weir was functionally able to begin removing hatchery fish from escaping above its location. It is worth noting that the escapement data reported in Table 10 have been updated through 2015 relative to those reported in the 2010 status review (Ford et al. 2011).

While more recent information is reported in WDFW's SCORE online system (see Table 10 citations).

The Elochoman had an in-basin fall Chinook salmon hatchery production program that released 2,000,000 fingerlings annually. That program was closed in 2009 (NMFS 2013). Closure of the hatchery program is consistent with the overall transition and hatchery reform strategy for tule Chinook salmon. The number of spawners in the Elochoman has ranged from several hundred to several thousand in recent years (Table 10) with most being hatchery-origin (Beamesderfer et al. 2011). The M/A/G population does not have an in-basin hatchery program, but still has several hundred spawners each year; however, numbers have decreased slightly in the most recent years (Table 10).

ODFW reported that hatchery strays contributed approximately 90% of the fall Chinook salmon spawners in both the Clatskanie and Scappoose over the last 30 years (ODFW 2010a). New information was considered when developing the status of the Clatskanie and Scappoose populations. Problems with the previous Clatskanie estimates are summarized in Dygert (2011). Escapement estimates for Clatskanie from 1974 to 2006 were based on expanded index counts, meaning if index counts were less than five, they were replaced with values based on averages of neighboring years. This occurred for 11 of the 33 years in the data set. From 2004 to 2006, there was also a computational error in the data reported, resulting in estimates that were about twice as high as they should have been. Index counts in the Clatskanie since 2006 (i.e., not using the expanded index counts) continue to show few spawners.

Table 10. Early-fall (tule) Chinook salmon (in Coast MPG) total natural spawner abundance estimates proportion of hatchery-origin fish (pHOS[1]) in the spawning grounds for the Coast Fall MPG populations, 1997-2015 (from WDFW SCORE[2]).

Year	**Clatskanie[3]**	**pHOS**	**Grays**	**pHOS**	**Elochoman[4]**	**pHOS**	**M/A/G[4]**	**pHOS**	**Youngs Bay[3]**	**pHOS**
1997	7	na	12	na	2,137	na	595	na	na	na
1998	9	na	93	na	358	na	353	na	na	na
1999	10	na	303	na	957	na	575	na	na	na
2000	26	90%	89	na	146	na	370	na	na	na
2001	26	90%	241	na	2,806	na	3,860	na	na	na
2002	39	90%	78	na	7,893	na	3,299	na	na	na
2003	47	90%	373	na	7,384	na	3,792	na	na	na
2004	11	90%	726	na	6,880	na	4,611	na	na	na
2005	10	90%	122	na	2,699	na	2,066	na	na	na
2006	4	90%	383	na	324	na	622	na	na	na
2007	9	90%	96	na	168	na	335	na	na	na
2008	9	90%	33	65%	1,320	na	780	na	na	na
2009	92	44%	210	62%	1,467	na	604	na	na	na
2010	12	88%	70	55%	154	88%	194	93%	1,152	61%
2011	12	92%	70	83%	59	95%	111	93%	4,011	61%
2012	6	92%	43	79%	64	73%	23	88%	6,686	61%
2013	3	92%	189	91%	187	71%	207	80%	409	61%
2014	7	91%	322	56%	192	78%	65	90%	119	61%
2015	6	91%	156	85%	313	68%	92	91%	382	61%

[1] proportion of hatchery-origin spawners (pHOS): hatchery fish escaping to the spawning grounds. For example, Clatskanie in 2007 had 9 natural-origin spawners and 90% hatchery spawners. To calculate hatchery-origin numbers multiply (9/ (1-.90))-9 = 81 hatchery-origin spawners.

[2] Online at: https://fortress.wa.gov/dfw/score/score/recovery/recovery.jsp#score Date Accessed: April 15, 2016

[3] Clatskanie and Youngs Bay estimates are from.http://odfwrecoverytracker.org/explorer/species/Chinook/run/fall/esu/241/244/ Date accessed: May 19, 2016

[4] Elochoman and Ge/Ab/Mi estimates from 1997-2009 are considered a proportion on the WDFW SCORE website. Elochoman estimates include the Skamokawa Creek Fall Chinook Spawners (proportion).

Surveys were conducted in the Scappoose for the first time from 2008 to 2010; two spawning adults were observed in 2008, but none were seen in 2009 or 2010. All of the information above suggests that there are significant problems with the historical time series for the Clatskanie that have been used in the past and that there is currently very little spawning activity in either the Clatskanie or Scappoose rivers.

Apparent problems with these escapement estimates have implications for earlier analyses that relied on that data. The Clatskanie data was used in life-cycle modeling analysis done by the NWFSC (2010). The Clatskanie data was also used indirectly for the modeling analysis of the Scappoose population. Because there were no direct estimates of abundance for the Scappoose, the data from the Clatskanie was rescaled to account for difference in subbasin size and then used in the life-cycle analysis for the Scappoose population. Results from the life-cycle analysis indicated that the two populations were supported largely by hatchery strays and that juvenile survival rates were inexplicably low relative to the generic survival rates used in the analysis. The general conclusion of the life-cycle analysis was that the populations were unproductive and not viable under current conditions. If there are substantive flaws in the escapement data, then results from the life-cycle analysis are also flawed. The general conclusion of the life-cycle analysis is still probably correct – the populations are not viable. But the recent data suggests that there are, in fact, few hatchery strays and little or no natural production in the Clatskanie or Scappoose, and that the populations may be extirpated or nearly so. Confirmation of these tentative conclusions will depend on continued monitoring.

The Big Creek and Youngs Bay populations are both proximate to large net pen rearing and release programs designed to provide for a localized, terminal fishery in Youngs Bay. ODFW again estimates that 90% of the fish that spawn in these areas are hatchery strays. The number of fish released at the Big Creek hatchery has been reduced with additional changes in hatchery practices to help reduce straying into the Clatskanie and other neighboring systems. These programs are expected to continue providing fish for ocean fisheries and localized terminal harvest opportunity. These are examples of actions the states have taken as part of a comprehensive program of hatchery reform to address the effects of hatcheries. The nature and scale of the reform actions were described in more detail in Frazier (2011) and Stahl (2011).

Cascade Fall MPG

There are ten populations in the Cascade MPG. Of these, only the Coweeman and East Fork Lewis are considered genetic legacy populations. The baseline persistence probability of all of these populations is very low. These determinations were generally based on assessments of status at the time of listing. Lower Cowlitz, Kalama, Clackamas, and Sandy populations are targeted for medium persistence probability and Toutle, Coweeman, Lewis, and Washougal populations are targeted for high-plus persistence probability in the recovery scenario. The target persistence probability for the other two populations is very low: Salmon Creek, a population within a highly urbanized subbasin with limited habitat recovery potential, and Upper Cowlitz, a population with reintroduction of spring Chinook salmon as the main recovery effort (NMFS 2013).

Total escapements to the Coweeman and East Fork Lewis have averaged 735 and 612, respectively, over the last eighteen years compared to recovery abundance targets of 900 and

1,500. The historical contribution of hatchery spawners to the Coweeman and East Fork Lewis populations is relatively low compared to that of other populations because the remaining populations are substantially affected by hatchery strays (Beamesderfer et al. 2011). The Kalama, Washougal, Toutle, and Lower Cowlitz populations are all associated with significant in-basin hatchery production and are subject to large numbers of hatchery strays (Beamesderfer et al. 2011). We have less information on returns to the Clackamas and Sandy Rivers, but ODFW indicated for both that 90% of the spawners are likely hatchery-origin fish from as many as three adjacent hatchery programs (NMFS 2013, Appendix A).

The Coweeman and Lewis populations do not have in-basin hatchery programs and are generally subject to less straying. Broodstock management practices for hatcheries are being revised to reduce the effects of hatchery-origin fish straying. Weirs are being operated on the Kalama River to assist with brood stock management, and on the Coweeman and Washougal Rivers to further assess and control hatchery straying in each system. These are examples of actions the states have taken as part of a comprehensive program of hatchery reform to address the effects of hatcheries. The nature and scale of the reform actions were described in more detail in Frazier (2011) and Stahl (2011).

Gorge Fall MPG

There are four populations of tule Chinook salmon in the Gorge Fall MPG: Lower Gorge, Upper Gorge, White Salmon, and Hood. The baseline persistence probability for all of these populations is very low. The recovery plan targets the White Salmon and Lower and Upper Gorge populations for medium persistence probability, and the Hood population for high persistence although, as discussed earlier in this subsection, it is unlikely that the high viability objective can be met. There is some uncertainty regarding the historical role of the Gorge populations in the ESU and whether they truly functioned historically as demographically independent populations (NMFS 2013). This is accounted for in the recovery scenario presented in the recovery plan.

Populations in the Gorge Fall MPG have been subject to the effects of a high incidence of naturally-spawning hatchery fish for years. The White Salmon population, for example, was limited by Condit Dam, as discussed above regarding Gorge Spring MPG, and natural spawning occurred in the river below the dam (NMFS 2013, Appendix C). The number of fall Chinook salmon spawners in the White Salmon increased from low levels in the early 2000s to an average of 1,086 for the period from 2010 to 2015 (Table 11), but spawning is dominated by tule Chinook salmon strays from the neighboring Spring Creek Hatchery and upriver bright from the production program in the adjoining Little White Salmon River[1] . The Spring Creek Hatchery, which is located immediately downstream from the Little White Salmon River mouth, is the largest tule Chinook salmon production program in the Columbia basin, releasing 15 million smolts annually. The White Salmon River was the original source for the hatchery brood stock, so whatever remains of the genetic heritage of the population is contained in the mix of hatchery and natural spawners. There is relatively little known about current natural fall Chinook salmon production in this basin, but it is presumed to be low.

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[1] These fish are not part of the LCR Chinook ESU.

The breaching of Condit Dam has allowed access to the upper White Salmon River for spawning. The White Salmon Working Group (WSWG), comprised of staff from the FWS, Yakama Nation, WDFW, NMFS, PacifiCorp, and U.S. Geological Survey, out-planted adult fall Chinook salmon upstream of Condit Dam in 2011 prior to the breaching, in lieu of adult collection and subsequent propagation. This was a one-time conservation measure to mitigate for the impacts of the expected sediment released downstream. As part of this measure, the WSWG collected 552 natural-origin and 127 hatchery-origin returning Chinook salmon (of which 299 were females) at the White Salmon weir located adjacent to the White Salmon hatchery ponds at RM 1.4 and transported them upstream of Northwestern Lake reservoir (NMFS 2012b). No additional trap and haul operations are planned at this time. Natural escapement and production will be monitored for the next four to five years. Thereafter, a decision will be made about future plans for recovery (NMFS 2013).

There is relatively little specific or recent information on the abundance of tule Chinook salmon for the other populations in the Gorge Fall MPG (Table 11). Stray hatchery fish are presumed to dominate the spawning in these tributaries. Hatchery strays contribute largely to the escapement to the Lower Gorge, Upper Gorge, and Hood River populations on the Oregon side of the river (NMFS 2013, Appendix A). These populations are heavily influenced by hatchery strays from the Bonneville Hatchery located immediately below Bonneville Dam, and the Spring Creek and Little White Salmon Hatcheries located just above Bonneville Dam. The abundance of returning Chinook salmon on the Washington side of the Lower and Upper Gorge populations is near 50 (Table 11). The tributaries in the Gorge on the Washington side of the river are similarly affected by hatchery strays, which the recent past five years of monitoring show pHOS levels at 69% (Table 11). As a consequence, hatchery-origin fish contribute to and likely maintain spawning levels in all of the Gorge area tributaries, but actual estimates are unknown for areas like Eagle Creek, Tanner Creek and Herman Creek.

Table 11. LCR tule Chinook salmon total natural spawner abundance estimates in Gorge Fall Strata populations, 2005-2015 (from WDFW SCORE[1])*

Year	Upper Gorge (WA estimates only White Salmon[1]		White Salmon[1]		Hood River[2]	
	Natural-Origin Spawners	pHOS[2]	Natural-Origin Spawners	pHOS[2]	Natural-Origin Spawners	pHOS[2]
2005	452	na	1,448	na	42	14%
2006	235	na	755	na	49	11%
2007	263	na	898	na	45	0%
2008	181	na	770	na	21	22%
2009	343	na	964	na	57	12%
2010	334	22%	1,097	27%	na	Na
2011	581	68%	335	12%	na	Na
2012	286	68%	517	7%	na	Na
2013	816	72%	829	32%	na	Na
2014	779	71%	1,304	23%	na	Na
2015	1,833	67%	557	52%	na	Na

[1] Online at: https://fortress.wa.gov/dfw/score/score/recovery/recovery.jsp#score
* Date Accessed: April 18, 2016
[2] For example, Hood River in 2005 had 42 natural-origin spawners and 14 % hatchery spawners. To calculate hatchery-origin numbers multiply (42/ (1-.14))-42 = ~7 hatchery-origin spawners.

Cascade Late Fall MPG

There are two late fall, "bright," Chinook salmon populations in the LCR Chinook ESU in the Sandy and Lewis Rivers. Both populations are in the Cascade MPG. The baseline persistence probability of the Lewis and Sandy populations are very high and high, respectively; both populations are targeted for very high persistence probability under the recovery scenario.

The Technical Advisory Committee (TAC) designated for the 2008-2017 *U.S. v. Oregon* Management Agreement provides estimates of the escapement of bright Chinook salmon to the Sandy River (Table 12); these are estimates of spawning escapement are estimates of peak redd counts obtained from direct surveys in a 16 km index area that is expanded to estimates of spawning escapement by multiplying by a factor of 2.5 (TAC 2008a). The recovery plan includes an appendix that describes how index counts are expanded to estimates of total abundance (ODFW 2010a, Appendix C). There are some minor differences between the values reported in Appendix C and those shown in Table 12 that reflect revisions in prior index area estimates. The abundance target for delisting is 3,747. Escapements have averaged about 3,000 since 1995 (Table 12).

The Lewis River population is the principal indicator stock for management within the Cascade Late Fall MPG. It is a natural-origin population with little or no hatchery influence. The escapement goal, based on estimates of maximum sustained yield (MSY), is 5,700. The escapement has averaged 9,000 over the last ten years and has generally exceeded the goal by a wide margin since at least 1980. Escapement was below goal from 2006 through 2008 (Table 12). The shortfall is consistent with a pattern of low escapements for other far-north migrating stocks in the region and can likely be attributed to poor ocean conditions. Escapement improved in 2009 and has been well above goal since (Table 12). NMFS (2013) identifies an abundance target under the recovery scenario of 7,300, which is 1,600 more fish than the currently managed for escapement goal. The recovery target abundance is estimated from population viability simulations and is assessed as a median abundance over any successive 12 year period. The median escapement over the last 12 years is 8,750, therefore exceeding the abundance objective (Table 12). Escapement to the Lewis River is expected to vary from year-to-year as it has in the past, but generally remain high relative to the population's escapement objectives, which suggests that the population is near capacity (NWFSC 2016).

Table 12. Annual escapement of LCR Chinook natural-origin salmon populations from 1995-2015.

Year	Lewis River[1, 2]	Sandy River[3]
1995	9,715	4,338
1996	13,077	2,115
1997	8,168	8,379
1998	5,173	3,237

1999	2,417	1,872
2000	8,741	352
2001	11,274	3,451
2002	13,293	5,339
2003	12,912	2,592
2004	12,928	2,517
2005	9,775	3,224
2006	5,066	4,732
2007	3,708	745
2008	5,485	2,521
2009	6,283	3,128
2010	9,294	1,713
2011	8,205	1,635
2012	8,143	568
2013	15,197	2,489
2014	20,809	565
2015	na	2,006

[1] Online at: https://fortress.wa.gov/dfw/score/score/recovery/recovery.jsp#score

* Date Accessed: May 23, 2016

[2] Data are total spawner estimates of wild late fall (bright) Chinook

[3] Data from 1995-2008 are index area counts are expanded to spawning escapement by multiplying by 4.2 based on method described in ODFW (2010a, Appendix C). Data from 2009-2015 are total fall Chinook, and may include components of both the bright and tule stocks, estimated by GRTS (Generalized Random Tessellation Stratified) based monitoring (tule is believed to be majority) (Personal comm., E. Brown 2016).

Summary

Spatial structure and diversity are VSP attributes that are evaluated for LCR Chinook Salmon ESU using a mix of qualitative and quantitative metrics. Spatial structure has been substantially reduced in many populations within the ESU (NMFS 2013). The estimated changes in VSP status for LCR Chinook salmon populations in Table 13 indicate that a total of 7 of 32 populations are at or near their recovery viability goals, although under the recovery plan scenario only two of these populations had scores above 3.0. The remaining 25 populations generally require a higher level of viability, and most require substantial improvements to reach their viability goals (NWFSC 2016). However, the populations that did meet their recovery goals were able to do so because the goals were set at status quo (low) levels.

Table 13. Summary of VSP scores and recovery goals for LCR Chinook salmon populations (NWFSC 2016).

MPG	State	Population	Total VSP Score	Recovery Goal
Cascade Spring	WA	Upper Cowlitz	0.5	3.5
	WA	Cispus	0.5	0.5
	WA	Tilton	0.5	2.0
	WA	Toutle	0.5	3.5
	WA	Kalama	0.5	1.0
	WA	NF Lewis	0.5	3.0

	OR	Sandy	2.0	3.0
Gorge Spring	WA	White Salmon	0.5	1.5
	OR	Hood	0	4.0
Coast Fall	OR	Youngs Bay	1.0	1.0
	WA	Grays/Chinook	0.5	2.5
	OR	Big Creek	0	1.0
	WA	Elochoman/Skamokawa	0.5	3.0
	OR	Clatskanie	0	3.0
	WA	Mill/Aber/Ger	0.5	3.0
	OR	Scappoose	1.0	3.0
Cascade Fall	WA	Lower Cowlitz	0.5	2.5
	WA	Upper Cowlitz	0.5	1.0
	WA	Toutle	0.5	3.5
	WA	Coweeman	0.5	3.5
	WA	Kalama	0.5	2.0
	WA	Lewis	4.0	4.0
	WA	Salmon	0.5	0.5
	OR	Clackamas	0	2.0
	OR	Sandy	0	2.0
	WA	Washougal	0.5	3.5
Gorge Fall	WA/OR	Lower Gorge	0.5	2.0
	WA/OR	Upper Gorge	0.5	2.0
	WA	White Salmon	0.5	2.0
	OR	Hood	0	3.0
Cascade Late Fall	WA	NF Lewis	0.5	3.5
	OR	Sandy	3.0	4.0

Notes: Summaries taken directly from Figures 60 and 61, in NWFSC (2016). All are on a 4 point scale, with 4 being the lowest risk and 0 being the highest risk. VSP scores represent a combined assessment of population abundance and productivity, spatial structure and diversity (McElhany et al. 2006). A VSP score of 3.0 represents a population with a 5% risk of extinction within a 100 year period.

Table 14 provides recently updated information about the abundance and productivity, spatial structure, diversity, and overall persistence probability for each population within the LCR Chinook Salmon ESU. Spatial structure has been substantially reduced in several populations. Low abundance, past broodstock transfers, other legacy hatchery effects, and ongoing hatchery straying may have reduced genetic diversity within and among LCR Chinook salmon populations. Hatchery-origin fish spawning naturally may also have reduced population productivity (NMFS 2016).

Out of the 32 populations that make up this ESU, only the two late-fall runs – the North Fork Lewis and Sandy – are considered viable. Most populations (26 out of 32) have a very low probability of persistence over the next 100 years (and some are extirpated or nearly so) (NMFS 2016). Five of the six strata fall significantly short of the WLC-TRT criteria for viability; one stratum, Cascade late-fall, meets the WLC TRT criteria (NMFS 2013; NMFS 2016).

Abundance and productivity (A/P) ratings for LCR Chinook salmon populations are currently low to very low for most populations, except for spring Chinook salmon in the Sandy River (moderate) and late-fall Chinook salmon in North Fork Lewis River and Sandy River (very high for both) (Table 14) (NMFS 2016). For some of these populations with low or very low A/P ratings, low abundance of natural-origin spawners (100 fish or fewer) has increased genetic and demographic risks. Other LCR Chinook salmon populations have higher total abundance, but several of these also have high proportions of hatchery-origin spawners. For tule fall Chinook salmon populations, poor data quality prevents precise quantification of population abundance and productivity; data quality has been poor because of inadequate spawning surveys and the presence of unmarked hatchery-origin spawners (NMFS 2016).

Table 14. LCR Chinook Salmon ESU MPG, ecological subregions, run timing, populations, and scores for the key elements (A/P, spatial structure, and diversity) used to determine overall net persistence probability of the population (NMFS 2013).[1]

MPG		**Spawning Population (Watershed)**	**A/P**	**Spatial Structure**	**Diversity**	**Overall Persistence Probability**
Ecological Subregion	**Run Timing**					
Cascade Range	Spring	Upper Cowlitz River (WA)	VL	L	M	VL
		Cispus River (WA)	VL	L	M	VL
		Tilton River (WA)	VL	VL	VL	VL
		Toutle River (WA)	VL	H	L	VL
		Kalama River (WA)	VL	H	L	VL
		North Fork Lewis (WA)	VL	L	M	VL
		Sandy River (OR)	M	M	M	M
	Fall	Lower Cowlitz River (WA)	VL	H	M	VL
		Upper Cowlitz River (WA)	VL	VL	M	VL
		Toutle River (WA)	VL	H	M	VL
		Coweeman River (WA)	L	H	H	L
		Kalama River (WA)	VL	H	M	VL
		Lewis River (WA)	VL	H	H	VL
		Salmon Creek (WA)	VL	H	M	VL
		Clackamas River (OR)	VL	VH	L	VL
		Sandy River (OR)	VL	M	L	VL
		Washougal River (WA)	VL	H	M	VL
	Late Fall	North Fork Lewis (WA)	VH	H	H	VH
		Sandy River (OR)	VH	M	M	VH
Columbia Gorge	Spring	White Salmon River (WA)	VL	VL	VL	VL
		Hood River (OR)	VL	VH	VL	VL
	Fall	Lower Gorge (WA & OR)	VL	M	L	VL
		Upper Gorge (WA & OR)	VL	M	L	VL
		White Salmon River (WA)	VL	L	L	VL
		Hood River (OR)	VL	VH	L	VL
Coast Range	Fall	Young Bay (OR)	L	VH	L	L
		Grays/Chinook rivers (WA)	VL	H	VL	VL
		Big Creek (OR)	VL	H	L	VL

MPG		Spawning Population (Watershed)	A/P	Spatial Structure	Diversity	Overall Persistence Probability
Ecological Subregion	**Run Timing**					
		Elochoman/Skamokawa creeks (WA)	VL	H	L	VL
		Clatskanie River (OR)	VL	VH	L	VL
		Mill, Germany, and Abernathy creeks (WA)	VL	H	L	VL
		Scappoose River (OR)	L	H	L	L

[1] Persistence probability ratings and key element scores range from very low (VL), low (L), moderate (M), high (H), to very high (VH) (NMFS 2016).

Figure 4 displays the extinction risk ratings for all four VSP parameters, including spatial structure and diversity attributes, for Oregon populations (Ford et al. 2011). The results indicate low to moderate spatial structure risk for most populations, but high diversity risk for all but two populations; the Sandy River bright and spring Chinook salmon populations. The assessments of spatial structure and diversity are combined with those abundance and productivity to give an assessment of the overall status of LCR Chinook salmon populations in Oregon. Risk is characterized as high or very high for all populations except the Sandy River late fall and spring populations. Relative to baseline VSP levels identified in the recovery plan (NMFS 2013) there has been an overall improvement in the status of a number of fall-run populations, although most are still far from the recovery plan goals (NWFSC 2016).

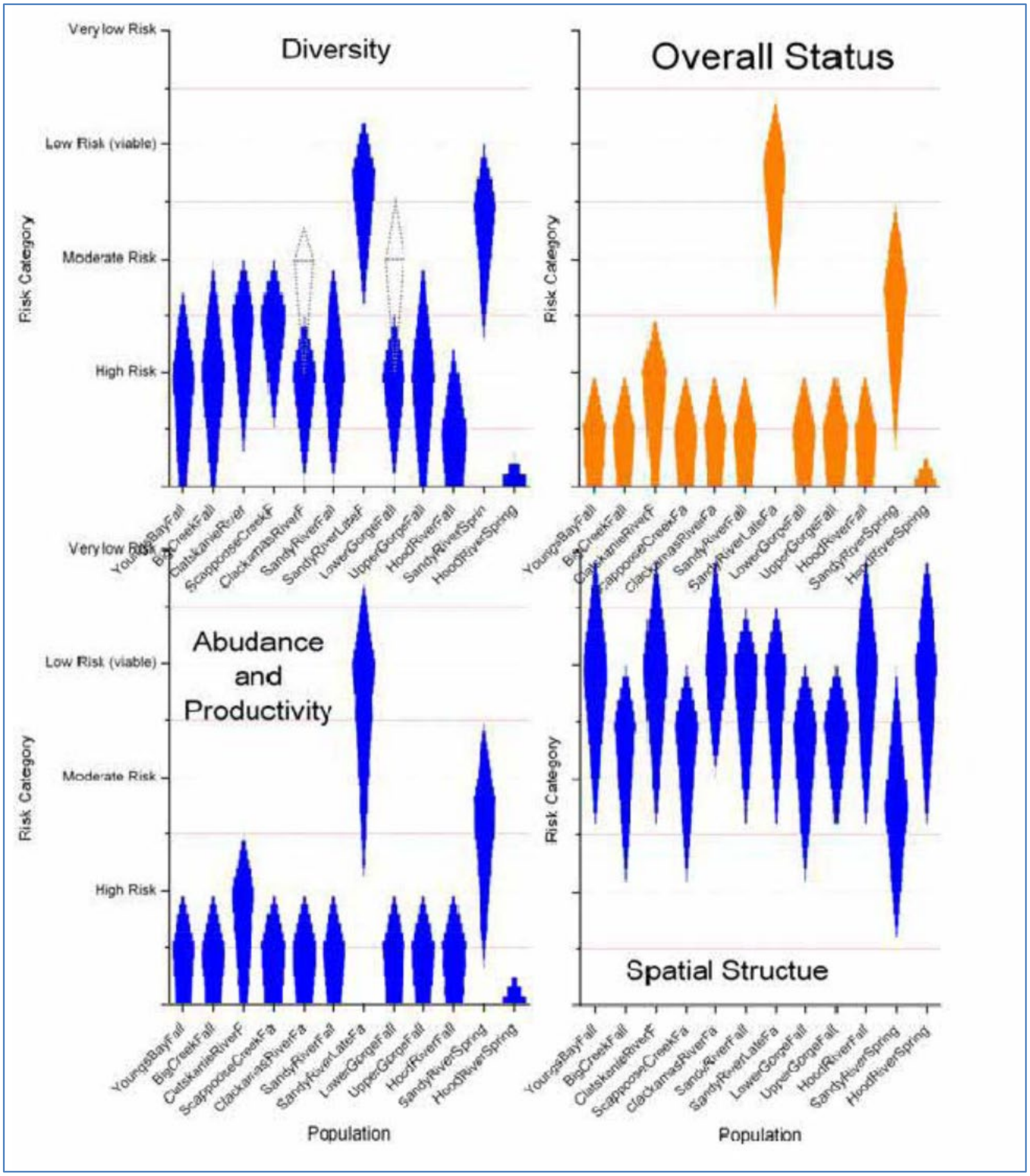

Figure 4. Extinction risk ratings for LCR Chinook salmon populations in Oregon for the assessment attributes abundance/productivity, diversity, and spatial structure, as well as overall ratings for populations that combine the three attributes (From Ford et al. 2011).

The recent status review (NWFSC 2016) concluded that there has been little change since the last status review (Ford et al. 2011) in the biological status of Chinook salmon populations in the LCR Chinook Salmon ESU, though there are some positive trends. For example, increases in abundances were observed in about 70 % of the fall-run populations, and decreases in the hatchery contribution were noted for several populations. The improved fall-run VSP scores reflect both changes in biological status and improved monitoring. However, the majority of the populations in this ESU remain at high risk, with low natural-origin abundance levels, especially the spring-run Chinook population in this ESU (NWFSC 2016). Hatchery contributions remain high for a number of populations, especially in the Coast Fall MPG, and it is likely that many returning unmarked adults are the progeny of hatchery-origin parents, which contributes to the high risk. Moreover, hatchery produced fish still represent a majority of fish retuning to the ESU even though hatchery production has been slightly reduced (NWFSC 2016). Because spring-run Chinook salmon populations have generally low abundance levels from hydroelectric dams cutting off access to essential spawning habitat, it is unlikely that there will be significant improvements in the status of this species until efforts to improve juvenile passage systems are put into place (NWFSC 2016).

Limiting Factors

There are many factors that affect the abundance, productivity, spatial structure, and diversity of the LCR Chinook Salmon ESU. Factors that limit the ESU provide 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. LCR Chinook salmon populations began to decline by the early 1900s because of habitat alterations and harvest rates that were unsustainable 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 the information regarding limiting factors and threats for the LCR Chinook Salmon ESU available from various sources (NMFS 2013).

Spawning spring Chinook salmon are made up of anywhere from 34% to 90% hatchery-origin fish, depending on the population (ODFW 2010, Table 4-8; LCFRB 2010, Table 3-8). Hatchery straying, combined with past stock transfers, has likely altered the genetics of LCR spring Chinook salmon population structure and diversity, and reduced the productivity as a result of this influence. However, a high proportion of hatchery-origin fish in spawning populations has been purposeful in some areas for reintroduction purposes (e.g., in the Hood, Cowlitz, and Lewis subbasins).

Most fall Chinook salmon currently returning to Lower Columbia tributaries are produced in hatcheries operated to produce fish for harvest. Hatchery production has been reduced from its peak in the late 1980s but continues to threaten the productivity of LCR fall Chinook salmon populations (NMFS 2013). Out-of-ESU Rogue River bright fall Chinook salmon released into Youngs Bay to support terminal harvest have been recovered in the Grays River, potentially affecting genetics and diversity within the Grays River population. Similar to spring Chinook populations, genetic stock integrity and productivity for fall Chinook salmon in the LCR Chinook Salmon ESU has likely declined as a result of the influence of hatchery-origin fish contributing to natural spawning.

Some scientists suspect that closely spaced releases of hatchery fish from all Columbia Basin hatcheries may lead to increased competition with natural-origin fish for food and habitat space in the estuary. NMFS 2010 [estuary module] and LCFRB (2010) identified competition for food and space among hatchery and natural-origin juveniles in the estuary as a critical uncertainty for which not much information currently existed on which to draw conclusions from. ODFW (2010) acknowledged that uncertainty but listed competition for food and space as a secondary limiting factor for juveniles of all populations. The NMFS West Coast Region and Northwest and Southwest Fisheries Science Center are working to better define and describe the scientific uncertainty associated with ecological interactions between hatchery-origin and natural-origin salmon in freshwater, estuarine, and nearshore ocean habitats.

Lower Columbia River Coho Salmon ESU

On June 28, 2005, NMFS listed the listed the LCR Coho Salmon ESU as a threatened species (70 FR 37160). The threatened status was reaffirmed on April 14, 2014 (Table X). Critical Habitat was originally proposed January 14, 2013 (Table X) and was finalized on January 24, 2016 (81 FR 9252).

Inside the geographic range of the ESU, 24 hatchery coho salmon programs are currently operational (Table 41). Up through 2008, 25 hatchery programs produced coho salmon considered to be part of the ESU. As explained above in Section 2.2.1.2, 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 Section 2.4.1 (NMFS 2005c). In 2009, the Elochoman Type-S and Type-N programs were discontinued. In 2011, NMFS recommended that these two programs be removed from the ESU (Jones Jr. 2011). Table 41 lists the 23 hatchery programs currently included in the ESU and the one excluded program (Jones Jr. 2011). LCR coho salmon are primarily limited to the tributaries downstream of Bonneville Dam (Figure 16). Coho salmon in the Willamette River spawning above Willamette Falls are not considered part of the LCR Coho Salmon ESU (70 FR 37160).

Table 15. LCR Coho Salmon ESU description and MPGs (Mitchell Act)

ESU Description[1]	
Threatened	Listed under ESA in 2005; updated in 2014
3 major population groups	24 historical populations
Major Population Group	***Populations***
Coast	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, Upper Gorge/White Salmon, Upper Gorge/Hood
Artificial Production	

Hatchery programs included in the ESU (23)	Grays River (Type-S), Sea Resources (Type-S), Peterson Coho Salmon Project (Type-S), Big Creek Hatchery (ODFW stock #13), Astoria High School (STEP) Coho Salmon Program, Warrenton High School (STEP) Coho Salmon Program, Cathlamet High School FFA Type-N Coho Salmon Program, Cowlitz Type-N Coho Salmon Program, Cowlitz Game and Anglers Coho Salmon Program, Friends of the Cowlitz Coho Salmon Program, North Fork Toutle River Hatchery (type-S), Kalama River Type -N Coho Salmon Program, Kalama River Type-S Coho Salmon Program, Lewis River Type-N Coho Salmon Program, Lewis River Type-S Coho Salmon Program, Fish First Wild Coho Salmon Program, Fish First Type-N Coho Salmon Program, Syverson Project Type-N Coho Salmon Program, Washougal River Type-N Coho Salmon Program, Eagle Creek NFH, Sandy Hatchery (ODFW stock #11), Bonneville/Cascade/Oxbow Complex (ODFW stock #14)
Hatchery programs *not* included in the ESU (1)	CCF Coho Salmon Program (Klaskanine River origin)

Twenty-four historical populations within three MPGs comprise the LCR Coho Salmon ESU with generally low baseline persistence probabilities (Table 5). 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.

Table 16. Current status for LCR coho salmon populations and recommended status under the recovery scenario (NMFS 2013e).

Major Population Group	**Population (State)**	**Status Assessment**		**Recovery Scenario**	
		Baseline Persistence Probability[1]	**Contribution**[2]	**Target Persistence Probability**	**Abundance Target**[3]
Coast	Youngs Bay (OR) - *Late*	VL	Stabilizing	VL	7
	Grays/Chinook (WA) - *Late*	VL	Primary	H	2,400
	Big Creek (OR) - *Late*	VL	Stabilizing	VL	12
	Elochoman/Skamokawa (WA) - *Late*	VL	Primary	H	2,400
	Clatskanie (OR) - *Late*	L	Primary	H	3,201
	Mill/Aber/Germ (WA) - *Late*	VL	Contributing	M	1,800
	Scappoose (OR) - *Late*	M	Primary	VH	3,208
Cascade	Lower Cowlitz (WA) - *Late*	VL	Primary	H	3,700
	Upper Cowlitz (WA) - *Early, late*	VL	Primary	H	2,000
	Cispus (WA) - Early, late	VL	Primary	H	2,000
	Tilton (WA) - Early, late	VL	Stabilizing	VL	--
	South Fork Toutle (WA) - *Early, late*	VL	Primary	H	1,900

	North Fork Toutle (WA) - *Early, late*	VL	Primary	H	1,900
	Coweeman (WA) - *Late*	VL	Primary	H	1,200
	Kalama (WA) - *Late*	VL	Contributing	L	500
	North Fork Lewis (WA) - *Early, late*	VL	Contributing	L	500
	East Fork Lewis (WA) - *Early, late*	VL	primary	H	2,000
	Salmon Creek (WA) - *Late*	VL	Stabilizing	VL	--
	Clackamas (OR) - *Early, late*	M	Primary	VH	11,232
	Sandy (OR) - Early, late	VL	Primary	H	5,685
	Washougal (WA) - *Late*	VL	Contributing	M+	1,500
Gorge	Lower Gorge (WA/OR) - *Late*	VL	Primary	H	1,900
	Upper Gorge/White Salmon (WA) - *Late*	VL	Primary	H	1,900
	Upper Gorge/Hood (OR) - *Early*	VL	Primary	H*	5,162

[1] VL = very low, L = low, M = moderate, H = high, VH = very high. These are adopted in the recovery plan

[2] 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.

[3] Abundance objectives account for related goals for productivity.

* Oregon’s analysis indicates a low probability of meeting the delisting objective of high persistence probability for this population

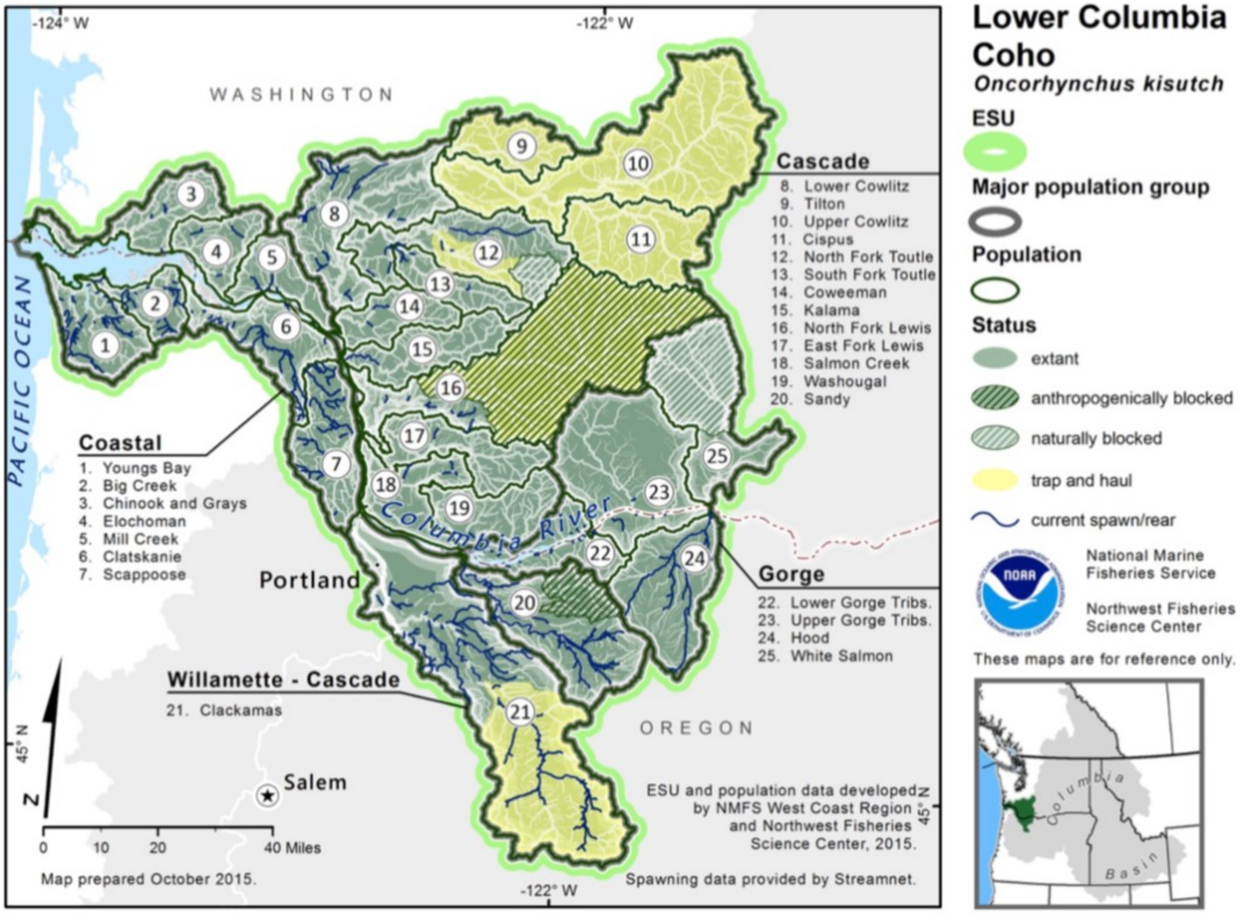

Figure 5. Map of the LCR Coho Salmon ESU spawning and rearing areas, illustrating populations and major population groups (NWFSC 2015).

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 fresh water entry. Fresh water entry timing for this ESU is also associated with ocean migration patterns (Table 43) 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 fresh water 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 (Sandercock 1991).

Table 17. Life-History and population characteristics of LCR coho salmon.

Characteristic	Life-History Features	
	Early-returning (Type-S)	**Late-returning (Type-N)**
Number of extant populations	10	23
Life history type	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	
Duration in freshwater	Usually 12-15 months	
Rearing habitat	Smaller tributaries, river edges, sloughs, off-channel ponds	
Estuarine use	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 British Columbia
Age at return	2-3 years	
Recent natural spawners	6,000	
Recent hatchery adults	5,000-90,000	12,000-180,000

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).

Regardless of adult freshwater entry timing, coho salmon fry move to shallow, low velocity rearing areas after emergence, primarily along the stream edges and in side 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.

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 baseline and target persistence probabilities are summarized in Table 42, along with target abundance for each population that would be consistent with delisting the species. 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%).

NMFS conducted status reviews of the LCR Coho Salmon ESU in 1996 (NMFS 1996a), in 2001 (NMFS 2001c), in 2005 (Good et al. 2005), in 2011 (Ford 2011), and most recently in 2015 (NWFSC 2015). In 1996, the BRT concluded that they could not identify any remaining natural populations of coho salmon in the LCR (excluding the Clackamas River) or along the Washington coast south of Point Grenville that warrant protection under the ESA, although this conclusion would warrant reconsideration if new information becomes available. In the 2001 review, the BRT was concerned that the vast majority (more than 90%) of the historical natural populations in the ESU were either extirpated or nearly so. The two populations with any significant production (Sandy and Clackamas River populations) were at appreciable risk because of low abundance, declining trends, and failure of the populations to improve after a dramatic reduction in harvest. The large number of hatchery coho salmon in the ESU was also considered an important risk factor. The majority of BRT members in 2001 believed that the species was ‘at risk of extinction’, with a small number of members believing that the species was ‘likely to become endangered’. An updated status evaluation was conducted in 2005, also with a majority of BRT votes for ‘at risk of extinction’ and a substantial minority for ‘likely to become endangered’.

Five evaluations of LCR coho salmon status, all based on WLC-TRT criteria, have been conducted since the last BRT status update in 2005 (McElhany et al. 2007; LCFRB 2010b; ODFW 2010a; Ford 2011). McElhany et al. (2007) concluded that the ESU is currently at high risk of extinction. ODFW (2010a) concluded that the Oregon portion of the ESU is currently at very high risk. The LCFRB (2010b) does not provide a statement on ESU-level status, but describes the high fraction of populations in the ESU that are at high or very high risk. According to Ford (2011), of the 27 historical populations in the ESU, 24 are considered at very high risk. The latest status review (NWFSC 2015) relied on data available through 2014. According to the NWFSC, the status of a number of coho salmon populations have changed since previous reviews, mostly due to the improved level of monitoring (and subsequent understanding of status) in Washington tributaries, rather than a true change in status over time. Furthermore, the NWFSC (2015) determined that while recovery efforts have likely improved the status of a number of coho salmon populations, abundance is still at low levels and the majority of DIPs remain at moderate or high risk.

For LCR coho salmon, poor data quality prevented precise quantification of abundance and productivity. Data quality has been poor because of inadequate spawning surveys and, until recently, the presence of unmarked hatchery-origin spawners. Mass marking of hatchery-origin LCR coho salmon began in 1999 (LCFRB 2010a) which generally allows assessment of what portion of escapement consists of hatchery-origin spawners and greatly improves the ability to assess the status of populations.

Hatchery production dominates the Washington side of this ESU and no populations are thought to be naturally self-sustaining because the majority of spawners are believed to be hatchery strays. Washington did not collect adult escapement estimates until recently. The state's monitoring strategy has instead relied primarily on a smolt monitoring program. Similar to the Washington populations, natural productivity on the Oregon side of the LCR Coho Salmon ESU is also believed to have decreased due to legacy effects of hatchery fish. While total hatchery production has been reduced from a peak in the 1980s most populations are still believed to have very low abundance of natural-origin spawners (NMFS 2013e; NWFSC 2015)[14].

In general, hatchery-origin fish comprise the large majority of LCR coho salmon annual adult returns (Table 7 and Table 8). Numbers can vary substantially from year-to-year because coho salmon encounter and are affected by the widely-varying conditions for marine survival related to environmental conditions particularly in the coastal upwelling zone. Until recently, no population was thought to be naturally self-sustaining, with the majority of spawners believed to be hatchery strays. Moreover, it is likely that hatchery effects have also decreased population productivity. New and added hatchery releases of coho salmon in areas upstream of the LCR may be impacting LCR coho salmon through straying, competition, and predation in the lower mainstem and estuary.

Information that has recently become available indicates that hatchery fish straying onto natural spawning grounds is actually quite low for several natural coho salmon populations, which are thought to be self-sustaining. Table 7 presents escapement of LCR coho salmon in selected Oregon tributaries (2002- 2015). Table 8 presents escapement of LCR coho salmon in selected Washington tributaries (2002 - 2015). New information about escapement of LCR coho salmon in Oregon and Washington that was not available in prior status reviews (Table 7 and Table 8) suggests that there has been an increase in the wild fraction of natural-origin coho salmon in their relative abundances. Additionally, hatchery-fish straying into Oregon populations within the LCR Coho Salmon ESU has decreased while pockets of natural production, such as with the Scappoose and Clackamas populations, are also now increasing in their contribution to the overall Oregon coho salmon abundance.

Table 7 and Table 8 provide estimates of escapement for tributaries on the Oregon and Washington sides of the lower Gorge population, respectively. It is unclear how comprehensive the surveys are or if the estimates are intended to be expanded estimates for the population as a whole. On the Washington side, the estimates are characterized as cumulative fish per mile index counts. This information, although limited, indicates there are several hundred spawners in these tributaries that collectively make up the population and that hatchery fractions are actually relatively low.

Table 18. Natural-origin spawning escapement numbers and the proportion of natural spawners composed of hatchery-origin fish (pHOS[1]) on the spawning grounds for LCR coho salmon populations in Oregon from 2002 through 2015. (Mitchell Act)*

Major Population Group	Oregon Populations	Origin	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Coast	Youngs Bay	Natural	411	113	149	79	74	21	82	26	68	161	129	-	-	-
		pHOS	86%	86%	86%	75%	84%	40%	22%	92%	61%	66%	46%	-	-	-
	Big Creek	Natural	98	435	112	219	225	212	360	792	279	160	409	-	-	-
		pHOS	90%	40%	70%	36%	50%	15%	54%	30%	52%	21%	18%	-	-	-
	Clatskanie[2]	Natural	167	563	398	494	421	927	996	1195	4686	1546	619	611	3246	240
		pHOS	22%	0%	0%	1%	10%	4%	0%	1%	3%	1%	11%	11%	4%	4%
	Scappoose	Natural	502	336	755	348	719	375	292	778	1960	298	210	979	1587	487
		pHOS	0%	10%	8%	0%	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Cascade	Clackamas	Natural	1981	1507	2874	1301	3464	3608	1694	7982	1757	2254	1580	3202	10670	1784
		pHOS	57%	10%	16%	28%	76%	14%	45%	27%	57%	10%	10%	2%	14%	11%
	Sandy	Natural	382	1348	1213	856	923	687	1277	1493	901	3494	1165	667	5942	443
		pHOS	57%	0%	9%	0%		9%	0%	10%	12%	8%	3%	12%	3%	5%
Gorge	Lower Gorge	Natural	338	-	-	263	226	126	223	468	920	216	96	151	362	30
		pHOS	17%	-	-	85%	70%	67%	46%	29%	7%	54%	56%	6%	51%	38%
	Upper Gorge/Hood	Natural	147	41	126	1262	373	170	69	65	223	232	169	561	42	4
		pHOS	60%	-	-	45%	48%	45%	29%	0%	85%	69%	78%	65%	76%	64%

[1] For example, Clatskanie in 2007 had 927 natural-origin spawners and 4% hatchery spawners. To calculate hatchery-origin numbers multiply (927/(1-.04))-583 = 39 hatchery-origin spawners.

*Data for table acquired April 13, 2016.

[2] Data from ODFW (2016e)

Table 19. Natural-origin spawning escapement numbers and the proportion of all natural spawners composed of hatchery-origin fish (pHOS[1]) on the spawning grounds for LCR coho salmon populations in Washington from 2002 through 2015. (Mitchell Act)*

Major Population Group	Washington Populations	Origin	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Coast	Gray's/Chinook	Natural	-	-	-	-	-	-	-	-	388	152	795	1212	3700	86
		pHOS	-	-	-	-	-	-	-	-	81%	97%	22%	65%	32%	80%
	Eloch/ Skam	Natural	-	-	-	-	-	-	-	-	834	851	505	721	4158	168
		pHOS	-	-	-	-	-	-	-	-	73%	56%	29%	43%	34%	50%
	Mill Creek	Natural	-	-	-	-	-	-	-	-	859	576	207	-	932	-
		pHOS	-	-	-	-	-	-	-	-	12%	21%	2%	-	12%	-
	Abernathy	Natural	-	-	-	-	-	-	-	-	490	183	256	-	832	-
		pHOS	-	-	-	-	-	-	-	-	12%	21%	2%	-	12%	-
	Germany	Natural	-	-	-	-	-	-	-	-	322	48	122	-	475	-
		pHOS	-	-	-	-	-	-	-	-	12%	21%	2%	-	12%	-
Cascade	Lower Cowlitz	Natural	-	-	-	-	-	-	-	-	6,274	3,394	-	-	12661	5132
		pHOS	-	-	-	-	-	-	-	-	15%	8%	-	-	5%	8%
	Upper Cowlitz/Cispus	Natural	54188	20695	28665	22329	25574	5691	13805	16162	18905	7326	2397	7941	25147	-
		pHOS	74%	72%	86%	80%	82%	60%	74%	74%	88%	49%	40%	0%	22%	-
	Tilton	Natural	1,732	601	722	1,332	738	827	1,006	1,305	929	2,025	1,301	2,744	9074	-
		pHOS	91%	92%	95%	85%	69%	66%	64%	70%	80%	75%	79%	67%	39%	-
	SF Toutle	Natural	-	-	-	-	-	-	-	-	1,518	490	2,063	-	10960	1537
		pHOS	-	-	-	-	-	-	-	-	21%	22%	14%	-	19%	53%
	NF Toutle[2]	Natural	-	-	-	-	-	-	-	-	1,252	302	1425	-	6597	868
		pHOS	-	-	-	-	-	-	-	-	63%	35%	24%	-	32%	65%
	Coweeman	Natural	-	-	-	-	-	-	-	-	3,528	2,436	2,964	4047	5021	767
		pHOS	-	-	-	-	-	-	-	-	10%	6%	5%	-	17%	25%
	Kalama	Natural	-	-	-	-	-	-	-	-	5	-	69	64	99	18
		pHOS	-	-	-	-	-	-	-	-	99%	-	78%	-	91%	90%
	NF Lewis[3]	Natural	-	-	-	-	-	-	-	-	700	604	827	-	0	45
		pHOS	-	-	-	-	-	-	-	-	.07%	2%	11%	-	100%	75%
	EF Lewis	Natural	-	-	-	-	-	-	-	-	1,363	1,025	3,681	-	2531	389

		pHOS	-	-	-	-	-	-	-	-	32%	6%	9%	-	20%	17%
	Salmon Creek	Natural	-	-	-	-	-	-	-	-	-	1,248	1,897	-	4257	1348
		pHOS	-	-	-	-	-	-	-	-	-	20%	22%	-	0%	0%
	Washougal	Natural	-	-	-	-	-	-	-	-	795	562	531	-	737	101
		pHOS	-	-	-	-	-	-	-	-	44%	8%	13%	-	65%	67%
Gorge	Lower Gorge	Natural	-	-	-	-	20	-	-	-	385	504	524	-	704	650
		pHOS	-	-	-	-	0%	-	-	-	29%	12%	2%	-	35%	11
	Upper Gorge/ Hood	Natural	-	-	-	-	-	152	86	71	35	111	96	106	24	80
		pHOS	-	-	-	-	-	-	-	-	-	-	-	-	23%	24%

[1] For example, Mill Creek in 2010 had 859 natural-origin spawners and 12 % hatchery spawners. To calculate hatchery-origin numbers multiply (859/(1-.12))-859 = 117 hatchery-origin spawners.

[2] Natural-origin escapement numbers and proportion of hatchery-origin fish combines the Green River (NF Toutle) coho salmon, the North Fork Toutle River coho salmon, and trap count data.

[3] Natural-origin escapement numbers and proportion of hatchery-origin fish combines the Cedar Creek (NF Lewis) coho salmon and the North Fork Lewis River Mainstem coho salmon.

* Data for table acquired April 13, 2016.

Natural-origin smolt production in some Washington populations occur within streams that have a substantial amount of hatchery-origin strays, while others occur in streams where hatchery straying is believed to be relatively limited. Information gathered over the last several years suggests there is more natural-origin smolt production than previously thought (Table 20).

Table 20. Most recent estimated smolt production from monitored coho salmon streams in the LCR Coho Salmon ESU (TAC 2008b); WDFW wild coho forecast reports for Puget Sound, Washington Coast, and Lower Columbia River available at: http://wdfw.wa.gov/conservation/research/projects/wild_coho.

Out-migrant Year	Mill	Abernathy	Germany	Grays	Tilton	Upper Cowlitz	Coweeman	Cedar[1]
1997	--	--	--	--	700	3,700	--	--
1998	--	--	--	--	16,700	110,000	--	38,400
1999	--	--	--	--	9,700	15,100	--	28,000
2000	--	--	--	--	23,500	106,900	--	20,300
2001	6,300	6,500	8,200	--	82,200	334,700	--	24,200
2002	8,200	5,400	4,300	---	11,900	166,800	--	35,000
2003	10,500	9,600	6,200	--	38,900	403,600	--	36,700
2004	5,700	6,400	5,100	--	36,100	396,200	--	37,000
2005	--	--	--	--	40,900	766,100	--	58,300
2006	6,700	4,400	2,300	--	33,600	370,000	--	46,000
2007	6,665	4,410	2,327	--	33,650	370,100	7,995	38,450
2008	7,044	3,282	2,342	--	34,190	277,400	8,784	29,340
2009	9,097	5,077	3,976	4,453	36,240	113,000	12,170	36,340
2010	6,283	3,761	2,576	2,377	40,640	123,800	12,290	61,140
2011	11,230	3,375	1,240	4,051	53,350	216,200	21,640	43,940
2012	8,563	5,520	3,535	2,182	55,950	33,739	23,261	60,778

[1] Lewis River tributary

Currently, it is impossible to determine whether the juveniles are produced by naturally spawning hatchery-origin fish or natural-origin spawners, and whether these populations would be naturally self-sustaining in the absence of hatchery-origin spawners. WDFW suggests that a substantial number of natural-origin spawners may return to the LCR each year, but are not observed because, until recently, there was no monitoring for coho salmon spawners for the Washington populations. Adult escapement data for Washington populations between 2010 and 2012 confirms that natural-origin spawners return to populations in the Coast MPG of the LCR Coho Salmon ESU (Table 20).

Any changes from the previous status review in VSP score for coho salmon populations in Table 21 reflect improvements in abundance, spatial structure, and diversity, as well as in monitoring monitoring (NWFSC 2016). Table 22 shows an overall summary of the abundance, productivity, spatial structure, and diversity ratings for each population within this ESU. Previous status reviews lacked adequate quantitative data on abundance and hatchery contribution for a number of populations whereas recent surveys provide a more accurate understanding of the status of these populations. However, with only two or three years of data, it is not possible to determine whether there has been a true improvement in status, though it is evident that the contribution of natural-origin fish is much higher than previously thought (NWFSC 2016).

Table 21. Summary of VSP scores and recovery goals for Lower Columbia River Coho salmon populations (NWFSC 2016).

Strata	State	Population	Total VSP Score	Recovery Goal
Coast	OR	Youngs Bay	0	0
	WA	Grays/Chinook	0.5	2.75
	OR	Big Creek	0	0
	WA	Eloc/Skamo	0.5	2.75
	WA	Mill/Abern/Ger	0.5	1.75
	OR	Clatskanie	1	3.5
	OR	Scappoose	2	3.5
Cascade	WA	Lower Cowlitz	0.5	2.75
	WA	Upper Cowlitz	0.5	2.75
	WA	Cispus	0.5	2.75
	WA	Tilton	0.5	.5
	WA	SF Toutle	0.5	2.75
	WA	NF Toutle	0.5	2.75
	WA	Coweeman	0.5	2.75
	WA	Kalama	0.5	.85
	WA	NF Lewis	0.5	.85
	WA	EF Lewis	0.5	2.75
	WA	Salmon	0.5	.5
	OR	Clackamas	2	3.5
	OR	Sandy	0	2.75
	WA	Washougal	0.5	2.25
Gorge	WA	Lower Gorge	0.5	2.25
	WA	Upper Gorge	0.5	2.25

Notes: Summaries taken directly from Figure 69 in NWFSC (2016). All are on a 4 point scale, with 4 being the lowest risk and 0 being the highest risk. Viable Salmon Population scores represent a combined assessment of population abundance and productivity, spatial structure and diversity (McElhany et al. 2006). A VSP score of 3.0 represents a population with a 5% risk of extinction within a 100 year period.

Table 22. LCR Coho Salmon ESU populations and scores for the key elements (A/P, spatial structure, and diversity) used to determine current overall net persistence probability of the population (NMFS 2013)[1].

Ecological Subregions	Population (Watershed)	A/P	Spatial Structure	Diversity	Overall Persistence Probability
Coast Range	Youngs Bay (OR)	VL	VH	VL	VL
	Grays/Chinook rivers (WA)	VL	H	VL	VL
	Big Creek (OR)	VL	H	L	VL
	Elochoman/Skamokawa creeks (WA)	VL	H	VL	VL
	Clatskanie River (OR)	L	VH	M	L

Ecological Subregions	Population (Watershed)	A/P	Spatial Structure	Diversity	Overall Persistence Probability
	Mill, Germany, and Abernathy creeks (WA)	VL	H	L	VL
	Scappoose River (OR)	M	H	M	M
Cascade Range	Lower Cowlitz River (WA)	VL	M	M	VL
	Upper Cowlitz River (WA)	VL	M	L	VL
	Cispus River (WA)	VL	M	L	VL
	Tilton River (WA)	VL	M	L	VL
	South Fork Toutle River (WA)	VL	H	M	VL
	North Fork Toutle River (WA)	VL	M	L	VL
	Coweeman River (WA)	VL	H	M	VL
	Kalama River (WA)	VL	H	L	VL
	North Fork Lewis River (WA)	VL	L	L	VL
	East Fork Lewis River (WA)	VL	H	M	VL
	Salmon Creek (WA)	VL	M	VL	VL
	Clackamas River (OR)	M	VH	H	M
	Sandy River (OR)	VL	H	M	VL
	Washougal River (WA)	VL	H	L	VL
Columbia Gorge	Lower Gorge Tributaries (WA & OR)	VL	M	VL	VL
	Upper Gorge/White Salmon (WA)	VL	M	VL	VL
	Upper Gorge Tributaries/Hood (OR)	VL	VH	L	VL

[1] Ratings range from very low (VL), low (L), moderate (M), high (H), to very high (VH) (NMFS 2016).

Figure 6 displays the extinction risk ratings for all four VSP parameters for Oregon populations (ODFW 2010). This figure was updated in 2010 using data available through 2008. The results indicate low to moderate extinction risk for spatial structure for most LCR coho salmon populations in Oregon, but high risk for diversity for all but two populations (the Sandy and Clackamas River populations). The assessments of spatial structure are combined with those of abundance and productivity to give an assessment of the overall status of LCR populations in Oregon. Extinction risk is rated as high or very high in overall status for all populations except the Scappoose and Clackamas river populations. Where updated ratings differ from those of (McElhany et al. 2007a) assessment the older rating is shown as an open diamond with a dashed outline (ODFW 2010a).

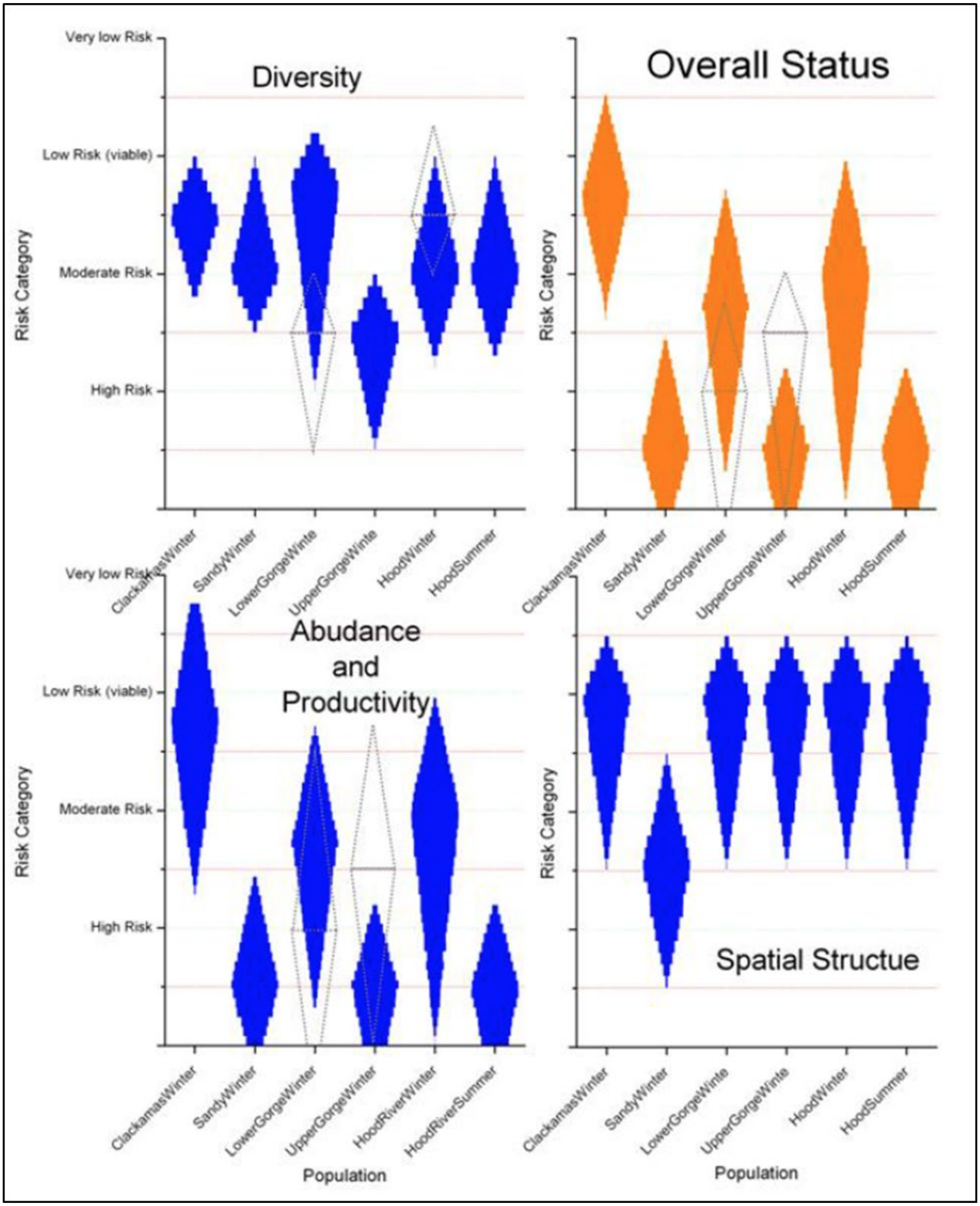

Figure 6. Extinction risk ratings for LCR coho populations in Oregon for the assessment attributes abundance/productivity, diversity, and spatial structure, as well as an overall rating for populations that combines the three attribute ratings (NMFS 2017b).

The lack of data, as well as poor data quality, has made it difficult to assess spatial structure and diversity VSP attributes for LCR coho salmon. Low abundance, past hatchery stock transfers, other legacy hatchery effects, and ongoing hatchery straying may have reduced genetic diversity within and among coho salmon populations (LCFRB 2010b; ODFW 2010a). The low persistence probability and risk category for the majority of LCR coho salmon populations reported above is related to the loss of spatial structure and reduced diversity. Spatial structure of some coho salmon populations is constrained by migration barriers (i.e., tributary dams) and development of lowland areas (NMFS 2013e). Inadequate spawning survey coverage, along with the presence of unmarked hatchery-origin coho salmon mixing with natural-origin spawners, also has made it difficult to ascertain the spatial structure of natural-origin populations. The mass marking of hatchery-origin fish and more extensive spawning surveys have provided better information regarding species status in the past five years (NWFSC 2015).

In summary, the 2015 status review (NWFSC 2015) concluded that the LCR Coho Salmon ESU is still at very high risk. A total of 6 of the 23 populations in the ESU are at or near their recovery viability goals (Figure 69 in NWFSC 2015), although under the recovery plan scenario these populations had recovery goals only greater than 2.0 (moderate risk). The remaining populations require a higher level of viability (NWFSC 2015) and therefore still require substantial improvements. Best available information indicates that the LCR Coho Salmon ESU is at high risk and remains at threatened status.

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. LCR 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).

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 on natural-origin coho salmon (NMFS 2013e). The recent 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 on 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 (2011c) and LCFRB (2010b) 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 (2010a) 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).

Lower Columbia River Steelhead DPS

On March 19, 1998, NMFS listed the Lower Columbia River (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 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 (NWFSC 2016). Excluded are steelhead in the upper Willamette River Basin above Willamette Falls, Oregon, and from the Little and Big White Salmon Rivers, Washington.

Inside the geographic range of the DPS, 29 hatchery programs are currently operational, of which only 7 are considered part of the ESA-listed DPS description (Table 23). In recent years, there were several programs discontinued within the boundary of the DPS, such as the Cowlitz Trout Hatchery Late Winter Steelhead plant in the Tilton and the Hood River Summer Steelhead (Skamania Stock) programs in 2009, the Hood River Summer (ODFW stock #50) Steelhead program in 2011, and the Cowlitz Trout Hatchery Late Winter plants in the Uppr Cowlitz and Cispus Rivers in 2012. Most recently, in 2014 the Cowlitz Early Winter Steelhead program was discontinued (Jones Jr. 2015).

The LCR Steelhead DPS is composed of 23 historical populations, distributed through two ecological zones, split by summer or winter life history resulting in four MPGs (Table 23). There are six summer populations and seventeen winter populations.

Table 23. LCR Steelhead DPS description and MPGs (Jones Jr. 2015; NWFSC 2016).

DPS Description	
Threatened	Listed under ESA in 1998; updated in 2014
4 major population groups	23 historical populations
Major Population Group	***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 (7)	Kalama River Wild Winter, Kalama River Wild Summer, Hood River Winter (ODFW stock # 50), Cowlitz Trout Hatchery Late Winter, Clackamas Hatchery Late Winter (ODFW stock # 122), Sandy Hatchery Late Winter (ODFW stock # 11), Lewis River Wild Late Winter.
Hatchery programs not included in ESU (22)	Upper Cowlitz River Wild Late Winter, Tilton River Wild Late Winter, Cowlitz Summer, Friends of the Cowlitz Summer, Cowlitz Game and Anglers Summer, North Toutle Summer, Kalama River Summer, Merwin Summer, Fish First Summer, Speelyai Bay Net-Pen Summer, EF Lewis Summer, Skamania Summer, Kalama River Winter, Cowlitz Early Winter, Merwin Winter, Coweeman Ponds Winter, EF Lewis Winter, Skamania Winter, Klineline Ponds Winter, Eagle Creek NFH Winter, Clackamas Summer, Sandy River Summer.

[1] The designations "(C)" and "(G)" identify Core and Genetic Legacy populations, respectively (NMFS 2013).

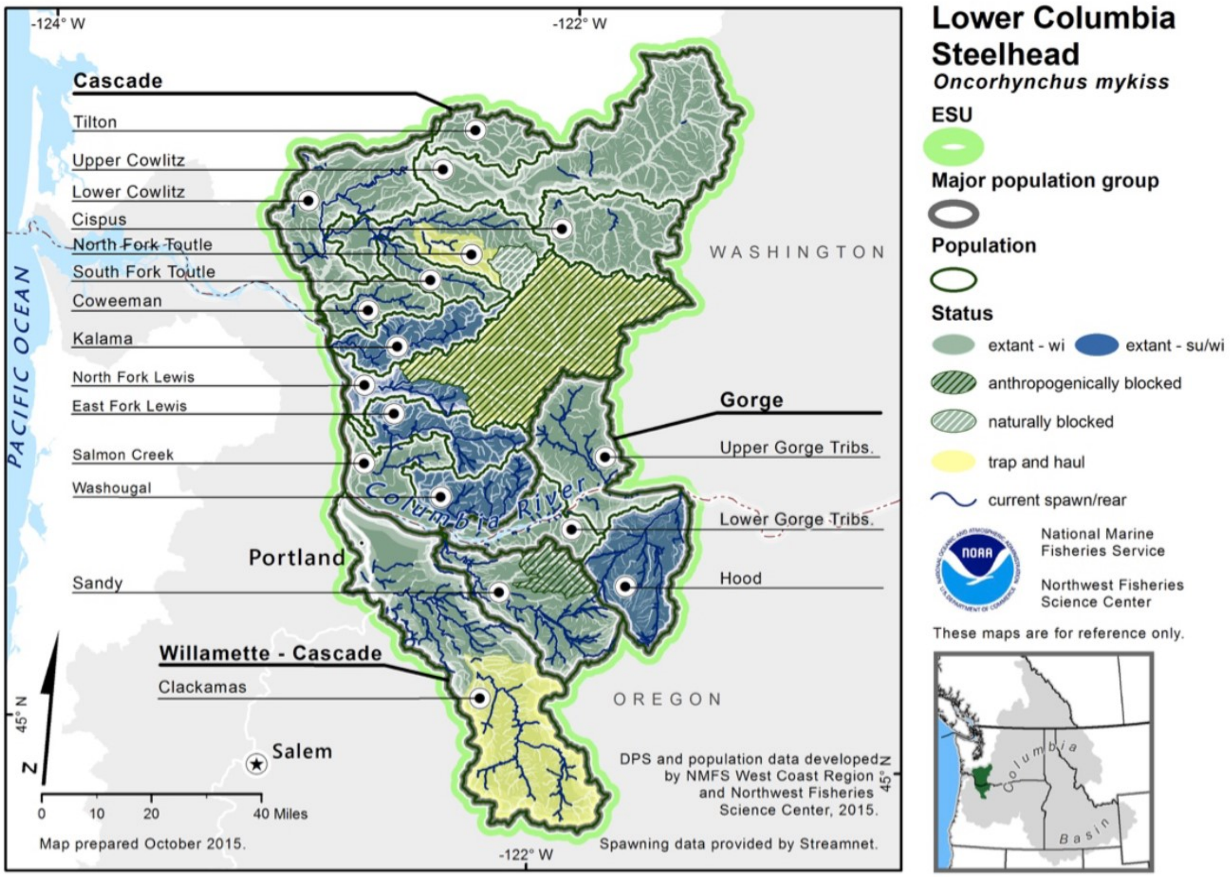

Figure 7. Map of the LCR Steelhead Salmon ESU spawning and rearing areas, illustrating populations and major population groups (NWFSC 2015).

LCR steelhead exhibit a complex life history. 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 under the jurisdiction of NMFS, while resident freshwater forms (rainbow or redband trout) are under the jurisdiction of the FWS. Steelhead are iteroparous, meaning they can spawn more than once. Repeat spawners are called “kelts” (NMFS 2013).

LCR basin populations include summer and winter steelhead (Table 24). The two life history types differ in degree of sexual maturity at freshwater entry, spawning time, and frequency of repeat spawning (NMFS 2013). Generally, summer steelhead enter fresh water from May to October in a sexually immature condition, and require several months in fresh water to reach sexual maturity and spawn between late February and early April. Winter steelhead enter fresh water from November to April in a sexually mature condition and spawn in late April and early May. 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 populations (Busby et al. 1996; Hulett et al. 1996; Leider et al. 1986).

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 24. Life history and population characteristics of LCR steelhead.

Characteristic	Life-History Features	
	Summer	**Winter**
Number of extant population	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

Steelhead spawn in a wide range of conditions ranging from large streams and rivers to small streams and side channels (Myers et al. 2006a). 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 spawning timing must optimize avoiding risks from gravel-bed scour during high flow 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 2013). 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 main stem 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 (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 fresh water (natal steams, 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 2013).

Catch 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 (Narver 1969; Shapovalov and Taft 1954; Ward and Slaney 1988b). Once in the river, adult steelhead rarely eat and grow little, if at all.

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 population's baseline and target persistence probabilities are summarized in Table 25, 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 %).

Table 25. Current status for LCR steelhead populations and recovery scenario targets (NMFS 2013).

MPG	Population (State)	Status Assessment		Recovery Scenario	
		Baseline Persistence Probability[1]	Contribution[2]	Target Persistence Probability	Abundance Target[3]
Cascade summer	Kalama (WA)	M	Primary	H	500
	North Fork Lewis (WA)	VL	Stabilizing	VL	--
	EF Lewis (WA)	VL	Primary	H	500
	Washougal (WA)	M	Primary	H	500
Gorge summer	Wind (WA)	H	Primary	VH	1,000
	Hood (OR)	VL	Primary	H*	2,008
Cascade winter	Lower Cowlitz (WA)	L	Contributing	M	400
	Upper Cowlitz (WA)	VL	Primary	H	500
	Cispus (WA)	VL	Primary	H	500
	Tilton (WA)	VL	Contributing	L	200
	South Fork Toutle (WA)	M	Primary	H+	600
	North Fork Toutle (WA)	VL	Primary	H	600
	Coweeman (WA)	L	Primary	H	500
	Kalama (WA)	L	Primary	H+	600
	North Fork Lewis (WA)	VL	Contributing	M	400
	East Fork Lewis (WA)	M	Primary	H	500
	Salmon Creek (WA)	VL	Stabilizing	VL	--
	Washougal (WA)	L	Contributing	M	350
	Clackamas (OR)	M	Primary	H*	10,671
	Sandy (OR)	L	Primary	VH	1,519
Gorge winter	Lower Gorge (WA/OR)	L	Primary	H	300
	Upper Gorge (WA/OR)	L	Stabilizing	L	--
	Hood (OR)	M	Primary	H	2,079

[1] LCFRB (2010) used the late 1990s as a baseline period for evaluating status; ODFW (2010b) assume average environmental conditions of the period 1974-2004. VL = very low, L = low, M = moderate, H = high, VH = very high. These are adopted in the recovery plan NMFS (2013).

[2] 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.

[3] Abundance objectives account for related goals for productivity (NMFS 2013).

* Oregon's analysis indicates a low probability of meeting the delisting objective of high persistence probability for this population.

If the recovery scenario in Table 25 is achieved, it would exceed the WLC TRT's viability criteria in the Cascade winter and summer MPGs. This is intentional given the scenario for uncertainties about the feasibility of meeting the viability criteria for populations within the Gorge MPGs. Questions remain concerning the historical role of the populations, specifically with the winter populations in the Gorge MPGs, and the current habitat potential (NMFS 2013).

NMFS (2013) commented on the uncertainties and practical limits to achieving high viability for the populations in the Gorge MPG. Recovery opportunities in the Gorge were limited by the small numbers of populations and the high uncertainty related to restoration because of Bonneville Dam passage and inundation of historically productive habitats. NMFS recognized the uncertainty regarding the TRT's MPG delineations between the Gorge and Cascade MPG populations, including questions of whether the Gorge populations were highly persistent historically, whether they functioned as independent populations within their stratum in the same way that the Cascade populations did, and whether the Gorge stratum itself should be considered a separate stratum from the Cascade stratum. As a result, the recovery plan recommends improvements in more than the minimum number of populations required in the Cascade summer and winter MPGs, to provide a safety factor 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.

Cascade summer MPG

There are four summer steelhead populations in the Cascade summer MPG: Kalama River, North Fork Lewis River, East Fork Lewis River, and Washougal River. Until recently migratory access for the North Fork Lewis River summer population was blocked by a series of impassable dams, although summer-run are not currently being considered as part of the reintroduction program. There is some uncertainty regarding the status of this population, specifically if currently residualized *O. mykiss* present above the dam contain a genetic legacy of the historical population and if they are capable of reinitiating an anadromous life-history (NWFSC 2016).

Summer steelhead have the greatest distribution of the Kalama subbasin populations. The Upper Kalama River Falls at RM 35 is the upstream limit to anadromous fish passage. Prior to the creation of a complete passage barrier at the Kalama Falls Hatchery through installation of the fish ladder in 1936, only summer steelhead are believed to have regularly passed upstream of the Lower Kalama Falls at RM 10 (NMFS 2013). Only unmarked steelhead are passed upstream of the ladder, where WDFW estimates a pHOS of 4% by modeling the current release number from the isolated summer steelhead hatchery program in the basin (WDFW 2014a). Hatchery summer steelhead trapped at the ladder are released back into the lower Kalama River attempting to reexpose them to harvest (a practice referred to as "recycling"), and are not included in the pHOS estimate. Since brood year 1997, Kalama Falls Hatchery trap counts indicate a high of 817 summer steelhead in 2003, after which annual returns dropped below 440 fish each brood year from 2005 to 2009 (Table 26).

Table 26. Total Cascade MPG summer steelhead natural-origin spawner abundance estimates in the Lower Columbia River, 1997-2015 (from WDFW SCORE[1])*.

Brood Year	Trap count	Snorkel Surveys	
	Kalama River	East Fork Lewis River	Washougal
1997	602	197	148
1998	182	141	120
1999	220	139	135
2000	140	229	140
2001	286	271	184
2002	454	440	404

2003	817	910	607
2004	549	425	na
2005	435	673	608
2006	387	560	636
2007	361	412	681
2008	237	365	755
2009	308	800	433
2010	370	600	787
2011	534	1,036	na
2012	646	1,084	842
2013	738	1,059	na
2014	400	617	544
2015	814	843	783

[1] Online at: https://fortress.wa.gov/dfw/score/score/recovery/recovery.jsp#score
* Date Accessed: April 19, 2016

The East Fork Lewis summer steelhead population is targeted for the largest improvement within the Cascade summer steelhead MPG. Mid-July snorkel index escapement surveys have been conducted in the East Fork Lewis (HSRG 2009), and indicate 2003, 2011, 2012, 2013 and 2015 as the only years that WDFW's established escapement goal of 814 adults spawning was exceeded for this population (Table 26). From 2005 to 2009 an average of 562 adult steelhead have been observed spawning, and the spawning population is reported to have the highest pHOS estimate, 35 %, for any summer steelhead population in the LCR Steelhead DPS (LCFRB 2010).

According to the most recent status review in 2015, long and short term trends for the Kalama, East Fork Lewis, and Washougal populations are positive, and absolute abundances have been in the hundreds of fish. The most recent surveys (2014) indicate a drop in abundance for all three populations. Whether this is a portent of changing oceanic conditions is not clear, but it is of some concern regardless of its cause (NWFSC 2016).

Washougal summer steelhead abundance estimates show a recent increasing trend (Table 26). From 2005 to 2009 snorkel surveys indicate an average of just over 600 annual summer steelhead adults spawning in the Washougal River, or roughly 50 % of WDFW's established 1,210 escapement goal. Spawning occurs throughout the Washougal Basin, extending to the main stem Washougal and tributaries upstream of Dougan Falls (RM 21), the Little Washougal, and the North Fork Washougal.

There are no adequate abundance trend data for the North Fork Lewis summer steelhead population. The North Fork Lewis summer steelhead population likely has low numbers of natural-origin returns (NORs) because of loss of habitat access related to Merwin Dam, ongoing hatchery programs that produce summer steelhead for harvest, and the manager's desire not to interfere with winter steelhead recovery efforts in the upper North Fork Lewis. Recovery efforts for summer steelhead in the North Fork Lewis River is likely to occur below Merwin Dam (NMFS 2013). Summer steelhead counts at the Merwin Dam Fish Collection Facility have remained below 100 NOR steelhead for the past 12 years (Table 27). Current spawning is in the lower North Fork Lewis River and tributaries (most notable is Cedar Creek) below Merwin Dam (NMFS 2007).

Table 27. Summer steelhead trapped at Merwin Dam Fish Collection Facility (Personal comm., E. Kinne 2016).

Year[1]	**Hatchery Origin**		**Natural Origin**	
	Trapped	**Released back to stream**	**Trapped**	**Released back to stream**
2003	8,342	7,240	51	51
2004	12,597	9,207	90	90
2005	9,082	6,894	71	68
2006	9,370	6,818	49	48
2007	3,902	2,549	39	39
2008	6,689	5,857	18	18
2009	6,624	4,407	17	17
2010	9,116	6,642	13	12
2011	2,401	1,453	15	15
2012	3,683	3,065	8	8
2013	455	244	16	16
2014	8,211	6,104	14	14
2015	4,103	2,820	24	24

[1]Before 2003 mark status of adult returns were not collected.

Gorge summer MPG

The Wind River and Hood River are the two populations in this MPG. Hood River summer-run steelhead have not been monitored since the last status review in 2011 (Ford et al. 2011); efforts are currently underway to provide accurate estimates of fish ascending the west fork of the Hood River. Adult abundance in the Wind River remains stable, but at a low level (hundreds of fish; Table 28). In addition, there is a catch and release fishery that allows targeting natural-origin summer steelhead in the Wind River; but in the Hood River encounter and incidental mortality are not currently available. Given the presence of only two summer-run populations, and only one is still currently monitored in this MPG (Table 28), the overall status of the MPG is uncertain (NWFSC 2016).

Table 28. Total Gorge MPG summer steelhead natural-origin spawner abundance estimates in the LCR, 1997-2015 (from WDFW SCORE).

Brood Year	**Wind River (WA)**[1 a *]	**Hood River (OR)**[2]	
		Total	**% wild**
1997	734	1,486	12.0
1998	320	513	13.0
1999	323	102	96.0

2000	218	149	99.0
2001	454	181	99.0
2002	690	538	77.0
2003	1,113	1,043	52.0
2004	893	387	47.0
2005	600	323	47.0
2006	658	306	56.0
2007	766	343	49.0
2008	638	248	48.0
2009	605	n/a	n/a
2010	777	n/a	n/a
2011	1,497	n/a	n/a
2012	815	n/a	n/a
2013	760	n/a	n/a
2014	281	n/a	n/a
2015	577	n/a	n/a

[1] online at:
https://fortress.wa.gov/dfw/score/score/recovery/recovery.jsp#score
[*] Date Accessed: April 19, 2016
[2] Summer Steelhead estimates at Powerdale Dam (NMFS 2010). This counting location was discontinued in 2009.
[a] Data since 2000 are based on jumper estimates at Shipherd Falls and are considered preliminary estimates.

For the Gorge summer steelhead MPG, Powerdale Dam on the Hood River hindered access of adult steelhead to historical spawning areas until its removal in 2010. The dam allowed ODFW to limit HOR fish from passing upstream, and to estimate NOR fish abundance. While the recent abundance trend between 2005 to 2009 has been decreasing (Table 28), hatchery-origin summer steelhead are no longer be released in the Hood River subbasin (NMFS 2013). Since 2005 NOR summer steelhead passed upstream of Powerdale Dam averaged 153 fish, or 18% of ODFW's estimated Hood River capacity of 884 summer steelhead under current habitat conditions (ODFW 2005).

The Wind River population has a high baseline persistence probability and is targeted for very high persistence. The smolt yield trend has been increasing, and the adult escapement exceeded the escapement goal of 957 in 2003 and again in 2011 (Table 28). Baseline abundance and productivity of the Wind River summer steelhead population are the highest in the DPS; however, improvements in diversity will be needed in the population to meet recovery objectives (NMFS 2013).

Cascade winter MPG

This MPG includes natural-origin winter-run steelhead in 14 populations from the Cowlitz River to the Washougal River. Abundances have remained fairly stable and, in general, are correlated with cyclical changes in ocean conditions. For most populations, total abundances and natural-origin abundances (where available) have remained low, averaging in the hundreds of fish.

Notable exceptions to this were the Clackamas[2] and Sandy River winter-run steelhead populations, which are exhibiting recent rises in NOR abundance and maintaining low levels of hatchery-origin steelhead on the spawning grounds (Jacobsen et al. 2014). Abundances in the Tilton and Upper Cowlitz/Cispus rivers are highly variable, in part because of ongoing changes in collection efficiency of juvenile downstream passage structures as well as the use of natural-origin adults as broodstock in developing an integrated hatchery stock (NWFSC 2016). The most recent total abundance information is provided in Table 29.

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[2] For the Clackamas River winter steelhead population, the North Fork Dam count provided the longest available data set for statistical analysis. This data set does not include winter steelhead spawning below the dam (for which only a shorter time series based on redd count expansions are available). For 2013 and 2014, total spawners below the dam were 1,831 (85% NOR) and 2,171 (99% NOR), respectively (Jacobsen et al. 2014).

Table 29. Total Cascade MPG winter steelhead spawner abundance estimates in the LCR, 1997-2015 (from ODFW Salmon and Steelhead Recovery Tracker[1] and WDFW SCORE[2])*.

Brood Year	Upper Cowlitz[3]	SF Toutle	NF Toutle[4]	Green[5]	Coweeman	EF Lewis	Kalama	Washougal[6]	Clackamas[7]	Sandy[7]
1997	34	388	183	132	108	238	507	92	483	1,253
1998	11	374	149	118	486	376	472	195	473	776
1999	52	562	133	72	198	442	544	294	295	816
2000	215	490	238	124	530	na	921	na	745	741
2001	295	348	185	192	384	377	1,042	216	1,489	902
2002	766	640	328	180	298	292	1,495	286	2,324	1,031
2003	523	1,510	410	438	460	532	1,815	764	2,049	584
2004	296	1,212	249	256	722	1,298	2,400	1,114	5,181	796
2005	280	520	166	222	370	246	1,982	320	1,559	563
2006	544	656	300	592	372	458	1,733	524	1,164	569
2007	622	548	155	410	384	448	1,011	632	1,208	782
2008	517	412	96	554	722	548	742	732	472	na
2009	513	498	89	610	602	688	1,044	418	622	na
2010	614	274	252	256	528	336	961	232	2,175	1,498
2011	627	210	170	246	408	308	622	204	1,242	527
2012	580	378	207	266	256	272	1,061	306	2,733	357
2013	343	972	123	430	622	488	811	678	2,427	3,509
2014	24	708	277	310	496	414	948	388	3,404	3,249
2015	na	1,340	618	922	940	678	1,206	648		

[1] Online at: http://www.odfwrecoverytracker.org/explorer/species/Steelhead/run/winter/esu/223/225/

* Date Accessed: July 13, 2016

[2] Online at: https://fortress.wa.gov/dfw/score/score/species/steelhead.jsp?species=Steelhead

* Date Accessed: April 19, 2016

[3] Does not include transports to the Tilton River.

[4] Trap counts from the North Toutle Fish Collection Facility represent a census count of the natural-origin steelhead hauled above the Sediment Retention Structure and released into the upper NF Toutle River.

[5] Data are total escapement estimates for the Green River (NF Toutle River tributary) based on expansion of redd counts from main stem and tributary index areas, including Devils Creek, Cascade Creek and Elk Creek (WDFW 2014c). Data from 1997-2004 are a proportion value, and data from 2005-2015 are total natural spawners

[6] Data from 1997-2004 were collected with aerial flight counts and AUC, and data from 2005-2015 are based on redd count expansion.

[7] Natural-origin spawners.

Within the Cascade winter steelhead MPG, 10 of 14 historical populations are targeted for high or better persistence probability. These include the two genetic legacy populations and six core populations (i.e., those that were historically the most productive). One of these, the Clackamas population, is targeted to move from medium to high persistence probability, but ODFW notes that achieving this target status is unlikely because the level of tributary habitat improvement needed is considered infeasible (ODFW 2010). The sixth core population in this MPG, the North Fork Lewis, is targeted for medium persistence probability. In this stratum, only Salmon Creek population, occurring in a highly urbanized subbasin, is expected to remain at its baseline persistence probability of very low.

The Cowlitz Basin holds half of all populations in the Cascade winter steelhead MPG. WDFW has not monitored the main stem Cowlitz at a population scale, so there is very little abundance data currently available (B. Glaser, personal communication). The same is true for the majority of the Upper Cowlitz populations, including the Tilton and Cispus winter steelhead populations. These populations were not historically monitored for and did not have escapement goals established. This is likely due to escapement goals only existing for six populations within this MPG (Coweeman at 1,064, South Fork Toutle at 1,058, North Fork Toutle/ Green at 1,100, East Fork Lewis at 204, Washougal at 814, and Kalama at 1,000), as most populations without previously established escapement goals went unmonitored.

Gorge winter MPG

This MPG contains three populations, Lower Gorge, Upper Gorge, and Hood River. In both the Lower and Upper Gorge populations, surveys for winter steelhead are very limited. Abundance levels have been low, but relatively stable, in the Hood River population. In recent years, spawners from the integrated hatchery program have constituted the majority of naturally spawning fish (NWFSC 2016). The most recent total abundance information for Hood River winter steelhead populations is provided in Table 30. The total winter steelhead returns to Hood River has numbered in the hundreds in recent years, but has been extremely variable. There are no adequate abundance trend data for the Lower Gorge winter steelhead population.

Table 30. Total Gorge MPG winter spawner abundance estimates in the LCR, 2001-2015 (from ODFW Salmon and Steelhead Recovery Tracker[1] and WDFW SCORE[2])*.

Year	Hood River[1]	Upper Gorge (Wind River)[2,3]
2001	877	49
2002	950	47
2003	654	25
2004	507	26
2005	273	20
2006	342	21
2007	423	11
2008	264	6
2009	170	18
2010	568	28
2011	271	16
2012	653	19

2013	312	17
2014	177	5
2015	na	10

[1] online at: http://odfwrecoverytracker.org/summary/#/species=2&run=3&esu=223/esu=223&metric=1&level=3/filter=223&start_year=1992&end_year=2016

[2] online at: https://fortress.wa.gov/dfw/score/score/recovery/recovery.jsp#score

[*] Date Accessed: April 19, 2016

[3] Wind River subpopulation. Trap count data for Winter Steelhead on Wind River near Shipherd Falls

Prior to the Hood River winter steelhead program discontinuation in 2009, winter steelhead Hood River stock hatchery adults were passed above Powerdale Dam in numbers not exceeding a 50:50 ratio between the wild and hatchery components of the winter run. The estimated number of winter steelhead smolts annually migrating downstream from 1994 to 2004 ranged from 4,271 to 22,538, with a carrying capacity estimate of 16,970 (Olsen 2003).

Of the three populations in the Gorge winter steelhead stratum, two—the Lower Gorge and the Hood River (both of which are a core and a genetic legacy population)—are targeted for high persistence probability. The third, the Upper Gorge, is designated as stabilizing and is expected to remain at its low baseline status because of questions about the historical role of the population and current habitat potential.

In the Hood River subbasin, Oregon installed a floating weir to remove stray hatchery winter steelhead and to implement a sliding scale for take of wild winter steelhead broodstock for an integrated hatchery program. There are no hatcheries at present in the Upper Gorge tributaries, and the WDFW plan proposes that this area be maintained as a refuge area for winter steelhead (LCFRB 2010). In the Lower Gorge, ODFW proposes to investigate placing a new weir and trap to sort hatchery-origin winter steelhead from natural-origin winter steelhead migrating upstream on Eagle Creek, Tanner Creek, or both. There are currently no hatcheries or winter steelhead releases in the Washington Lower Gorge tributaries (NMFS 2013).

Summary

Spatial structure for LCR steelhead has largely been maintained for most populations in the DPS (NMFS 2013). This means that returning adults can access most areas of historical habitat. Except for the North Fork Lewis subbasin, where dams have impeded access to historical spawning habitat, most summer steelhead populations continue to have access to historical production areas in forested, mid- to-high-elevation subbasins that remain largely intact. For the Upper Cowlitz, Cispus, Tilton, and North Fork Lewis winter populations, passage to upper basin habitat is partially or entirely blocked by dams (LCFRB 2010; ODFW 2010); the Upper Gorge winter population is constrained by hatchery weirs, and the Hood winter population is constrained by the presence and operation of an irrigation dam. However, steelhead distribution has been partially restored in the Upper Cowlitz, Cispus, and Tilton subbasin by trapping and transferring adults and juveniles around impassable dams (NMFS 2013).

Historical hatchery effects, and ongoing hatchery straying have reduced genetic diversity and productivity in both summer and winter LCR steelhead populations (NMFS 2013). For summer populations, the Hood River population has the highest pHOS at 53 % (ODFW 2010). The

LCFRB (2010) reported that the highest pHOS rate among the Washington populations was 35 % for the East Fork Lewis, and modeled estimates of current production in the LCR indicate pHOS estimates as high at 51 % in the Cowlitz River for winter steelhead (WDFW 2014b, Attachment 3).

The methods and results for categorizing spatial distribution from the LCRFB Plan (2010) for LCR steelhead populations are reported in Appendix B of NMFS' recovery plan and summarized with updates from NWFSC (2016) below in Table 31. This overview suggests that risk related to diversity is higher than that for spatial structure (Table 31).

Table 31. Summary of VSP scores and recovery goals for LCR steelhead populations (NWFSC 2016).

Strata	State	Population	Total VSP Score	Recovery Goal
Cascade Summer	WA	Kalama	2	3
	WA	North Fork Lewis	0.5	0.5
	WA	EF Lewis	0.5	3
	WA	Washougal	2	2
Gorge Summer	WA	Wind	3	4
	OR	Hood	0	3
Cascade Winter	WA	Lower Cowlitz	1	2
	WA	Cispus	0.5	3
	WA	Tilton	0.5	1
	WA	South Fork Toutle	2	3.5
	WA	North Fork Toutle	0.5	3
	WA	Coweeman	1	3
	WA	Kalama	1	3.5
	WA	North Fork Lewis	0.5	2
	WA	East Fork Lewis	2	3
	WA	Salmon Creek	0.5	0.5
	WA	Washougal	1	2
	OR	Clackamas	2	3
	OR	Sandy	1	4
Gorge Winter	WA/OR	Lower Gorge	1	3
	WA/OR	Upper Gorge	1	1
	OR	Hood	na	na

Notes: Summaries taken directly from Figures 75 and 76, in NWFSC (2016). All are on a 4 point scale, with 4 being the lowest risk and 0 being the highest risk. VSP scores represent a combined assessment of population abundance and productivity, spatial structure and diversity (McElhany et al. 2006). A VSP score of 3.0 represents a population with a 5% risk of extinction within a 100 year period.

The estimated changes in VSP status for steelhead populations in Table 31 indicate that a total of 5 out of 22 populations are at or near their recovery viability goals, although only two of these populations had scores above 2.0 under the recovery plan scenario. The remaining populations generally require substantial improvements to reach their viability goals (NWFSC 2016).

Table 32 displays the abundance, productivity, spatial structure, diversity, and overall persistence probability for LCR steelhead, organized by individual populations. It is likely that genetic and life history diversity has been reduced as a result of pervasive hatchery effects and population bottlenecks. Spatial structure remains relatively high for most populations. Out of the 23 populations, 16 are considered to have a "low" or "very low" probability of persisting over the next 100 years, and six populations have a "moderate" overall persistence probability. All four strata in the DPS fall short of the WLC-TRT criteria for viability (NMFS 2016).

Baseline persistence probabilities were estimated to be "low" or "very low" for three out of the six summer steelhead populations that are part of the LCR Steelhead DPS, moderate for two, and high for one – the Wind, which is considered viable. Thirteen of the 17 LCR winter steelhead populations have "low" or "very low" baseline probabilities of persistence, and the remaining four are at "moderate" probability of persistence (Table 32) (NMFS 2016).

Table 32. LCR steelhead populations, and scores for the key elements (A/P, spatial structure, and diversity) used to determine current overall net persistence probability of the population (NMFS 2013a)[1].

Stratum		**Population (Watershed)**	**A/P**	**Spatial Structure**	**Diversity**	**Overall Persistence Probability**
Ecological Subregion	**Run Timing**					
Cascade Range	Summer	Kalama River (WA)	H	VH	M	M
		North Fork Lewis River (WA)	VL	VL	VL	VL
		East Fork Lewis River (WA)	VL	VH	M	VL
		Washougal River (WA)	M	VH	M	M
	Winter	Lower Cowlitz River (WA)	L	M	M	L
		Upper Cowlitz River (WA)	VL	M	M	VL
		Cispus River (WA)	VL	M	M	VL
		Tilton river (WA)	VL	M	M	VL
		South Fork Toutle River (WA)	M	VH	H	M
		North Fork Toutle River (WA)	VL	H	H	VL
		Coweeman River (WA)	L	VH	VH	L
		Kalama River (WA)	L	VH	H	L
		North Fork Lewis River (WA)	VL	M	M	VL
		East Fork Lewis River (WA)	M	VH	M	M
		Salmon Creek (WA)	VL	H	M	VL
		Clackamas River (OR)	M	VH	M	M
		Sandy River (OR)	L	M	M	L
		Washougal River (WA)	L	VH	M	L
Columbia Gorge	Summer	Wind River (WA)	VH	VH	H	H
		Hood River (OR)	VL	VH	L	VL
	Winter	Lower Gorge (WA & OR)	L	VH	M	L
		Upper Gorge (OR & WA)	L	M	M	L
		Hood River (OR)	M	VH	M	M

[1] Ratings range from very low (VL), low (L), moderate (M), high (H), to very high (VH) (NMFS 2016).

Figure 8 displays the extinction risk ratings for all four VSP parameters, including spatial structure and diversity attributes, for Oregon populations (Ford et al. 2011; ODFW 2010c). The results indicate low to moderate spatial structure and diversity risk for all but two populations. The assessments of spatial structure and diversity are combined with those of abundance and productivity to give an assessment of the overall status of LCR steelhead populations in Oregon. Risk is characterized as high or very high for three populations and moderate for the remaining populations. For populations other than Sandy, less than 5% of historical habitat has been lost for Oregon populations, indicating spatial structure for Oregon populations is a lower risk factor (NMFS 2013, Appendix A).

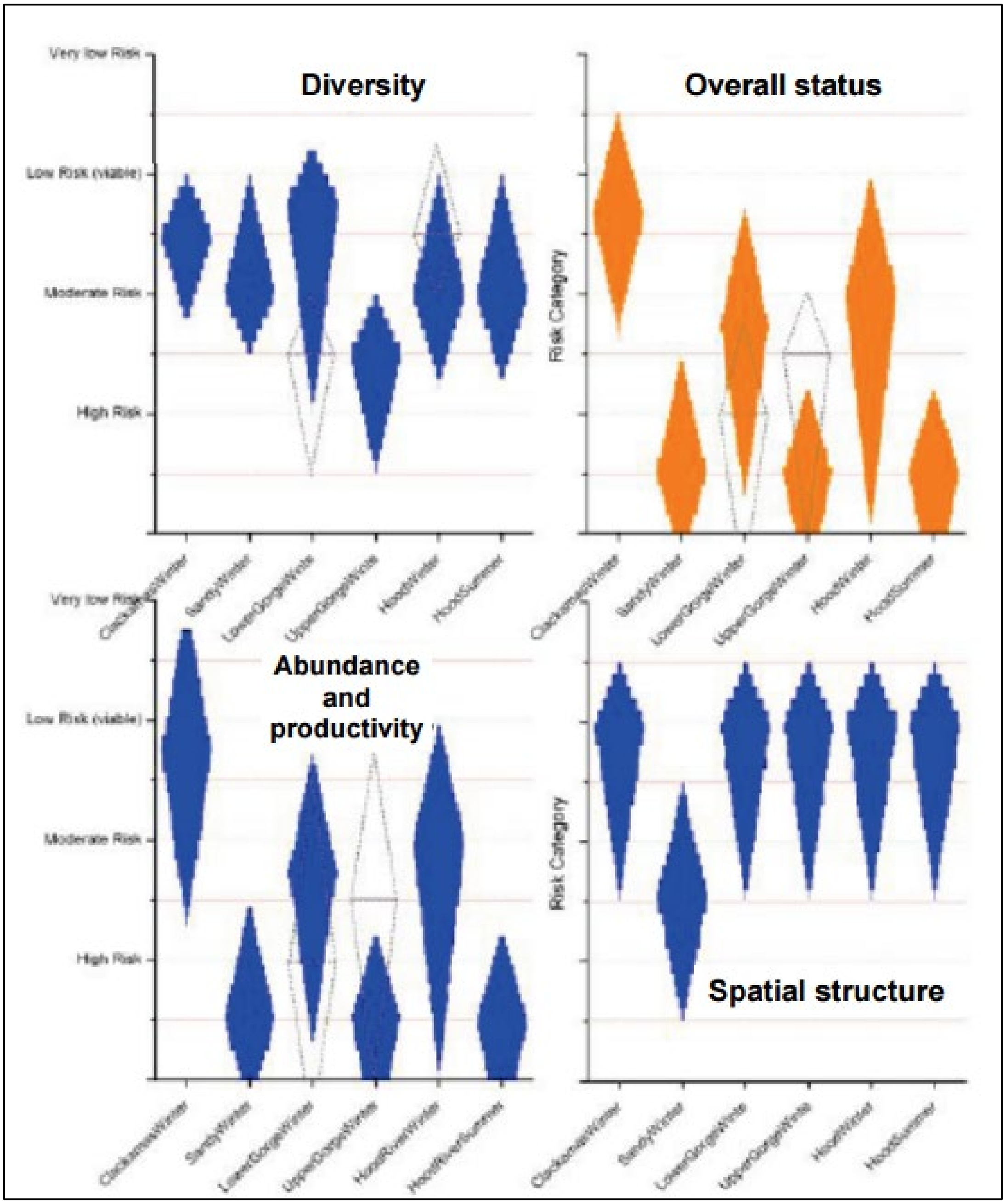

Figure 8. Extinction risk ratings for LCR steelhead populations in Oregon for the assessment attributes abundance/productivity, diversity, and spatial structure, as well as overall ratings for populations that combined the three attributes (From Ford et al. 2011).

The most recent status review (NWFSC 2016) concluded that the majority of winter and summer steelhead populations continue to persist at low abundances. Hatchery interactions remain a concern in select basins, but the overall situation is somewhat improved compared to the prior review in 2011. The decline in the Wind River summer population is a source of concern, given that this population has been considered one of the healthiest of the summer population; however, the most recent abundance estimates suggest that the decline was a single year aberration. Efforts to provide passage above dams in the North Fork Lewis River offer the opportunity for substantial improvements in the winter steelhead population and the only opportunity to reestablish the summer steelhead population. Habitat degradation continues to be a concern for most populations. Even with modest improvements in the status of several winter-run populations, none of the populations appear to be at fully viable status, and similarly none of the MPGs meet the criteria for viability. The DPS therefore continues to be at moderate risk (NWFSC 2016).

Limiting Factors

Understanding the limiting factors and threats that affect the LCR steelhead DPS 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 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 2013).

Columbia River Chum Salmon ESU

On March 25, 1999, NMFS listed the Columbia River (CR) Chum Salmon ESU as a threatened species (64 FR 14508). The threatened status was reaffirmed on April 14, 2014 (Table 3). Critical habitat was designated on September 2, 2005 (70 FR 52746).

Inside the geographic range of the ESU, four hatchery chum salmon programs are currently operational. Table 42 lists these hatchery programs, with three included in the ESU and one excluded from the ESU.

Table 33. CR 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. 2006b; NMFS 2013).

ESU Description	
Threatened	Listed under ESA in 1999; updated in 2014)
3 major population groups	17 historical populations
Major Population Group	***Populations***
Coast	Youngs Bay (C), Grays/Chinook (C,G), Big Creek (C), Elochoman/Skamakowa (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[1]
Artificial production	

Hatchery programs included in ESU (3)	Chinook River/Sea Resources Hatchery, Grays River, Washougal Hatchery/Duncan Creek
Hatchery programs not included in ESU (1)	Big Creek Hatchery

[1] Includes White Salmon population.

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 33. This ESU is composed of three MPGs that has 17 populations. 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.

Table 34. Current status for CR chum salmon populations and recommended status under the recovery scenario (NMFS 2013c).

Major Population Group	**Population (State)**	**Status Assessment**		**Recovery Scenario**	
		Baseline Persistence Probability[1]	**Contribution**	**Target Persistence Probability[2]**	**Abundance Target[3]**
Coast	Youngs Bay (OR)	VL	Stabilizing	VL	<500
	Grays/Chinook (WA)	M	Primary	VH	1,600
	Big Creek (OR)	VL	Stabilizing	VL	<500
	Elochoman/Skamakowa (WA)	VL	Primary	H	1,300
	Clatskanie (OR)	VL	Primary	H	1.000
	Mill/Abernathy/Germany (WA)	VL	Primary	H	1,300
	Scappoose (OR)	VL	Primary	H	1,000
Cascade	Cowlitz – fall (WA)	VL	Contributing	M	900
	Cowlitz – summer (WA)	VL	Contributing	M	900
	Kalama (WA)	VL	Contributing	M	900
	Lewis (WA)	VL	Primary	H	1,300
	Salmon Creek (WA)	VL	Stabilizing	VL	--
	Clackamas (OR)	VL	Contributing	M	500
	Sandy (OR)	VL	Primary	H	1,000
	Washougal (WA)	VL	Primary	H+	1,300
Gorge	Lower Gorge (WA/OR)	H	Primary	VH	2,000
	Upper Gorge (WA/OR)	VL	Contributing	M	900

[1] VL=very low, L=low, M=moderate, H=high, VH = very high. These are adopted in the recovery plan.

[2] 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.

[3] Abundance objectives account for related goals for productivity.

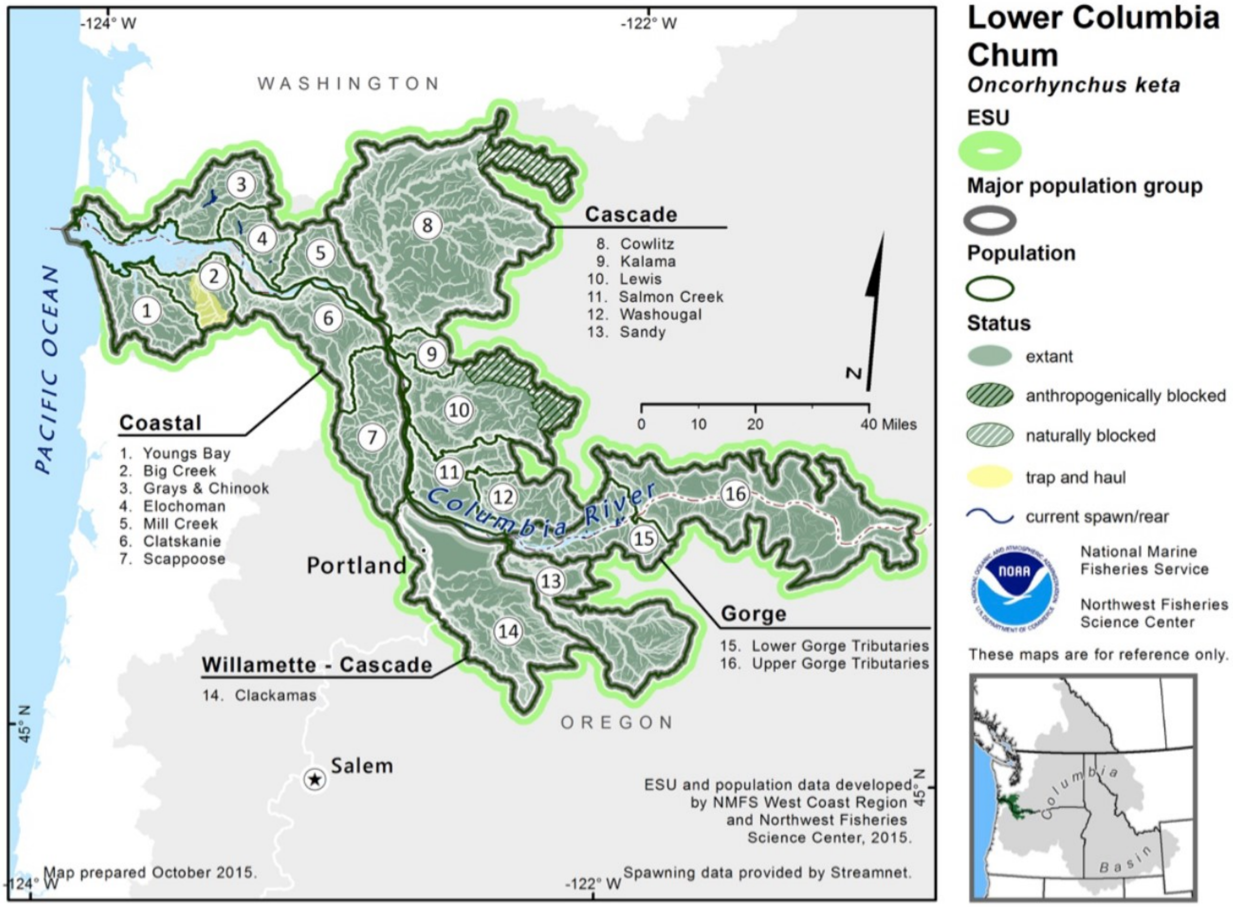

Figure 9. Map of the CR Chum Salmon ESU's spawning and rearing areas, illustrating populations and major population groups (From NWFSC 2016).

Columbia River chum salmon are classified as fall-run fish, entering fresh water from mid-October through November and spawning from early November to late December in the lower main stems of the 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. 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 et al. 1991). Chum salmon fry emerge from March through May (LCFRB 2010b), typically at night (ODFW 2010a), 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 2010b). Their small size at emigration is thought to make chum salmon susceptible to predation mortality during this life stage (LCFRB 2010b).

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 2011b). 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 2011b). 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.

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. Each Columbia River chum salmon population baseline and target persistence probability is summarized in along with target abundance for each population that would be consistent with delisting criteria. 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 %).

Over the last century, Columbia River chum salmon returns have collapsed from hundreds of thousands to just a few thousand per year (NMFS 2013). Of the 17 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 2013; NWFSC 2016). 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. The abundance targets in Oregon populations are minimum abundance thresholds (MATs) because Oregon lacked sufficient data to quantify abundance targets. MATs are a relationship between abundance, productivity, and extinction risk based on specific assumptions about productivity; more information about MATs can be found in McElhany et al. (2006).

Currently almost all natural production occurs in just two populations: the Grays/Chinook and the Lower Gorge. The most recent total abundance information for Columbia River chum salmon in Washington is provided in Table 35, including chum salmon counted passing Bonneville Dam. For the other Washington populations not listed in Table 25 and all Oregon populations there are only occasional reports of only a few chum salmon (NWFSC 2016).

Table 35. Peak spawning ground counts for fall chum salmon in index reaches in the LCR, and Bonneville Dam counts 2001-2014 (from WDFW SCORE[1])*.

Return Year	Grays River				Hamilton Creek Total	Hardy Creek	Main stem Columbia (area near I-205)	Bonneville Count
	Crazy Johnson Creek	Main stem	West Fork Grays	Grays River Total				

2001	1,234	811	2,201	4,246	617	835	na	29
2002	2,792	2,952	4,749	10,493	1,794	343	3,145	98
2003	4,876	5,026	5,657	15,559	821	413	2,932	411
2004	1,051	5,344	6,757	13,152	717	52	2,324	42
2005	1,337	1,292	1,166	3,795	257	71	902	139
2006	3,672	1,444	1,129	6,245	478	109	869	165
2007	837	1,176	1,803	3,816	180	12	576	142
2008	992	684	725	2,401	221	3	644	75
2009	968	724	1,084	2,776	216	46	1,118	109
2010	843	3,536	1,704	6,083	594	175	2,148	124
2011	2,133	2,317	5,603	10,053	867	157	4,801	50
2012	3,363	1,706	2,713	7,782	489	75	2,498	65
2013	1,786	1,292	1,754	4,832	647	56	1,364	167
2014	1,380	1,801	1,078	4,259	922	108	1,387	122

[1] online at https://fortress.wa.gov/dfw/score/score/species/chum.jsp?species=Chum

*Date Accessed: April 12, 2016.

The methods and results for categorizing spatial distribution from the LCFRB Plan (2010) for Columbia River chum salmon populations are reported in the recovery plan, and updated scores are summarized here in Table 37. Under baseline conditions, constrained spatial structure at the ESU level (related to conversion, degradation, and inundation of habitat) contributes to very low abundance and low genetic diversity in most populations, increasing risk to the ESU from local disturbances. Diversity has been greatly reduced at the ESU level because of presumed extirpations and low abundance in the remaining populations (LCRFRB 2010). Population status is characterized relative to persistence (which combines the abundance and productivity criteria), spatial structure, diversity, and also habitat characteristics. This overview for chum salmon populations suggests that risks related to diversity are higher than those for spatial structure (Table 37). The scores generally average between 2 and 3 for spatial structure, and between 1 and 2 for diversity. McElhany et al. (2006) reported the methods used to score the spatial structure and diversity attributes for chum salmon populations in Oregon required more data.

Table 36. Columbia River Chum Salmon ESU populations and scores for the key elements (A/P, diversity, and spatial structure) used to determine current overall net persistence probability of the populations (NMFS 2013a).[1]

MPG		**Spawning Population (Watershed)**	**A/P**	**Diversity**	**Spatial Structure**	**Overall Persistence Probability**
Ecological Subregion	**Run Timing**					
Coast Range	Fall	Youngs Bay (OR)	*	*	*	VL
		Grays/Chinook rivers (WA)	VH	M	H	M
		Big Creek (OR)	*	*	*	VL
		Elochoman/Skamokawa rivers (WA)	VL	H	L	VL
		Clatskanie River (OR)	*	*	*	VL
		Mill, Abernathy and Germany creeks (WA)	VL	H	L	VL
		Scappoose Creek (OR)	*	*	*	VL

MPG		Spawning Population (Watershed)	A/P	Diversity	Spatial Structure	Overall Persistence Probability
Ecological Subregion	**Run Timing**					
Cascade Range	Summer	Cowlitz River (WA)	VL	L	L	VL
	Fall	Cowlitz River (WA)	VL	H	L	VL
		Kalama River (WA)	VL	H	L	VL
		Lewis River (WA)	VL	H	L	VL
		Salmon Creek (WA)	VL	L	L	VL
		Clackamas River (OR)	*	*	*	VL
		Sandy River (OR)	*	*	*	VL
		Washougal River (WA)	VL	H	L	VL
Columbia Gorge	Fall	Lower Gorge (WA & OR)	VH	H	VH	H
		Upper Gorge (WA & OR)	VL	L	L	VL

[1] Ratings range from low (VL), low (L), moderate (M), high (H), to very high (VH) (NMFS 2013; NMFS 2016).
* No data are available to make a quantitative assessment.

The most recent status review (NWFSC 2016) concluded that a total of 3 of 17 populations are at or near their recovery viability goals, although under the recovery plan scenario these populations have very low recovery goals of 0 (Table 37). The remaining populations generally require a higher level of viability and most require substantial improvements to reach their viability goals. Even with the improvements observed during the last five years, the majority of individual populations in this ESU remain at a high or very high risk category and considerable progress remains to be made to achieve the recovery goals (NWFSC 2016).

Table 37. Summary of VSP scores and recovery goals for CR chum salmon populations (NWFSC 2016).

MPG	State	Population	Total VSP Score	Recovery Goal
Coast	OR	Youngs Bay	0	0
	WA	Grays/Chinook	2	4
	OR	Big Creek	0	0
	OR	Clatskamie	0	3
	WA	Elochoman/Skamokawa	0.5	3
	WA	Mill/Abern/Ger	0.5	3
	OR	Scappoose	0	3
Cascade	WA	Cowlitz (fall)	0.5	2
	WA	Cowlitz (summer)	0.5	2
	WA	Kalama	0.5	2
	WA	Lewis	0.5	3
	WA	Salmon Creek	0.5	0
	OR	Clackamas	0	2
	OR	Sandy	0	3
	WA	Washougal	0.5	3.5
Gorge	WA	Lower Gorge	3	4
	WA	Upper Gorge	0	2

Notes: Summaries taken directly from Figure 82 in NWFSC (2016). All are on a 4 point scale, with 4 being the lowest risk and 0 being the highest risk. Viable Salmon Population scores represent a combined assessment of population abundance and productivity, spatial structure and diversity (McElhany et al. 2006). A VSP score of 3.0 represents a population with a 5% risk of extinction within a 100 year period.

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. Columbia River chum salmon were historically abundant and were subject to extensive harvest until the 1950s (Johnson et al. 1997; NWFSC 2016). There are many factors that affect the abundance, productivity, spatial structure, and diversity of the Columbia River Chum ESU. Factors that limit the ESU have been, and continue to be, loss and degradation of spawning and rearing habitat, impacts of main stem 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 2013). Other threats to the species include climate change impacts, as discussed in Section 2.2.3.

The release of hatchery juveniles was not identified as a limiting factor. Chum salmon have never been subject to significant hatchery production in the Columbia River for fishery mitigation programs. Chum salmon fry from all populations may experience predation by hatchery-origin coho salmon, steelhead, and Chinook salmon smolts, although differences in life history patterns may moderate effects, and the significance of interactions is unknown; however, predation by hatchery smolts of other species in the estuary is identified as a secondary limiting factor for all CR chum salmon (NMFS 2013). Chum salmon may be also be impacted by hatchery fish through competition for space with other salmon and steelhead juveniles reared in hatcheries.

ESA-listed Salmon and Steelhead upstream of the Lower Columbia River Domain

Other ESA-listed salmon and steelhead upriver of the Lower Columbia River may be present in the proposed action area during the release of juvenile hatchery fish from SAFE net pens and subsequent return as adults. These species include Upper Willamette spring Chinook salmon and winter steelhead, Middle Columbia steelhead, Upper Columbia spring Chinook salmon and steelhead, and Snake River spring/summer Chinook salmon, fall Chinook salmon and steelhead. Several of these ESUs and DPSs were determined to not be adversely affected by the proposed action as described in Section 2.13 of this document.

NMFS (2020) fully describes the life history, abundance and productivity, spatial structure, and diversity of the upriver salmon and steelhead stocks and is incorporated here by reference. The current limiting factors/threats and overall status of these stocks is also fully described in NMFS (2020). For all of these species, the overall status is currently still poor. A suite of limiting factors/threats continue to depress these species including poor survival of juvenile fish due to passage mortality through hydropower and flood control dams, land management activities that have degraded freshwater habitat capacity and productivity, negative effects from hatchery fish, and fishery harvest. Ecological interactions in the Columbia River estuary have not been identified as a primary limiting factor/threat for these species. For further descriptions of the specific status of these species, see NMFS (2020).

2.2.2. Climate Change

Climate change has negative implications for salmonid species and designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004b; ISAB 2007; Scheuerell and Williams 2005; Zabel et al. 2006). For a detailed discussion of climate change and how it affects salmonid species in the Pacific Northwest, see below in Section 2.4.2.

2.3. Action Area

The "Action Area" means all areas to be affected directly or indirectly by the Proposed Action, in which the effects of the action can be meaningfully detected, measured, and evaluated (50 CFR 402.02). The Action Area resulting from this analysis includes the Columbia River estuary and plume[3].

In our analysis for the Mitchell Act Biological Opinion (NMFS 2017a), NMFS considered whether the ocean should be included in the Action Area but was unable to detect or measure effects of the Proposed Action beyond the area described above (i.e., outside of the Columbia River plume), based on best available scientific information (NMFS 2009a). Available knowledge and techniques are insufficient to discern the role and contribution of the Proposed Action to density dependent interactions affecting salmon and steelhead growth and survival in the Pacific Ocean. From the scientific literature, the general conclusion is that the influence of density dependent interactions on growth and survival is likely immeasurably small. While there is evidence that hatchery production can impact salmon survival at sea, the degree of impact or level of influence is not yet understood or predictable. Given these same limitations, we conclude here that the appropriate action area does not extend out into the ocean, beyond the plume of the Columbia River. NMFS will monitor emerging science and information and will reinitiate Section 7 consultation in the event that new information reveals effects of the action to ESA-listed species or critical habitat in a manner or to an extent not considered in this consultation (50 CFR 402.16).

2.4. Environmental Baseline

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultations, and the impact of State or private actions

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[3] 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 NMFS. 2017b. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. NOAA's National Marine Fisheries Service's implementation of the Mitchell Act Final Environmental Impact Statement preferred alternative and administration of Mitchell Act hatchery funding. January 15, 2017. NMFS Consultation No.: WCR-2014-697. 535p.

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

2.4.1. Habitat and Hydropower

A discussion of the baseline condition of habitat and hydropower throughout the Columbia River Basin occurs in our Biological Opinion on the Mitchell Act Hatchery programs (NMFS 2017b). Here we summarize some of the key impacts on salmon and steelhead habitat, primarily in the lower Columbia River and estuary because some of the effects from the Proposed Action are in this subarea.

Anywhere hydropower exists, some general effects exist, though those effects vary depending on the hydropower system. In the Action Area, some of these general effects from hydropower systems on biotic and abiotic factors include, but are not limited to:

- Juvenile and adult passage survival at the five run-of-river dams on the mainstem Columbia River (safe passage in the migration corridor);
- Water quantity (i.e., flow) and seasonal timing (water quantity and velocity and safe passage in the migration corridor; cover/shelter, food/prey, riparian vegetation, and space associated with the connectivity of the estuarine floodplain);
- Temperature in the reaches below the large mainstem storage projects (water quality and safe passage in the migration corridor)
- Sediment transport and turbidity (water quality and safe passage in the migration corridor)
- Total dissolved gas (water quality and safe passage in the migration corridor)
- Food webs, including both predators and prey (food/prey and safe passage in the migration corridor)

Furthermore, the mainstem dams and the associated reservoirs present fish-passage hazards, 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 (NMFS 2017b). Mainstem dams and reservoirs can also affect water quality by influencing temperature due to storage, diversions, and irrigation return flows, reducing turbidity, increasing total dissolved gas, and contributing toxic contaminants. All of these impacts affect the migration of adults and juveniles in the mainstem Columbia River.

Specifically for LCR salmonid populations above Bonneville Dam, hydropower effects include impacts from upstream and downstream passage at Bonneville Dam and loss of important spawning and rearing habitat in the lower reaches of the tributaries used by the Upper Gorge populations that was inundated by Bonneville pool.

The Biological Opinion on the Mitchell Act Hatchery programs (NMFS 2017b) provides a substantial discussion on the impacts on salmon and steelhead habitat within the Lower Columbia River ESUs/DPS. These impacts on tributary habitat result from the widespread development and other land use activities have disrupted watershed processes, reduced water quality, and diminished habitat quantity, quality, and complexity in most of the LCR subbasins. Past and/or current land use or water management activities have adversely affected stream and side channel structure, riparian conditions, floodplain function, sediment conditions, and water quality and quantity, as well as the watershed processes that create and maintain properly functioning conditions for salmon and steelhead (LCFRB 2010a; LCFRB 2010b; NMFS 2014b; ODFW 2010a). Oregon's recovery plan for the LCR ESA-listed species contains a detailed description of the factors affecting habitat quantity and quality in the Columbia River Basin (ODFW 2010a). ODFW (2010a) also identified increased fine sediments in the spawning grounds from forest and rural roads, and from glacially influence water transfers between basins. Also identified as limiting factors affecting the physical habitat quality include past activities, such as stream cleaning, straightening and channelization, diking, wetland filling, and lack of larger wood recruitment, which resulted in the loss of habitat diversity for all three listed species in the basin.

2.4.2. Climate Change

Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004a; ISAB 2007; Scheuerell and Williams 2005; Zabel et al. 2006). Average annual Northwest air temperatures have increased by approximately 1ºC since 1900, or about 50% more than the global average over the same period (ISAB 2007). The latest climate models project a warming of 0.1 ºC to 0.6 ºC per decade over the next century. According to the Independent Scientific Advisory Board (ISAB), these effects pose the following impacts over the next 40 years:

- Warmer air temperatures will result in diminished snowpacks and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a smaller snowpack, these watersheds will see their runoff diminished earlier in the season, resulting in lower streamflows in the June through September period. River flows in general and peak river flows are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures are expected to rise, especially during the summer months when lower streamflows co-occur with warmer air temperatures.

These changes will not be spatially homogeneous across the entire Pacific Northwest. Low-lying areas are likely to be more affected. Climate change may have long-term effects that include, but are not limited to, depletion of important cold water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, premature emergence of fry, and increased competition among species (ISAB 2007).

To mitigate for the effects of climate change on listed salmonids, the ISAB (2007) recommended in 2007 to prepare for future climate conditions by implementing protective tributary, mainstem, and estuarine habitat measures, as well as protective hydropower mitigation measures. In particular, the ISAB (2007) suggests increased summer flow augmentation from cool/cold storage reservoirs to reduce water temperatures or to create cool water refugia in mainstem reservoirs and the estuary; and the protection and restoration of riparian buffers, wetlands, and floodplains.

While planning for future general effects, it is important to note that climate change is already actively altering environments around the globe as temperature and precipitation patterns change and become more variable. The year 2015 broke numerous global records, including the highest greenhouse gas concentration and highest land and sea surface temperatures ever recorded (Blunden and D.S. Arndt 2016). The year 2016 surpassed global temperature records set in 2015 (NOAA website, http://www.ncdc.noaa.gov/cag)[4], and has already set records for minimum sea ice extent in the Arctic (2nd lowest on record) and maximum sea ice extent in the Antarctic (lowest on record; http://nsidc.org/arcticseaicenews).

Projections of how earth's climate will continue to change depend on the rate of anthropogenic emissions. By the end of the 21st century, global temperatures are expected to increase by 0.3°C (with reduced emissions), to 4.8°C (high emissions) from the present, with more frequent extreme hot temperatures and fewer extreme cold temperatures (IPCC 2014). Precipitation is also expected to change, with some areas becoming wetter and others drier. Extreme precipitation events will very likely become more intense and more frequent (IPCC 2014). In the ocean, global sea level is expected to rise by 0.3 meters (low emissions) to 0.9 meters (high emissions) by the end of the century. The oceans are also expected to become more acidic as more CO_2 is absorbed by the world's oceans (IPCC 2014).

In the Pacific Northwest (defined as southern British Columbia, Washington, and Oregon), likely some air and stream temperature changes due to climate change have already occurred. There is likely no trend in precipitation over this period (neither strongly increase nor decrease), although summers may become drier and winters wetter due to changes in the same amount of precipitation being subjected to altered seasonal temperatures (Mote and Eric P. Salathé Jr. 2010; PCIC 2016). Warmer winters will result in reduced snowpack throughout the Pacific Northwest, leading to substantial reductions in stream volume and changes in the magnitude and timing of low and high flow patterns (Beechie et al. 2013; Dalton et al. 2013). Many basins that currently have a snowmelt-dominated hydrological regime (maximum flows during spring snow melt) will become either transitional (high flows during both spring snowmelt and fall-winter) or rain-dominated (high flows during fall-winter floods; (Beechie et al. 2013; Schnorbus et al. 2014). Summer low flows are expected to be reduced between 10-70% in areas west of the Cascade Mountains over the next century, while increased precipitation and snowpack is expected for the Canadian Rockies. More precipitation falling as rain and larger future flood events are expected to increase maximum flows by 10-50% across the region (Beechie et al. 2013).

In marine waters of the Pacific Northwest, sea surface temperatures (SSTs) are expected to increase by 1.2°C by 2040 (Mote and Eric P. Salathé Jr. 2010) and up to 2°C in northern British Columbia and Alaska (Foreman et al. 2014; Hollowed et al. 2009). Increased temperatures will increase water column stratification, which can be beneficial for productivity in northern areas but detrimental in southern areas (Gargett 1997). Effects of climate change on the timing and intensity of ocean upwelling, which brings nutrient-rich waters to the surface in coastal areas of the California Current, are poorly understood with some climate models show upwelling will be delayed in the spring and become more intense in the summer, while others show it largely

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[4] Pending final analysis for December 2016 data and possible error corrections. This information will not be final until the first quarter of 2017, but is unlikely to change drastically in scale.

unchanged (Bakun et al. 2015; Rykaczewski et al. 2015). Our intent with this summary is not to provide an exhaustive review of what is known about current conditions contributing to current status delineations, but instead to provide an overview, with a particular emphasis on environmental factors that are important to anadromous fish productivity and survival. In many cases, current environmental conditions are outside the range of observations; therefore, their biological effects are difficult to predict. Only in hindsight will we be able to tell how these conditions affected survival and these effects are discussed here to ensure that it's understood they are incorporated into status levels.

2.4.2.1. Climate change and Pacific Northwest salmon

Climate change is predicted to cause a variety of impacts on Pacific salmon and their ecosystems (Crozier et al. (2008a); Martins et al. (2012); Mote et al. (2003); Wainwright and Weitkamp (2013)). During the last century, average regional air temperatures increased by 1.5°F, and increased up to 4°F in some areas. As the climate changes, air temperatures in the Pacific Northwest are expected to increase <1°C in the Columbia Basin by the 2020s and 2°C to 8°C by the 2080s (Mantua et al. 2010). Overall, about one-third of the current cold-water fish habitat in the Pacific Northwest is likely to exceed key water temperature thresholds by the end of this century (USGCRP 2009). While total precipitation changes are uncertain, increasing air temperature will result in more precipitation falling as rain rather than snow in watersheds across the basin (NMFS 2015).

The complex life cycles of anadromous fishes including salmon rely on productive freshwater, estuarine, and marine habitats for growth and survival, making them particularly vulnerable to environmental variation (Morrison et al. 2016). Ultimately, the effect of climate change on salmon and steelhead across the Pacific Northwest will be determined by the specific nature, level, and rate of change and the synergy between interconnected terrestrial/freshwater, estuarine, nearshore and ocean environments.

The primary effects of climate change on Pacific Northwest salmon and steelhead are:

- direct effects of increased water temperatures on fish physiology
- temperature-induced changes to stream flow patterns
- alterations to freshwater, estuarine, and marine food webs
- changes in estuarine and ocean productivity

While all habitats used by Pacific salmon will be affected, the impacts and certainty of the change vary by habitat type. Some effects (e.g., increasing temperature) affect salmon at all life stages in all habitats, while others are habitat-specific, such as stream flow variation in freshwater, sea level rise in estuaries, and upwelling in the ocean. How climate change will affect each stock or population of salmon also varies widely depending on the level or extent of change and the rate of change and the unique life history characteristics of different natural populations (Crozier et al. 2008b). For example, a few weeks' difference in migration timing can have large differences in the thermal regime experienced by migrating fish (Martins et al. 2011).

Temperature Effects

Like most fishes, salmon are poikilotherms ("cold-blooded" animals), so increasing temperatures in all habitats can have pronounced effects on their physiology, growth, and development rates (see review by Whitney et al. (2016)). 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. 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 and likewise in the Fraser River have recently been attributed to higher water temperatures, as increasing temperatures during adult upstream migration are expected to result in increased mortality of sockeye salmon adults by 9-16% 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. 2008b).

By contrast, 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 et al. 2008a; Martins et al. 2012). Temperature is also an important behavioral cue for migration (Sykes et al. 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).

Freshwater Effects

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 salmon populations largely depends on their specific life history characteristics and location, which vary at fine spatial scales (Crozier et al. 2008b; Martins et al. 2012). 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 survival of others was determined by flow (Crozier and Zabel 2006). 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 (Beechie et al. 2013; Crozier et al. 2008b). However, river flow is already becoming more variable in many Puget Sound rivers, and is believed to negatively affect Chinook salmon survival more than other environmental parameters (Ward et al. 2015). It is likely this increasingly variable flow is detrimental to multiple salmon and steelhead populations 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 salmon may be either predators or prey (Lynch et al. 2016; Rehage and Blanchard 2016). How juvenile salmon 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).

Estuarine Effects

In estuarine environments, the two big concerns associated with climate change are rates of sea level rise and temperature warming (Limburg et al. 2016; Wainwright and Weitkamp 2013). 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; Limburg et al. 2016; Wainwright and Weitkamp 2013). 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 (Lemmen et al. 2016; Verdonck 2006). 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 salmon 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.

Marine Impacts

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 (Asch 2015; Cheung et al. 2015; Lucey and Nye 2010). 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 (Fisher et al. 2015; Pearcy 2002).

Exotic species benefit from these extreme conditions to increase their distributions. Green crab (*Carcinus maenas*) recruitment increased in Washington and Oregon waters during winters with warm surface waters, including 2014 (Yamada et al. 2015). Similarly, Humboldt squid (*Dosidicus gigas*) dramatically expanded their range during warm years of 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).

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 et al. 1992; Morris et al. 2007; Weitkamp and Neely 2002). 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 species, including the California Current and Gulf of Alaska.

California Current

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; Peterson 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 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).

Gulf of Alaska

Columbia River 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[5] 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.

Ocean acidification

In addition to becoming warmer, the world's oceans are becoming more acidic as increased atmospheric 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

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[5] Downwelling occurs when wind causes surface water to build up along a coastline and the surface water eventually sinks toward the bottom (http://oceanservice.noaa.gov/facts/upwelling.html).

reviews by Haigh et al. (2015); 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).

Uncertainty in climate predictions

In 2016, NMFS released their Guidance for Treatment of Climate Change in NMFS Endangered Species Act Decisions (Weiting 2016), which recommended use of the most current reports from the Intergovernmental Panel on Climate Change (IPCC) in evaluating effects of climate change in section 7(a)(2) biological opinions under the ESA. This guidance states that "NMFS will use climate indicator values projected under the Intergovernmental Panel on Climate Change (IPCC)'s Representative Concentration Pathway 8.5 when data are available. When data specific to that pathway are not available, we will use the best available science that is as consistent as possible with RCP 8.5" (Weiting 2016). Global climate projections provided in the most recent IPCC reports (IPCC 2014) are informative and, in some cases, the only or the best scientific information available for use.

There is considerable uncertainty in the predicted effects of climate change on the globe as a whole, and on Pacific Northwest anadromous fish 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 et al. 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 salmon 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. (2008b); Martins et al. (2012); Martins et al. (2011). 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. 2008a; Waples et al. 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; Whitney et al. 2016).

Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycles. 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, though 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.

In conclusion, the current literature supports previous concerns that natural climatic variability can amplify and exacerbate long-term climate change impacts. Recent estimates of rates of climate change are similar to those previously published. Anthropogenic climate change will likely, to varying degrees, affect all west coast anadromous fish species, especially when interacting factors are incorporated (e.g., existing threats to populations, water diversion, accelerated mobilization of contaminants, hypoxia, invasive species). However, through historical selective processes anadromous fish have adapted their behavior and physiology to inhabit available habitat ranging from southern California up to the Alaskan western coastline. This process, by which Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, required a certain degree of plasticity, and may show resilience to future environmental conditions that mimic this natural variation. While climate change effects will certainly result in changes, it is unlikely that specifics are possible to predict. Alternate life history types, such as those associated with extended lake or estuarine rearing, provide an important component of the species diversity with which to guard against an uncertain future. However, the life history types that will be successful in the future are neither static nor predictable and, therefore, maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is essential for continued existence of populations into the future (Bottom et al. 2011; Schindler et al. 2010).

2.4.3. Columbia River Estuary and Plume

The estuary and plume of the Columbia River do not have unambiguous, agreed-upon boundaries. For purposes of this document, we define estuary and plume as they are described in current recovery planning documents.(e.g., NMFS 2011a). The Columbia River estuary is the tidally influenced portion of the river and tributary reaches upstream from the Columbia mouth, which extends upstream146 miles to Bonneville Dam and up the Willamette River to Willamette Falls. During low flows, reversal of river flow has been measured as far upstream as Oak Point at RM 53 (RKm 84.8). The intrusion of saltwater is generally limited to Harrington Point at RM 23 (RKm 36.8), but saltwater intrusion can extend past Pillar Rock at RM 28 (RKm 44.8).

The Columbia River plume is generally defined by a reduced-salinity contour near the ocean surface of approximately 31 parts per thousand (Fresh et al. 2005). The plume's location varies seasonally with discharge, winds, and currents. In summer, it extends far to the south and offshore along the Oregon coast. During the winter, it shifts northward and inshore along the Washington coast. Strong density gradients between ocean and plume waters create stable habitat features where organic matter and organisms are concentrated (Fresh et al. 2005). The plume can extend beyond Cape Mendocino, California, and influences salinity in marine waters as far away as San Francisco. Here we limit discussion of the plume to be off the immediate coasts of both Oregon and Washington and to extend outward to the continental shelf (30-50 km).

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 4 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. The estuary and plume served as a physical and biological engine for salmon. Juveniles from hundreds of populations of steelhead, chum, Chinook, and coho salmon entered the estuary and plume every month of the year, with their timing honed over evolutionary history to make use of habitats rich with food. This genetic variation in behavior was an important trait that allowed salmon and steelhead to occupy many habitat niches in time and space.

Today the estuary and plume are much different. Notably, jetties at the mouth of the river restrict the marine flow of nutrients into the estuary. Dikes and levees lining the Washington and Oregon shores prevent access to areas that once were wetlands. New islands have been formed by dredged materials, and pile dike fields reach across the river, redirecting flows. Less visible but arguably equally important are changes in the size, timing, and magnitude of flows that, 200 years ago, regularly allowed the river to top its banks and provide salmon and steelhead with important access to habitats and food sources. Flow factors, along with ocean tides, are key determinants of habitat opportunity and capacity in the estuary and plume.

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 (LCREP 1999). 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.

The estuary and plume provide salmonids with a food-rich environment where they can undergo the physiological changes needed to make the transition from freshwater to saltwater habitats, and vice versa. Every anadromous salmonid that spawns in the Columbia River basin undergoes such a transformation twice in its lifetime—the first time during its first year of life (or soon after) when migrating out to sea, and the second time 1 to 3 years later, as an adult returning to spawn. The transition zone where juvenile salmonids undergo this transformation is thought to extend from the estuary itself to the near-shore ocean and plume habitats and into rich upwelling areas near the continental shelf (Casillas 1999).

The estuary and plume also serve as rich feeding grounds where juveniles have the opportunity for significant growth as they make the important transition from freshwater to seawater. Studies have shown that juvenile salmon released within the estuary and plume returned as larger adults and in greater numbers than juveniles released outside the transition zone (Emmett and Schiewe 1997 as cited in Casillas 1999). Thus, although juvenile salmonids face risks from a variety of threats in the estuary and plume, these environments are critically important. In the salmon life cycle, successful estuarine and plume residency by juveniles is critical for fast growth and the transition to a saltwater environment.

Below we discuss in more detail the current state of the estuary and plume, but it is essential to understand beforehand that utilization of the estuary and plume, and thus the impacts because of changes to these areas vary considerably according to major life history types of the salmonids experiencing them. Anadromous salmonids fall into two major life history classes, according to freshwater rearing strategy: ocean-type and stream-type. Ocean-type salmonids migrate to sea early in their first year of life, after spending only a short period in freshwater (Fresh et al. 2005). Ocean types may rear in the estuary for weeks or months, making extensive use of shallow, vegetated habitats such as marshes and swamps, where significant changes in flow and habitat have occurred (Fresh et al. 2005). Conversely, stream-type salmonids migrate to sea after rearing for more extended periods in freshwater, usually at least one year (Fresh et al. 2005). In terms of ESA-listed fish, coho, steelhead, sockeye, and upper Columbia spring Chinook, and spring/summer Chinook in the Snake Basin, are stream-type fish. Fall Chinook and chum are ocean-type fish. Lower Columbia and Willamette spring Chinook are technically ocean-type fish but naturally represent a mixture of the two types. Within these major types, historically there was a considerable diversity of estuary use, especially in ocean-type Chinook, with fish utilizing the estuary at various fry, fingerling, subyearling, and yearling stages (Fresh et al. 2005), but many previously common patterns are now considered rare.

Both ocean- and stream-type salmonids experience significant mortality in the estuary. However, as just mentioned, because the two types typically spend different amounts of time in the estuary and plume environments and use different habitats, they are subject to somewhat different combinations of threats and opportunities. For ocean-type juveniles, mortality is believed to be related most closely to lack of habitat, changes in food availability, and the presence of contaminants, including persistent, bioaccumulative contaminants present in sediments in the shallow-water habitats where ocean-type juveniles rear in the estuary. Stream types are affected by these same factors, although presumably to a lesser degree because of their shorter residency times in the estuary. However, stream types are particularly vulnerable to bird predation in the estuary because they tend to use the deeper, less turbid channel areas located near habitat preferred by piscivorous birds (Fresh et al. 2005). Table 38 compares the relative importance of major limiting factors to the two life-history types. The factors are explained in the next sections.

Table 38. Relative importance to ocean- and stream-type salmonids of limiting factors in the Columbia estuary, for factors rated as significant or higher in one of the two life-history types. Adapted from Table 3-1 of NMFS (2011a).

Factor	Ocean-type	Stream-type
Flow-related habitat changes	Major	Moderate
Sediment-related habitat changes	Significant	Moderate
Flow-related changes to access to off-channel habitat	Major	Moderate
Bankful elevation changes	Major	Minor
Flow-related plume changes	Moderate	Major
Water temperature	Major	Moderate
Reduced macrodetrital inputs	Major	Moderate
Avian and pinniped predation	Minor	Major

Toxicants	Significant	Minor-Moderate

Estuary and plume limiting factors are a vast topic, about which much has been written, and the interplay of factors can be quite complicated. Here we follow NMFS (2011a) in considering three major categories, the effects of which can be interrelated: changes in physical habitat, changes in food web that have largely been driven by physical habitat changes; and toxicants.

Habitat-Related Limiting Factors

Mean flow into the estuary has been reduced 16% from historical levels, but the pattern of flow has changed considerably. Spring freshets, important for downstream migration, have been reduced 44% and occur earlier in the year, and flow is higher than it was historically at other times of the year. This decreased flow, coupled with overall climate change, has increased mean water temperatures at Bonneville Dam 4° C since 1938, and temperature levels of 20°C, considered the upper tolerance level for salmon (NRC 2004) occur earlier in the year and more frequently than they did historically. Variation in flow has been reduced, particularly the frequency of bank overflows, which historically was a key element in sustaining the food web.

Development and decreased flow has decreased the size of the estuary about 20%. Much of the decrease is due to reduction in channel complexity and increase in diking. By some estimates, over 70% of the historical tidal marsh habitat is now inaccessible. Levee construction has reduced the frequency of overbank flows because more water is now needed to cause overbank flow, now 24,000 cfs compared to 18,000 cfs historically (Jay and Kukulka 2003). The reduction in overbank events reduces the availability of food and refugia for ocean-type juveniles rearing in the estuary. Less dominant stream-type juveniles are affected the same way.

The combination of decreased flow and upstream impoundments have reduced sediment inputs 60%, which has reduced the ability of the estuary to build habitat, and also had food web consequences in the estuary and plume.

The plume supports ocean productivity by increasing primary plant production during the spring freshet period, distributing juvenile salmonids in the coastal environment, concentrating food sources and providing refugia from predators in the more turbid, low-salinity plume waters (Fresh et al. 2005). Changes in the volume and timing of Columbia River flow have altered both the size and structure of the plume during the spring and summer months (NPCC 2000). Reductions in spring freshets and associated sediment transport processes may now be suboptimal for juvenile salmonids (Casillas 1999). Changes in flow to the plume include surface area, volume, extent and intensity of frontal features, and the extent and distance offshore (Fresh et al. 2005).

Food-Web Limiting Factors

The estuarine food web historically was based on macrodetrital inputs that originated from emergent, forested, and other wetland rearing areas in the estuary (NPCC 2004). Today, detrital sources from emergent wetlands in the estuary are approximately 84 % less than they were historically (Bottom et al. 2005). The reduction of macrodetritus in the estuary reduces the food sources for juvenile salmonids. As a result, juveniles may have reduced growth, lipid content, and fitness prior to ocean migration or may need to reside longer in the estuary. Macrodetrital plant production has declined because of revetment construction, disposal of dredged material in areas where plant materials or insects could drop into the water, simplification of habitat through the removal of large wood, and reductions in flow. Historically, much of the detrital inputs occurred during overbank events, which provided additional shallow-water habitat for juvenile salmonids and resulted in significant detrital inputs to the estuary.

The current food web is based on decaying phytoplankton delivered from upstream reservoirs and nutrient inputs from urban, industrial, and agricultural development. The amount of this microdetritus has increased dramatically (Bottom et al. 2005). The switch in the estuarine food web from a macrodetritus-based source to a microdetritus-based source has altered the productivity of the estuary (Bottom et al. 2005). The substitution of detrital sources in the estuary also has contributed to changes in the spatial distribution of the food web (Bottom et al. 2005). Historically the macrodetritus based food web was distributed evenly throughout the estuary, including in the many shallow-water habitats favored by ocean-type salmonids. But the contemporary microdetrital food web is concentrated within the estuarine turbidity maximum in the middle region of the estuary (Bottom et al. 2005). This location is less accessible to ocean-type fish that use peripheral habitats and more accessible to species such as American shad that feed in deep-water areas. Pelagic fish such as shad may also benefit from the fact that the estuarine turbidity maximum traps particles and delays their transport to the ocean up to 4 weeks, compared to normal transport of around 2 days (NPCC 2004).

Another aspect of the food web change is predation and competition. Predation and competition for habitat and prey resources limit the success of juvenile salmonids entering the estuary and plume. Competition among salmonids and between salmonids and other fish may be occurring in the estuary (LCFRB 2004), with the estuary possibly becoming overgrazed when large numbers of ocean-type salmonids enter the area. Food availability may be reduced as a result of the temporal and spatial overlap of juveniles from different locations (Bisbal and McConnaha 1998). Ecosystem-scale changes in the estuary have altered the relationships between salmonids and other fish, birds, and mammal species, both native and exotic. Some native species' abundance levels have decreased from historical levels, while others have increased to levels far exceeding those in recorded history, with associated changes in predation of salmon and steelhead juveniles. Changes in physical habitat have increased opportunities for piscivorous birds such as terns and cormorants, to which stream-type smolts are especially vulnerable. Predation by northern pikeminnows has likely increased as well due to lower turbidity; both stream- and ocean-type juveniles are affected. Predation by pinnipeds has also increased over historical levels.

The introduction of exotic species has altered the ecosystem through competition, predation, disease, parasitism, and alterations in the food web. At least 37 fish species, 27 invertebrate species, and 18 plant species have been introduced into the estuary (NPCC 2004; Sytsma et al. 2004). Introduced species affect ocean-type ESUs more than they do stream-type ESUs because of the ocean types' longer juvenile estuary residency times and use of shallow-water habitats. Two of these introduced species have had especially profound consequences. American shad adult returns now exceed 4 million annually (NPCC 2004). Shad do not eat salmonids, but they exert tremendous pressure on the estuary food web given the sheer weight of their biomass. Some evidence suggests that planktivorous American shad have an impact on the abundance and size of *Daphnia* in Columbia River mainstem reservoirs (Haskell et al. 1996 in ISAB 2008), thereby reducing this important food source for subyearling fall Chinook.

2.4.4. Harvest

The impacts of SAFE fisheries on ESA-listed salmon and steelhead are managed under the auspices of the *U.S. v. Oregon* 2018-2027 management agreement and NMFS (2018a) section 7 Biological Opinion. The SAFE fisheries for spring Chinook salmon are managed under the winter/spring management period. Fishery impacts in the SAFE areas are included in the total allowable fishery impacts for non-treaty fisheries per the agreement. The impacts allowed each year is dependent upon the abundance of spring Chinook stocks based upon a sliding scale where higher impacts are allowed when abundance is high and lower impacts when abundance is lower (NMFS 2018b). A similar fall management period exists for SAFE coho salmon fisheries affecting ESA-listed salmon and steelhead in these areas. Impacts from SAFE fall fisheries are included in the allowable impacts for non-treaty fisheries during this period per the agreement and NMFS (2018a). Therefore, any fishing-related effects of the proposed action are currently authorized by NMFS (2018a).

Two of the primary goals of the SAFE project were to develop fisheries that provided greater protection for depressed and listed stocks and to maximize harvest of returning SAFE produced adults while minimizing catch of non-SAFE stocks. The Oregon SAFE Spring Chinook program is managed to provide hatchery spring Chinook salmon to supplement harvest in ocean, Columbia River, and Select Area commercial and recreational fisheries. Coded-wire tag recoveries from 2001-2008 broods indicate harvest rates of SAFE spring Chinook range from 88% for Tongue Point releases to over 97% for Youngs Bay and Blind Slough. Because the program consists mostly of net pen releases we consider escapement of SAFE spring Chinook as natal if the tags are recovered in Oregon Select Area basins (i.e., Tributaries draining into Youngs Bay, Blind Slough and Tongue Point) and non-natal (stray) if recovered anywhere else. The overall stray rate for all release areas combined is 0.7%; this includes recoveries in hatcheries and tributaries to the Columbia River including the Willamette River. The stray rate to the Upper Willamette River (above Willamette Falls) is 0.1% (ODFW 2017).

The Oregon SAFE Coho program is managed to provide Coho production to supplement harvest in ocean, Columbia River, and Select Area commercial fisheries and ocean, Columbia River and Select Area recreational fisheries. Incidental take of listed stocks in Select Area fisheries is included in biological assessments and opinions adopted for Columbia River fisheries (*U.S. v. Oregon* 2008; *U.S. v. Oregon* 2018; NMFS 2018a). Impact rates on ESA-listed fish in SAFE fisheries has been negligible as most (greater than 94%) of the fish are of SAFE origin (ODFW 2021b).

The Washington SAFE Deep River net pen program is designed to put marked hatchery coho salmon in ocean, Buoy 10, and terminal fisheries where they can be harvested with minimal impact on ESA-listed natural-origin fish. These coho salmon are not meant to contribute to any natural populations or recovery of the ESU (WDFW 2018).

2.4.5. Hatcheries

A more comprehensive discussion of hatchery programs in the Columbia Basin can be found in the current Biological Opinions governing hatchery management in the Lower Columbia River (e.g., NMFS 2017a; NMFS 2017b; NMFS 2019). The Mitchell Act funded programs have all gone through ESA Section 7 consultations and thus are included as part of the baseline both for past effects and for effects into the future. The Mitchell Act 2017 opinion observed that, because most programs are ongoing, the past effects of each are reflected in the most recent status of the species (NWFSC 2015) and were summarized in Section 2.2.1 of this opinion. Similarly in the Upper Willamette River, broodstock collection and juvenile rearing have also gone through ESA section 7 consultation (NMFS 2019) and thus these actions are included as part of the environmental baseline.

In the past, hatcheries have been used to compensate for factors that limit anadromous salmonid viability (e.g., harvest, human development) by maintaining fishable returns of adult salmon and steelhead. Hatchery programs started being used in the 1980s and 1990s as a tool to conserve the genetic resources of depressed natural populations and to reduce short-term extinction risk (e.g., Snake River sockeye salmon). Hatchery programs have also been used to help improve viability and expand spatial distribution by supplementing natural population abundance. The changes in hatchery practices are ongoing and are expected to reduce the impacts of hatchery fish on natural-origin populations and are included in the environmental baseline (NMFS 2017b; NMFS 2019).

2.5. Effects on ESA Protected Species and on Designated Critical Habitat

Under the ESA, “effects of the action” are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 CFR 402.17). In our analysis, which describes the effects of the proposed action, we considered 50 CFR 402.17(a) and (b).

This section describes the methodology NMFS follows to analyze hatchery effects. The methodology is based on the best available scientific information.

“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, including abundance, productivity, diversity, and spatial structure. The effects of a hatchery program on the status of an ESU or steelhead DPS “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 also analyzes and takes into account the effects of hatchery facilities, for example, operation of fish collection facilities and water use, on each VSP attribute and on designated critical habitat.

NMFS' analysis of the proposed action is in terms of effects expected on ESA-listed species and designated critical habitat, based upon the best scientific information. The effects are assessed at a site-specific level, population scale, as well as at the ESU and DPS level, in order for NMFS to make a jeopardy determination based on a comprehensive assessment of effects.

In general, the effects range from beneficial to negative for hatchery programs depending upon the specific goals and objectives of the program. In the case of SAFE programs in this consultation, the goal of all of the programs is for fishery harvest and there is no other conservation or supplementation objectives. Since there is no purposeful beneficial goals of these SAFE programs with respect to natural-origin salmon and steelhead in the Lower Columbia region, NMFS is evaluating the effects of the action and use of "best management practices" to minimize hatchery-related risks to the local, natural populations. When hatchery programs use fish originating from a different population, MPG, or from a different ESU or DPS, NMFS is particularly interested in how effective the program will be at isolating hatchery fish and avoiding co- occurrence and effects that potentially put the natural population at a disadvantage.

NMFS analyzes six categories of effects to determine the risks and benefits of the hatchery program. Essentially every biological and ecological effect of a hatchery program is evaluated within one or more of the following categories. These six categories are:

(1) broodstock origin and collection,

(2) hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds,

(3) hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas, mainstem rivers, estuary, and ocean,

(4) research, monitoring, and evaluation (RM&E) supporting hatchery program implementation,

(5) operation, maintenance, and construction of hatchery facilities (i.e., facility effects), and

(6) fisheries that would not exist but for the availability of hatchery fish to catch.

These six categories of effects are collectively analyzed by NMFS in previous opinions (NMFS 2017b; NMFS 2018a; NMFS 2019) and below for the proposed action.

2.5.1. Effects of the Proposed Action

2.5.1.1.Broodstock Collection

All of the hatchery broodstock used to produce juvenile salmon for release at SAFE net pens is entirely fish of hatchery-origin. No natural-origin salmon are collected and used to produce SAFE hatchery fish. Natural-origin salmon may return to hatchery facilities where broodstock are collected and spawned, but none of these fish are purposefully used for SAFE broodstock. The HGMPs describe previous years' collections and the management protocols for collecting broodstock for the spring Chinook salmon and coho salmon programs releasing hatchery fish at the SAFE net pens.

For each of the hatchery facilities used to collect broodstock for the production of salmon for the proposed action, existing ESA Biological Opinions govern operations at these facilities. Specifically, for the spring Chinook salmon releases, the Clackamas stock is collected from the Clackamas Hatchery on the Clackamas River, and the North and South Santiam broodstocks are collected from the Minto Fish Facility and Foster Fish Facility, respectively. NMFS (2017b) and NMFS (2019) Biological Opinions assessed the effects of broodstock collection on ESA-listed salmon and steelhead in those populations. In that opinion we concluded that the effects of broodstock collection in the Upper Willamette River is low. Adult salmon are collected at the Fish Collection Facilities as the base of the federal dams. Most salmon are trapped and hauled above the dams for reintroduction purposes. Other salmon are used for broodstock to continue the hatchery program. Adult broodstock collected for the SAFE production is a small component of this overall effort and does not add any additional effects on natural-origin spring Chinook salmon. The broodstock for the SAFE program is 100% hatchery-origin salmon.

For coho salmon, a similar situation occurs. No natural-origin coho salmon are used for SAFE broodstock. More salmon are used for broodstock, but overall effects are not any different because in most years more hatchery salmon are collected than used for broodstock. NMFS (2017b) evaluated the effects of broodstock collection, including fish produced for SAFE releases, on ESA-listed salmon and steelhead in the Lower Columbia region. The Action Agencies and other agencies responsible for implementing the proposed action are required to implement their respective broodstock collection actions in accordance with the Mitchell Act opinion and corresponding Incidental Take Statements (NMFS 2017b).

For the coho salmon program in Oregon, Klaskanine hatchery facilities may be used as a backup facility to collect coho salmon if insufficient returns occur at Big Creek hatchery. However, NMFS (2017b) fully evaluated operation of this hatchery and collection of fall Chinook salmon broodstock, which would overlap the collection of coho salmon (if needed). Thus, there are no additional effects from what was assessed in NMFS (2017b) in the event coho salmon broodstock need to be collected at Klaskanine hatchery facilities.

2.5.1.2.Hatchery fish and the progeny of naturally spawning hatchery fish on the spawning grounds

NMFS analyzes the effects of hatchery returns and the progeny of naturally spawning hatchery fish on the spawning grounds. There are two aspects to this part of the analysis: genetic effects and demographic effects. When genetic introgression occurs, NMFS generally views genetic effects as detrimental. Based on the weight of available scientific information, we believe that artificial breeding and rearing is likely to result in some degree of genetic change and fitness reduction in hatchery-propagated fish and in the progeny of naturally spawning hatchery fish relative to desired levels of diversity and productivity for natural populations. Hatchery fish thus pose a threat to natural population rebuilding and recovery when they interbreed with fish from natural populations and transfer their inherent fitness limitations to the offspring of the natural population.

NMFS also recognizes that there are sometimes benefits to having hatchery fish spawn naturally as well, and that the domestication risks may be irrelevant when demographic or short-term extinction risks are significant to population abundance, diversity and productivity. Conservation hatchery programs may 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 2011). Furthermore, NMFS also recognizes there is often considerable uncertainty regarding genetic risk. The extent and duration of genetic change and fitness loss and the short and long-term implications and consequences for different species, for species with multiple life-history types, and for species subjected to different hatchery practices and protocols is not fully understood and is subject of further scientific investigation. As a result, NMFS believes that hatchery intervention can be 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 fisheries and other applicable laws and policies.

In the case of the proposed action, the hatchery fish are released with the sole purpose of providing salmon for harvest. There are no conservation objectives associated with these programs and therefore, there are no demographic benefits intended for the listed ESUs. Thus the following analysis is therefore focused on the genetic effects of the SAFE program salmon potentially not being harvested in fisheries and subsequently spawning naturally in the Lower Columbia River. It should also be noted here that NMFS (2017b) and NMFS (2019) govern the effects of returning hatchery fish in the population areas where the hatchery facilities are used to collect broodstock for these programs, including SAFE production. The genetic effects of hatchery fish are fully evaluated in these opinions and the funding and operating agencies are obligated to comply with the terms and conditions of these consultations.

Spring Chinook Salmon

Spring Chinook salmon have a unique life history in that adults return in the spring and early summer to freshwater. The salmon hold in freshwater for months until they spawn in late September through early October. Given this, spring Chinook salmon are an ideal species for the SAFE fisheries because they mill around the net pens where they were released as smolts, making them extremely susceptible to the commercial fisheries for months. The harvest rate on these spring Chinook salmon is very high, and therefore, few salmon remain in the river come spawning time in late September. The incidence of straying into nearby streams to spawn is very low to non-existent based upon monitoring since this project started in the mid-1990s. Siniscal et al. (2017) reports in recent years, only hatchery fall Chinook salmon have been observed in nearby areas (no spring Chinook salmon). In addition, if spring Chinook salmon do escape the fisheries and end up spawning naturally, the nearby natural population areas in the Lower Columbia River ESU has not been designated as populations needed for spring Chinook salmon recovery. The core populations of spring Chinook that are emphasized for recovery are further upriver in the Cowlitz, Kalama, Lewis, and Sandy Rivers and governed by NMFS (2017b) and NMFS (2019), as appropriate. There is no record of SAFE program spring Chinook salmon being collected at facilities or spawning naturally in these core population areas. Therefore, any stray hatchery spring Chinook salmon not harvested in the SAFE areas are of no consequence to ESA recovery objectives in nearby natural population areas.

NMFS has reviewed information on the monitoring of spring Chinook salmon straying and spawning throughout the Lower Columbia River in annual reports funded by BPA for this project since the mid-1990's and the incidence of straying has been so low that monitoring has recently been discontinued (Siniscal et al. 2017).

Coho Salmon

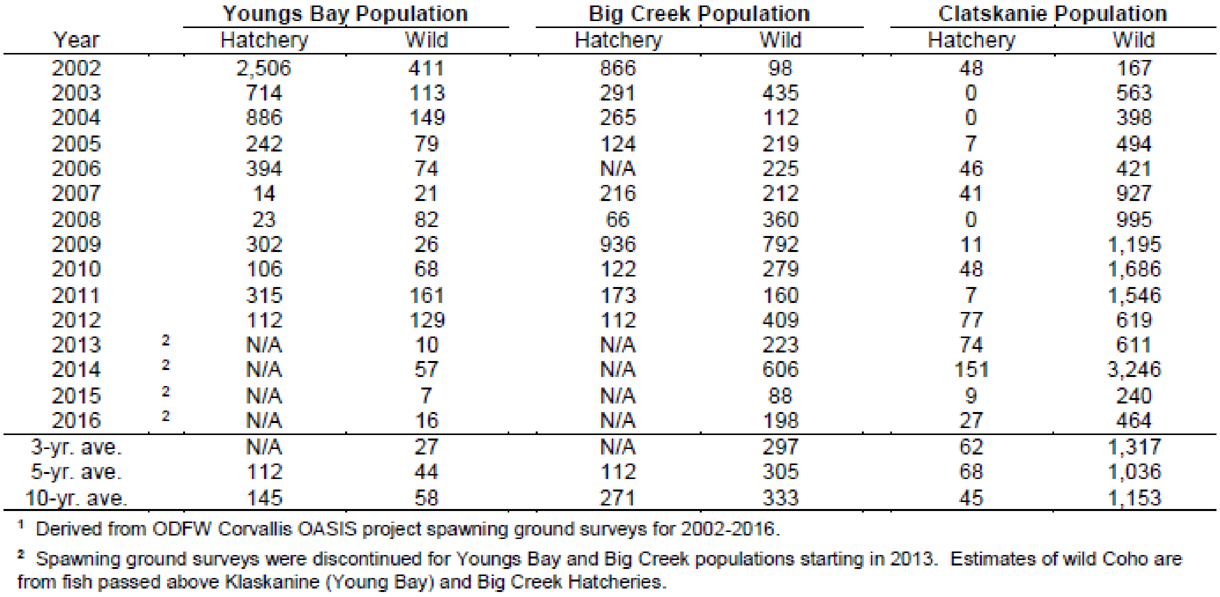
The life history of coho salmon is adults return to freshwater sexually mature and spawn within weeks of entering the Lower Columbia River. The harvest rates on returning coho salmon back to the SAFE areas is high, but some salmon escape the fisheries and end up spawning naturally in nearby streams.

Genetic pedigree analyses is a direct measure of the genetic contribution of hatchery fish into natural-origin populations. However, this type of data is not available for SAFE coho salmon releases in the LCR coho salmon ESU because no pedigree analyses have been conducted in nearby areas. These studies require substantial funding, appropriate trapping facilities to collect 100% of the run, and must be conducted for at least three to six years. This has not occurred in the action area. Given this, the best proxy on the potential for any genetic interactions between hatchery and natural coho salmon is pHOS (the proportion of hatchery fish on the spawning grounds). High pHOS would indicate a high risk for genetic influence from hatchery fish on the natural population, especially if the spawn timing overlaps substantially. Then the final calculation in getting a reasonable estimate of potential genetic effects would be the relative reproductive success of hatchery fish when spawning in the wild. Reproductive success of hatchery fish in the wild depends upon many factors such as species, extent of hatchery rearing, hatchery stock, and domestication effects.

The estimates of pHOS for coho salmon in the LCR ESU is monitored annually and shown in Table 39 and Table 40 for streams in Oregon and Washington, respectively. The highest pHOS values occur in the streams nearest to the net-pen facilities where coho salmon are released.

This section evaluates the effects of SAFE hatchery coho salmon releases on the genetics of natural populations in the Lower Columbia River. The complicating factor in this assessment is there are other hatchery programs in the vicinity that also release hatchery coho salmon and contribute to pHOS. Therefore, several hatchery programs are contributing to the pHOS rates for coho salmon observed in nearby streams in Tables 39 and 40, in addition to SAFE (e.g. Grays River and Elochoman River hatchery coho programs). Available information indicates of all the hatchery coho salmon spawning in the Grays and Elochoman basins, only 15% and 8% of the hatchery fish were from SAFE Deep River net-pens releases, respectively (LeFleur 2021b). The majority of hatchery coho salmon spawning naturally in the Grays and Elochoman basins were from the Grays River hatchery coho salmon program (LeFleur 2021b). SAFE Deep River net-pen released coho salmon have not been observed in other upriver populations.

Table 39. Estimated Coho spawner abundance in select Oregon populations of the Lower Columbia ESU, 2002-2016. Table taken from Siniscal et al. (2017).



	Youngs Bay Population		Big Creek Population		Clatskanie Population	
Year	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild
2002	2,506	411	866	98	48	167
2003	714	113	291	435	0	563
2004	886	149	265	112	0	398
2005	242	79	124	219	7	494
2006	394	74	N/A	225	46	421
2007	14	21	216	212	41	927
2008	23	82	66	360	0	995
2009	302	26	936	792	11	1,195
2010	106	68	122	279	48	1,686
2011	315	161	173	160	7	1,546
2012	112	129	112	409	77	619
2013 [2]	N/A	10	N/A	223	74	611
2014 [2]	N/A	57	N/A	606	151	3,246
2015 [2]	N/A	7	N/A	88	9	240
2016 [2]	N/A	16	N/A	198	27	464
3-yr. ave.	N/A	27	N/A	297	62	1,317
5-yr. ave.	112	44	112	305	68	1,036
10-yr. ave.	145	58	271	333	45	1,153

[1] Derived from ODFW Corvallis OASIS project spawning ground surveys for 2002-2016.

[2] Spawning ground surveys were discontinued for Youngs Bay and Big Creek populations starting in 2013. Estimates of wild Coho are from fish passed above Klaskanine (Young Bay) and Big Creek Hatcheries.

Table 40. pHOS results for Lower Columbia River coho populations that are monitored by WDFW (LeFleur 2021a).

NOAA Population	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Coweeman	8.6%	4.3%	3.0%	12.0%	16.6%	21.7%	13.3%	4.7%	4.5%	32.1%
EF Lewis	25.3%	4.7%	6.0%	8.5%	18.6%	23.0%	55.9%	37.0%	12.1%	7.4%
Elochoman_Skamokawa	73.2%	56.7%	30.7%	41.4%	34.4%	46.6%	40.0%	18.3%	36.3%	38.9%
Grays_Chinook	83.1%	95.9%	40.2%	63.2%	35.0%	67.8%	60.2%	80.3%	84.2%	89.5%
Kalama	99.3%	97.4%	89.3%	88.2%	90.9%	89.9%	66.2%	68.1%	69.3%	70.3%
Lower Cowlitz	9.3%	8.4%	12.4%	20.3%	7.2%	8.1%	8.5%	23.9%	20.3%	4.7%
Lower Gorge	24.2%	8.8%	13.8%	19.8%	29.4%	11.3%	6.2%	16.9%	19.9%	27.7%
MAG	12.0%	19.3%	2.1%	7.4%	12.1%	6.5%	13.0%	8.1%	14.9%	27.7%
NF_MS Toutle	57.2%	25.5%	18.4%	16.9%	32.3%	54.8%	58.6%	30.3%	32.3%	44.6%
North Fork Lewis	3.8%	11.2%	16.4%	85.7%	80.5%	90.2%	76.6%	62.4%	84.7%	66.8%
Salmon Creek	2.5%	2.8%	4.0%	1.6%	1.1%	1.8%	3.5%	9.3%	9.9%	9.2%
SF Toutle	20.2%	13.9%	10.5%	13.8%	19.1%	49.8%	21.3%	8.0%	6.4%	11.6%
Tilton	71.7%	69.7%	77.9%	58.3%	34.7%	36.4%	61.6%	46.0%	65.6%	74.3%
Upper Cowlitz and Cispus	86.6%	61.2%	75.3%	99.9%	76.5%	71.3%	90.6%	51.1%	96.7%	62.4%
Washougal	40.5%	7.5%	9.9%	31.1%	71.7%	69.4%	75.1%	75.5%	78.7%	56.5%
Average	41.2%	32.5%	27.3%	37.9%	37.3%	43.2%	43.4%	36.0%	42.4%	41.6%

NMFS (2017b) governs the management of non-SAFE hatchery coho salmon programs in the Grays and Elochoman rivers. There are several hatchery reform actions underway that are expected to reduce pHOS in these rivers, including the termination of the Grays River hatchery coho salmon program. In addition, the reforms proposed for the SAFE coho salmon program in this consultation, including broodstock changes and adjustments in smolt releases, are expected to reduce the genetic effects of hatchery coho salmon on natural populations. In total, NMFS (2017b) projected pHOS will be reduced to levels consistent with the recovery strategies identified for these “stabilizing” and “primary” coho salmon populations in the ESA Recovery Plan for the Lower Columbia coho salmon ESU. The proposed action will not result in straying to a level that will change the outlook for meeting these pHOS limits.

2.5.1.3.Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas (tributaries, mainstem, estuary, and ocean).

The ecological effects of the hatchery programs on juvenile salmon and steelhead in the Lower Columbia River are assessed below. The ecological interactions evaluation in this biological opinion is somewhat different than NMFS has applied in previous analyses such as NMFS (2017b) and NMFS (2019) due to the proposed action. This proposed action occurs entirely in the estuary and plume, consistent with the action area as described in Section 2.3, where ecological interactions are entirely different than in freshwater areas with daily tidal changes, species composition, abundance of hatchery fish, river temperatures, and other aspects. The behaviors of juvenile salmon in estuarine habitats are greatly different than in freshwater rivers and streams.

The ecological interactions between hatchery-origin and natural-origin salmonids in the proposed action area of the Lower Columbia River is an important effect to fully evaluate, yet specific quantitative analyses to do so does not exist. NMFS uses PCDRisk to inform ecological interactions in freshwater habitat areas, but the model is not applicable to marine habitats where the behavior of salmonids is entirely different. In an effort to better understand juvenile salmonid interactions, NMFS has quantified the spatial and temporal overlap of juvenile hatchery fish and natural-origin salmon and steelhead (as described in the following sections). NMFS is unaware of any additional assessments of ecological interactions specifically for releases of hatchery fish from net pens in the Lower Columbia River estuary. This analysis relies on the best available information to assess the risks posed by the presence of juvenile hatchery fish in the action area. In addition, much work has been conducted on the ecological interactions between hatchery fish and juvenile salmon in other areas. Many of the results of these studies have been included here in the assessment, as appropriate for juvenile salmon and steelhead ecological interactions.

There are three primary types of effect considered here: competition between hatchery and natural salmon and steelhead, predation by hatchery fish on juvenile salmon and steelhead, and transfer of disease pathogens from hatchery fish to juvenile salmon and steelhead. Each effect is a function of both spatial and temporal overlap; the effect can only take place when hatchery and natural-origin salmon and steelhead encounter each other or are rearing together.

The proposed action specifies the species released from the SAFE facilities, the timing of those releases, and the size of smolts released. All of these factors are analyzed here with respect to the spatial and temporal overlap with natural-origin salmonids to determine the extent of ecological interactions. The specific details of the SAFE releases in further described in Appendix A.

In order to evaluate the effects of competition, predation, and disease on juvenile salmon and steelhead, this opinion considers the following spatial and temporal factors:

- Establish the area of potential overlap between releases of hatchery fish and co-occurring juvenile natural-origin salmon and steelhead in the same area.
- Establish when hatchery fish from each program are released, and thus available to interact with juvenile natural-origin salmon and steelhead.

Given PCDrisk is not used here for modeling ecological interactions in the estuary, the effects below are not quantitative but describe the potential risks on a qualitative basis.

Spatial Overlap

The spatial overlap between the release of hatchery spring Chinook salmon and coho salmon as part of the proposed action and natural-origin salmon and steelhead is confined to the Lower Columbia River estuary (Figure 1). The releases of hatchery fish occur from the net pens in Blind Slough, Tongue Point, Deep River, and Youngs Bay all near the mouth of the Columbia River near Astoria, Oregon. All fish are released as smolts that have been acclimated for some time to saltwater while in the net pens. The physiological state of these fish is to readily emigrate towards the ocean over a short period of time. The entire action area is the lowermost 23 miles of the Lower Columbia River before entering the ocean out past the tips of the jetties.

The potential spatial overlap would only occur in this area. All habitats upriver of the net pens would not be affected by the proposed action because hatchery fish from the net pens do not occur there.

Temporal Overlap

In addition to the geographic extent of hatchery fish released within the Lower Columbia River estuary (i.e., space), another aspect of the interaction between hatchery fish and natural-origin juvenile salmon and steelhead is the period of time affected by the presence of hatchery fish. For the proposed action, hatchery spring Chinook salmon are released at specified times when their physiological state is smolting in March and April (see Appendix A for further details). Hatchery coho salmon are also released as smolts in March, April, and May. Hatchery fish are released in batches all at once when they are ready to emigrate to the ocean. Releases do not occur each day throughout these two month windows. Further information on emigration timing is below.

The target release size for all hatchery fish in the proposed action is the smolt life stage for both spring Chinook salmon and coho salmon. Depending upon the species, average fork length ranges from seven inches (~170 mm) for spring Chinook salmon and five to seven inches (120-170 mm) for coho salmon. Given that hatchery fish are released as smolts and in the estuary, the potential interaction period is expected to be short (less than one week) because the hatchery fish are actively emigrating to the ocean. The physiological condition of the hatchery smolts triggers their desire to emigrate.

Roegner et al. (2016) provides detailed information on the presence of juvenile salmonids in the Lower Columbia River estuary throughout the year which informs the temporal overlap of the proposed action with natural-origin salmonids that may also be present in the action area. They found all species and life stages may potentially be found in the estuary during the period of March through May, when hatchery fish are released from the net pens. The use of estuary habitat by salmonids differs among life stages, with smolts primarily using the deeper waters of the estuary and younger life stages using shallower, nearshore habitats.

Large high tides in late evening are preferred by CCF for releasing smolts as Ledgerwood et al. (1997) found that fish released near high tide emigrated out of Youngs Bay within one tidal cycle

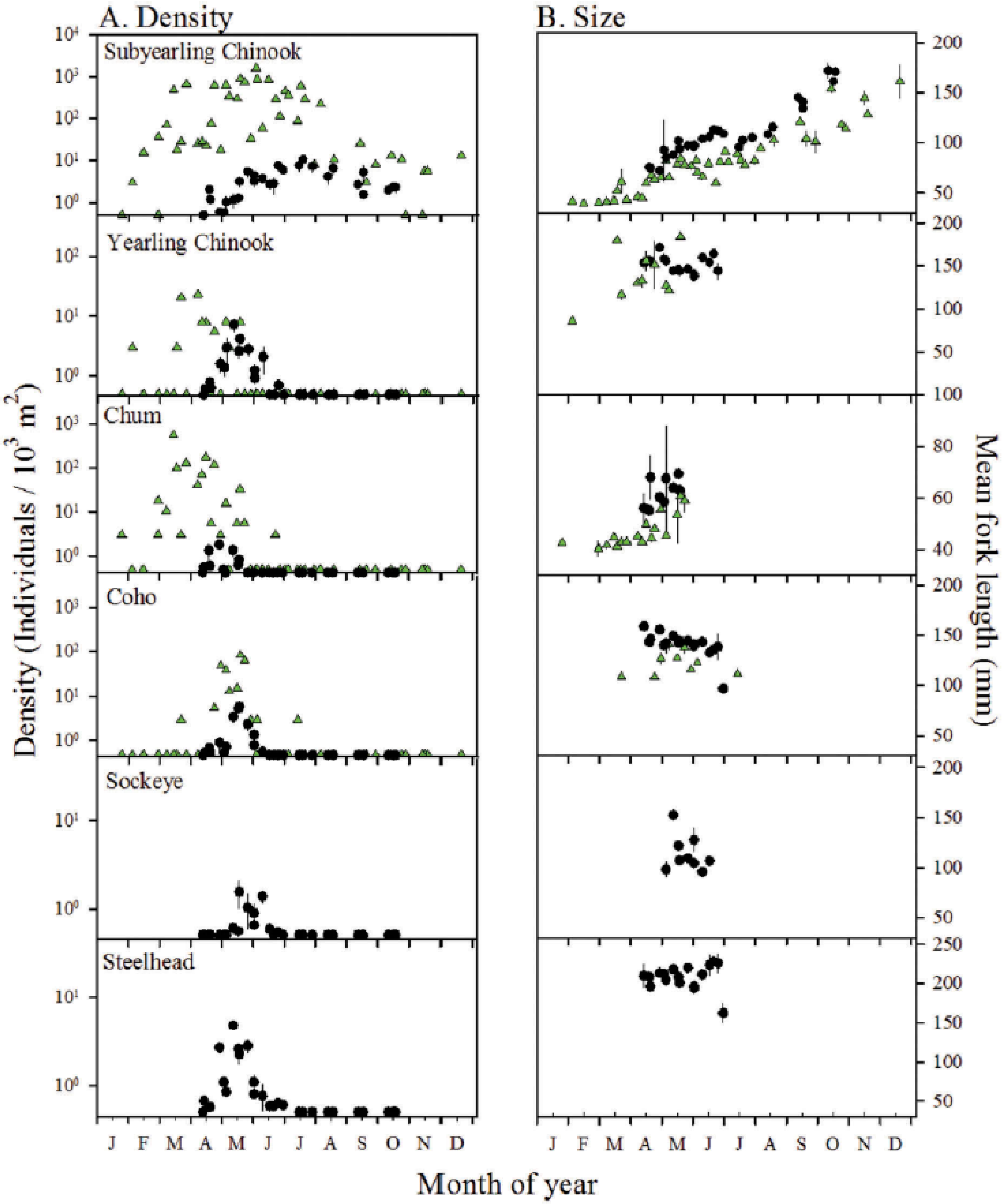


Figure 10. Time series of density and length of salmonids in the Lower Columbia River estuary. Circles represent fish found in channel habitat and triangles represent fish found in shoreline habitats. Figure taken from Roegner et al. (2016).

Predation

Predation among salmonids is most likely to occur when different life stages co-occur in the same habitats. Older aged life stages of salmon and steelhead are known to predate upon younger aged fish that are smaller, especially larger hatchery steelhead co-occuring in microhabitats with younger, smaller salmonids (Naman and Sharpe 2012). In the Lower Columbia River estuary, predation by hatchery fish can occur, especially for younger aged chum salmon and fall Chinook salmon fry that may be present in the estuary. This predation risk is likely to be low because spring Chinook salmon and coho salmon are found primarily in the deeper water habitats where smaller salmonids are not able to reside (Roegner et al. 2016). Younger and smaller salmon primarily occur in the shallow, nearshore habitats where hatchery coho salmon and spring Chinook salmon are not common. In addition, the exposure time of hatchery fish released from the net pens is likely to be less one week, which minimizes the overall potential for predation to occur from the proposed action. Other similar sized smolts are not at risk to predation from hatchery fish.

Competition

Competition occurs with salmonids when a resource is limited in space or time. Given the proposed action occurs in the Lower Columbia River estuary, the behavior of juvenile salmonids is greatly different than when the fish are rearing in freshwater habitats prior to smolting. As smolts, the fish school together for protection and defending territories among conspecifics is not as prevalent as when in freshwater. Therefore, competition among hatchery- and natural-origin salmonids is not judged to be a negative effect; particularly in the estuary environment where salmonids are transitioning from freshwater to the ocean and no limiting resources have been identified.

Disease

The hatchery programs will be operated in compliance with regional fish health protocols pertaining to movement and monitoring of cultured fish which helps minimize risks associated with hatchery fish (IHOT 1995). When egg-to-release survival rates are high for fish propagated in the hatchery programs that are part of the proposed action, 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 emigrate to the ocean relatively quickly, limiting exposure time and/or pathogen shedding in freshwater. Although fish are monitored monthly during rearing, there are situations where fish that may be infected with pathogens are released into the watershed. Sometimes this may occur as a measure to mitigate the spread of disease further in a hatchery environment. However, this practice also may contribute to increased pathogen levels in the natural environment if the disease does occur. This is rare occurrence and used only when preventive measures do not mitigate the outbreak.

Although a variety of pathogens have been detected in Oregon hatcheries over the last few years, no novel or exotic pathogens have been found and no devastating outbreaks have occurred in UWR hatchery programs in recent years. However, it is important to note that detection of a pathogen does not mean that disease was observed. It indicates the number of epizootics (20-30 per year) occurring from some pathogens is much less than the number of pathogen detections

3,000-4,000 per year. In addition, many of the epizootics are curable using treatments approved for use in fish culture such as formalin, hydrogen peroxide, and various antibiotics.

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.

2.5.1.4.Research, monitoring, and evaluation

NMFS analyzes the incidental effects of the proposed research, monitoring, and evaluation (RM&E) on listed species. The HGMPs for the Proposed Action address the five factors that NMFS takes into account when it analyzes and weighs the beneficial and negative effects of hatchery RM&E (see Factor 4 in the Appendix). The Proposed Action includes RM&E activities that will continue to monitor the Performance Indicators identified in Section 1.10 of the HGMPs, ensure compliance with this opinion, and inform future decisions over how the hatchery programs can be adjusted to meet their goals while further reducing impacts on ESA-listed species.

No research specific to the SAFE spring Chinook salmon or coho programs is currently being conducted or proposed. The SAFE project has conducted or been involved in several studies with a goal of maximizing smolt survival, improving smolt quality, and minimizing impacts on endangered salmonids and their habitat. From 1995-2006, the programs spent considerable time investigating various rearing, feeding, and release strategies; the results of which are now incorporated into a preferred rearing and release regime.

Many of the monitoring activities of the SAFE spring Chinook salmon and coho programs are incorporated into routine ODFW operations and in place to minimize risks to ESA-listed species. Spawning ground surveys, CWT recovery and analysis, as well as the monitoring of hatchery facilities and juvenile fish health occur regularly. The HGMPs define the criteria and guidelines for these monitoring activities to ensure the actions are ceased if natural-origin fish encounters go above prescribed limits. The effects of these RM&E actions on the viability of ESA-listed spring Chinook salmon and winter steelhead are expected to be negligible. NMFS anticipates that greater than 99% of the RM&E activities specifically included in the proposed action for this project would be non-lethal observation and harassment of ESA-listed salmon and steelhead, as the net pens are maintained. Any ESA-listed fish near the project facilities would volitionally migrate away from the net pens as human presence occurs. Occasional handling (fewer than 10 juveniles and up to one adult per year) of listed fish may occur, with no lethal handling effects anticipated. In nearly all cases, the information and data gained from RM&E is critical to help inform the conservation and recovery of ESA-listed populations. The larger RM&E programs conducting spawning ground surveys and other activities are authorized by NMFS in separate consultations under the research limit of section 4(d), and are not included in this proposed action.

2.5.1.5.The operation, maintenance, and construction of hatchery facilities

The construction/installation, operation, and maintenance of hatchery facilities can alter fish behavior and harm all life stages of salmon and steelhead in the affected areas. Operation of the hatchery facilities can also degrade stream and riparian habitats near the hatcheries. The withdrawal of water from the stream in order to raise fish in the hatchery can reduce water in the stream between the inlet and outlet of the facilities.

All of the hatchery facilities that are part of the proposed action currently exist and are in operation. No new facilities or operations are proposed. All facilities are included in the environmental baseline. NMFS (2017b) and NMFS (2019) assessed the effects of the hatchery facilities used to collect broodstock, incubate eggs, and rear juvenile salmon prior to the transfer of fish to SAFE facilities. This includes all of the facilities used for SAFE broodstock collection and rearing facilities such as Clackamas Hatchery, Minto Fish Facility, Foster Fish Facility, and Dexter facilities for spring Chinook salmon and Big Creek, Klaskanine, S.F. Klaskanine, Beaver Creek, Cowlitz, Kalama Falls, Lewis River, Washougal, and Merwin fish collection facilities for coho salmon.

This consultation includes the operation and maintenance of the SAFE net pens and associated hatchery facilities (or portions thereof) used to produce (rear) and release spring Chinook salmon and coho salmon specified in the proposed action.

Net pen complexes are sufficiently constructed to avoid accidents due to weather. Water system failure or flooding incidents are not possible since the pens and fish are immersed in large water bodies rather than supplied by an external source. In the event of net pen failure, fish would be capable of leaving the pens on their own and could not be recovered. Pen complexes are arranged to provide protection to the net pens and minimize the chances of early release.

2.5.1.6. Fisheries

The proposed action does not include any effects related to fishing. Fisheries targeting adult salmon returning from the SAFE hatchery releases is managed under the auspices of the *U.S. v. Oregon* 2018-2027 management agreement and NMFS (2018a) section 7 Biological Opinion. This management agreement governs the allowable fishing impacts on ESA-listed salmon and steelhead from these fisheries, and the effects of these fisheries are included in the environmental baseline. See section 2.4.4 above for further details on these fisheries.

2.5.1.7. Effects of the Action on Critical Habitat

This consultation analyzes the Proposed Action for its effects on designated critical habitat and has determined that operation of the hatchery programs will have a negligible effect on PCEs in the Action Area. The net pen facilities in the action area were previously constructed and consulted upon in past ESA consultations and therefore are included as part of the environmental baseline. The only effects resulting from the Proposed Action are those associated with the continued release of hatchery fish annually from these net pens and routine operation and maintenance of the net pens. Operation and maintenance activities would include net pen maintenance, cleaning of debris and algae growth on the nets. These activities would not be expected to degrade water quality or adversely modify designated critical habitat, because they would occur infrequently, and only result in minor temporary effects. The effects of these actions on critical habitat are negligible given the scope of the actions.

Hatchery fish returning as adults can have a beneficial effect on critical habitat if the salmon are not harvested and end up spawning naturally in the environment. The beneficial effects on critical habitat, specifically freshwater spawning and rearing habitat, are from the conveyance of marine-derived nutrients from the carcasses of hatchery spawners and from conditioning of spawning gravel by hatchery spawners (Cederholm et al. 1999; Montgomery et al. 1996). Salmon 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 increasing forage species (i.e., aquatic and terrestrial insects), aquatic vegetation, and riparian vegetation to name a few. Benefits to the natural environment from hatchery salmon carcasses are expected to be negligible for the proposed action because the vast majority of hatchery fish are harvested and do not spawn naturally.

2.6. Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02 and 402.17(a)). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

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 (Section 2.4).

The cumulative impacts from these programs contribute to the total impacts from hatcheries in the entire Columbia River Basin, which is noted in the Mitchell Act Biological Opinion (NMFS 2017b). Between those programs which have already undergone consultation and those for which consultation is underway, it is likely (though uncertain for ongoing consultations) that the type and extent of salmon and steelhead hatchery programs and the numbers of fish released in the Columbia River Basin 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 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. Where needed, reductions in 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
- Incorporation of new research results and improved best management practices for hatchery operations
- More accurate estimates of natural-origin salmon and steelhead abundance for abundance-based fishery management approaches

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 versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the Action Area are described in the environmental baseline (link to section).

These potential changes to hatchery operations combined with the ongoing operations of the hatchery programs described in the proposed action result in a net beneficial change to current conditions. While the hatchery programs around the basin, and those under review here as well, lead to negative impacts on listed salmonid species as described above, when the beneficial changes to hatchery practices are also combined with the potential negative impacts from these hatchery programs and the rest of the operations in the Columbia River basin, a net beneficial result is expected as hatchery practices continue to improve and to reduce their negative impacts.

2.7. Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.5.1) 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.

The Proposed Action is to provide federal funding to assist in on-going hatchery programs where hatchery fish are released from net pens in off-channel, slough areas of the in the Lower Columbia River specifically for fishery harvest upon return as adults. All other previous activities associated with this program are included in the environmental baseline. The primary areas affected by the proposed action include habitat areas where the net pens continue to rear and release hatchery fish, the release of hatchery fish, and the effects of hatchery fish not harvested and straying into nearby natural areas for spawning. As analyzed in section 2.5.1, above, there is no effect from the collection of broodstock associated with the proposed action.

Straying by hatchery fish into adjacent habitat areas by spring Chinook salmon and coho salmon will not affect the abundance and productivity of ESA-listed populations in the Lower Columbia River. The ecological effects from the continued release of hatchery fish from SAFE facilities in the Lower Columbia River is expected to be minimal and short-lived in space and time. The spatial distribution and diversity of Lower Columbia River natural populations will not be affected by the proposed action. In conclusion, the summation of effects on the VSP parameters of affected ESA-listed ESUs and DPSs is minimal to non-existent.

The effects of the proposed action are minimized by the continued implementation of best management practices of the SAFE program over the last two decades. The proposed action limits impacts from the release of hatchery fish by releasing hatchery fish that are ready to emigrate to the ocean as smolts, thus limiting the ecological effects. Habitat-related effects are minimized due to the location and limited scope of habitat affected by the continued operation of the net pens; even with the expected effects of climate change in freshwater habitats. The adjacent natural population areas are not identified as primary populations needed for recovery. Therefore, any straying of hatchery salmon that are not harvested in fisheries would not compromise achievement of recovery goals of the Chinook salmon and coho salmon ESUs. The effects of fishery harvest on returning adult hatchery fish has proved to be within allowable fishery impacts under the ESA. Therefore, the proposed program has negligible impacts and all within the scope of ESA-approved limits.

2.7.1. Critical Habitat

The continued operation and maintenance of the net pens in the Lower Columbia River estuary and release of hatchery spring Chinook salmon and coho salmon pose a negligible effect on designated critical habitat in the Action Area. Since the net pens are small with localized effects diminished from the daily tide cycles, habitat effects are negligible. No new construction or expansion of the existing net pens is proposed; only the continued operation of existing facilities included in the environmental baseline.

2.8. Conclusion

After reviewing the current status of the listed species, the environmental baseline within the Action Area (including actions analyzed by NMFS (2017b), NMFS (2018a), and NMFS (2019)), the effects of the Proposed Action, and other cumulative effects, it is NMFS' biological opinion that the Proposed Action is not likely to jeopardize the continued existence of Lower Columbia River Chinook salmon ESU, Lower Columbia River coho salmon ESU, Lower Columbia River steelhead DPS, Columbia River chum salmon ESU, Upper Willamette River spring Chinook salmon ESU, Snake River spring/summer Chinook salmon ESU, or destroy or adversely modify designated critical habitat for these species.

2.9. Incidental Take Statement

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

2.9.1. Amount or Extent of Take

In section 2.5, above, NMFS analyzed six categories of effects for the Proposed Action, collectively including: (1) broodstock origin and collection, (2) hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds, (3) hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas, mainstem rivers, estuary, and ocean, (4) research, monitoring, and evaluation (RM&E) supporting hatchery program implementation, (5) operation, maintenance, and construction of hatchery facilities (i.e., facility effects), and (6) fisheries that would not exist but for the availability of hatchery fish to catch.

Other existing ESA consultations govern the take of species associated with the activities considered here, including broodstock collection and rearing at various hatchery facilities throughout the Lower Columbia River and its tributaries (1), operation and maintenance of non-SAFE facilities (5), and fishery harvest (6). The incidental take statements of NMFS (2017b), NMFS (2018a), and NMFS (2019) provide the limitations on take associated with these activities.

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

2.9.1.1.Take from Hatchery Fish on the Spawning Grounds

SAFE hatchery programs may take natural-origin salmon in the Lower Columbia River if hatchery fish stray and spawn naturally in the wild with natural-origin fish, resulting in potential genetic introgression, which is a form of harm to listed salmonids. The SAFE facilities have been located in off-channel areas in the estuary to maximize fishery harvest of returning adults and minimize adverse effects on the ESUs from hatchery fish straying into natural populations. The extent of take through genetic introgression cannot be quantified because the take is not observable and available monitoring has not measured gene flow from this hatchery program into natural populations. Therefore, NMFS will rely on a surrogate, in the form of the census pHOS rate. Take from hatchery fish on the spawning grounds will not be exceeded as long as the three year rolling arithmetic mean census pHOS from hatchery spring Chinook salmon and coho salmon in the following population are not exceeded: 10% for spring Chinook salmon in the Kalama, Clackamas, and Sandy; 30% for coho salmon in the Grays/Chinook Rivers, Elochoman/Skamokawa Rivers, Lower Cowlitz River, North Fork Toutle, Washougal; 10% for coho salmon in the Clatskanie, Scappoose, Coweeman, South Fork Toutle, East Fork Lewis, Clackamas, and Sandy.

These pHOS rates are prescribed by NMFS (2017b) for management of hatchery programs in the Lower Columbia River. These populations represent the "primary" and "contributing" populations needed for viability of the ESUs leading to delisting; therefore, if the census pHOS is below these targets, this indicates that the take through genetic introgression is appropriately limited[6]. If census pHOS is above these targets, NMFS will evaluate which hatchery programs are contributing the most to pHOS and make adjustments accordingly.

Census pHOS is an appropriate surrogate for take by genetic effects because it is rationally connected to those effects by measuring the extent to which hatchery and natural-origin salmon co-occur on the spawning grounds and have the opportunity to interbreed. Census pHOS can be reasonably and reliably measured and monitored through spawning ground surveys conducted annually by ODFW and WDFW in the appropriate populations.

2.9.1.2.Take from Hatchery Fish in Juvenile Rearing Areas

The SAFE program releases hatchery salmon in the Lower Columbia River estuary where the ecological interactions between hatchery and natural salmon and steelhead can occur and cause take in the form of harm to threatened salmonid juveniles from predation and to threatened salmonid smolts through competition. It is impossible to quantify the take associated with competition and predation between SAFE releases and natural-origin fish; either modeled or direct measurements. Therefore, NMFS will rely on a take surrogate that relies on the ability of the program to meet several parameters, which tend to demonstrate whether take has stabilized or not. Take is estimated to be that which would occur from ecological interactions under the following circumstances. Except as noted, failure to meet any one of the following parameters would suggest that the take associated with the proposed action has been exceeded.

Numbers of Hatchery Fish Released:

- Release of hatchery smolts in any given year must not exceed the smolt release goal for the hatchery program plus 10% for annual variability. The effects analysis considered up to this limit annually, plus a slight buffer to allow for occasional overages based upon factors outside the direct control of the hatchery operators;
- The five-year rolling average of smolt releases for each hatchery program must not exceed 102% of the annual smolt release goal for that program. This surrogate ensures the effects are within the scope analyzed in the opinion based upon the number of hatchery fish released, while allowing some variability for any particular year (see previous bullet), provided the variability does not result in average releases in excess of the expected program size;

Size of Hatchery Fish Released:

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[6] The "stabilizing" population areas of Youngs Bay and Big Creek have not been identified as needed for recovery (ODFW 2017) and thus the 10% pHOS limit will not be applied to these basins to estimate the extent of take.

- If the actual size of fish released is greater than 10% of the planned release size for each program, then take may be potentially exceeded through ecological interactions and require NMFS to reconsider its Opinion.

Location of Where Hatchery Fish are Released:

- Any change in release location from the locations identified in the HGMPs for the programs included in the proposed action must not expand the interaction area between hatchery and natural fish (releases will be from SAFE facilities).

This approach has a rational connection to the extent of take associated with ecological effects because the relative numbers of hatchery fish released and their physical size are commensurate with the extent of the risk, and the release location is a key factor in limiting that risk. All of these matters are reliably monitored by the co-managers annually as part of their regular hatchery monitoring and reporting to NMFS. All of these metrics are available each year for evaluation.

2.9.1.3.Take from Research, Monitoring, and Evaluation Activities

All of the hatchery programs conduct research, monitoring, and evaluation (RME) periodically to evaluate program performance, the effects of hatchery fish, and the status of natural-origin populations. These activities involve primarily incidental take by observation of salmon and steelhead, but may also occasionally collect fish for sampling. The majority of the expected take of natural-origin salmon and steelhead is non-lethal from observation, harassment and/or collection, where natural-origin fish may be incidentally captured, handled, and then released alive. Any mortality of salmon and steelhead would be inadvertent and accidental, unless the RME specifically needs natural-origin salmon or steelhead (e.g., direct take) for study.

The estimated take of natural-origin juvenile and adult salmon and steelhead associated with research, monitoring, and evaluation of the SAFE hatchery programs will be subject to the limits specified in NMFS (2017b) because this program is interrelated with other activities authorized under this consultation. Cumulative take associated with this consultation and NMFS (2017b) will be tracked by the operating agencies. This includes all incidental capture, handling, and mortality associated with monitoring and evaluation of the SAFE program in entirety (all funding sources). All capture and handling of juvenile and adult salmonids will be recorded and reported.

2.9.1.4.Take from Operation and Maintenance of SAFE Hatchery and Net Pen Facilities

No new construction or modification of the hatchery facilities or net pens is included in the proposed action.

The SAFE net pens occur within established areas of the Lower Columbia River estuary where the net pens are naturally watered by the tides and river. No water is manipulated or altered. Take associated with the operation and maintenance of the net pens can occur through changes in water quality directly adjacent to the net pens through fish rearing and cleaning of algal growth from the nets. Increased turbidity plumes could occur during installation and removal of the net pens in the off-season when hatchery fish are not being reared. All of these effects are unquantifiable because they result in sub-lethal effects on ESA-listed salmon and steelhead through behavior modification if near the net pens and/or short-lived effects on water quality before being diluted. These potential effects cannot be reliably observed or measured.

Since take cannot be quantified, NMFS will consider the take limit associated with the operation of the SAFE net pens to have been exceeded if the net pen facilities are expanded greater than 30% from the existing production areas. This surrogate is rationally connected to the extent of take because modification of the proposed action to this extent (>30%) would increase the amount of habitat affected by the net pens, potentially increase the required maintenance activities of the net pens, and thus be additional effects not directly analyzed in this Opinion. Our expectation is that take will be within the expectations of our opinion as long as the facilities are operated and maintained in accordance with the HGMPs for these programs.

2.9.2. Effect of the Take

In Section 2.9, NMFS determined that the level of incidental take, coupled with other effects of the Proposed Action, is not likely to jeopardize the continued existence of the LCR Chinook Salmon ESU, LCR Coho ESU, LCR Steelhead DPS, CR Chum ESU, UWR Chinook salmon, and SR spring/summer Chinook salmon, or result in the destruction or adverse modification of their designated critical habitat (section 2.5). In addition, for the other ESA-listed species that may be potentially affected when migrating through the Lower Columbia River estuary in the action area, NMFS has determined the proposed action is also not likely to jeopardize the continued existence of these species (section 2.5).

Section 2.12 includes the species that the proposed action is not likely to adversely affect and for which no take is expected.

2.9.3. Reasonable and Prudent Measures

“Reasonable and prudent measures” are nondiscretionary measures to minimize the amount or extent of incidental take (50 CFR 402.02).

NMFS concludes that the following reasonable and prudent measures are necessary and appropriate to minimize incidental take. The action agencies (NMFS, USFWS, BPA), in cooperation with ODFW, WDFW, and CCF, shall ensure the following measures:

1. Fund and implement operation and maintenance and monitoring and evaluation of the three SAFE hatchery programs, and operation and maintenance of the SAFE facilities, according to the Proposed Action specified above and in the SAFE spring Chinook salmon and coho salmon HGMPs (ODFW 2021a; ODFW 2021b; WDFW 2018).

2. Minimize the effects of the SAFE hatchery programs on ESA-listed natural-origin salmon and steelhead in the Lower Columbia River and its tributaries.

3. Provide periodic progress reports on the implementation of the HGMPs.

2.9.4. Terms and Conditions

The terms and conditions described below are non-discretionary, and the Action Agencies (or any other agencies associated with the proposed actions, i.e., ODFW, WDFW, CCF) must comply with them in order to implement the Reasonable and Prudent Measures specified above (50 CFR 402.14). The BPA, NMFS, USFWS, ODFW, WDFW, and CCF have 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 Opinion and 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.

1a. Production and Release of SAFE hatchery spring Chinook salmon – In accordance with the proposed action, the BPA, NMFS, and USFWS shall ensure funding of acclimation and release and monitoring and evaluation activities, and facility operation and maintenance, at SAFE facilities in support of ODFW and CCF's implementation of the SAFE hatchery spring Chinook program. ODFW and CCF will provide non-federal funding for full implementation of the program, and will produce up to a maximum of 4.25 million smolts annually, as described in sections 1.3 and 1.3.1, above. This production level is authorized by the Incidental Take Statement in section 2.9, above. Changes to the agencies' funding of the hatchery spring Chinook salmon production may occur in the future as long as the maximum annual production is not exceeded.

1b. Production and Release of SAFE hatchery Coho Salmon – In accordance with the proposed action, BPA, NMFS, and USFWS shall ensure funding of the acclimation and release of SAFE hatchery Coho salmon at SAFE facilities, monitoring and evaluation, and operation and maintenance of the SAFE facilities. These programs will produce up to a maximum of 4.3 million smolts annually, as described in sections 1.3 and 1.3.1 above with the addition of non-federal funding. This production level is authorized by the Incidental Take Statement in section 2.9, above. Changes to the agencies funding of the hatchery coho salmon production may occur in the future as long as the maximum annual production is not exceeded.

2a. Brood Sources, Production Caps, and Harvest Tools – NMFS, ODFW, and WDFW (as fish agency co-managers) will coordinate through other hatchery production and harvest forums and related consultations (NMFS 2017b for Clackamas stock, NMFS 2018a for *U.S. v. Oregon* harvest, NMFS 2019 for Willamette hatcheries) for the SAFE spring chinook and coho programs, to appropriately adjust broodstock sources, annual production levels, and incorporation of harvest-related tools to avoid or decrease effects on ESA-listed fish from SAFE hatchery production. WDFW shall notify NMFS 30 days in advance of using any backup brood sources for the Deep River coho salmon program and get concurrence.

2b. In order to minimize the negative effects of ecological interactions between hatchery- and natural-origin fish in the Lower Columbia River and its tributaries, the program operators shall ensure high-quality juvenile salmon are transferred to and released from the SAFE net pen facilities. Juvenile salmon shall be transferred, reared, and released using the best management practices to produce healthy smolts ready to make the transition to saltwater.

2c. The program operators, with federal funding from the appropriate Action Agencies, shall monitor the straying and natural spawning of SAFE hatchery fish in the Lower Columbia River. The proportion of SAFE hatchery fish spawning naturally shall be kept to the lowest levels feasible, consistent with the pHOS levels described in NMFS (2017b) for the affected natural populations.

3a. The program operators shall send to NMFS SFD (contact below) the annual production plans for SAFE facilities each year. All other funding and operating agencies for this program should also receive a copy.

3b. The funding agencies shall ensure funding for program operators to regularly produce written reports related to the SAFE program. The agencies may incorporate SAFE hatchery reporting into existing reporting requirements and schedules through BPA-funded and operator-authored reporting under BPA Project # 1993-060-00 and NMFS (2017b) Mitchell Act funding reporting (due January 31st for the previous fiscal year). These reports, once completed by the operators, shall be sent to NMFS SFD (contact below), specifically describing:

a. The number of hatchery fish, by species and run type, released from the SAFE facilities annually.
b. Monitoring of SAFE program hatchery fish on the natural spawning grounds.
c. Any proposed changes to the HGMPs and/or future hatchery production.
d. These reports in written form shall be sent to:

Allyson Purcell, Branch Chief
NMFS – Sustainable Fisheries Division (SFD)
Anadromous Production and Inland Fisheries Program
1201 N.E. Lloyd Boulevard, Suite 1100
Portland, Oregon 97232

Technical Contact:
Lance Kruzic , lance.kruzic@noaa.gov
(541) 957-3381

2.10. Conservation Recommendation

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 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 (50 CFR 402.02).

NMFS has not identified any conservation recommendations for this Proposed Action.

2.11. Reinitiation of Consultation

This concludes formal consultation on the SAFE hatchery programs.

As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

Among other considerations, NMFS may reinitiate consultation if there is significant new information indicating that impacts on ESA-listed species, beyond those considered in this opinion, are occurring from the operation of the proposed hatchery programs, including the operation of weirs and traps, and RM&E in support of the hatchery programs, or if the specific RM&E activities listed in the terms and conditions are not implemented.

If the amount or extent of take considered in this opinion is exceeded, NMFS may reinitiate consultation. SFD will consult with the operators to determine specific actions and measures that can be implemented to address the take or implement further analysis of the impacts on listed species. If the amount and extent of take cannot be reduced to levels considered in this opinion, NMFS will reinitiate consultation.

2.12. "Not Likely to Adversely Affect" Determinations

There are ESA-listed species considered in this consultation for which NMFS determined the proposed action "may affect, but not likely to adversely affect" these species. For these determinations, the effects of the proposed action are expected to be discountable, insignificant, or completely beneficial. Discountable effects are those effects that are extremely unlikely to occur. Insignificant effects relate to the magnitude of the impact where the action should never reach the scale where "take" occurs. Beneficial effects are contemporaneous positive effects without any adverse effects on the species. Refer to the biological opinion for a description of the proposed action and action area. The following species in Table 36 are included as may affect, but not likely to adversely affect, determinations for this consultation.

All of these species may potentially be in the Lower Columbia River estuary near the net pens when SAFE hatchery fish are also present. A further assessment of these determinations is included below.

Table 41. Listing status and critical habitat designations for species considered in this opinion. (Listing status: 'T' means listed as threatened under the ESA; 'E' means listed as endangered.)

SPECIES	LISTING STATUS	CRITICAL HABITAT
Chinook salmon (*Oncorhynchus tshawytscha*)		
Snake River fall-run	T: 6/28/05 (NMFS 2005c)	12/28/93 (NMFS 1993)
Sockeye salmon (*O. nerka*)		
Snake River	E: 6/28/05 (NMFS 2005c)	12/28/93 (NMFS 1993)
Steelhead *(O. mykiss)*		
Upper Willamette River	T: 1/5/06 (NMFS 2006b)	09/02/05 (NMFS 2005d)
Middle Columbia River	T: 1/5/06 (NMFS 2006b)	09/02/05 (NMFS 2005d)
Upper Columbia River	T: 8/24/09	09/02/05 (NMFS 2005d)
Snake River Basin	T: 1/5/06 (NMFS 2006b)	09/02/05 (NMFS 2005d)
Green Sturgeon *(Acipenser medirostris)*		
Southern DPS of Green Sturgeon	E: 4/7/06 (NMFS 2006c)	10/09/09
Killer Whales *(Orcinus orca)*		
Southern Resident DPS Killer Whales	E: 11/18/05 (NMFS 2005e)	11/29/06 (NMFS 2006d)
Eulachon *(Thaleichthys pacificus)*		
Southern DPS	T: 3/18/10	10/20/11

Other ESA-listed Salmon and Steelhead

ESA-listed salmon and steelhead produced in the Upper Willamette, Middle Columbia, Upper Columbia, and Snake Basin may be present in the Lower Columbia River estuary when SAFE hatchery fish are also present. However, the co-occurrence of these species near the SAFE facilities and when hatchery fish are present is extremely unlikely due to their off-channel location and/or timing of the release of juvenile SAFE hatchery fish when the other upriver stocks are not likely to be present in the estuary. All of the potential interaction would be ecological and no competition or predation is expected due to the larger size of these smolts compared to SAFE releases. ESA-listed fish from the Lower Columbia ESUs and DPS and chum salmon are evaluated in the opinion above.

For the adult life stage, adult hatchery fish from the SAFE project may be present with adults migrating back to other production areas in the Columbia River. Due to the limited overlap in space and time (February through June), these ecological interactions are not expected to be adverse and entirely negligible. There is no information suggesting hatchery fish migrating upriver with natural-origin fish in the Lower Columbia would cause an adverse effect on listed salmon and steelhead.

Green sturgeon

The southern green sturgeon DPS includes all natural populations of green sturgeon that spawn south of the Eel River in Humboldt County, California. Critical habitat is designated for the lower Columbia River up to Rkm 74. The proposed action would increase the prey base of salmonids potentially available to green sturgeon from the release of hatchery fish (both juvenile and adult hatchery fish). Negative ecological impacts from the proposed action are not likely due to the size of green sturgeon (sub-adult and adult), differential habitat use, and life histories. Water quality and quantity effects from the operation of the hatchery facilities on green sturgeon critical habitat in estuarine waters is discountable due to the short-lived effect of hatchery effluent in upstream streams and rivers. We conclude green sturgeon may be affected, but are not adversely affected by the proposed action.

Eulachon

Eulachon are present in the Lower Columbia River and some of the larger tributaries. Critical habitat is designated for eulachon in the lower Columbia River and SAFE hatchery fish are present only in this area. The overlap between eulachon and these hatchery fish is from February through June in the lower Columbia River. Eulachon would be migrating up the lower Columbia River to spawn and the hatchery fish would emigrating to the ocean as juveniles and upstream as adults. Potential adverse effects are unlikely due to differences in habitat use and behavior between eulachon and hatchery fish. Hatchery fish are readily emigrating to the ocean and not rearing in the river. The operation of the SAFE facilities will not affect eulachon because the fish are not likely to be present for any extent of time in these off-channel net pen areas. Given the potential for interaction between hatchery fish and eulachon is entirely ecological in the action area, eulachon may be affected, but not likely to be adversely affected.

Southern Resident Killer Whales

Southern resident killer whales reside predominantly in the Strait of Juan de Fuca and Puget Sound regions during late spring through summer. During this period, these killer whales feed predominantly on returning Chinook salmon to the region, with selective preference given to consuming the older and largest Chinook salmon (Hanson et al. 2010). During the fall and winter periods, southern resident killer whales have been observed outside the Puget Sound Region, ranging from central California to northern Vancouver Island, Canada (Hilborn et al. 2012). While Chinook salmon still continues to be the preferred prey species of these killer whales, other marine species such as lingcod, greenling, sole, sablefish, and squid have also been observed in their diet (NMFS 2014[7]). The limited data available suggest the highest likelihood of southern resident killer whales being found potentially off the mouth of the Columbia River is from late fall through early spring. The occurrence of killer whales along the Oregon-Washington coasts likely varies from year to year, but known southern resident killer whales have been observed off these coasts several times over the last decade. During the period when killer whales are most likely to be present along the Oregon-Washington coasts (late fall through early spring), a mixture of Chinook salmon stocks originating from California to southeast

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[7] Information available from: http://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/killer_whale/index.html. Accessed February 13, 2014.

Alaska have been found (Weitkamp 2010). Therefore, Chinook salmon potentially consumed by killer whales would not be solely from the SAFE hatchery programs, and only a small percentage of the total abundance of Chinook salmon would be from the proposed hatchery programs described herein, based on the abundance of hatchery-origin Chinook salmon relative to total Chinook salmon. In addition to Chinook salmon, a variety of other salmonids and marine species are also available for consumption by killer whales along the Oregon-Washington coasts.

The proposed action includes the release of hatchery Chinook salmon which are a preferred prey source for these killer whales. Therefore, NMFS has determined the proposed action may affect killer whales, but the effects are not likely to be adverse. The proposed action will affect the natural production of salmon (the effects of hatcheries on natural-origin salmon), as evaluated above, and the proposed action increases the prey base of Chinook salmon for killer whales. Based on this, NMFS believes in total, the proposed action will not adversely affect Southern Resident killer whales.

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

The consultation requirement of section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or Proposed Actions that may adversely affect EFH. The MSA (Section 3) defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Adverse effects include the direct or indirect physical, chemical, or biological alterations 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 EFH, and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH.

This analysis is based, in part, on descriptions of EFH for Pacific Coast salmon (PFMC 2003) contained in the fishery management plans developed by the Pacific Fishery Management Council (PFMC) and approved by the Secretary of Commerce.

3.1. Essential Fish Habitat Affected by the Project

Section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. Under the MSA, this consultation is intended to promote the conservation of EFH as necessary to support sustainable fisheries and the managed species' contribution to a healthy ecosystem. For the purposes of the MSA , EFH means "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity", and includes the physical, biological, and chemical properties that are used by fish (50 CFR 600.10). Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) of the MSA also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH. Such recommendations may include measures to avoid, minimize, mitigate, or otherwise offset the adverse effects of the action on EFH [CFR 600.905(b)]

This analysis is based, in part, on the EFH assessment provided by the **[***Federal agency***]** and descriptions of EFH for **[***choose appropriate Fishery Management Plans (FMPs)* Pacific Coast groundfish (Pacific Fishery Management Council [PFMC] 2005), coastal pelagic species (CPS) (PFMC 1998), Pacific Coast salmon (PFMC 2014); and highly migratory species (HMS) (PFMC (2007)**]** contained in the fishery management plans developed by the PFMC and approved by the Secretary of Commerce.

The Proposed Action is the implementation of a spring Chinook salmon and coho salmon hatchery programs in Oregon and coho salmon hatchery program in Washington for fisheries enhancement, as described in Section 1.3. The Action Area includes habitat described as EFH for

Chinook and coho salmon (PFMC 2003) within the Columbia River Basin. Because EFH has not been described for steelhead, the analysis is restricted to the effects of the Proposed Action on EFH for Chinook and coho salmon.

It is still reasonable to consider EFH impacts as described by PFMC (2003). As laid out there, the freshwater EFH for Chinook and coho salmon has five habitat areas of particular concern (HAPCs): (1) complex channels and floodplain habitat; (2) thermal refugia; (3) spawning habitat; (4) estuaries; and (5) marine and estuarine submerged aquatic vegetation. HAPC 1 and 3 are potentially affected by the Proposed Action.

3.2. Adverse Effects on Essential Fish Habitat

The Proposed Action has negligible, if any, effects on the major components of EFH. The net pens where hatchery fish are released have been in operation for years and are located in tidal, off-channel backwater areas of the Lower Columbia River. The amount of EFH habitat affected by the placement of net pens is insignificant. Nearshore habitat is not affected as the net pens are in deeper waters and secured by existing piling structures. The proposed hatchery programs include designs to minimize each of these effects.

The PFMC (2003) recognized concerns regarding the "genetic and ecological interactions of hatchery and wild fish… [which have] been identified as risk factors for wild populations." The biological opinion describes in considerable detail the impacts the hatchery programs might have on natural populations of Chinook and coho salmon. Ecological effects of juvenile and adult hatchery-origin fish on natural-origin fish are discussed in Sections 2.5 and 2.6. Hatchery fish returning to the Lower Columbia River River are expected to be caught at side stream/terminal fisheries and not spawn naturally. Coho salmon are more likely to stray and spawn naturally than spring Chinook salmon due to their life history differences. The areas where hatchery fish are likely to spawn near the SAFE terminal areas are not the core populations needed for recovery of the ESUs and thus not consequential to salmon recovery.

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 the HGMPs and the ITS (Section 2.9) includes the best approaches to avoid or minimize those adverse effects. Thus, NMFS has no conservation recommendations specifically for Chinook and coho salmon EFH.

3.4. Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, NMFS, BPA, and the USFWS 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' 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 the 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. Therefore, we ask that in your statutory reply to the EFH portion of this consultation, you clearly identify the number of conservation recommendations accepted.

3.5. Supplemental Consultation

The action agencies must reinitiate EFH consultation if the Proposed Action is substantially revised by the applicants 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

Section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-554) ("Data Quality Act") 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, document compliance with the Data Quality Act, 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. NMFS has determined, through this ESA Section 7 consultation that operation of Select Area Fisheries Enhancement spring Chinook salmon and coho salmon programs as proposed will not jeopardize ESA-listed species and will not destroy or adversely modify designated critical habitat. Therefore, NMFS can issue an ITS. The intended users of this opinion are the NMFS (permitting entity), and the BPA (funding entity), and WDFW and ODFW (program operators). The scientific community, resource managers, and stakeholders benefit from the consultation through the anticipated increase in returns of salmonids, and through the collection of data indicating the potential effects of the operation on the viability of natural populations of ESA-listed salmon and steelhead in the Columbia River Basin. This information will improve scientific understanding of hatchery salmon and steelhead effects that can be applied broadly within the Pacific Northwest area for managing benefits and risks associated with hatchery operations.

4.2. Integrity

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

4.3. Objectivity

Information Product Category: Natural Resource Plan

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased, and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA Regulations, 50 CFR 402.01 *et seq*., and the MSA implementing regulations regarding EFH, 50 CFR 600.920(j).

Best Available Information: This consultation and supporting documents use the best available information, as described in the references section. The analyses in this biological opinion/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. APPENDIX A: HATCHERY PRODUCTION TABLES FOR THE SAFE PROGRAM

Table A-1. Proposed annual production/release numbers, rearing and release locations for ODFW SAFE spring Chinook salmon program.

Life Stage, Size and Number	**Marking and Coded-wire tagging (CWT) protocols**	**Egg Incubation Location**	**Rearing Location**	**Acclimation Site**	**Release Location**	**Release Time**
250,000 yearlings; 12 fpp	100% adipose fin clip; 10% CWT	Clackamas Hatchery[1]/ Big Creek Hatchery[1]	Big Creek Hatchery[1]	Tongue Point Net Pens	Columbia River	March
250,000 yearlings; 12 fpp	100% adipose fin clip; 10% CWT	Marion Forks Hatchery[2]	Marion Forks Hatchery[2]	Youngs Bay Net Pens	Youngs Bay	Early April
200,000 yearlings; 16 fpp	100% adipose fin clip; 12.5% CWT	Marion Forks Hatchery[2]	Marion Forks Hatchery[2]	Tongue Point Net Pens	Columbia River	Late April
300,000 yearlings; 14 fpp	100% adipose fin clip; 8.3% CWT	Marion Forks Hatchery[2]	Marion Forks Hatchery[2]	Youngs Bay Net Pens	Youngs Bay	Late March
150,000 yearlings; 25 fpp	100% adipose fin clip; 16.7% CWT	South Santiam Hatchery[2]/ Gnat Creek Hatchery	Gnat Creek Hatchery/ Blind Slough Net Pens	Blind Slough Net Pens	Columbia River	Mid-March
400,000 yearlings; 25 fpp	100% adipose fin clip; 6.3% CWT	South Santiam Hatchery[2]/ Gnat Creek Hatchery	Gnat Creek Hatchery/ Youngs Bay Net Pens	Youngs Bay Net Pens	Youngs Bay	Late March
400,000 yearlings; 12 fpp	100% adipose fin clip; 6.3% CWT	South Santiam Hatchery[2]/ Gnat Creek Hatchery	Gnat Creek Hatchery	None	Gnat Creek	March
750,000 yearlings; 12 fpp	100% adipose fin clip; 3.3% CWT	Oxbow Hatchery	Oxbow Hatchery/ Klaskanine Hatchery	None	North Fork Klaskanine	Early March

500,000 yearlings; 25 fpp	100% adipose fin clip; 10% CWT	Oxbow Hatchery	Oxbow Hatchery/ Gnat Ck.	None	Gnat Creek	March
150,000 yearlings; 14 fpp	100% adipose fin clip; 6.3% CWT	Oxbow Hatchery	Oxbow Hatchery/ Youngs Bay Net Pens	Youngs Bay Net Pens	Youngs Bay	Late March
100,000 yearlings; 12 fpp	100% adipose fin clip; 25% CWT	Oxbow Hatchery	Oxbow Hatchery/ Blind Slough Net Pens	Blind Slough Net Pens	Columbia River	Early April
Back up facilities	N/A	McKenzie Hatchery[2]/ Leaburg Hatchery[2]	Bonneville Hatchery	N/A	N/A	N/A

[1] The effects of incubation and/or rearing at these facilities were analyzed in (NMFS 2017b).

[2] The effects of incubation and/or rearing at these facilities were analyzed in NMFS (2019).

Table A-2. Proposed annual production/release numbers, rearing and release locations for ODFW and WDFW SAFE coho salmon program.

Life Stage, Size and Number	**Marking**	**Egg Incubation Location**	**Rearing Location**	**Acclimation Site**	**Release Location**	**Release Time**
705,000 yearlings; 14 fpp	100% ad clip; 3.5% CWT	Cascade Hatchery[1]	Cascade Hatchery[1]/ Clackamas Hatchery[1]/ Tongue Point Net Pens	Tongue Point Net Pens (over winter)	Columbia River	March
800,000 yearlings; 15 fpp	100% ad clip; 3.1% CWT	Cascade Hatchery[1]	Cascade Hatchery[1]/ Clackamas Hatchery/ North Fork Klaskanine	None	North Fork Klaskanine River	May
825,000 yearlings; 15 fpp	100% ad clip; 3% CWT	Cascade Hatchery[1]	Cascade Hatchery[1]/ Clackamas/ Youngs Bay Net Pens	Youngs Bay Net Pens (over winter)	Youngs Bay	April
385,000 yearlings; 12 fpp	100% ad clip; 6.5% CWT	Cascade Hatchery[1]	Cedar Creek Hatchery[1]/ South Fork Klaskanine Hatchery[1]	None	South Fork Klaskanine River	April
400,000 yearlings; 15 fpp	100% ad clip; 6.3% CWT	Oxbow Hatchery[1]	Oxbow Hatchery[1]/Upper Herman Creek	Blind Slough Net Pens	Columbia River	April

			Ponds[1]/Blind Slough Net Pens			
630,000 yearlings; 15 fpp	100% ad clip; 4% CWT	Big Creek Hatchery[1]	Klaskanine Hatchery[1]	None	North Fork Klaskanine River	May
Back up facilities - OR	N/A	Salmon River Hatchery	Salmon River Hatchery	N/A	N/A	N/A
400,000 yearlings: 15 fpp	100% ad clip; 45,000 CWT from total Deep River SAFE production (400k)	Beaver Creek Hatchery, Cowlitz Hatchery, Kalama Falls Hatchery, Lewis River Hatchery, Washougal Hatchery[3],	Beaver Creek Hatchery, Cowlitz Hatchery, Kalama Falls Hatchery, Lewis River Hatchery, Washougal Hatchery	Deep River Net Pens (5-6 months)	Columbia River	May

[1] The effects of incubation and/or rearing at these facilities were analyzed in (NMFS 2017b). Beginning in brood year 2019, all eggs for this program will be Big Creek Hatchery stock (NMFS 2017b).

[2] The effects of incubation and/or rearing at these facilities were analyzed in NMFS (2014).

[3] Washougal Hatchery located in Washougal, WA

6. APPENDIX B: FACTORS CONSIDERED WHEN ANALYZING HATCHERY EFFECTS

6.1. Factors That Are Considered When Analyzing Hatchery Effects

NMFS has substantial experience with hatchery programs and has developed and published a series of guidance documents for designing and evaluating hatchery programs following best available science (Hard et al. 1992; Jones 2006; McElhany et al. 2000; NMFS 2004; NMFS 2005b; NMFS 2008; NMFS 2011c). 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 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.
"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' analysis of the Proposed Action is in terms of effects it would be expected to have 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 seven factors of hatchery operation on each listed species at the population level, which in turn allows the combination of all such effects with other effects accruing to the species to determine the likelihood of posing jeopardy to the species as a whole.

Information that NMFS needs to analyze the effects of a hatchery program on ESA-listed species must be included in an HGMP. Draft HGMPs are reviewed by NMFS for their sufficiency before formal review and analysis of the Proposed Action can begin. Analysis of an HGMP or Proposed Action for its effects on ESA-listed species and on designated critical habitat depends on 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, migratory corridor, estuary and ocean
(4) 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.

NMFS' analysis assigns an effect category for each factor (negative, negligible, or positive/beneficial) on 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; (3) the target viability for the affected natural population(s) and; (4) the Environmental Baseline, including the factors currently limiting population viability.

The analysis assigns an effect for each factor from the following categories. The categories are:

(1) positive or beneficial effect on population viability,
(2) negligible effect on population viability, and
(3) negative effect on population viability.

"The effects of hatchery fish on the status of an ESU will depend on which of the four key attributes are currently limiting the ESU, and how the hatchery within the ESU affect each of the attributes" (NMFS 2005b). The category of affect assigned is based on an analysis of each factor weighed against the affected population(s) current risk level for abundance, productivity, spatial structure and diversity, the role or importance of the affected natural population(s) in ESU or steelhead DPS recovery, the target viability for the affected natural population(s), and the Environmental Baseline including the factors currently limiting population viability.

Table B-1. An overview of the range of effects on natural population viability parameters from the two categories of hatchery programs.

Natural population viability parameter	Hatchery broodstock originate from the local population and are included in the ESU or DPS	Hatchery broodstock originate from a non-local population or from fish that are not included in the same ESU or DPS
Productivity	**Positive to negative effect** Hatcheries are unlikely to benefit productivity except in cases where the natural population's small size is, in itself, a predominant factor limiting population growth (i.e., productivity) (NMFS 2004c).	**Negligible to negative effect** Productivity is dependent on differences between hatchery fish and the local natural population (i.e., the more distant the origin of the hatchery fish, the greater the threat), the duration and strength of selection in the hatchery, and the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the closer to a negligible effect).
Diversity	**Positive to negative effect** Hatcheries can temporarily support natural populations that might otherwise be extirpated or suffer severe bottlenecks and have the potential to increase the effective size of small natural populations. On the other hand, broodstock collection that homogenizes population structure is a threat to population diversity.	**Negligible to negative effect** Diversity is dependent on the differences between hatchery fish and the local natural population (i.e., the more distant the origin of the hatchery fish, the greater the threat) and the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the closer to a negligible effect).
Abundance	**Positive to negative effect** Hatchery-origin fish can positively affect the status of an ESU by contributing to the abundance of the natural populations in the ESU (70 FR 37204, June 28, 2005, at 37215). Increased abundance can also increase density dependent effects.	**Negligible to negative effect** Abundance is dependent on the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the closer to a negligible effect), handling, RM&E, and facility operation, maintenance and construction effects.
Spatial Structure	**Positive to negative effect** Hatcheries can accelerate re-colonization and increase population spatial structure, but only in conjunction with remediation of the factor(s) that limited spatial structure in the first place. "Any benefits to spatial structure over the long term depend on the degree to which the hatchery stock(s) add to (rather than replace) natural populations" (70 FR 37204, June 28, 2005 at 37213).	**Negligible to negative effect** Spatial structure is dependent on facility operation, maintenance, and construction effects and the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the closer to a negligible effect).

6.1.1. Factor 1. The hatchery program does or does not promote the conservation of genetic resources that represent the ecological and genetic diversity of a salmon ESU or steelhead DPS

This factor considers broodstock practices and whether they promote the conservation of genetic resources that represent the ecological and genetic diversity of a salmon ESU or steelhead DPS. It considers the risk to a natural population from the removal of natural-origin fish for hatchery broodstock. The effect of this factor ranges from neutral or negligible to negative.

A primary consideration in analyzing and assigning effects for broodstock collection is the origin and number of fish collected. The analysis considers whether broodstock are of local origin and the biological pros and cons 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 tapped to provide hatchery broodstock. "Mining" a natural population to supply hatchery broodstock can reduce population abundance and spatial structure. Also considered here is whether the program "backfills" with fish from outside the local or immediate area. The physical process of collecting hatchery broodstock and the effect of the process on ESA-listed species is considered under Factor 2.

6.1.2. 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

NMFS also analyzes the effects of hatchery fish and the progeny of naturally spawning hatchery fish on the spawning grounds. The effect of this factor ranges from positive to negative.

There are two aspects to this part of the analysis: genetic effects and ecological effects. NMFS generally views genetic effects as detrimental because at this time, based on the weight of available scientific information, we believe that artificial breeding and rearing is likely to result in some degree of genetic change and fitness reduction in hatchery fish and in the progeny of naturally spawning hatchery fish relative to desired levels of diversity and productivity for natural populations. Hatchery fish can thus pose a threat to natural population rebuilding and recovery when they interbreed with fish from natural populations.

However, NMFS recognizes that there are benefits as well, and that the risks just mentioned may be outweighed under circumstances where demographic or short-term extinction risk to the population is greater than risks to population diversity and productivity. Conservation hatchery programs may 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). Furthermore, NMFS also recognizes there is considerable debate regarding genetic risk. The extent and duration of genetic change and fitness loss and the short and long-term implications and consequences for different species, for species with multiple life-history types, and for species subjected to different hatchery practices and protocols remains unclear and should be the subject of further scientific investigation. As a result, NMFS believes 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 2011c).

Hatchery fish can have a variety of genetic effects on natural population productivity and diversity when they interbreed with natural-origin fish. Although there is biological interdependence between them, NMFS considers three major areas of genetic effects of hatchery programs: within-population diversity, outbreeding effects, and hatchery-influenced selection. As we have stated above, in most cases, the effects are viewed as risks, but in small populations these effects can sometimes be beneficial, reducing extinction risk.

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, a random loss of diversity due to population size. The rate of loss is determined by the population's effective population size (N_e), which can be considerably smaller than its census size. For a population to maintain genetic diversity reasonably well, the effective size should be in the hundreds (e.g., Lande and Barrowclough 1987), and diversity loss can be severe if N_e drops to a few dozen.

Hatchery programs, simply by virtue of creating more fish, can increase N_e. In very small populations this 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, such as the Snake River sockeye salmon program are important genetic reserves. However, hatchery programs can also directly depress N_e by two principal methods. One is by the simple removal of fish from the population so that they can be used in the hatchery. 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). N_e can also be 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 semen is especially problematic because when semen 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). Factorial mating schemes, in which fish are systematically mated multiple times, can be used to increase N_e (Busack and Knudsen 2007; Fiumera et al. 2004). An extreme form of N_e reduction is the Ryman-Laikre effect (Ryman et al. 1995; Ryman and Laikre 1991), when N_e is reduced through the return to the spawning grounds of large numbers of hatchery fish from very few parents.

Inbreeding depression, another N_e-related phenomenon, is caused by the mating of closely related individuals (e.g., sibs, half-sibs, cousins). The smaller the population, the more likely spawners will be related. Related individuals are likely to contain similar genetic material, and the resulting offspring may then have reduced survival because they are less variable genetically or have double doses of deleterious mutations. The lowered fitness of fish due to inbreeding depression accentuates the genetic risk problem, helping to push a small population toward extinction.

Outbreeding effects are caused by gene flow from other populations. Gene flow occurs naturally among salmon and steelhead populations, a process referred to as straying (Quinn 1993; Quinn 1997). 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 programs can result in straying outside natural patterns for two reasons. First, hatchery fish may exhibit reduced homing fidelity relative to natural-origin fish (Goodman 2005; Grant 1997; Jonsson et al. 2003; Quinn 1997), resulting in unnatural levels of gene flow into recipient populations, either in terms of sources or rates. Second, even if hatchery fish home at the same level of fidelity as natural-origin fish, their higher abundance can cause unnatural straying levels into recipient populations. One goal for hatchery programs should be to ensure that hatchery practices do not lead to higher rates of genetic exchange with fish from natural populations than would occur naturally (Ryman 1991). Rearing and release practices and ancestral origin of the hatchery fish can all play a role in straying (Quinn 1997).

Gene flow from other populations can have two effects. It 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 broodstocks. Additionally, unusual rates of straying into other populations within or beyond the population’s MPG or ESU or a steelhead DPS can have an 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. Reduction of within-population and among-population diversity can reduce adaptive potential.

The proportion of hatchery fish (pHOS)[8] among natural spawners is often used as a surrogate measure of gene flow. Appropriate cautions and qualifications should be considered when using this proportion to analyze hatchery effects. Adult salmon may wander on their return migration, entering and then leaving tributary streams before finally 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). Caution must also be taken in assuming that strays 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 (Blankenship et al. 2007; Saisa et al. 2003). The causative factors for poorer breeding success of strays are likely similar to those identified as responsible for reduced productivity of hatchery-origin fish in general, e.g.,

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[8] NMFS analyzes outbreeding effects as a risk only when the hatchery fish are from a different genetic population than the naturally produced fish. If they are from the same population, then the risk is from hatchery-influenced selection. Non-native hatchery fish may also contribute to hatchery-induced selection.

differences in run and spawn timing, spawning in less productive habitats, and reduced survival of their progeny (Leider et al. 1990; McLean et al. 2004; Reisenbichler and McIntyre 1977; Williamson et al. 2010).

Hatchery-induced selection (often called domestication) occurs when selection pressures imposed by 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 hatchery-origin fish, typically from the same population. 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-induced 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).

Genetic change and fitness reduction resulting from hatchery-induced selection depends on: (1) the difference in selection pressures; (2) the exposure or amount of time the fish spends in the hatchery environment; and, (3) the duration of hatchery program operation (i.e., the number of generations that fish are propagated by the program). On an individual level, exposure time in large part equates to fish culture, both the environment experienced by the fish in the hatchery and natural selection pressures, independent of the hatchery environment. On a population basis, exposure is determined by the proportion of natural-origin fish being used as hatchery broodstock and the proportion of hatchery-origin fish spawning in the wild (Ford 2002; Lynch and O'Hely 2001), and then by the number of years the exposure takes place. In assessing risk or determining impact, all three levels must be considered. Strong selective fish culture with low hatchery-wild interbreeding can pose less risk than relatively weaker selective fish culture with high levels of interbreeding.

Most of the empirical evidence of fitness depression due to hatchery-induced selection comes from studies of species that are reared in the hatchery environment for an extended period – one to two years – prior to release (Berejikian and Ford 2004). Exposure time in the hatchery for fall and summer Chinook salmon and Chum salmon is much shorter, just a few months. One especially well-publicized steelhead study (Araki et al. 2007; Araki et al. 2008), showed dramatic fitness declines in the progeny of naturally spawning hatchery steelhead. Researchers and managers alike have wondered if these results could be considered a potential outcome applicable to all salmonid species, life-history types, and hatchery rearing strategies.

Critical information for analysis of hatchery-influenced selection includes the number, location and timing of naturally spawning hatchery fish, the estimated level of interbreeding between hatchery-origin and natural-origin fish, the origin of the hatchery stock (the more distant the origin compared to the affected natural population, the greater the threat), the level and intensity of hatchery selection and the number of years the operation has been run in this way.

More recently, the Hatchery Scientific Review Group (HSRG) developed gene flow criteria/guidelines based on mathematical models developed by Ford (2002) and by Lynch and O'Hely (2001). Guidelines for isolated programs are based on pHOS and guidelines for integrated programs are based on a metric called proportionate natural influence (PNI), which is a function of pHOS and the proportion of natural-origin fish in the broodstock (pNOB). PNI is meant to represent the relative influence of the hatchery and natural environments on the fitness of an integrated population: a PNI value greater than 0.5 indicates more influence from natural selective forces, with 1.0 representing a theoretical optimum for natural fitness. The HSRG guidelines vary according to type of program (isolated or integrated) and the conservation importance of the natural population. For a population of high conservation importance their guidelines are a pHOS of no greater than 5% for isolated programs or a pHOS no greater than 30% and PNI of at least 67% for integrated programs (HSRG 2009). The HSRG concedes that higher levels of hatchery influence are acceptable, however, when a population is at high risk or very high risk of extinction due to low abundance and the hatchery program is being used to conserve the population and reduce extinction risk, in the short-term. HSRG (2004) offered additional guidance regarding isolated programs, stating that genetic 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.

Another HSRG team recently reviewed California hatchery programs and developed guidelines that differed considerably from those developed by the earlier group (California HSRG 2012). The California HSRG felt that truly isolated programs in which no hatchery-origin returnees interact genetically with natural populations were impossible in California, and was “generally unsupportive” of the concept. However, if programs were to be managed as isolated, they recommend a pHOS of less than 5%. They 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 natural-origin 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 hatchery- and natural-origin fish, and societal values, such as angling opportunity”. They 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% in most cases, although in supplementation or reintroduction programs the acceptable pHOS could be much higher than 5%, even approaching 100% at times. They also recommended for conservation programs that pNOB approach 100%, but pNOB levels should not be so high they pose ecological risk to the natural population.

Discussions involving pHOS can be problematic due to variation in its definition. Most commonly the term pHOS refers to the proportion of the total natural spawning population consisting of hatchery fish, and the term has been used in this way in all NMFS documents. However, the HSRG has defined pHOS inconsistently in its Columbia Basin system report, equating it with “the proportion of the natural spawning population that is made up of hatchery fish” in the Conclusion, Principles and Recommendations section (HSRG 2009), but with “the proportion of *effective* hatchery origin spawners” in their gene flow criteria. In addition, in their Analytical Methods and Information Sources section (HSRG 2009, appendix C) they introduce a new term, *effective pHOS*. Despite these inconsistencies, their overall usage of pHOS indicates an intent to use pHOS as a surrogate measure of gene flow potential. This is demonstrated very well in the fitness effects appendix (HSRG 2009, appendix A1), in which pHOS is substituted for a gene flow variable in the equations used to develop the criteria. NMFS concludes that if pHOS guidelines are used in analysis of hatchery effects then the pHOS metric should, as much as possible, represent gene flow potential. Therefore pHOS should be considered the *effective* proportion of hatchery-origin fish in the natural spawning population that successfully spawned.

Thus, the “census” pHOS should be adjusted as appropriate for RRS or other factors limiting the success of hatchery-origin spawners to yield a value closer to the true expected gene flow, or “effective pHOS”. This adjustment should not be done indiscriminately, however. As discussed above, enough research has been done to conclude that hatchery-origin spawners are generally less successful in the wild than natural spawners, but unless population-specific information is available, assumptions about effectiveness should be conservative.

A simple analysis of the expected proportions of mating types provides additional perspective on pHOS. Figure B-1 shows the expected proportion of mating types in a mixed population of natural-origin (N) and hatchery-origin (H) fish as a function of the census pHOS, assuming that N and H adults mate randomly[9]. For example, the vertical line on the diagram marks the situation at a census pHOS level of 10%. At this level, expectations are that 81% of the matings will be NxN, 18% will be NxH, and 1% will be HxH. This diagram can also be interpreted as probability of parentage of naturally produced progeny, assuming random mating and equal reproductive success of all mating types. Under this interpretation, progeny produced by a parental group with a pHOS level of 10% will have an 81% chance of having two natural-origin parents, etc.

Random mating assumes that the natural-origin and hatchery-origin spawners overlap completely spatially and temporally. As overlap decreases, the proportion of NxH matings decreases and with no overlap the proportion of NxN matings is (1-pHOS) and the proportion of HxH matings is pHOS. RRS does not affect the mating type proportions directly, but changes their effective proportions. Overlap and RRS can be related. For example, in the Wenatchee River, hatchery spring Chinook salmon tend to spawn lower in the system than natural-origin fish, and this accounts for a considerable amount of their lowered reproductive success (Williamson et al. 2010). In that particular situation the hatchery-origin fish were spawning in inferior habitat.

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[9] These computations are purely theoretical, based on a simple mathematical binomial expansion ((a+b)2=a2 + 2ab + b2).

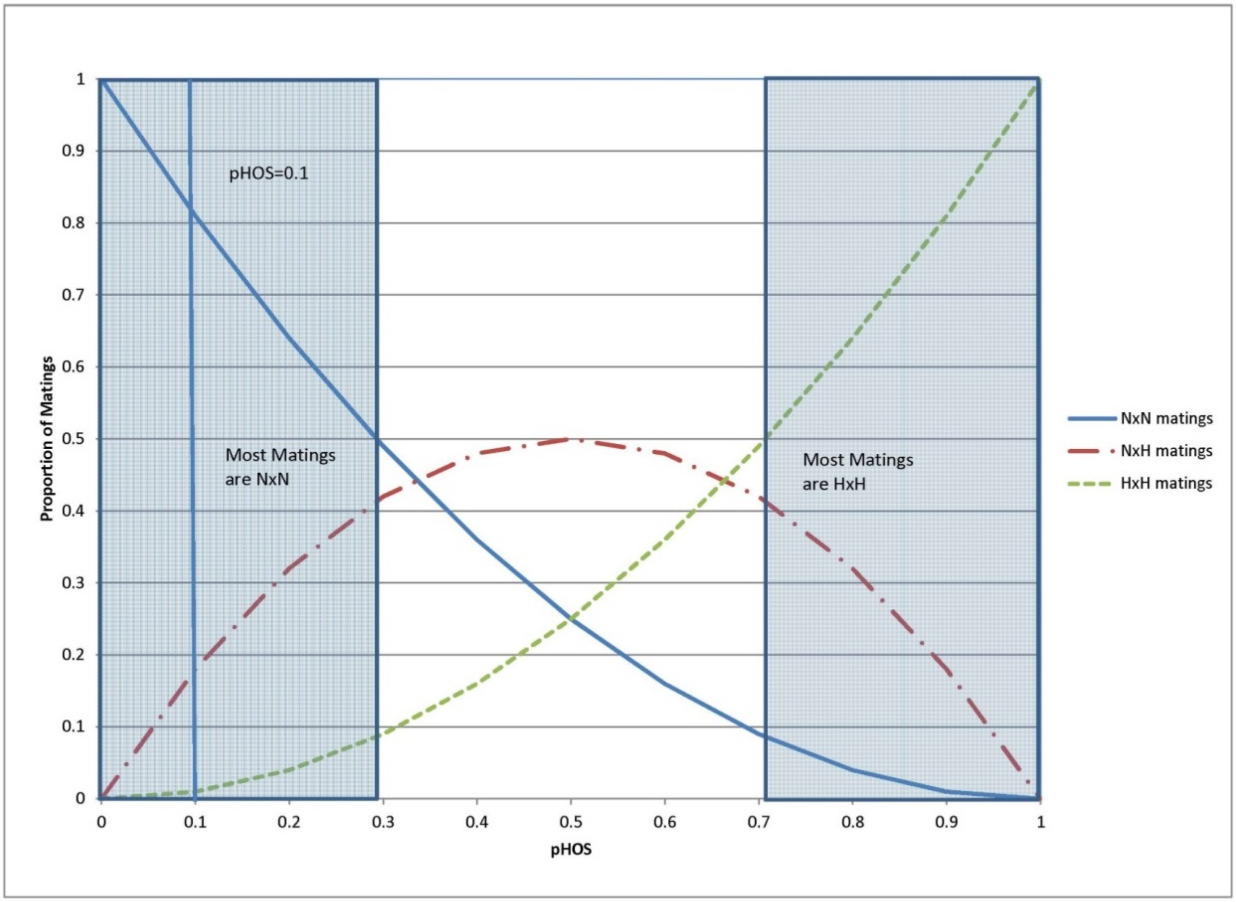

Figure B-1. Relative proportions of types of matings as a function of proportion of hatchery-origin fish on the spawning grounds (pHOS) (NxN – natural-origin x natural-origin; NxH – natural-origin x hatchery; HXH – hatchery x hatchery).

Acclimation

One factor the 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 (2008) and Keefer and Caudill (2013) provide extensive literature reviews regarding homing in Pacific Salmon and Steelhead. 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 or olfactory stimuli to which the juvenile salmonids were exposed while living in the stream and migrating from it years earlier (Dittman and Quinn 2008; Keefer and Caudill 2013). Fisheries managers use this innate ability for salmon and steelhead to home to specific streams when using acclimation ponds to support the reintroduction of species into newly accessible habitat or into areas where they have been extirpated as well as a way to provide for local fisheries (Dunnigan 2000; Quinn 1997; YKFP 2008).

Having 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. By having the hatchery fish home to a particular location, those fish can be removed (e.g., through fisheries, at a hatchery facility, or by the use of a weir) or they can be isolated from primary spawning areas. Factors that can affect the success of this measure include the timing of the acclimation, such that a majority of the hatchery juveniles are going through the parr-smolt transformation during acclimation; whether the water source is unique enough to attract returning adults; whether or not the hatchery fish can access the stream reach where they were released; and whether the water quantity and quality is such that returning hatchery fish will hold in that area prior to their removal and/or harvest in fisheries.

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 (Gresh et al. 2000; Kline et al. 1990; Larkin and Slaney 1996; Murota 2003; Piorkowski 1995; Quamme and Slaney 2003; Wipfli et al. 2003). As a result, the growth and survival of juvenile salmonids may increase (Bell 2001; Bilton et al. 1982; Bradford et al. 2000; Brakensiek 2002; Hager and Noble 1976; Hartman and Scrivener 1990; Holtby 1988; Johnston et al. 1990; Larkin and Slaney 1996; Quinn and Peterson 1996; Ward and Slaney 1988a).

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 in that to the extent there is spatial overlap between hatchery and natural 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).

The analysis also considers the effects from encounters with natural-origin fish that are incidental to the conduct of 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 volunteering into the hatchery itself, typically into a ladder and holding pond, while others sort through the run at large, usually at a weir, ladder, or sampling facility. Generally speaking, 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-origin and hatchery-origin fish that are intended to spawn naturally and to 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 in-stream and adjacent, volitional-entry structures, either temporary or permanent, that are used to collect hatchery broodstock. NMFS analyzes effects on fish, juveniles and adults, from encounters with these structures and effects on habitat conditions that support and promote viable salmonid populations. NMFS wants to know, for example, if 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. NMFS also analyzes changes to riparian habitat, channel morphology and habitat complexity, water flows, and in-stream substrates attributable to the construction/installation, operation, and maintenance of these structures. NMFS also analyzes the effects of structures, either temporary or permanent, that are used to remove hatchery fish from the river or stream and prevent them from spawning naturally, effects on fish, juveniles and adults, from encounters with these structures and effects on habitat conditions that support and promote viable salmonid populations.

6.1.3. Factor 3. Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas, migration corridor, estuary, and ocean

NMFS also analyzes the potential for competition, predation, and premature emigration when the progeny of naturally spawning hatchery fish and hatchery releases share juvenile rearing areas. The effect of this factor ranges from negligible to negative.

Generally speaking, 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 (SIWG 1984). Naturally produced fish may be competitively displaced by hatchery fish early in life, especially when hatchery fish are more numerous, are of equal or greater size, when hatchery fish take up residency before naturally produced fry emerge from redds, and if hatchery fish residualize, meaning they fail to out-migrate as smolts as intended. Hatchery fish might alter naturally produced salmon behavioral patterns and habitat use, making them more susceptible to predators (Hillman and Mullan 1989; Steward and Bjornn 1990). Hatchery-origin fish may also alter naturally produced salmonid migratory responses or movement patterns, leading to a decrease in foraging success (Hillman and Mullan 1989; Steward and Bjornn 1990). Actual impacts on naturally produced fish would 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).

Competition may result from direct interactions, or through indirect means, as when utilization of a limited resource by hatchery fish reduces the amount available for naturally produced fish (SIWG 1984). Specific hazards associated with competitive impacts of hatchery salmonids on listed naturally produced salmonids may include competition for food and rearing sites (NMFS 2012a). In an assessment of the potential ecological impacts of hatchery fish production on naturally produced salmonids, the Species Interaction Work Group (SIWG 1984) concluded that naturally produced coho and Chinook salmon and steelhead are all potentially at "high risk" due to competition (both interspecific and intraspecific) from hatchery fish of any of these three species. In contrast, the risk to naturally produced pink, chum, and sockeye salmon due to competition from hatchery salmon and steelhead was judged to be low.

Several factors influence the risk of competition posed by hatchery releases: whether competition is intra- or interspecific; the duration of freshwater 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). Intraspecific competition would be expected to be greater than interspecific, and competition would be expected to increase with prolonged freshwater co-occurrence. Although newly released hatchery smolts are commonly larger than natural-origin fish, and larger fish usually are superior competitors, natural-origin fish have the competitive advantage of prior residence when defending territories and resources in shared natural freshwater habitat. Tatara and Berejikian (2012) further reported that hatchery-influenced developmental differences from co-occurring natural-origin fish life stages are variable and can favor both hatchery- and natural-origin fish. They concluded that of all factors, fish density of the composite population in relation to habitat carrying capacity likely exerts the greatest influence.

En masse hatchery salmon smolt releases may cause displacement of rearing naturally produced juvenile salmonids from occupied stream areas, leading to abandonment of advantageous feeding stations, or premature out-migration (Pearsons et al. 1994). Pearsons et al. (1994) reported small-scale displacement of juvenile natural-origin rainbow trout from stream sections by hatchery steelhead. Small-scale displacements and agonistic interactions observed between hatchery steelhead and naturally produced juvenile trout were most likely a result of size differences and not something inherently different about hatchery fish.

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. They also may prey on younger, smaller-sized juvenile salmonids. 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 from residual Chinook and coho hatchery salmon on naturally produced salmonids is definitely a consideration, especially given that the number of smolts per release is generally higher; 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.

The risk of adverse competitive interactions between hatchery-origin 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 naturally produced fish in freshwater (California HSRG 2012; Steward and Bjornn 1990).

- Operating hatcheries such that hatchery fish are reared to sufficient size 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 timing if substantial competition with naturally rearing juveniles is determined likely.

Critical to analyzing competition risk is information on the quality and quantity of spawning and rearing habitat in the action area,[10] 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.

Another potential ecological effect of hatchery releases is predation. Salmon and steelhead are piscivorous and can prey on other salmon and steelhead. Predation, either direct (direct consumption) or indirect (increases in predation by other predator species due to enhanced attraction), can result from hatchery fish released into the wild. Considered here is predation by hatchery-origin fish and by the progeny of naturally spawning hatchery fish and by avian and other 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, so they are more likely to emigrate quickly to the ocean, can 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 (residuals) where they can prey on stream-rearing juveniles over a more prolonged period. The progeny of naturally spawning hatchery fish also can prey on fish from a natural population and pose a threat. In general, the threat from predation is greatest when natural populations of salmon and steelhead are at low abundance and when spatial structure is already reduced, when habitat, particularly refuge habitat, is limited, and when environmental conditions favor high visibility.

SIWG (1984) rated most risks associated with predation as unknown, because there was relatively little documentation in the literature of predation interactions in either freshwater or marine areas. More studies are now available, but they are still too sparse to allow many generalizations to be made about risk. Newly released hatchery-origin yearling salmon and steelhead may prey on juvenile fall Chinook and steelhead, and other juvenile salmon in the freshwater and marine environments (Hargreaves and LeBrasseur 1986; Hawkins and Tipping 1999; Pearsons and Fritts 1999). Low predation rates have been reported for released steelhead juveniles (Hawkins and Tipping 1999; Naman and Sharpe 2012). Hatchery steelhead timing and

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[10] "Action area" 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.

release protocols used widely in the Pacific Northwest were shown to be associated with negligible predation by migrating hatchery steelhead on fall Chinook fry, which had already emigrated or had grown large enough to reduce or eliminate their susceptibility to predation when hatchery steelhead entered the rivers (Sharpe et al. 2008). Hawkins (1998) documented hatchery spring Chinook salmon yearling predation on naturally produced fall Chinook salmon juveniles in the Lewis River. Predation on smaller Chinook salmon was found to be much higher in naturally produced smolts (coho salmon and cutthroat, predominately) than their hatchery counterparts.

Predation may be greatest when large numbers of hatchery smolts encounter newly emerged fry or fingerlings, or when hatchery fish are large relative to naturally produced fish (SIWG 1984). Due to their location in the stream or river, size, and time of emergence, newly emerged salmonid fry are likely to be the most vulnerable to predation. Their vulnerability is believed to be greatest immediately upon emergence from the gravel and then their vulnerability decreases as they move into shallow, shoreline areas (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 up to 1/2 their length (HSRG 2004; Pearsons and Fritts 1999) but other studies have concluded that salmonid predators prey on fish 1/3 or less their length (Beauchamp 1990; Cannamela 1992; CBFWA 1996; Hillman and Mullan 1989; Horner 1978). Hatchery fish may also be less efficient predators as compared to their natural-origin conspecifics, reducing the potential for predation impacts (Bachman 1984; Olla et al. 1998; Sosiak et al. 1979).

There are several steps that hatchery programs can implement to reduce or avoid the threat of predation:

- Releasing all hatchery fish as actively migrating smolts through volitional release practices so that the fish migrate quickly seaward, limiting the duration of interaction with any co-occurring natural-origin fish downstream of the release site.
- Ensuring that a high proportion of the population have physiologically achieved full smolt status. Juvenile salmon tend to migrate seaward rapidly when fully smolted, limiting the duration of interaction between hatchery fish and naturally produced 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.
- Operating hatchery programs and releases to minimize the potential for residualism.

Based on a review of the scientific literature, NMFS's conclusion is that the influence of density-dependent interactions on the growth and survival of salmon and steelhead is likely small compared with the effects of large-scale and regional environmental conditions and, while there is evidence that large-scale hatchery production can effect salmon survival at sea, the degree of effect or level of influence is not yet well understood or predictable. The same thing is true for main stem rivers and estuaries. NMFS will watch for new research to discern and to measure the frequency, the intensity, and the resulting effect of density-dependent interactions between hatchery and natural-origin fish. In the meantime, NMFS will monitor emerging science and information and will consider that re-initiation of Section 7 consultation is required in the event that new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not considered in this consultation (50 CFR 402.16).

6.1.4. Factor 4. Research, monitoring, and evaluation that exists because of the hatchery program

Generally speaking, negative effects on the fish from RM&E are weighed against the value or benefit of new information, particularly information that tests key assumptions and that reduces critical uncertainties. RM&E actions including but not limited to collection and handling (purposeful or inadvertent), holding the fish in captivity, sampling (e.g., the removal of scales and tissues), tagging and fin-clipping, and observation (in-water or from the bank) can cause harmful changes in behavior and reduced survival. These effects should not be confused with handling effects analyzed under broodstock collection. In addition, NMFS also considers the overall effectiveness of the RM&E program. There are five factors that NMFS takes into account when it assesses the beneficial and negative effects of hatchery RM&E: (1) the status of the affected species and effects of the proposed RM&E on the species and on designated critical habitat, (2) critical uncertainties over effects of the proposed action on the species, (3) performance monitoring and determining the effectiveness of the hatchery program at achieving its goals and objectives, (4) identifying and quantifying collateral effects, and (5) tracking compliance of the hatchery program with the terms and conditions for implementing the program. After assessing the proposed hatchery RM&E and before it makes any recommendations to the action agencies, 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.

Hatchery actions also must be assessed for masking effects. For these purposes, masking is when hatchery fish included in the proposed action mix with and are not identifiable from other fish. The effect of masking is that it 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. 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.

6.1.5. 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. It 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 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. The effect of this factor ranges from negligible to negative.

6.1.6. Factor 6. Fisheries that exist because of the hatchery program

There are two aspects of fisheries that are potentially relevant to NMFS' analysis of HGMP effects in a Section 7 consultation. One is where there are fisheries that exist because of the HGMP (i.e., the fishery is an interrelated and interdependent action) and listed species are inadvertently and incidentally taken in those fisheries. The other is when fisheries are used as a tool to prevent the hatchery fish associated with the HGMP, including hatchery fish included in an ESA-listed ESU or steelhead DPS from spawning naturally. The effect of this factor ranges from negligible to negative.

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