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

Snake River Fall-run Chinook Salmon Hatchery Programs, ESA section 10(a)(1)(A) permits, numbers 16607–3R and 16615–3R

NMFS Consultation Number: WCRO-2025-00524

Action Agency: National Marine Fisheries Service (for issuance of permits)
U.S. Fish and Wildlife Service (USFWS)
Bonneville Power Administration (BPA)

Program Operator: Washington Department of Fish and Wildlife (WDFW)
Nez Perce Tribe (NPT)
Oregon Department of Fish and Wildlife (ODFW)
Idaho Power Company (IPC)

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is the Action Likely to Adversely Affect Species	If likely to adversely affect, Is the Action Likely to Jeopardize the Species?	Is the Action Likely to Adversely Affect Critical habitat?	If likely to adversely affect, Is the Action Likely to Destroy or Adversely Modify Critical Habitat?
Snake River fall-run Chinook salmon (*Oncorhynchus tshawytscha*)	Threatened	Yes	No	No	No
Snake River spring/summer-run Chinook salmon (*Oncorhynchus tshawytscha*)	Threatened	Yes	No	No	No
Snake River sockeye salmon (*O. nerka*)	Endangered	Yes	No	No	No
Snake River steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Southern Resident Killer Whale (*Orcinus orca*)	Threatened	No	No	No	No

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

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

Issued By:

Ryan J. Wulff

Assistant Regional Administrator

Date: May 27, 2025

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1. INTRODUCTION

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

The underlying activities that drive the Proposed Actions are the operation and maintenance (O&M) and monitoring and evaluation (M&E) of four hatchery programs rearing and releasing ESA-listed Snake River fall-run Chinook salmon in the Snake River basin. The hatchery programs are operated by Federal, state, and/or Tribal agencies and funded by Federal agencies and private power companies as described in Table 1. This Proposed Action specifically addresses changes in the O&M and M&E of Lyons Ferry Hatchery (LFH), Fall Chinook Acclimation Project (FCAP), Nez Perce Tribal Hatchery (NPTH), and Idaho Power Company (IPC) hatchery programs rearing and releasing Snake River fall-run Chinook salmon (SRCHF) in the Snake River Basin as outlined in their respective Hatchery and Genetic Management Plans (HGMPs) and co-manager submitted Addendum. Programs are described in detail in these HGMPs (NPT 2011; Washington Department of Fish and Wildlife et al. 2011), which were originally submitted to NMFS for review in 2011 and later updated in supplementary material in the form of Addendums (NPT et al. 2018). Program locations are described in Figure 1.

Table 1. Programs included in the Proposed Action and ESA coverage pathway requested.

Program	HGMP/addendum Receipt[1]	Program Operator[2]	Funding Agency	Program Type and Purpose
Snake River Stock Fall Chinook salmon Lyons Ferry Hatchery (LFH)	May 28, 2024	WDFW	LSRCP[3]	Integrated Recovery
Fall Chinook Acclimation Project (FCAP)		NPT	LSRCP[4]	Integrated Recovery
Snake River Stock Fall Chinook salmon Nez Perce Tribal Hatchery (NPTH)		NPT	BPA	Integrated Recovery
Snake River Stock Fall Chinook salmon Idaho Power Company (IPC)		WDFW and ODFW	IPC	Integrated Recovery

[1]Most recent HGMP or addendum receipt (NPT et al. 2024) All HGMP or addendums were previously submitted in April 2018 (NPT et al. 2018) and May of 2011 (NPT 2011; Washington Department of Fish and Wildlife et al. 2011)

[2]Primary hatchery operators are listed in the table, but all programs are coordinated between States, Tribes, and Federal agencies collectively. These entities include: Washington Department of Fish and Wildlife (WDFW), Nez Perce Tribe (NPT), Confederated Tribes of the Umatilla Indian Reservation (CTUIR), Idaho Fish and Game (IDFG), Oregon Department of Fish and Wildlife (ODFW), United States Fish and Wildlife Service (USFWS), Bonneville Power Administration (BPA), and Idaho Power Company (IPC).

[3]The United States Fish and Wildlife Service (USFWS) is the funding agency through the Lower Snake River Compensation Plan (LSRCP)

[4] BPA funded FCAP O&M and M&E until 2019. O&M funding for the FCAP facilities and assets were transferred to LSRCP in 2019. Funding for Snake River fall-run Chinook salmon Monitoring and Evaluation (M&E) and marking and tagging comes from multiple sources, including but not limited to BPA, LSRCP, and IPC. Apportionment of M&E funding in 2019 will be consistent with recent allocation; future M&E funding apportionment would be addressed in accordance with Section 2.9.3 Terms and Conditions.

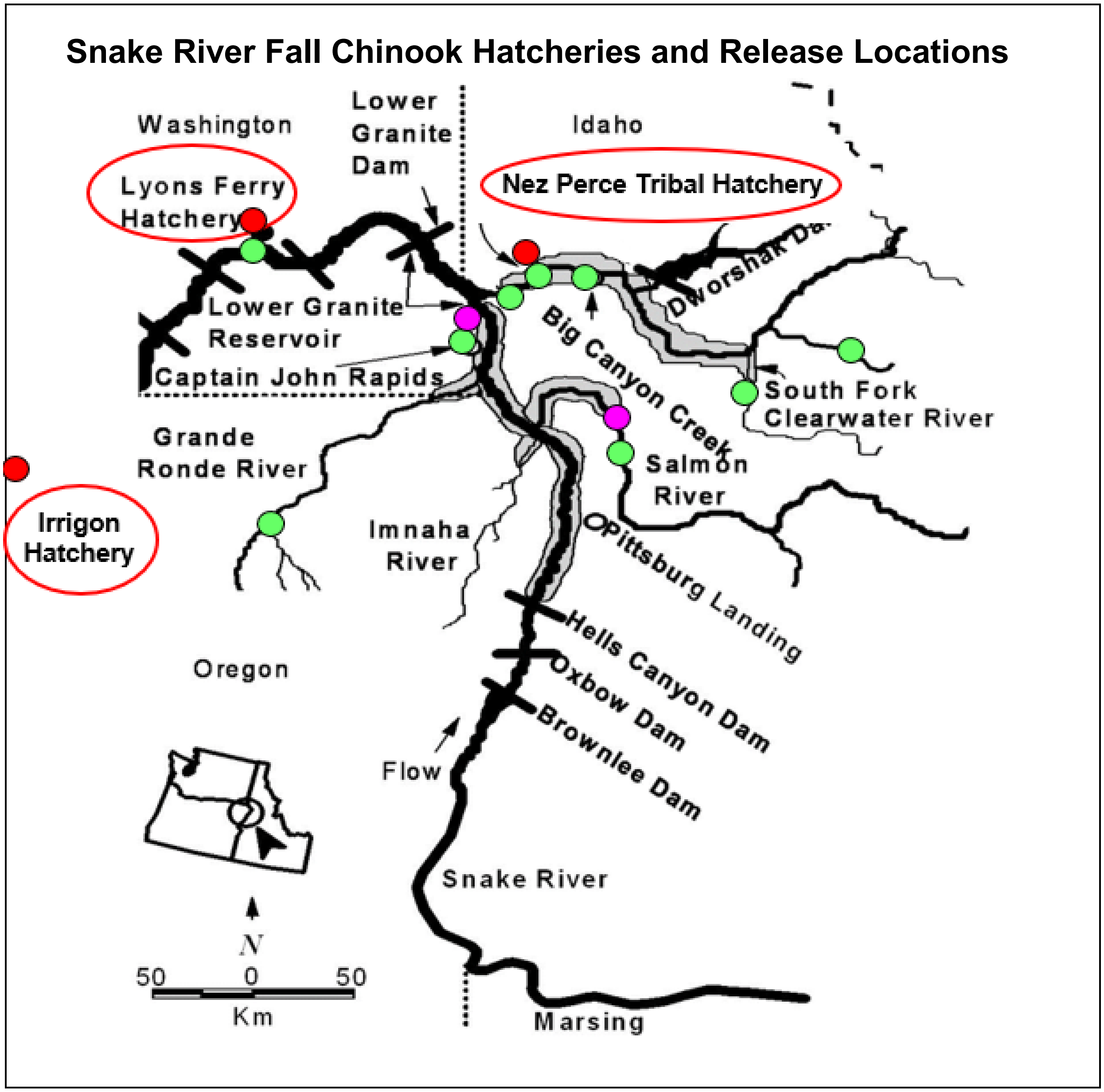

Figure 1. Hatchery facilities (Red dot = main hatchery facility, Green dot = acclimation facility/acclimated release, Purple dot = direct stream release) in the Snake Basin included in the Proposed Action.

This Biological Opinion evaluates NMFS' proposed issuance of two ten-year section 10(a)(1)(A) permit actions that may affect Snake River fall-run Chinook salmon, Snake River spring/summer-run Chinook salmon, Snake River sockeye salmon, and Snake River steelhead. The permits will allow operation of four interrelated hatchery programs that release ESA-listed Snake River fall-run Chinook salmon and associated monitoring and evaluation programs, as described in the application documents, which consist of two hatchery and genetic management plans (NPT 2011; Washington Department of Fish and Wildlife et al. 2011) and an Addendum (NPT et al. 2018) submitted on April 10, 2018. This Biological Opinion supersedes the previous

Snake River Chinook Salmon Hatchery Programs Biological Opinion (NMFS 2012d) and accompanying section 10(a)(1)(A) permits (numbers 16607 and 16615) (NMFS 2012b; 2012a). This Biological Opinion was prepared by the NOAA's National Marine Fisheries Service (NMFS) in accordance with section 7(b) of the Endangered Species Act (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 federal action agencies: NMFS (issuing the Section 10(a)(1)(A) permits), the United States Fish and Wildlife Service (USFWS) (funding), and Bonneville Power Administration (BPA) (funding).

1.1. Background

The National Marine Fisheries Service (NMFS) prepared the biological opinion (opinion) and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531, et seq.), as amended, and implementing regulations at 50 CFR part 402.

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

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (DQA) (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available within 2 weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. A complete record of this consultation is on file with the Sustainable Fisheries Division 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 ESA. Snake River sockeye salmon were listed as an endangered species on November 20, 1991, Snake River spring/summer-run Chinook salmon and Snake River fall-run Chinook salmon were listed as threatened species on April 22, 1992, and the first hatchery consultation and opinion was completed on April 7, 1994 (NMFS 1994; 2008b). 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 at that time jeopardized 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 percent of the annual natural population in the receiving stream. Soon after, NMFS reinitiated consultation when LCR Chinook salmon, UCR spring-run 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).

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 FWS 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 2008b)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" (NMFS 2008b, 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 2008). NMFS also "promised to share key considerations in analyzing HGMPs" and provided those materials to interested parties in February 2009 (Jones 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 Endangered Species Act (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…."

NMFS issued a Biological Opinion and ESA section 10(a)(1)(A) permits #16607 and #16615 on October 9, 2012 for the Snake River fall-run Chinook salmon programs described by co-managers in HGMPs (NPT 2011; WDFW et al. 2011) and a supplemental Addendum (WDFW and NPT 2011) submitted to NMFS July 18, 2011. These Section 10 permits expired December 31, 2017. NMFS began pre-consultation discussions on the Snake River fall-run Chinook salmon hatchery programs with the co-managers and interested parties including the Washington Department of Fish and Wildlife (WDFW), the Nez Perce Tribe (NPT), Idaho Department of Fish and Game (IDFG), Oregon Department of Fish and Wildlife (ODFW), United States Fish and Wildlife Service (USFWS), and the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) in May of 2017 during the renegotiations for the *U.S. v. Oregon* Management Agreement. After the new *U.S. v. Oregon* Management Agreement negotiations and Biological Opinion (NMFS et al. 2018) were completed, Bonneville Power Administration (BPA) was invited to attend monthly coordination meetings to participate in pre-consultation discussions. Co-managers organized a *Snake River Fall Chinook Symposium* that took place on May 16th-17th (USFWS 2017). Symposium presentations reviewed research, monitoring, and evaluation results over the length of the previous Biological Opinion and associated permits (NMFS 2012d). Refer to Section 1.3.6 for additional information on this symposium. NMFS received a new Addendum (NPT et al. 2018) to the previous HGMPs (NPT 2011; Washington Department of Fish and Wildlife et al. 2011) submitted on April 10, 2018 for the four Snake River fall-run Chinook salmon programs: Lyons Ferry, Idaho Power Company, Nez Perce Tribal Hatchery, and Fall Chinook Acclimation Program (FCAP) hatchery programs on April 10, 2018. This Addendum was edited by NMFS before final submission, and edits were given back to the principal operators in an email dated April 5, 2018. NMFS accepted the Addendum on May 29, 2018 during our monthly coordination call. The applications were made available for a 30-day public comment period on June 4, 2018 (76FR43986), which was closed on July 5, 2018. NMFS issued the new Biological Opinion and updated ESA section 10(a)(1)(A) permits #16607-2R and #16615-2R on August 13th, 2018 with the permits set to expire in 2027.

An important development since the 2012 consultation was the completion of the Snake River fall-run Chinook salmon recovery plan (NMFS 2017f). This recovery plan outlines the following three potential recovery scenarios: (Scenario A) Achieve highly viable status for the extant Lower Snake River population and viable status for the currently extirpated Middle Snake River population; (Scenario B) Achieve highly viable status for Lower Snake River population; and (Scenario C) Achieve highly viable status for Lower Snake River population with the creation of a Natural Production Emphasis Area (NPEA). Creating an NPEA under Scenario C addresses genetic risks to the population in an innovative way. An NPEA is a region of greatly reduced hatchery influence relative to other spawning areas. Updated homing fidelity information from the *Snake River Fall Chinook Symposium* (USFWS 2017) has informed the preliminary feasibility of the NPEA, and such a scenario may be possible with the reprogramming of the IPC Hells Canyon releases to the Salmon River in the 2018 consultation. Taking this a step further, the 2025 Proposed Action proposes to move the Fall Chinook Acclimation Project (FCAP) to the Pittsburg Landing Acclimation (PLA) and release site from the Snake River to the Salmon River as well as shifting the Grande Ronde River release from a direct stream release near Cougar Creek (WA) to an acclimatized release at Big Canyon Acclimation Facility on Deer Creek in the Grand Ronde sub-basin. Even though these releases were relocated to increase survival rates for that component of the program, an ancillary benefit may be an opportunity to evaluate the concept of an NPEA. The Snake River Fall-run Chinook Salmon Hatchery program also converts all remaining yearling releases (Lyon's Ferry) to subyearling (Section 1.3).

In 2022, the hatchery co-managers approached NMFS to start the re-consultation process. On May 28th 2024, the hatchery co-managers submitted the proposed action for re-consultation.

Updates to the regulations governing interagency consultation (50 CFR part 402) were effective on May 6, 2024 (89 Fed. Reg. 24268). We are applying the updated regulations to this consultation. The 2024 regulatory changes, like those from 2019, were intended to improve and clarify the consultation process, and, with one exception from 2024 (offsetting reasonable and prudent measures), were not intended to result in changes to the Services' existing practice in implementing section 7(a)(2) of the Act. 89 Fed. Reg. at 24268; 84 Fed. Reg. at 45015. We have considered the prior rules and affirm that the substantive analysis and conclusions articulated in this biological opinion and incidental take statement would not have been any different under the 2019 regulations or pre-2019 regulations. If an incidental take statement relies upon the 2024 regulations and includes one or more offsetting RPMs, then the above paragraph should be modified to acknowledge the inclusion of such measures by adding this clause to the end of the sentence: "except we note that we have included offsetting reasonable and prudent measures in the incidental take statement (an option that was not included in the section 7 regulations prior to 2024)."

1.3. PROPOSED FEDERAL 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 (see 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. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration.

There are three Proposed Federal Actions we are considering in this opinion:

- The Proposed Action for Bonneville Power Administration (BPA) is the funding of the operation and maintenance (O&M) and monitoring and evaluation (M&E) of the NPT hatchery program and M&E of the FCAP program[1] to support efforts to mitigate for effects of the development and operation of the Federal Columbia River Power System (FCRPS) on fish and wildlife in the mainstem Columbia River and its tributaries, under the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (Northwest Power Act) (16 USC section 839b(h)(10)(A)).

- The Proposed Action for the United States Fish and Wildlife Service (USFWS) is the funding of the O&M and M&E of the Lyons Ferry and Irrigon Fish Hatcheries (and associated facilities) and O&M of the FCAP program[1] through the Lower Snake River Compensation Plan (LSRCP), which is approved by the Water Resources Development Act of 1976, (Public Law 94-587, Section 102, 94th Congress) to offset losses of anadromous fish in the Snake River Basin caused by the four dam and navigation lock projects in the Lower Snake River.
- The Proposed Action for NMFS is the issuance of two section 10(a)(1)(A) permits for the Snake River Stock Fall-run Chinook salmon Nez Perce Tribal Hatchery (permit #16615-3R) and the FCAP/WDFW Lyons Ferry/ODFW/Idaho Power Company Hatchery (permit #16607-3R) programs. NMFS' issuance of the 10(a)(1)(A) permits would allow the operation of hatchery-related activities for these programs.

At the heart of these actions is the continued operation of the proposed Snake River fall-run Chinook salmon hatchery programs, whose purpose is to increase the viability of the natural population and to provide returning adult fish for harvest. The four hatchery programs described in this document use exclusively individual Chinook salmon from the ESA-listed Snake River fall-run Chinook ESU as broodstock, making these all integrated programs. The programs are funded as mitigation for losses of salmon caused by the construction and operation of the Federal Lower Snake dams and mainstem Columbia dams and by the construction and operation of the Hells Canyon Complex dams owned and operated by the IPC. The hatchery production from these programs is intended to be consistent with the ESA Recovery Plan for the Snake River Fall-Run Chinook Salmon Evolutionarily Significant Unit (ESU) (NMFS 2017f) and operate in agreement with the *U.S. v. Oregon* Management Agreement (Parties to *U.S. v. Oregon* 2018). As previously described, the three potential recovery scenarios included in this recovery plan are: (Scenario A) Achieve highly viable status for the extant Lower Snake River population and viable status for the currently extirpated Middle Snake River population; (Scenario B) Achieve highly viable status for Lower Snake River population; and (Scenario C) Achieve highly viable status for Lower Snake River population with the creation of a Natural Production Emphasis Area (NPEA).

This Proposed Action specifically addresses changes in the O&M and M&E of Lyons Ferry Hatchery, FCAP, Nez Perce Tribal Hatchery, and IPC hatchery programs rearing and releasing Snake River fall-run Chinook salmon in the Snake River Basin as outlined in their respective HGMPs (NPT 2011; Washington Department of Fish and Wildlife et al. 2011) and associated Addendum (NPT et al. 2024). These programs were previously consulted on with NMFS

[1] BPA funded FCAP O&M and M&E until 2019. O&M funding for the FCAP facilities and assets were transferred to LSRCP in 2019. Funding for Snake River fall-run Chinook salmon Monitoring and Evaluation (M&E) and marking and tagging comes from multiple sources, including but not limited to BPA, LSRCP, and IPC. Apportionment of M&E funding in 2019 will be consistent with recent allocation; future M&E funding apportionment would be addressed in accordance with Section 2.9.3 Terms and Conditions.

(Consultation WCR-2018-9988) and USFWS (Consultation 01EIFW00-2018-TA-1558) resulting in ESA section 10(a)(1)(A) permits #16607-2R and #16615-2R. See Table 2 for a summary list of proposed changes (below) to these hatchery programs compared to the *U.S. v. Oregon* Biological Opinion (NMFS et al. 2018) and previous 2018 Biological Opinion (NMFS 2018e). The priority of the release group listed in Table 2 is based on performance of adult returns and harvest contribution.

Table 2. Past (*U.S. v. Oregon Agreement (2018-2027) Biological* Opinion) and Proposed Action releases from production originating from LFH, Irrigon FH or NPTH.

Lyons Ferry, Irrigon, Fall-run Chinook Acclimation Project Hatchery Production										
Priority	**Production Program 2018-2027 *U.S. v. Oregon* Management Agreement**					**Proposed Program**[1]				
	Rearing Facility	**Release Number**	**Age**	**Release Location**	**Marking**	**Rearing Facility**	**Release Number**	**Age**	**Release Location**	**Marking** [2]
1	Lyons Ferry	450,000	1+	On Station	450K AdCWT	Lyons Ferry	500,000	0+	On Station	500K AdCWT
2	Lyons Ferry	450,000	0+	Captain John Rapids	200K AdCWT 250K no clip	Lyons Ferry	450,000	0+	Captain John Rapids 1	100K AdCWT, 350K no clip
3	Lyons Ferry	450,000	0+	Big Canyon	200K AdCWT 250K no clip	Lyons Ferry	450,000	0+	Big Canyon 1	100K AdCWT, 350K no clip
4	Lyons Ferry	500,000	0+	On Station	200K AdCWT 300K no clip	Lyons Ferry	500,000	0+	On Station	500K Ad only
5	Lyons Ferry	400,000	0+	Pittsburg Landing	200K AdCWT 200K no clip	Lyons Ferry	400,000	0+	Pittsburg Landing OR Salmon River @ Russell Bar 1	100K AdCWT, 300K no clip
6	Lyons Ferry	200,000	0+	Captain John Rapids 2	200K AdCWT	Lyons Ferry	200,000	0+	Captain John Rapids 2	100K AdCWT; 100k no clip
7	Lyons Ferry	200,000	0+	Big Canyon 2	200K AdCWT	Lyons Ferry	400,000	0+	Big Canyon 2	100K AdCWT, 300K no clip
8	Lyons Ferry	200,000	0+	Pittsburg Landing 2	200K AdCWT	Lyons Ferry	200,000	0+	Pittsburg Landing 2 OR Salmon River @ Russell Bar 2	100K AdCWT; 100k no clip
9	Irrigon	1,000,000	0+	Salmon River (Hammer Creek)	200K AdCWT 800K no clip	Irrigon	1,000,000	0+	Salmon River (Hammer Creek)	100K AdCWT, 100k Ad; 800K no clip
10	Irrigon	200,000	0+	Grande Ronde	200K AdCWT	Irrigon	500,000	0+	Grande Ronde (Big Canyon)	100K AdCWT, 400K Ad only
11	Lyons Ferry	200,000 [2]	0+	On Station	200K no clip	Lyons Ferry	200,000 [3]	0+	On Station	200K Ad only
12						Irrigon	600,000	0+	Couse Creek (Snake)	100K AdCWT, 250K Ad only, 250K noclip
Total		4,250,000					5,400,000			
Clipped		2,250,000					2,850,000			
Unclipped		2,000,000					2,550,000			
Nez Perce Tribal Hatchery Production										
1	NPTH	500,000	0+	On station	100K AdCWT 400K no clip	NPTH	500,000	0+	On station	100K AdCWT, 400K no clip
2	NPTH	350,000[4]	0+	Luke's Gulch	100K AdCWT 250K no clip	NPTH	350,000[4]	0+	Luke's Gulch	100K AdCWT, 250K no clip
	NPTH	350,000[4]	0+	Cedar Flats	100K AdCWT 250K no clip	NPTH	250,000[4]	0+	Cedar Flats	100K AdCWT, 150K no clip

3	NPTH	200,000[5]	0+	North Lapwai Valley	100K AdCWT 100K no clip	NPTH	300,000[5]	0+	North Lapwai Valley	100K AdCWT, 200K no clip
Total		1,400,000					1,400,000			
Clipped		400,000					400,000			
Unclipped		1,000,000					1,000,000			

[1]Marking strategy may change in the future with a further reduction in CWT rate for groups above Lower Granite Dam (LGR) as PBT replaces CWT recoveries for annual run reconstructions. Additional Ad only groups will replace ADCWT to keep the clip rate the same. A minimum of 500k AdCWT will be maintained at LFH on-station as a Snake River harvest index group
[2]In addition to the standard marking/tagging shown, all release sites and times will be PIT Tagged and all releases will be PBT marked/tagged.
[3]If available, these will be included with Priority #4.
[4]Anticipated release numbers based on capacity (actual release numbers may be less depending on environmental conditions). Fish may alternatively be released on station at NPTH or North Lapwai Valley.
[5] If environmental conditions preclude acclimation at North Lapwai Valley these fish will be released on station at NPTH

The 2018 *U.S. v. Oregon* Management Agreement (and the 2018 Snake River Fall-run Chinook Salmon Biological Opinion) compared to this Proposed Action:

1) Changes at Lyons Ferry Hatchery –

The proposed action would convert remaining yearling releases from Lyons Ferry Hatchery to subyearling production.[2] Because of anticipated lower smolt-to-adult rates from subyearlings compared to yearlings, the total number of subyearling smolts to be released would increase by 1,150,000 individuals over the production approved in 2018. Total subyearling production would be increased from 5.2 million to 6.8 million. Specific proposed changes in release sizes are listed below:

a. Yearling production would be reduced by 450,000 individuals to zero for the LFH program.

b. The on-station release of subyearlings for the LFH program would increase from 700,000 to 1,200,000 individuals, which will be partially reared in one of the large rearing lakes located at LFH.

c. The 2nd release of subyearlings at Big Canyon Acclimation Facility (Big Canyon 2 - FCAP) on the Clearwater River would increase from 200,000 to 400,000.

d. Potential move of the acclimation facility currently located at Pittsburg Landing on the mainstem Snake River to a location on the Salmon River near Russell Bar, approximately 20 miles north of Riggins, ID. Facility operations at this new site would attempt to mimic those previously permitted at the Pittsburg Landing FCAP facility.

2) Changes at Irrigon Fish Hatchery

a. The Grande Ronde River release would increase from 200,000 to 500,000, and the release strategy/site will be changed from a direct stream release near Cougar Creek (WA) into the lower Grande Ronde River to an acclimated release at Big Canyon

[2] As a result, all releases of Snake River fall-run Chinook salmon will be subyearlings – the typical life history of natural-origin fall-run Chinook salmon.

Acclimation Facility on Deer Creek (a tributary to the Wallowa River) in the Grande Ronde subbasin.

b. A direct stream release of 600,000 subyearlings at Couse Creek (Snake River, ~9.5 rkm downstream of the Captain John's Acclimation Facility) would also be added. This is a re-initiation of the fall-run Chinook salmon subyearling release totaling 200,000 that were directly released at Couse Creek from 2005 to 2013.

3) Changes at the Nez Perce Tribal Hatchery

a. The transfer of 100,000 non-clipped fall-run Chinook salmon from the Cedar Flats Acclimation Facility release site to the North Lapwai Valley Acclimation Facility site to improve rearing densities and to reallocate production of those fish.

4) This Proposed Action describes the marking of Snake River fall-run Chinook salmon occurring under a comprehensive mark strategy (all programs). Changes to that strategy beginning in 2025 include:

a. Each release site and group, with the exception of Lyons Ferry hatchery on-station release, would have a representative 100,000 AD/CWT mark. The NPTH production releases would also be represented by 100,000 AD/CWT groups. The NPTH production release groups would be combined into an upper basin (Lukes Gulch and Cedar Flats) and a lower basin (NPTH on station and North Lapwai Valley). All broodstock fish would be genotyped, making all released fish identifiable through parentage-based tagging (PBT). PBT will be the preferred approach toward the evaluation of release groups/strategies.

b. A minimum of 500,000 AD/CWT fish would be released at LFH on-station to maintain the Snake River index group. This is a reduction from 2.25 million pieces of coded wire (current production) to 1.4 million pieces of coded wire. Ocean and Columbia River harvest evaluations for groups released above LGR would be combined to increase tag recoveries and estimate an overall harvest rate.

c. All release groups will be parentage-based tagged (PBT). Systematic PBT sampling of the returns at the Lower Granite Dam (LGR) adult trap would provide age, origin, and hatchery release group data used to complete a run reconstruction. Overall, the CWT tag rate would decline, and the AD clip rate would increase slightly.

The four programs listed in Table 1 and Table 2 are described individually below. Descriptions include the purpose and goals as described in the HGMPs (NPT 2011; Washington Department of Fish and Wildlife et al. 2011) and Addendums (NPT et al. 2018 and 2024). The HGMPs contain a considerable amount of detail on fish cultural methods beyond that presented in this section. Proposed and ongoing basin-wide research, monitoring, and evaluation activities are also described. Because of the complex history of Snake River fall-run Chinook salmon and the interrelatedness of the four programs, the individual program descriptions are preceded by an overview. Unless otherwise indicated, all information in Section 1.3 is from the Addendum (NPT et al. 2024), the Snake River Fall Chinook salmon Lyons Ferry/Idaho Power Company/FCAP HGMP (WDFW et al. 2011), or the Snake River Fall Chinook salmon Nez Perce Tribal Hatchery HGMP (NPT 2011). All aspects of the programs except for certain new and expanded monitoring and evaluation measures are currently operational; therefore, except for those new activities and any anticipated changes from recent operations, the description of the proposed action will be evaluated in the present rather than future tense.

The objective of this opinion is to determine the likely effects on ESA-listed salmon and steelhead and their designated critical habitat resulting from the operation of the Snake River fall-run Chinook salmon hatchery programs. The applicants and co-managers propose to wholly carry out all ongoing activities described in the HGMPs (NPT 2011; Washington Department of Fish and Wildlife et al. 2011) and the Addendum (NPT et al. 2024).

This opinion will determine if the Proposed Actions comply with the provisions of section 7(a)(2) of the ESA.

1.3.1. Funding Actions

Under the Pacific Northwest Electric Power Planning and Conservation Act of 1980, 16 U.S.C. §§ 839 et seq. (Northwest Power Act), BPA provides funding to protect, mitigate, and enhance fish and wildlife and their habitat affected by the development, operation, and management of federal hydroelectric facilities on the Columbia River and its tributaries. Under this authority, BPA funds O&M and M&E for the NPT Hatchery Program and components of the FCAP Program.

The LSRCP Program was authorized by the Water Resources Development Act of 1976 (Public Law 94-587, Section 102, 94th Congress) to mitigate losses caused by the construction and operation of the four lower Snake River dams and navigation lock projects. The LFH program and O&M of the FCAP program are included in the Proposed Action and are funded through the Lower Snake River Compensation Plan (LSRCP), which is managed by the USFWS with funds received from the Bonneville Power Administration.

The remaining program is funded by the Idaho Power Company (IPC) as part of the 1980 Hells Canyon Settlement Agreement for the Hells Canyon Complex dams and is operated collectively by WDFW, NPT, IDFG, and ODFW.

1.3.2. Program Purpose and Type

Specific information regarding the purpose and type of hatchery program for the four Snake River hatchery programs included in this Proposed Action are largely described in the 2012 and 2018 Snake River Fall-run Chinook Salmon Hatchery Programs Biological Opinions (NMFS 2012d; 2018e) and ESA section 10(a)(1)(A) permits (NMFS 2012b; 2012a; 2018b; 2018a). The purpose of the IPC-funded portion of hatchery production is to mitigate for anadromous fish loss caused by the construction and operation of the Hells Canyon Complex (HCC). The purpose of the LSRCP-funded portion of hatchery production is to meet mitigation, harvest, and conservation objectives, and as part of the LSRCP, is congressionally mandated, pursuant to PL

99-662. The purpose of the LSRCP is to replace salmon and steelhead lost by the construction and operation of four hydroelectric dams on the Lower Snake River. The purpose of the BPA-funded portion of hatchery production is to meet obligations under the Northwest Power Act. Refer to Table 1 for additional information regarding hatchery programs' purpose and type.

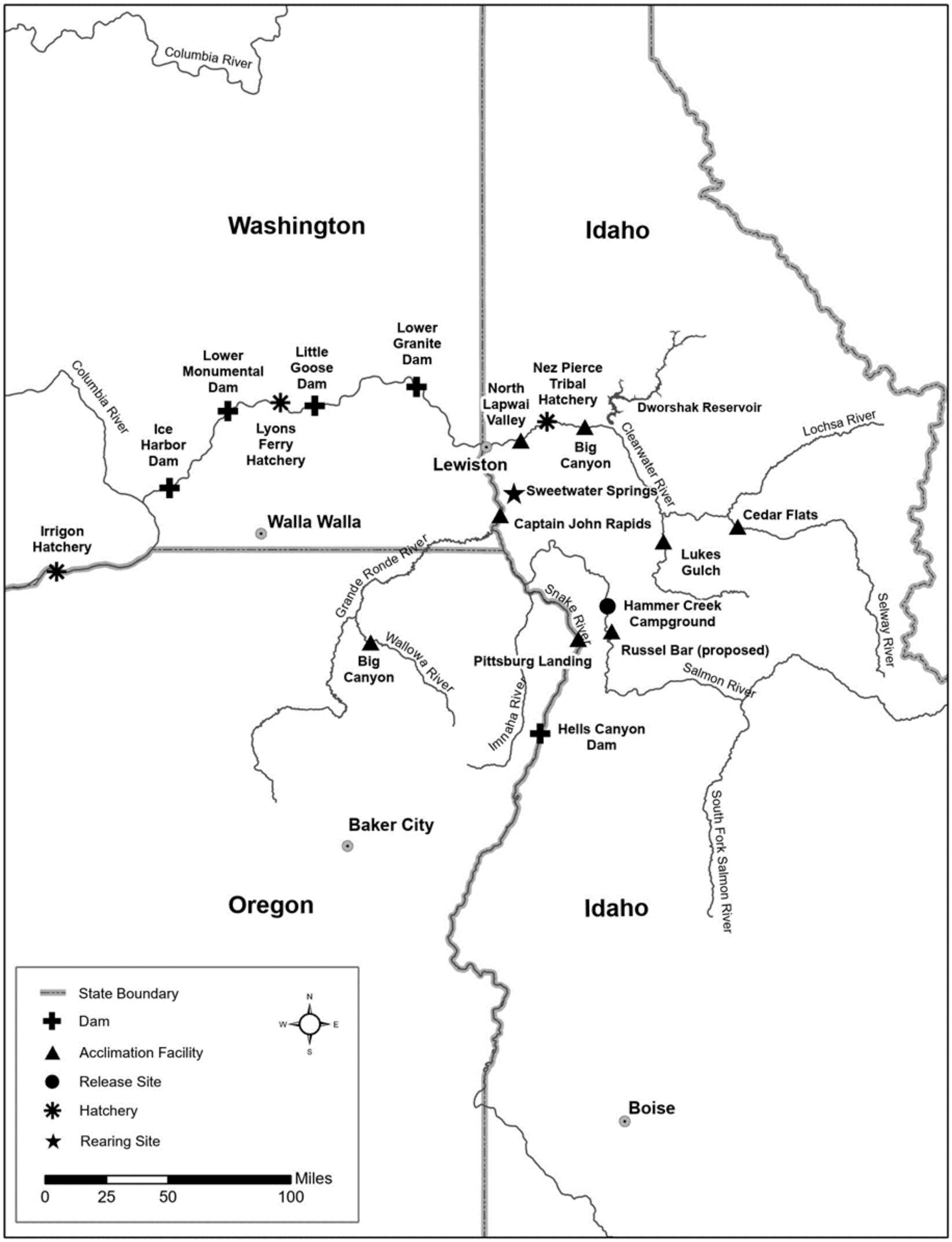

Figure 2. Map of Snake River fall-run Chinook salmon hatcheries and acclimation facilities (Gilmore 2024).

1.3.3. Proposed Hatchery Broodstock Collection Details

Broodstock collection will remain the same as described in the October 2012 Snake River Fall-run Chinook Salmon Hatchery Programs Biological Opinion and ESA section 10(a)(1)(A) permits (NMFS 2012d) and respective HGMPs (NPT 2011; Washington Department of Fish and Wildlife et al. 2011). These details are described below under the specific sections for broodstock collection per facility. The primary broodstock focus is on collecting adults returning to LGR trap. Trapping rates are adjusted, as necessary, based on the estimated return strength of the run. Broodstock is collected at LFH and NPTH hatcheries only as needed to reach production goals.

Future development of a localized broodstock is envisioned for the NPTH program using brood captured at a weir placed just above the mouth of the South Fork Clearwater River (NPT 2011; WDFW et al. 2011). The localized brood program would be initiated once spawner abundance in the SF Clearwater, as determined by redd count abundance, reaches a predetermined trigger identified in the Nez Perce Tribal Hatchery Management Plan. At that time, the envisioned localized Broodstock program would be subject to scientific and program review and possible analysis under NEPA and ESA. The weir will be installed no later than Oct. 1 and removed around Dec. 1. Localized broodstock will contribute to the overall NPTH brood collection goals. This is not part of the proposed action and is not analyzed further here. We note for informational purposes that if the program is initiated, it will be analyzed separately at the proper time.

Since 2017, an average of 3,233 fish have been collected to meet the production and run-reconstruction needs of the Snake River fall-run Chinook salmon hatchery program (NPT et al., 2024). Collected broodstock are divided between LFH and NPTH, usually at a 70:30 ratio as agreed upon annually. Broodstock trapping objectives have increased since the 2018 Biological Opinion (2,700 broodstock), with an estimated additional 500 total adults being required to meet hatchery needs. The increase in broodstock is still covered under the ESA Section 10 permits. The new broodstock trapping objectives are for 3,200 adults (1,700 females) for LFH and 950 (475 females) for NPTH (total = 4,150;2,175 females). Males are spawned with multiple females and are not necessarily needed at a 1:1 rate, and fewer may be collected in any given year.

Trapping protocols at LGR rely on the forecasted run size of fall-run Chinook salmon, coho salmon, and steelhead, therefore they vary yearly. The general operation is to systematically sample and collect broodstock from across the full extent of the run at LGR. Broodstock collection typically begins as early as August. Trapping usually ends the third week in November. However, trapping has taken place into early December when the returns and hatchery broodstock collections were very low (WDFW 2012).

All fall-run Chinook salmon handled at the trap are 100% electronically sampled for passive integrated tags (PIT) and coded wire tags (CWT), and all receive a fin clip, which may be utilized for parentage-based tagging (PBT). Run-at-large fish are then assigned a subsampling rate for selecting which subsamples are read for PBT (based on the LGR trap rate). All fish collected for broodstock are PIT tagged (if one is not detected), to track throughout the trapping, holding, and spawning process. Fin clip samples from all broodstock fish are processed for PBT.

Broodstock fish that can be identified as originating out-of-basin (through PIT, PBT, or CWT) are not used for spawning in an effort to preserve the genetic integrity of the population (but may be used for as much of 5% of the production, if necessary to meet egg-take goals). Parentage-based profiling is currently being used to distinguish unmarked in-basin hatchery-origin fish from natural-origin and unmarked strays (Section 1.3.6.1). Since 2016, all in-basin hatchery returns have been genetically identifiable. Based on associated PBT profiling, any unmarked fish not assigned to in-basin hatchery returns will be identified as natural-origin after the out-of-basin component is estimated. Spawning begins in mid-October and generally continues into late November or early December annually at both LFH and NPTH, though not always at the same time. Single-pair mating involves some reuse of males. The impact of male reuse size on population effective size is monitored (Busack 2007). Fish are chosen non-randomly for mating, with a deliberate effort to use larger, older fish as broodstock, as compensation for both the overrepresentation of younger fish in previous years (NMFS 2012d; Bumgarner and Fortier 2022) and the tendency of hatchery fish to return at younger ages than wild fish. The operators have set a target of integrating 30% or more natural-origin returns into the broodstock. The proportion of natural-origin fish utilized in spawning is limited by how many fish are available in the run and captured in the LGR trap.

1.3.4. Proposed Hatchery Egg Incubation, Juvenile Rearing, Acclimation, Fish Health, and Release

Egg incubation, juvenile rearing, and fish health protocols will remain similar to what was included in the October 2012 Snake River Fall-run Chinook Salmon Hatchery Programs Biological Opinion and ESA section 10(a)(1)(A) permits (NMFS 2012d) and respective HGMPs (NPT 2011; Washington Department of Fish and Wildlife et al. 2011). There have been some modifications to the rearing and release locations for various program components since the HGMPs were submitted in 2011. The goal of these methods is to provide segregation throughout the rearing cycle for each PBT release group. These modifications include discontinuation of rearing, acclimation, and release locations, as described in the introduction of Section 1.3 (Table 2). Table 3 and Table 4 specifically outline the proposed changes to juvenile production by hatchery facility of origin.[3] The total of Snake River fall-run Chinook salmon released in the Snake River Basin from all hatchery programs and facilities is 6.8 million subyearlings on an average yearly basis. In addition, there is a 10% overage buffer of juvenile releases, whereby in a single year, the operators may release up to an additional 10%. This accounts for occasional increases in hatchery survival, which are balanced against the years in which the total number of smolts released is below the limit. Releases should not be in locations other than those proposed, and the number released by life-stage should not exceed 110% of the proposed production levels in any individual year. This additional production buffer should be used in a minority of situations, and annual operational adjustments to maintain consistency with the proposed production levels and life stages, which should be addressed during the development of the

[3] It is worth noting that, during the transition year (2025) production will not be as it is defined in Table 3 and Table 4. Because yearling production is being phased out into subyearling releases, this means that there will be an overlap in releases in 2025. Specifically, Brood Year 2023 yearlings from the Lyons Ferry Hatchery program are not scheduled to be released until 2025 and are currently in the rearing process. This combined with the new proposed subyearling releases means that a total of 7.25 million Snake River fall-run Chinook salmon will be released in 2025 instead of the 6.8 million in the new production tables. This will be a single occurrence during the transition year in 2025.

annual operation plan(s). Please refer to the previous 2012 Biological Opinion (NMFS 2012d), the 2018 Biological Opinion (NMFS 2018e) as well as the *U.S. v. Oregon* Management Agreement Biological Opinion (NMFS et al. 2018) for information regarding past releases.

Table 3. Snake River fall-run Chinook salmon production for three of the hatchery programs in the Proposed Action (the Lower Snake River Compensation Program (LSRCP) at Lyons Ferry and Irrigon Hatchery, the Fall Chinook Acclimation Program (FCAP), and the Idaho Power Program (IPC)). In addition to these yearly average releases, there is a 10% overage buffer for these juvenile releases.

Priority	Rearing Facility	Number	Age	Release Location(s)	Marking[1]
1	Lyons Ferry	500,000	0+	On station	500KAdCWT
2	Lyons Ferry	450,000	0+	Captain John Rapids 1	100K AdCWT 350K no clip
3	Lyons Ferry	450,000	0+	Big Canyon 1	100K AdCWT 350K no clip
4	Lyons Ferry	500,000	0+	On station	500k Ad only
5	Lyons Ferry	400,000	0+	Pittsburg Landing 1 or Salmon River @ Russell Bar 1[2]	100K AdCWT 300K no clip
6	Lyons Ferry	200,000	0+	Captain John Rapids 2	100K AdCWT 100k no clip
7	Lyons Ferry	400,000	0+	Big Canyon 2	100K AdCWT 300K no clip
8	Lyons Ferry	200,000	0+	Pittsburg Landing 2 or Salmon River @ Russell Bar 2[2]	100K AdCWT 100K no clip
9	Irrigon	1,000,000	0+	Salmon River	100K AdCWT 100K Ad only 800K no clip
10	Irrigon	500,000	0+	Grande Ronde River (Big Canyon)	100K AdCWT 400K Ad only
11	Lyons Ferry	200,000	0+	On station	200K Ad only
12	Irrigon	600,000	0+	Couse Creek (Snake)	100K AdCWT 250K Ad only 250K no clip
TOTAL	Subyearlings	5,400,000			

[1]For all Snake River Fall-run Chinook salmon hatchery programs, tissue samples are collected annually from broodstock and incorporated into a parentage-based tagging (PBT) baseline. The hatchery programs effectively 'tag' ~90-100% of annual releases. All release sites and groups will be PIT tagged and differentially PBT marked/tagged. PBT will be utilized for all fish, including those marked "no clip". No clip means no adipose fin clip and no CWT wire mark.

[2] The release location is dependent on the construction of the Russell Bar Acclimation facility. Construction is on-going and is expected to be completed during the permit term.

Table 4. Snake River fall-run Chinook salmon production for the Nez Perce Tribal Hatchery. In addition to these yearly average releases, there is a 10% overage buffer for these juvenile releases.

Priority	Number	Age	Release Location(s)	Marking[1]
1	500,000	0+	On station	100K AdCWT 400K no clip
2	350,000[2]	0+	Luke's Gulch	100K AdCWT 250K no clip
	350,000[2]	0+	Cedar Flats	100K AdCWT 150K no clip
3	200,000[3]	0+	North Lapwai Valley	100K AdCWT 200K no clip
TOTAL	1,400,000			

[1]For all Snake River Fall-run Chinook salmon hatchery programs, tissue samples are collected annually from broodstock and incorporated into a parentage-based tagging (PBT) baseline. The hatchery programs effectively 'tag' ~90-100% of annual releases. All release sites and groups will be PIT tagged and differentially PBT marked/tagged. PBT will be utilized for all fish, including those marked "no clip"
[2]Anticipated release numbers based on facility capacity. Actual release numbers may be less depending on environmental conditions. Fish not released at these sites will be released on station at NPTH
[3]If environmental conditions preclude acclimation at North Lapwai Valley these fish will be released on station at NPTH

1.3.5. Proposed Disposition of Excess Juvenile and Adult Hatchery Fish

Disposition of excess juvenile and adult hatchery fish remains the same as it did in the 2012 and 2018 Biological Opinion(NMFS 2012d; 2018e). Hatchery-origin returning adult fish in excess of broodstock needs for these hatchery programs are intended for harvest purposes, although some hatchery returns from these integrated programs escape to spawn naturally. Disposition of surplus hatchery fall-run Chinook salmon during broodstock collection varies based on adult return numbers and management objectives. Surplus fish have been transported back to the mainstem Snake and Clearwater Rivers. Carcasses may be distributed to tribal entities for subsistence or ceremonial use, to charitable organizations for human consumption, nutrient enhancement, and/or provided for research or educational purposes, and frozen for rendering at a later date. Please refer to Table 5 for transplanting details per program facility.

Table 5. Adult transplant locations excess to broodstock needs

Program Facility	Transport Locations of adults/jacks
Lyons Ferry Hatchery	-Tucannon River -Grande Ronde River -Mainstem Snake River
NPTH	-Lower mainstem Clearwater River, below North Fork

If there are eggs or juvenile fish in excess of hatchery production targets (above the standard 10% overage included in the Proposed Action), the co-managers and funding agencies will consult with NOAA Fisheries prior to disposition.

1.3.6. Research, Monitoring, and Evaluation Activities

The research, monitoring, and evaluation (RM&E) needs remain similar as they were identified in the previous 2012 and 2018 Biological Opinion(NMFS 2012d; 2018e), with some exceptions. The *Snake River Fall Chinook Symposium* that took place on May 16th-17th, 2017 (USFWS 2017) answered critical uncertainties that no longer require RM&E effort, as well as highlighted some additional information that is needed to assess the status of this essential single-population ESU. For this Proposed Action, ongoing monitoring activities, including standard production monitoring (Table 3; Table 4), will continue for all programs. Run reconstruction of the returning adults to LGR will be completed to estimate the age, sex, and abundance of hatchery- and natural-origin adults (Young et al. 2023). In addition, the co-operators will continue to assess the effects of the previous changes in release sites/strategies on the distribution of natural and hatchery origin spawners in the Snake River, above the mouth of the Salmon River, to Hells Canyon Dam. This assessment will utilize ongoing redd surveys and include carcass recoveries and PBT analysis. For the proposed changes in release numbers and locations in this proposed action, the current monitoring, as described in Table 3 and Table 4, will be adequate to determine the effects of these release locations on the SRFCH population.

Data from the past M&E effort associated with the 2012 Biological Opinion (NMFS 2012d) indicate that a reconfiguration of releases could create the opportunity for an area of the basin to have a sufficiently reduced level of hatchery influence as to reduce risk to the entire Snake River fall-run Chinook salmon population (NMFS 2018e). The movement of 1 million fish (IPC release) from the Upper Snake area to the Salmon River, as included in the *US v. Oregon* Management Agreement and accompanying Biological Opinion (NMFS et al. 2018), provided this opportunity. Analyses described in the *US v. Oregon* Management Agreement Biological Opinion in addition to analyses described in the previous Biological opinion (NMFS 2018e), indicate a general trend of reducing hatchery influence in the Upper Snake region. Continuing this trend, the hatchery program is moving to an all subyearling release for 2025 (as described in Section 1.3).

Collectively, the M&E measures will provide important information that will guide future management of the Snake River fall-run Chinook salmon hatchery programs after the permit period is over. The results of M&E measures may vary and may not be immediate.

1.3.6.1. RM&E Actions in this Biological Opinion

At present, Snake River fall-run Chinook salmon constitute a single-population ESU (NMFS 2005b), and approximately 75% of the fish in the ESU are of hatchery-origin. Thus, monitoring the effects of the hatchery programs on natural production is a critical concern. Because of their diverse life history, large-riverine habitat, and expansive geographic range, it is challenging to quantify the spawning, rearing, and productivity of natural-origin Snake River fall-run Chinook salmon. The same factors, coupled with logistic difficulties and management constraints, make evaluation of the effects of the hatchery programs on the natural production of Snake River fall-run Chinook salmon very challenging.

Due to the Snake River fall-run Chinook Salmon ESU being a single population, the significance of the hatchery programs to tribal and non-tribal interests, and the potential impacts of the hatchery programs on the population, monitoring of hatchery programs for achievement of program goals is essential to the success of this hatchery program. Past efforts have been extensive and comprehensive compared to many other hatchery monitoring efforts in the Columbia Basin. Survival data presented in the 2017 Snake River Fall-run Chinook Salmon Performance Evaluation White Paper (Rosenberger et al. 2017) helped inform the program changes, which included the transfer of the IPC releases in the Upper Snake River to an alternative release site in the Salmon River, and the conversion of yearlings to subyearling releases above LGR (NMFS 2018e). In addition, the 2022 Snake River Fall-run Chinook Salmon Hatchery White Paper (Bumgarner et al. 2022) helped inform additional program changes to include the conversion of all remaining yearlings to subyearlings, as described in this Proposed Action.

For this Proposed Action, ongoing monitoring activities, including standard production monitoring (Table 6), will continue for all programs. In addition, the co-operators are exploring additional monitoring efforts that will assess the effects of the changes in release sites/strategies on the distribution of spawners in the Snake River by utilizing ongoing redd surveys and may include carcass recoveries and PBT.

Table 6. Standard RM&E activities, purpose, and implementers for all of the Snake River fall-run Chinook salmon programs (NPT et al. 2024).

Activity	Purpose	Implementers	Associated Programs
Adult trapping and tissue sampling at LGR and hatchery traps for recording: date, sex, length, origin (hatchery or natural), numbers, marks/tags, and disposition.	Identify and track returns to the Snake River Basin. Track program performance and strategies of individual release groups.	WDFW, NPT	LFH, NPTH, IPC, FCAP
Monitoring of survival metrics for all life stages in the hatchery from spawning to release.	Track in-hatchery program performance and identify limiting factors	WDFW, NPT, ODFW	LFH, NPTH, IPC, FCAP
Monitor health and condition of adults and juveniles associated with hatchery production	Track in hatchery fish health and perform prerelease sampling	WDFW, NPT, ODFW, USFWS	LFH, NPTH, IPC, FCAP

Strategic marking and tagging of hatchery production; Adipose clipping, coded wire tagging, PIT Tagging and 100% marking of hatchery production via Parentage Based Tagging-PBT.	Continued estimates of adult harvest (coastwide and in-river), adult escapement of both HOR and NOR to Snake Basin and pNOB in program. Estimates of in-river and overall survival estimates from smolt to adult return. Contributes to estimation of overall fisheries mitigation benefit. Continued exclusion of strays from hatchery broodstocks and estimation of strays to spawning grounds.	WDFW, ODFW, IPC, NPT, PBT Sampling combined for CRITFC, IDFG and WDFW labs.	LFH, NPTH, IPC, FCAP
Complete run reconstruction. PBT sampling of LGR Run-at-Large and hatchery broodstock.	Adult escapement of both HOR and NOR to Snake Basin. pHOS in the natural population and pNOB in hatchery program. Estimates of in-river and overall survival from smolt-to-adult return. Contributes to estimation of overall mitigation benefit and survival by hatchery release group. Contributes to life cycle modeling and natural productivity estimation. Estimation of strays in the broodstock and spawning grounds.	WDFW, IPC, NPT, NMFS and CRITFC, IDFG and WDFW labs for PBT analysis.	LFH, NPTH, IPC, FCAP
Redd counts across spawning areas	Adult spawning distribution and success. Informs natural population abundance and life-cycle modeling.	IPC, USFWS, USGS, NPT, WDFW	LFH, NPTH, IPC, FCAP

1.3.6.2. RM&E Methods

A static stratified trapping rate at LGR is established pre-season annually, and in-season adjustments may occur to accommodate fish handling limitations and broodstock needs for both hatchery and run reconstruction. Adult trapping at LGR supports estimates of age and origin based on run-reconstruction efforts. Run-reconstruction data include estimating population age structure from tags and scale pattern analysis, estimating abundance and trend data for the natural population, and estimating returns for both hatchery and wild fish and Smolt-to-Adult return rates (SARs) for hatchery fish. Run-reconstruction estimates were substantially modified in 2011 to increase the accuracy and precision of estimated returns of both hatchery and natural fish for all return years back to 2003. Run reconstruction methods are being validated using parentage-based tagging and will be further modified as needed. Beginning in 2016, the standard CWT run-reconstruction for return by origin has been compared to PBT run-reconstruction with nearly identical results. Redd counts are used as an indicator of spawner spatial distribution. Underwater camera observation of redds in deep water areas supplements aerial counts in the mainstem Snake River spawning aggregate. Age-structure of spawners estimated from scale samples and tag recoveries (CWT and PBT) of hatchery releases are obtained from all broodstock, sub-samples at LGR, and potentially from carcass recoveries in the Tucannon, Clearwater, Salmon, and/or Snake Rivers. Sex ratio of spawners is estimated using scale samples and tag recoveries as well.

Estimating the proportions of natural-origin and hatchery-origin fish in the returning adults is a critical aspect of monitoring. Because not all hatchery-origin fish are marked/tagged or PIT tagged, determination of origin of unmarked/untagged fall-run Chinook salmon, as previously mentioned, relies on run-reconstruction using expansions based on tagging rate of fish recovered with CWTs or PBTs.

The harvest of Snake River fall-run Chinook salmon is substantial, occurring in the ocean, mainstem, and tributary fisheries. As tributary fisheries expand, the management agencies will coordinate appropriate sampling programs, either through the recovery of CWTs or PBT sampling, to document hatchery fish harvest and estimate natural-origin impacts.

Abundance and distribution data on juveniles is limited, especially for natural-origin juveniles. It is not available for any spawning aggregate above LGR but does exist for the Tucannon River aggregate below the LGR. Collection of juveniles occurs at three of the four Lower Snake River dams, and fish guidance efficiencies are estimated. However, Snake River fall-run Chinook salmon exhibit diverse juvenile life history patterns with prolonged emigration and smoltification as both subyearlings and yearlings. This diversity, combined with the inability to run fish collection systems at the dams during the winter, precludes estimation of juvenile abundance and absolute juvenile survival. PIT tags implanted in hatchery release groups provide survival information for general production subyearling and yearling releases. Survival information for PIT-tagged wild fish is primarily from the Clearwater River, the Upper and Lower Snake River spawning aggregates, and the Tucannon River. However, survival estimates for natural-origin and NPTH subyearling production must be characterized by combining the probability of emigration and survival, because a significant proportion emigrates as yearlings. Distribution and emigrant survival information is collected for the Clearwater River and the Upper and Lower Snake River through beach seining.

Additional monitoring will occur through passive and or remote methods to detect or observe migration and spawning activities that require no handling or direct observation. Aerial surveys from remote-controlled and manned aircraft will be used to monitor and document spawning and PIT-tag detection arrays will be in place to monitor distribution. Carcass sampling will also occur concurrently with these aerial spawning surveys, but this will not result in the handling of pre-spawned fish. These activities are not expected to result in additional take of listed species.

1.3.7. Proposed Operation, Maintenance, and/or Construction of Hatchery Facilities

The Snake River Fall-run Hatchery program operates three hatchery facilities and nine different acclimation sites. Irrigon hatchery is located outside of the Action Area, but is only used for rearing juveniles and does not release or collect broodstock. For a more detailed look on each hatchery and acclimation facility, please refer to Table 7.

All hatchery programs rely on diverted river water for their operation, and return water to the diverted creek or river (minus any leakage and evaporation) along with any groundwater discharge. Water at all facilities is withdrawn in accordance with state-issued water rights. For any diversions which have been assessed by NMFS for compliance with (insert NMFS screening criteria document), if NMFS screening and passage criteria are updated, facilities will be re-evaluated against future NMFS criteria, as appropriate. The strategy is to work with NMFS and cooperators to discuss compliance outcomes and to prioritize those facilities with compliance issues that need to be addressed based on individual risk, program risk, and compliance concerns. Modifications and upgrades will be based on the prioritized list and acted upon as funding becomes available. Additional facilities will adopt a similar approach to determine compliance with NMFS screening criteria.

Programs that rear over 20,000 pounds of fish operate under applicable National Pollutant Discharge Elimination System (NPDES) general permits. Minor armoring would be maintained at the intake diversions, fish ladders, and effluent outfalls. Ongoing efforts by funding agencies and operators exist to identify facility water source issues, and problems are resolved after they arise. For additional information regarding facility water sources for each program, please refer to Table 7.

Several routine (and semi-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" (occurring on an annual basis) or "semi-routine" (occurring with regularity, but not necessarily on an annual basis) 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 and Federal agencies
    - Follow a pollution and erosion control plan that addresses equipment and materials 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 before in-water work is performed
- 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 (OHWM)
    - Be staged and fueled with appropriate distance from any water body
    - Be cleaned and free of vegetation before they are brought to the site

The effects relating to the construction of the new acclamation facility on Russell Bar located on the Salmon River in Idaho, are beyond the scope of this consultation and are not covered under the Proposed Action. However, the operation and maintenance of the new facility are covered under the Proposed Action.

Specific details regarding the operation of each hatchery facility are described in Table 7.

Table 7. Facility water source and use for hatchery program operations for the Snake River fall-run Chinook salmon program.

Hatchery Facility	Total Facility Water Use (cfs)	Surface Water Used[1] (cfs)	Ground-water Used (cfs)	Water Source	Amount Used for fall-run Chinook salmon (cfs)	Proportion Used for fall-run Chinook salmon (%)	Discharge Location	Meet NMFS screening criteria	NPDES Permit
Lyons Ferry Hatchery	118.1	0	118	Ground-water	28	24	Snake River	N/A	Yes
Nez Perce Tribal Hatchery	17.25	13.4	3.85	Ground-water and Clearwater River	6.4	37	Clearwater River	Yes	N/A
Irrigon Hatchery	47	0	47	Ground-water	5	10	Columbia River	N/A	Yes
Pittsburgh Landing Acclimation Facility	4.5	4.5	0	Snake River	4.5	100	Snake River	Yes	N/A
Russell bar Acclimation facility[1]	4.5-5.6	4.5-5.6	0	Salmon River	4.5-5.6	100	Salmon River	Yes[2]	NA
Big Canyon Acclimation Facility (NPT)	4.5	4.5	0	Clearwater River	4.5	100	Clearwater River	Yes	N/A
Captain John Rapids Acclimation Facility	5.6	5.6	0	Snake River	5.6	100	Snake River	Yes	N/A
Lukes Gulch Acclimation Facility	2.8	2.2	0.6	South Fork Clearwater River	2.8	100	South Fork Clearwater River	Yes	N/A
Sweetwater Springs Satellite Facility	3.44	0	3.44	Upland spring	3.44	100	West Fork Sweetwater Creek	N/A	N/A
Cedar Flats Acclimation Facility	2.2	2.2	0	Selway River	2.2	100	Selway River	Yes	N/A
Big Canyon Acclimation Facility (ODFW)	3.0	3.0	0	Deer Creek	3.0	100	Wallowa River	Yes	NA
North Lapwai Valley Acclimation Facility	5	1.4	3.6	Ground-water and Lapwai Creek	5	100	Lapwai Creek	Yes	N/A

[1]The Russell Bar Acclimation Facility is currently under construction and all values are estimates.
[2]The Acclimation Facility will be built to all current NOAA screening criteria

1.4. OTHER ACTIONS

Fisheries are not part of this Proposed Action, but the Snake River fall-run Chinook fishery is a direct consequence of the hatchery program covered by the proposed action. The fall-run Chinook salmon fishery takes place on the Snake, Grande Ronde, Tucannon and Clearwater rivers, and a portion of the Salmon River and is on adipose-intact adults in addition to the already ongoing fishery that targets adipose-clipped fall-run Chinook salmon, summer-run steelhead and proposed Coho fisheries in the Snake Basin (IDFG 2019). The Fisheries Management Evaluation Plan (FMEP) was submitted by IDFG, ODFW, and WDFW while the management of fall-run Chinook salmon within the Snake basin, including harvest is determined through a co-management process that includes IDFG, ODFW, WDFW, CTUIR, SBT, NPT, NMFS, and USFWS. The fishery takes place between mid-August and closes no later than November 31st.The fishery and its effects are described in more detail in section 2.4.6.

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. Section 7(a)(2) of the ESA requires Federal agencies to consult with the FWS, NMFS, or both, to ensure that their 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) to minimize such impacts.

2.1. ANALYTICAL APPROACH

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

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

The designations of critical habitat for Snake River fall-run Chinook salmon, Snake River spring/summer-run Chinook salmon, Snake River Basin steelhead, and Snake River sockeye salmon use the term primary constituent element (PCE) or essential features. The 2016 final rule (81 FR 7414; February 11, 2016) that revised the critical habitat regulations (50 CFR 424.12) replaced this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

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

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

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

2.2. Rangewide Status of the Species and Critical Habitat

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

Table 8. Federal Register notices for the final rules that list species, designate critical habitat, or apply protective regulations to ESA listed species considered in this consultation.

Species	Listing Status	Critical Habitat	Protective Regulations
Chinook salmon *(Oncorhynchus tshawytscha)*			
Snake River fall-run	Threatened, 79 FR[1] 20802, April 14, 2014	58 FR 68543, December 28, 1993	70 FR 37160, June 28, 2005
Snake River spring/summer-run	Threatened, 79 FR 20802, April 14, 2014	64 FR 57399, October 25, 1999	70 FR 37159, June 28, 2005
Sockeye salmon *(O. nerka)*			
Snake River	Endangered, 79 FR 20802, April 14, 2014	58 FR 68543, December 28, 1993	Issued under ESA Section 9

Steelhead *(O. mykiss)*			
Snake River Basin	Threatened, 79 FR 20802, April 14, 2014	70 FR 52769, September 2, 2005	70 FR 371659, June 28, 2005

[1]Citations to "FR" are citations to the Federal Register

"Species" Definition: The ESA of 1973, as amended, 16 U.S.C. 1531 *et seq.* defines "species" to include any "distinct population segment (DPS) of any species of vertebrate fish or wildlife which interbreeds when mature." To identify DPSs of salmon species, NMFS follows the "Policy on Applying the Definition of Species under the ESA to Pacific Salmon" (56 FR 58612, November 20, 1991). Under this policy, a group of Pacific salmon is considered a DPS and hence a "species" under the ESA if it represents an ESU of the biological species. The group must satisfy two criteria to be considered an ESU: (1) It must be substantially reproductively isolated from other con-specific population units; and (2) It must represent an important component in the evolutionary legacy of the species. To identify DPSs of steelhead, NMFS applies the joint FWS-NMFS DPS policy (61 FR 4722, February 7, 1996). Under this policy, a DPS of steelhead must be discrete from other populations, and it must be significant to its taxon. Snake River fall-run Chinook salmon, Snake River spring/summer-run Chinook salmon, Snake River sockeye salmon, and Snake River steelhead each constitute an ESU or DPS of the taxonomic species *Oncorhynchus tshawytscha, Oncorhynchus nerka*, and *Oncorhynchus mykiss,* respectively*,* and, as such, each is considered a "species" under the ESA.

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. 2000b). These "viable salmonid population" (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. (2000b) 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. 2000b).

In describing the rangewide 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. 2000b).

2.2.1.1. Life History and Current Rangewide Status of Snake River Fall-run Chinook Salmon ESU

On April 22, 1992, NMFS listed the Snake River Fall-Run Chinook Salmon ESU as a threatened species (57 FR 23458). More recently, the threatened status was reaffirmed on June 28, 2005 (70 FR 37160), on April 14, 2014 (79 FR 20802), as well as in the latest 5-year status review (NMFS 2022b) (Table 8). Critical habitat was designated on December 28, 1993 (58 FR 68543) (Table 8).

The Snake River Fall-run Chinook Salmon ESU includes naturally spawned fish in the lower mainstem of the Snake River and the lower reaches of several of the associated major tributaries including the Tucannon, the Grande Ronde, Clearwater, Salmon, and Imnaha Rivers, along with the four of the proposed artificial propagation programs (Jones Jr. 2015; NWFSC 2015; Ford 2022). All of the hatchery programs are included in the ESU.

Table 9. Snake River Fall-run Chinook Salmon ESU description and MPGs (Jones Jr. 2015; NWFSC 2015; Ford 2022).

ESU Description	
Threatened	Listed under ESA in 1992; updated in 2014 (see Table 8)
1 major population groups	2 historical populations (1 extirpated)
Major Population Group	***Population***
Snake River	Lower Mainstem Fall-run
Artificial production	
Hatchery programs included in ESU (4)	Lyons Ferry Hatchery fall, Fall Chinook Acclimation Project fall, Nez Perce Tribal Hatchery fall, Idaho Power fall.

Two historical populations (one extirpated) within one MPG comprise the Snake River Fall-run Chinook Salmon ESU. The extant natural population spawns and rears in the mainstem Snake River and its tributaries below Hells Canyon Dam. Figure 3 shows a map of the ESU area. The decline of this ESU was due to heavy fishing pressure beginning in the 1890s and loss of habitat with the construction of Swan Falls Dam in 1901 and the Hells Canyon Complex from 1958 to

1967, which extirpated one of the historical populations. Hatcheries mitigating for losses caused by the dams have played the role in the production of Snake River fall-run Chinook salmon since the 1980s (NMFS 2012d). Since the species were originally listed in 1992, fishery impacts have been reduced in both ocean and river fisheries. Total exploitation rate has been relatively stable in the range of 40% to 50% since the mid-1990s (Ford 2022).

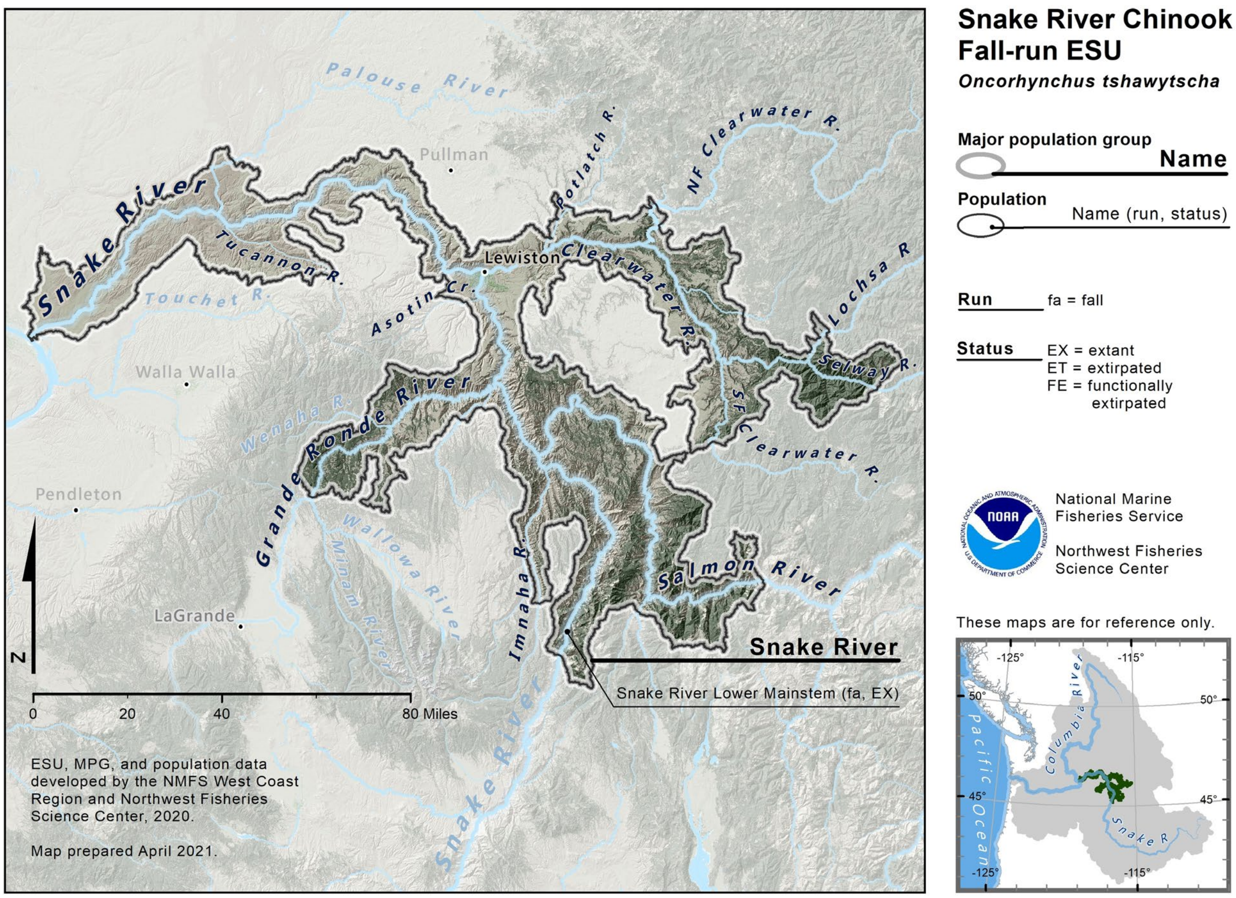

Figure 3. Map of the Snake River Fall-run Chinook Salmon ESU's spawning and rearing areas, illustrating populations and MPGs (NWFSC 2015; Ford 2022).

The ICTRT identified five Major Spawning Areas (MaSAs) within the extant Lower Snake River population. The population's MaSAs include tributary habitats that support diversity and potential resilience for recovery under today's ecological conditions. The five MaSAs are:

1) Upper Hells Canyon MaSA ─ The primary (largest and most productive) MaSA in the Lower Snake River population extends 59.6 miles from Hells Canyon Dam on the Snake River downstream to the confluence with the Salmon River. Fall-run Chinook salmon production in the adjoining lower Imnaha and Salmon Rivers is considered part of this MaSA. The ICTRT considered spawning in the lower mainstem sections of the Imnaha and Salmon Rivers to be contiguous with and therefore part of the Upper Hells Canyon MaSA.

2) Lower Hells Canyon MaSA ─ This second mainstem Snake River MaSA extends 42.9 miles downstream from the Salmon River confluence to the upper end of the contemporary LGR pool. It includes production from two adjoining tributaries, Alpowa and Asotin Creeks.
3) Clearwater River MaSA ─ The MaSA includes the lower mainstem Clearwater River. Some historical evidence suggests that the Selway River and other tributaries also supported fall-run Chinook salmon.
4) Grande Ronde River MaSA ─ The MaSA covers the lower Grande Ronde River. Isolated reaches in tributaries to the Grande Ronde River may have also supported fall-run Chinook salmon production at one time.
5) Tucannon River MaSA ─ The MaSA includes the lower Tucannon River and the adjacent inundated mainstem Snake River section associated with Little Goose and Lower Monumental Dams. Fall-run Chinook salmon spawners may have historically used the lowest potential spawning reaches in the Snake River, currently inundated by Ice Harbor Dam (Dauble et al. 2003). Spawners using these reaches could have been associated with either the Lower Snake River population or a population centered on mainstem Columbia River spawning areas currently inundated by John Day and McNary Dams (NWFSC 2015).

Historically, the primary fall-run Chinook salmon spawning areas were located on the upper mainstem Snake River (Connor et al. 2005). Now, a series of Snake River mainstem dams block access to the Upper Snake River and about 85% of ESU's historical spawning and rearing habitat. Swan Falls Dam, constructed in 1901, was the first barrier to upstream migration in the Snake River, followed by the Hells Canyon Complex beginning with Brownlee Dam in 1958, Oxbow Dam in 1961, and Hells Canyon Dam in 1967. Because the fall-run Chinook life cycle is oriented to mainstem and lower habitats than spring/summer Chinook, natural spawning is currently limited to the Snake River from the upper end of LGR reservoir to Hells Canyon Dam; the lower reaches of the Imnaha, Grande Ronde, Clearwater, Salmon, and Tucannon rivers; and small areas in the tailraces of the Lower Snake River hydroelectric dams (Good et al. 2005a). Some fall-run Chinook salmon also spawn in smaller streams such as the Potlatch River, and Asotin and Alpowa Creeks, and they may be spawning in other similarly sized tributaries. The vast majority of spawning today occurs upstream of LGR, with the largest concentration of spawning sites in the mainstem Snake River (about 60 %) and in the Clearwater River, downstream from Lolo Creek (about 30 %) (NMFS 2012d).

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

Snake River fall-run Chinook salmon also spawned historically in the lower mainstems of the Clearwater, Grande Ronde, Salmon, Imnaha, and Tucannon River systems. At least some of these areas probably supported production, but at much lower levels than in the mainstem Snake River. Smaller portions of habitat in the Imnaha and Salmon Rivers have supported Snake River fall-run Chinook salmon. Some limited spawning occurs in all these areas, although returns to the Tucannon River are predominantly releases and strays from the Lyons Ferry Hatchery program (NMFS 2012d).

NMFS designated critical habitat for Snake River fall-run Chinook salmon on December 28, 1993 (58 FR 68543). The designation consists of all Columbia River estuarine areas, as well as river reaches upstream to the confluence of the Columbia and Snake Rivers, and all Snake River reaches from the confluence of the Columbia River upstream to Hells Canyon Dam. It also includes the Palouse River from its confluence with the Snake River upstream to Palouse Falls, the Clearwater River from its confluence with the Snake River upstream to its confluence with Lolo Creek, and the North Fork Clearwater River from its confluence with the Clearwater River upstream to Dworshak Dam. Critical habitat also includes river reaches presently or historically accessible (except reaches above impassable natural falls, and Dworshak and Hells Canyon Dams) to Snake River fall-run Chinook salmon in the following hydrologic units: Clearwater, Hells Canyon, Imnaha, Lower Grande Ronde, Lower North Fork Clearwater, Lower Salmon, Lower Snake, Lower Snake-Asotin, Lower Snake-Tucannon, and Palouse. Designated areas consist of the water, waterway bottom, and the adjacent riparian zone (defined as an area 300 feet from the normal high-water line on each side of the river channel) (58 FR 68543).

Abundance, Productivity, Spatial Structure, and Diversity

Best available information indicates that the Snake River Fall-run Chinook Salmon ESU remains at threatened status (NMFS 2022b), which is based on a low risk rating for abundance and productivity and a moderate risk rating for spatial structure and diversity (NWFSC 2015). Therefore, the Snake River Fall-run Chinook Salmon ESU is considered to be at a moderate-to-low risk of extinction, with viability largely unchanged from the prior review (Ford 2022).

In terms of spatial structure and diversity, the Lower Mainstem Snake River fall-run Chinook salmon population was rated at low risk for Goal A (allowing natural rates and levels of spatially mediated processes) and moderate risk for Goal B (maintaining natural levels of variation) in the status review update (NWFSC 2015; Ford 2022), resulting in an overall spatial structure and diversity rating of moderate risk. The moderate risk rating was driven by changes in major life history patterns, shifts in phenotypic traits, and high levels of genetic homogeneity in samples from natural-origin returns. In addition, risk associated with indirect factors (e.g., the high levels of hatchery spawners (70%) in natural spawning areas, the potential for selective pressure imposed by current hydropower operations, and cumulative harvest impacts) contribute to the current rating level (Ford 2022).

Considering the most recent information available, an increase in estimated productivity or a decrease in the year-to-year variability associated with the estimate would be required to achieve delisting status, assuming that natural-origin abundance of the single extant Snake River fall-run Chinook salmon population remains relatively high. An increase in productivity could occur with a further reduction in mortalities across life stages. Such an increase could be generated by actions such as a reduction in harvest impacts (particularly when natural-origin spawner return levels are below the minimum abundance threshold) and/or further improvements in juvenile survivals during downstream migration. It is also possible that survival improvements resulting from various actions (e.g., improved flow-related conditions affecting spawning and rearing, expanded spill programs that increased passage survivals) in recent years have increased productivity, but that increase is effectively masked as a result of the relatively high spawning levels in recent years. A third possibility is that productivity levels may decrease over time as a result of negative impacts of chronically high hatchery proportions across natural spawning areas. Such a decrease would also be largely masked by the high annual spawning levels.

The Snake River Fall-run Chinook Recovery Plan (NMFS 2017f) states that a single population viability scenario could be possible given the unique spatial complexity of the Lower Mainstem Snake River fall-run Chinook salmon population. The recovery plan notes that such a scenario could be possible if major spawning areas supporting the bulk of natural returns are operating consistent with long-term diversity objectives in the proposed plan. Under this single population scenario, the requirements for a sufficient combination of natural abundance and productivity could be based on a combination of total population natural abundance and relatively high production from one or more major spawning areas with relatively low hatchery contributions to spawning, i.e., low hatchery influence for at least one major natural spawning production area. This Recovery Plan (NMFS 2017f) outlines three potential recovery scenarios, each consistent with the basic set of viability objectives use by the ICTRT. The three scenarios are summarized below:

- **Scenario A- Two Populations (one highly viable, one viable)**

  This scenario focuses on achieving highly viable status for the extant Lower Snake River population and viable status for the currently extirpated Middle Snake River population that historically spawned above Hells Canyon Complex. This scenario requires providing juvenile and adult passage above Hells Canyon Complex, using hatchery fish for reintroduction efforts, and would likely take decades to achieve.

- **Scenario B- Single Population (highly viable, measured in the aggregate)**

  In order to achieve highly viable status with a single population, hatchery production would need to be substantially reduced in the extant Lower Snake River population. Reasons for this include: 1) current levels of hatchery production are likely too high for long-term maintenance of acceptable productivity, and 2) the current levels of hatchery production make it nearly impossible to determine the underlying productivity of the population.

- **Scenario C-Single Population (highly viable, with Natural Production Emphasis Area(s)**

This scenario is a variation on the alternative single-population approach to meeting the basic ESA recovery objectives underlying ICTRT's viability criteria. In this scenario, instead of evaluating population status in the aggregate, as under Scenario B, the VSP parameters would be evaluated based on having substantial amount of natural production for the ESU come from one or two of the five MaSAs that would demonstrate low hatchery spawner contributions. This area or area(s) would be designated as Natural Production Emphasis Area(s) or NPEAs. The NPEA(s) would be managed to have low percentage of hatchery-origin spawners and to support significant levels of natural-origin spawners. This essentially serves as a diversity/productivity reserve for the population.

Limiting Factors

Factors that limit the ESU's survival and recovery include: hydropower projects, predation, harvest, degraded estuary habitat, and degraded mainstem and tributary habitat (Ford et al. 2011a). Ocean conditions have also affected the status of this ESU. Ocean conditions affecting the survival of Snake River fall-run Chinook salmon were generally poor during the early part of the last 20 years (NMFS 2012d). Crozier et al. (2019) rated the Snake River Fall-run Chinook Salmon ESU as having high vulnerability to the effects of changing environmental conditions based on high biological sensitivity, high exposure to climate effects and high adaptive capacity. It is believed migrating adults may be the most vulnerable life stay for this ESU (NMFS 2022b).

This ESU has been reduced to a single remnant population with a narrow range of available habitat. However, the overall adult abundance has been increasing from the mid-1990s, with substantial growth since the year 2001 (NMFS 2012d).

Overall, the status of Snake River fall-run Chinook salmon has clearly improved compared to the time of listing and since the time of prior status reviews. The single extant population in the ESU is currently meeting the criteria for a rating of viable developed by the ICTRT, but the ESU as a whole is not meeting the recovery goals described in the draft recovery plan for the species, which require the single population to be "highly viable with high certainty" and/or will require reintroduction of a viable population above the Hells Canyon Dam complex (NWFSC 2015; Ford 2022).

NMFS (2012d) determined the range-wide status of critical habitat by examining the condition of its PBF (also called PCEs, in some designations) that were identified when critical habitat was designated. These features are essential to the conservation of the listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration, and foraging). PCEs for Snake River fall-run Chinook salmon are shown in Table 10.

Table 10. PCEs identified for Snake River fall-run Chinook salmon (NMFS 2012d).

Habitat Component	Primary Constituent Elements (PCEs)
Spawning and juvenile rearing areas	1) spawning gravel 2) water quality 3) water quantity 4) cover/shelter 5) food (juvenile rearing) 6) riparian vegetation 7) space
Adult and juvenile migration corridors	1) substrate 2) water quality 3) water quantity 4) water temperature 5) water velocity 6) cover/shelter 7) food (juvenile) 8) riparian vegetation 9) space 10) safe passage
Areas for growth and development to adulthood	1) Ocean areas – not identified

Although the status of the ESU is improved relative to measures available at the time of listing, the ESU has remained at threatened status (NMFS 2022b). The ESU also continues to face threats from tributary and mainstem habitat loss, degradation, or modification; disease; predation; harvest; hatcheries; and changing environmental conditions (NMFS 2022b).

2.2.1.2. Life History and Current Rangewide Status of Snake River Spring/Summer-run Chinook Salmon ESU

On June 3, 1992, NMFS listed the Snake River Spring/Summer-run Chinook Salmon ESU as a threatened species (57 FR 23458). More recently, the threatened status was reaffirmed on June 28, 2005 (70 FR 37160), again on April 14, 2014 (79 FR 20802), and in the latest 5-year status review (NMFS 2022a) (Table 8). Critical habitat was originally designated on December 28, 1993 (58 FR 68543) but updated most recently on October 25, 1999 (65 FR 57399) (Table 8).

The Snake River Spring/Summer-run Chinook Salmon ESU includes all naturally spawned populations of spring/summer-run Chinook salmon in the mainstem Snake River and the Tucannon River, Grande Ronde River, Imnaha River, and Salmon River sub-basins, including 13 artificial propagation programs (Ford 2022). However, inside the geographic range of the ESU, there are a total of 19 hatchery spring/summer-run Chinook salmon programs currently operational (NMFS 2022a). Table 11 lists the natural and hatchery populations included in (or excluded from) the ESU.

Table 11. Snake River Spring/Summer-Run Chinook Salmon ESU description and MPGs (Jones Jr. 2015; NWFSC 2015; Ford 2022)

ESU Description	
Threatened	Listed under ESA in 1992; updated in 2014 (see Table 8)
5 major population groups	27 historical populations (4 extirpated)
Major Population Group	***Populations***
Lower Snake River	Tucannon River
Grande Ronde/Imnaha River	Wenaha, Lostine/Wallowa, Minam, Catherine Creek, Upper Grande Ronde, Imnaha
South Fork Salmon River	Secesh, South Fork Salmon River Mainstem, East Fork South Fork Salmon, Little Salmon
Middle Fork	Bear Valley, Marsh Creek, Sulphur Creek, Loon Creek, Camas Creek, Big Creek, Chamberlain Creek, Lower Middle Fork (MF) Salmon, Upper MF Salmon
Upper Salmon	Lower Salmon Mainstem, Lemhi River, Pahsimeroi River, Upper Salmon Mainstem, East Fork Salmon, Valley Creek, Yankee Fork, North Fork Salmon
Artificial production	
Hatchery programs included in ESU (13)	Tucannon River Spr/Sum, Lostine River Spr/Sum, Catherine Creek Spr/Sum, Looking Glass Hatchery Reintroduction Spr/Sum, Upper Grande Ronde Spr/Sum, Imnaha River Spr/Sum (including Big Sheep Creek), McCall Hatchery summer, Johnson Creek Artificial Propagation Enhancement summer, Pahsimeroi Hatchery summer, Sawtooth Hatchery spring, Yankee Fork Program, South Fork Salmon Eggbox Program (Dollar Creek Program), Panther Creek Program.

Twenty-eight historical populations (4 functionally extirpated) within five MPGs comprise the Snake River Spring/Summer-run Chinook Salmon ESU. The natural populations are aggregated into the five extant MPGs based on genetic, environmental, and life history characteristics. Figure 4 shows a map of the current ESU and the MPGs within the ESU.

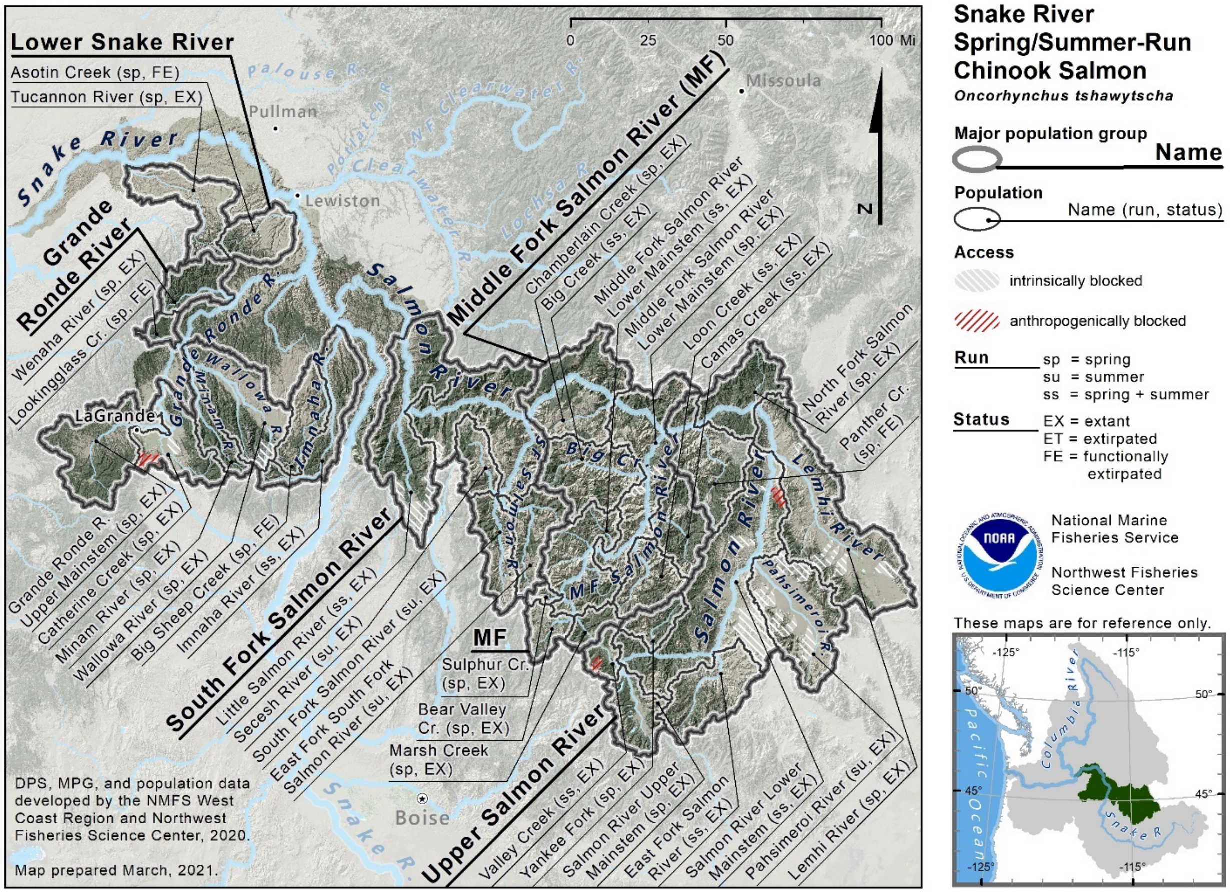

Figure 4. Snake River Spring/Summer-Run Chinook Salmon ESU spawning and rearing areas, illustrating natural populations and MPGs (Ford 2022).

Chinook salmon have a wide variety of life history patterns that include: variation in age at seaward migration; length of freshwater, estuarine, and oceanic residence; ocean distribution; ocean migratory patterns; and age and season of spawning migration. Two distinct races of Chinook salmon are generally recognized: “stream-type” and “ocean-type” (Healey 1991; Myers et al. 1998). The Snake River Spring/Summer-run Chinook Salmon ESU consists of “stream-type” Chinook salmon, which spend 2 to 3 years in ocean waters and exhibit extensive offshore ocean migrations. Spring/summer-run Chinook salmon return to the Columbia River from the ocean in early spring through August. These fish spawn high in the watershed. The eggs incubate over the following winter, and hatch in late winter and early spring of the following year. Juveniles rear through the summer, overwinter, and typically migrate to sea in the spring of their second year of life, although some juveniles may spend an additional year in fresh water. Snake River spring/summer-run Chinook salmon spend two or three years in the ocean before returning to tributary spawning grounds primarily as 4- and 5- year-old fish. A small fraction of the fish return as 3-year old “jacks,” heavily predominated by males.

Historically, the Snake River drainage is thought to have produced more than 1.5 million adult spring/summer-run Chinook salmon in some years during the late 1800s (Matthews and Waples 1991). By the 1950s, the abundance of spring/summer-run Chinook salmon had declined to an annual average of 125,000 adults, and continued to decline through the 1970s. In 1995, only

1,797 spring/summer-run Chinook salmon adults returned (hatchery and wild fish combined). Returns at (LGR (hatchery and wild fish combined) dramatically increased after 2000, with 185,693 adults returning in 2001. The large increase in 2001 was due primarily to hatchery returns, with only 10 percent of the returns from fish of natural-origin (NMFS 2012d).

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

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on Viable Salmonid Population (VSP) criteria including abundance, productivity, spatial structure, and diversity of its constituent natural populations (McElhany et al. 2000b). NMFS has initiated recovery planning for the Snake River drainage, organized around a subset of management unit plans corresponding to state boundaries. The recovery plans will incorporate VSP criteria recommended by the Interior Columbia Technical Recovery Team (ICTRT). The ICTRT recovery criteria are hierarchical in nature, with ESU/DPS level criteria being based on the status of natural-origin Chinook salmon assessed at the population level. The population level assessments are based on a set of metrics designed to evaluate risk across the four VSP elements. The ICTRT approach calls for comparing estimates of current natural-origin abundance and productivity against predefined viability curves(NWFSC 2015). Achieving recovery (i.e., delisting the species) of each ESU is the longer-term goal of the recovery plan. Table 12 shows the most recent metrics for the Snake River Spring/Summer-run Chinook Salmon ESU.

The majority of populations in the Snake River Spring/Summer-run Chinook Salmon ESU remained at high overall risk, with three populations (Minam River, Bear Valley, and Marsh Creek) improving to an overall rating of “maintained” due to an increase in abundance/ productivity when measured over a 10-20 year period (Table 12)(Ford 2022). However, natural-origin abundance has generally decreased over the levels reported in the prior review for most populations in this ESU, in many cases sharply. Relatively low ocean survivals in recent years are likely a major factor in recent abundance patterns. All but three populations in this ESU remained at high risk for abundance and productivity (Ford 2022). Spatial structure ratings remain unchanged from the prior reviews, with low or moderate risk levels for the majority of populations in the ESU. Four populations from three MPGs (Catherine Creek and Grande Ronde River Upper Mainstem, Lemhi River, and Middle Fork Salmon River Lower Mainstem) remain at high risk for spatial structure loss. Overall, Ford (2022) concludes that the Snake River Spring/Summer-run Chinook Salmon ESU continues to be at moderate-to-high risk.

Table 12. Snake River spring/summer-run Chinook salmon population status relative to ICTRT viability criteria, grouped by MPG. Natural spawning abundance: most recent 10-yr geometric mean (range). ICTRT productivity: 20-yr geometric mean for parent escapements below 75 percent of population threshold. Current abundance and productivity estimates are geometric means. Range in annual abundance, standard error, and number of qualifying estimates for productivities in parentheses. Populations with no abundance and productivity data are given a default High A/P Risk rating (Ford 2022)[1].

Population	Abundance/Productivity Metrics				Spatial Structure and Diversity Metrics			Overall Risk Rating
	ICTRT Threshold	*Natural Spawning*	*ICTRT Productivity*	*Integrated A/P Risk*	*Natural Processes*	*Diversity Risk*	*Integrated SS/D Risk*	
Lower Snake River MPG								
Tucannon River	750	116 (sd 205)	1.09 (0.31 17/20)	High	Low	Moderate	Moderate	High
Grande Ronde/Imnaha MPG								
Wenaha River	750	437 (sd 191)	1.21 (0.16 15/20)	High	Low	Moderate	Moderate	High
Lostine/Wallowa R.	1,000	654 (sd 400)	0.97 (0.21 18/20)	High	Low	Moderate	Moderate	High
Minam R.	750	544 (sd 256)	1.44 (0.15 15/20)	Moderate	Low	Moderate	Moderate	Maintained
Catherine Creek	1,000	200 (sd 207)	0.76 (0.27 20/20)	High	Moderate	Moderate	Moderate	High
Upper Gr. Ronde R.	1,000	80 (sd 157)	0.47 (0.25 20/20)	High	High	Moderate	High	High
Imnaha River	750	513 (sd 214)	0.65 (0.27 14/20)	High	Low	Moderate	Moderate	High
South Fork Salmon River MPG								
South Fork Mainstem	1,000	381 (sd 514)	0.96 (0.20 12/20)	High	Low	Moderate	Moderate	High
Secesh River	750	472 (sd 396)	-	High	Low	Low	Low	High
East F South F Salmon.	1,000	483 (sd 265)	-	High	Low	Low	Low	High
Little Salmon River	750	*Insf. data*	-	-	Low	Low	Low	High
Middle Fork Salmon River MPG								
Chamberlain Creek	750	342 (sd 171)	1.36 (0.34 17/20)	High	Low	Low	Low	High
Middle Fork Salmon River Lower Mainstem	1,000	163 (sd 114)	1.47 (0.34 20/20)	High	Very Low	Moderate	Moderate	High
Big Creek	500	45 (sd 37)	1.95 (0.33 13/20)	High	Low	Moderate	Moderate	High
Camas Creek	500	42 (sd 27)	1.37 (0.42 17/20)	High	Low	Moderate	Moderate	High
Loon Creek	500	*Insf. data*	*Insf.data*	-	Moderate	Moderate	Moderate	High
Middle Fork Salmon River Upper Mainstem	750	71 (sd 43)	1.30 (0.34 17/20)	High	Low	Moderate	Moderate	High
Sulphur Creek	500	67 (sd 65)	1.02 (0.25 13/20)	High	Low	Moderate	Moderate	High
Marsh Creek	500	333 (sd 262)	2.11 (0.32 7/20)	Moderate	Low	Low	Low	Maintained
Bear Valley Creek	750	428 (sd 327)	2.22 (0.26 13/20)	Moderate	Very Low	Low	Low	Maintained
Upper Salmon River MPG								
North Fork Salmon River	2,000	71 (sd 87)	1.30 (0.23 20/20)	High	Low	Low	Low	High
Lemhi River	1,000	326 (sd 270)	1.13 (0.31 18/20)	High	Low	Low	Low	High
Salmon River Lower Mainstem	1,000	218 (sd 168)	1.26 (0.20 20/20)	High	Moderate	High	High	High

Pahsimeroi River	2,000	250 (sd 159)	1.63 (0.28 19/20)	High	High	High	High	High
East Fork Salmon River	500	113 (sd 100)	1.63 (0.26 17/20)	High	Low	Moderate	Moderate	High
Yankee Fork	1,000	288 (sd 291)	2.00 (0.28 17/20)	High	Low	High	high	High
Salmon River Upper Mainstem	500	62 (sd 139)	0.99 (0.51 17/20)	High	Moderate	High	High	High
Valley Creek	500	*Insf. data*	*Insf. data*	-	Low	Low	Low	High
Panther Creek	750	*Insf. data*	*Insf. data*					See text

[1] Interior Columbia Technical Recovery Team (ICTRT) recommended minimum abundances based on a 10-year geometric mean.

Limiting Factors

Understanding the limiting factors and threats that affect the Snake River Spring/Summer-run Chinook Salmon ESU provides important information and perspective regarding the status of a species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. The abundance of spring/summer-run Chinook salmon had already begun to decline by the 1950s, and it continued declining through the 1970s. In 1995, only 1,797 spring/summer-run Chinook salmon total adults (both hatchery and natural combined) returned to the Snake River (NMFS 2012d).

There are many factors that affect the abundance, productivity, spatial structure, and diversity of the Snake River Spring/Summer-run Chinook Salmon ESU. Factors that limit the ESU's survival and recovery include migration through the Federal Columbia River Power System (FCRPS) dams, the degradation and loss of estuarine areas that help fish transition between fresh and marine waters, spawning and rearing areas that have lost deep pools, loss of cover, reductions in side-channel refuge areas, reductions in high-quality spawning gravels, and interbreeding and competition with hatchery fish that may outnumber natural-origin fish (Ford 2011). The most serious risk factor is low natural productivity and the associated decline in abundance to low levels relative to historical returns. The biological review team (Ford 2011) was concerned about the number of hatchery programs across the ESU, noting that these programs represent ongoing risks to natural populations and can make it difficult to assess trends in natural productivity.

2.2.1.3. Life History and Current Rangewide Status of Snake River Sockeye Salmon ESU

On April 5, 1991, NMFS listed the Snake River Sockeye Salmon ESU as an endangered species (56 FR 14055) under the Endangered Species Act (ESA). This listing was affirmed in 2005 (70 FR 37160), and again on April 14, 2014 (79 FR 20802) (Table 8). Critical habitat was designated on December 28, 1993 (58 FR 68543) and reaffirmed on September 2, 2005 (Table 8).

This ESU includes all anadromous and residual sockeye salmon originating from the Snake River Basin, Idaho, as well as artificially propagated sockeye salmon from the Snake River Sockeye Salmon Captive Broodstock Program (Table 13).

Table 13. Snake River Sockeye Salmon ESU description and MPG (Jones Jr. 2015; NMFS 2015b).

ESU Description	
Threatened	Listed under ESA in 1991; updated in 2014 (see Table 8)
1 major population group	6 historical populations (5 extirpated)
Major Population Group	***Population***
Stanley Basin Sockeye	Redfish Lake
Artificial production	
Hatchery programs included in ESU (1)	Redfish Lake Captive Broodstock

Historically, Snake River sockeye salmon spawned in five lakes (Alturas, Stanley, Redfish, Yellow Belly, and Pettit Lakes) near Stanley, Idaho, and in the headwaters of the Salmon River, Big Payette Lake in central Idaho, and Wallowa Lake in eastern Oregon (Waples et al. 1991; Good et al. 2005b). The Payette and Wallowa Lakes are blocked to sockeye salmon by hydropower or irrigation dams (Chapman et al. 1990). Sockeye access to the Payette Basin was eliminated in 1923 with the construction of Black Canyon Dam. Sunbeam Dam on the Salmon River blocked sockeye salmon from Redfish Lake and all other lakes in the Upper Salmon River from 1910 to 1934, though eyewitness accounts document spawning sockeye salmon in Redfish Lake before dam removal in 1934. Irrigation diversions in Alturas Lake Creek eliminated return of sockeye to Alturas Lake. In 1997, IDFG removed the irrigation diversion to help with reintroduction efforts at Alturas Lake.

The extant MPG contains one extant population (Redfish Lake) and two to four historical populations (Alturas, Pettit, Stanley, and Yellowbelly Lakes) (NMFS 2015b) (Figure 5). At the time of listing in 1991, the only confirmed extant population included in this ESU was the beach-spawning population of sockeye salmon from Redfish Lake, with about 10 fish returning per year (NMFS 2015b). Historical records indicate that sockeye salmon once occurred in several other lakes in the Stanley Basin, but no adults were observed in these lakes for many decades; once residual sockeye salmon were observed, their relationship to the Redfish Lake population was uncertain (McClure et al. 2005). Since ESA-listing, progeny of the Redfish Lake sockeye salmon population have been out planted to Pettit and Alturas Lakes within the Stanley Basin for recolonization purposes (NMFS 2011d).

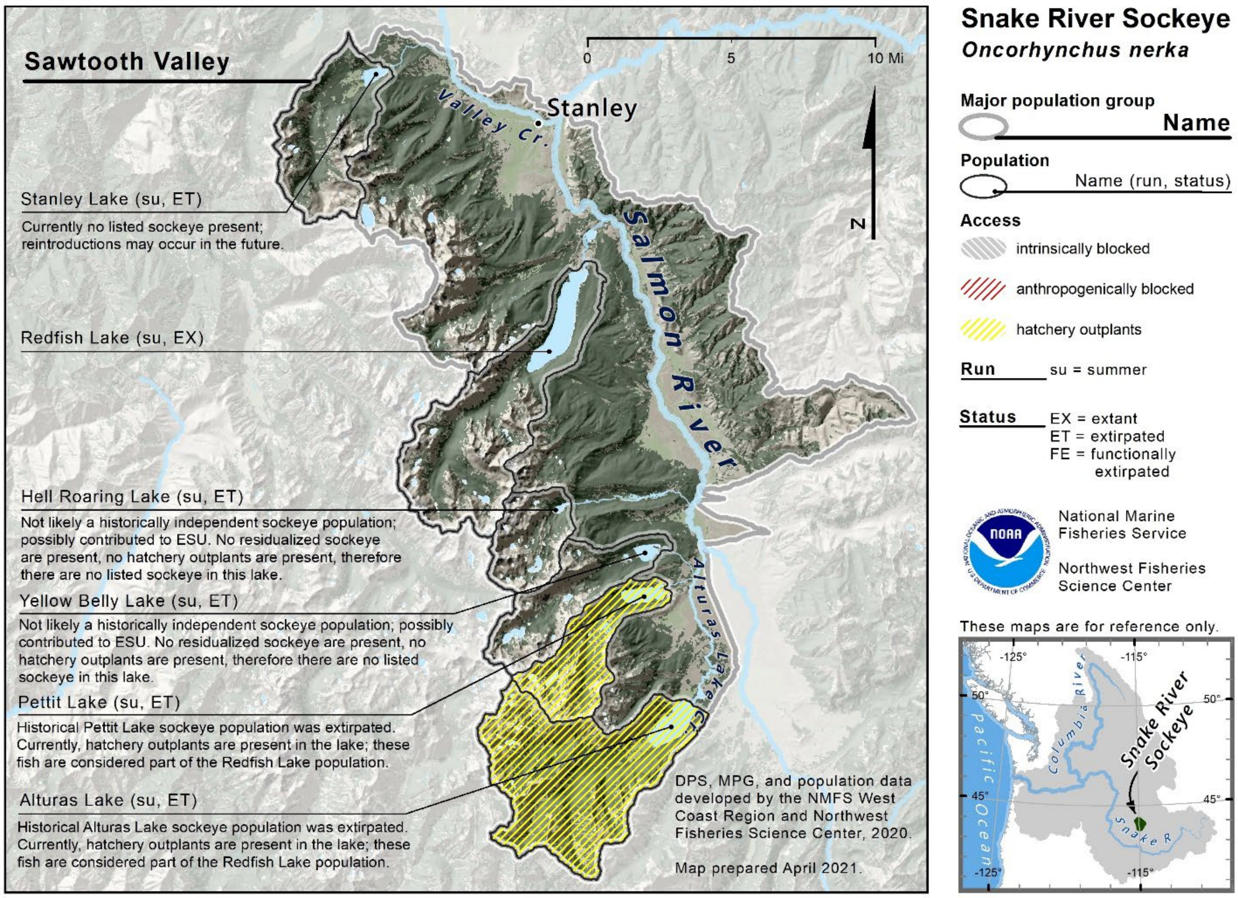

Figure 5. Map of the Snake River Sockeye Salmon ESU's spawning and rearing areas, illustrating populations and MPGs (Ford 2022).

Adult Snake River sockeye salmon enter the Columbia River in late-May through July and normally pass Bonneville Dam from early June to late July, and LGR from late June to late August, on their 900-mile migration to their spawning grounds in the Upper Salmon River near Stanley, Idaho (Figure 5). Adult sockeye salmon arrive at Stanley Basin lakes in August and September. The adults are lake spawners, spawning along the lake shoals. Juveniles typically rear in the lake for 1 to 3 years after emergence from the gravel. Anadromous sockeye salmon returning to Redfish Lake in Idaho's Stanley Basin travel a greater distance from the sea, 900 miles, to a higher elevation (6,500 feet.) than any other sockeye salmon population. They are the southernmost population of sockeye salmon in the world (NMFS 2015b).

Juvenile sockeye salmon migrate from the Stanley Basin lakes during late April through May. Pit-tagged smolts from Redfish Lake generally pass LGR during mid-May to mid-July. Snake River sockeye salmon may spend from 1 to 4 years in the ocean before returning to fresh water to spawn. Although sockeye salmon are primarily anadromous, some populations spend their entire life cycle in fresh water without a period in the ocean.

Abundance, Productivity, Spatial Structure, and Diversity

The endangered Snake River Sockeye Salmon ESU was making headway towards meeting the biological viability criteria (i.e., indication that the ESU is self-sustaining and naturally producing and no longer qualifies as a threatened species), with increasing annual returns and the creation of the Captive Broodstock program. However, in 2015 due to low snowpack coupled with high air temperatures within the Columbia Basin, instream temperatures were warm, causing very low survival between Bonneville Dam and LGR, therefore derailing the trend towards recovery (NMFS 2016a). The increased abundance of hatchery-reared Snake River sockeye salmon reduces the risk of immediate loss, but levels of naturally produced sockeye salmon returns remain extremely low and at high risk from changes in environmental conditions (Ford 2022).

The large increases in returning adults in recent years reflect improved downstream and ocean survivals, as well as increases in juvenile production, starting in the early 1990s. Although total sockeye salmon returns to the Stanley Basin in recent years have been high enough to allow for some level of natural spawning in Redfish Lake, the hatchery program remains at its initial phase with a priority on genetic conservation and building sufficient returns to support sustained out planting and recolonization of the species historical range (NMFS 2015b; NWFSC 2015).

In NMFS' Status Review Update for Pacific salmon and steelhead listed under the ESA (Ford 2011), it was not possible to quantify the viability ratings for Snake River sockeye salmon. Ford (2011) determined that the Snake River sockeye captive broodstock-based program has made substantial progress in reducing extinction risk, but that natural production levels of anadromous returns remain extremely low for this species. At present, anadromous returns are dominated by production from the captive spawning component. The ongoing reintroduction program is still in the phase of building sufficient returns to allow for large scale reintroduction into Redfish Lake, the initial target for restoring natural program (NMFS 2015b). There is some evidence of very low levels of early timed returns in some recent years from out-migrating naturally produced Alturas Lake smolts. At this stage of the recovery efforts, the ESU remains rated at extremely high risk for spatial structure, diversity, abundance, and productivity(NWFSC 2015). In the most recent 2020 status update, viability of Snake River Sockeye Salmon ESU has declined since the 2015 report (Ford 2022). It was noted that in the most recent 5-year status review of the Snake River Sockeye Salmon ESU (NMFS 2022c), NMFS concluded that the risk to the species persistence because of habitat destruction or modification has improved slightly since the 2016 5 year review (NMFS 2016b; 2022c). However, the information analyzed for this 5-year review, including Ford (2022), indicates that the ESU continues to exhibit extreme low abundance of naturally produced SR sockeye salmon and low survival across multiple life-stages, reducing productivity, despite the improvements (e.g., CRS operational changes, improved water quality regulatory controls at the state level, increased hatchery production and improved hatchery practices) since the previous 2016 5-year review (NMFS 2022c).

Limiting Factors

There are many factors that affect the abundance, productivity, spatial structure, and diversity of the Snake River Sockeye Salmon ESU. Factors that limit the ESU have been, and continue to be, impaired mainstem and tributary passage from the mainstem Snake and Columbia River hydropower system, reduced tributary stream flows and high temperatures, historical commercial fisheries, chemical treatment of Stanley Basin lakes in the 1950s and 1960s, and poor ocean conditions (NMFS 2008e). Changes in environmental conditions are also recognized as a possible factor in Snake River salmon declines (Tolimieri and Levin 2004; Scheuerell and Williams 2005; NMFS 2012d). These combined factors reduced the number of sockeye salmon that make it back to spawning areas in the Stanley Basin to the single digits, and in some years, zero. The decline in abundance itself has become a major limiting factor, making the remaining population vulnerable to catastrophic loss and posing significant risks to genetic diversity (NMFS 2015b; NWFSC 2015). However, some limiting factors have improved since the original listing of Snake River sockeye salmon and now present little harm to the ESU. Fisheries are now better regulated through ESA constraints and management agreements, significantly reducing harvest-related mortality. Potential habitat-related threats to the fish, especially in the Stanley Basin, pose limited concern since most passage barriers have been removed and much of the natal lake area and headwaters remain protected (NMFS 2015b). Hatchery-related concerns have also been reduced through improved management actions (NMFS 2015b).

2.2.1.4. Life History and Current Rangewide Status of Snake River Steelhead DPS

On August 18, 1997, NMFS listed the Snake River Basin Steelhead DPS as a threatened species (62 FR 43937). The threatened status was reaffirmed in 2006 and most recently on April 14, 2014 (79 FR 20802) (Table 8). Critical habitat for the DPS was designated on September 2, 2005 (70 FR 52769) (Table 8).

The Snake River Basin steelhead DPS includes all naturally spawned anadromous *O. mykiss* (steelhead) populations below natural and manmade impassable barriers in streams in the Snake River basin of southeastern Washington, northeastern Oregon, and Idaho, as well as several hatchery programs (Ford 2022). The Snake River Basin Steelhead DPS comprises twenty-four historical populations within six MGPs comprise the Snake River Basin Steelhead DPS. Inside the geographic range of the DPS, 19 hatchery steelhead programs are currently operational. Nine of these artificial programs are included in the DPS (Table 14). Managers classify Snake River summer steelhead runs into two groups based primarily on ocean age, run timing and adult size on return to the Columbia River: A-run steelhead are primarily returning to spawning areas beginning in the summer and the B-run steelhead are larger, predominated by age-2 ocean fish and begin their migration in the fall. Figure 6 shoes a map of the current DPS and the MPGs within the DPS.

Table 14. Snake River Basin Steelhead DPS description and MPGs (Jones Jr. 2015; NWFSC 2015; Ford 2022).

DPS Description	
Threatened	Listed under ESA as threatened in 1997; updated in 2014 (see Table 8)
6 major population groups	27 historical populations (1 extirpated)
Major Population Group	***Populations***
Grande Ronde	Joseph Creek, Upper Mainstem, Lower Mainstem, Wallowa River
Imnaha River	Imnaha River
Clearwater	Lower Mainstem River, Lolo Creek, Lochsa River, Selway River, South Fork Clearwater
Salmon River	Little Salmon/Rapid, Chamberlain Creek, Secesh River, South Fork Salmon, Panther Creek, Lower Middle Fork Salmon, Upper Middle Fork Salmon, North Fork, Lemhi River, Pahsimeroi River, East Fork Salmon, Upper Mainstem Salmon
Lower Snake	Tucannon River, Asotin Creek
Hells Canyon Tributaries	n/a – area excluded from listing due to lack of available habitat
Artificial production	
Hatchery programs included in DPS (7)	Tucannon River summer, Little Sheep Creek/Imnaha River Hatchery summer, EF Salmon River A, Dworshak NFH B, Lolo Creek B, Clearwater Hatchery B, SF Clearwater (localized) B

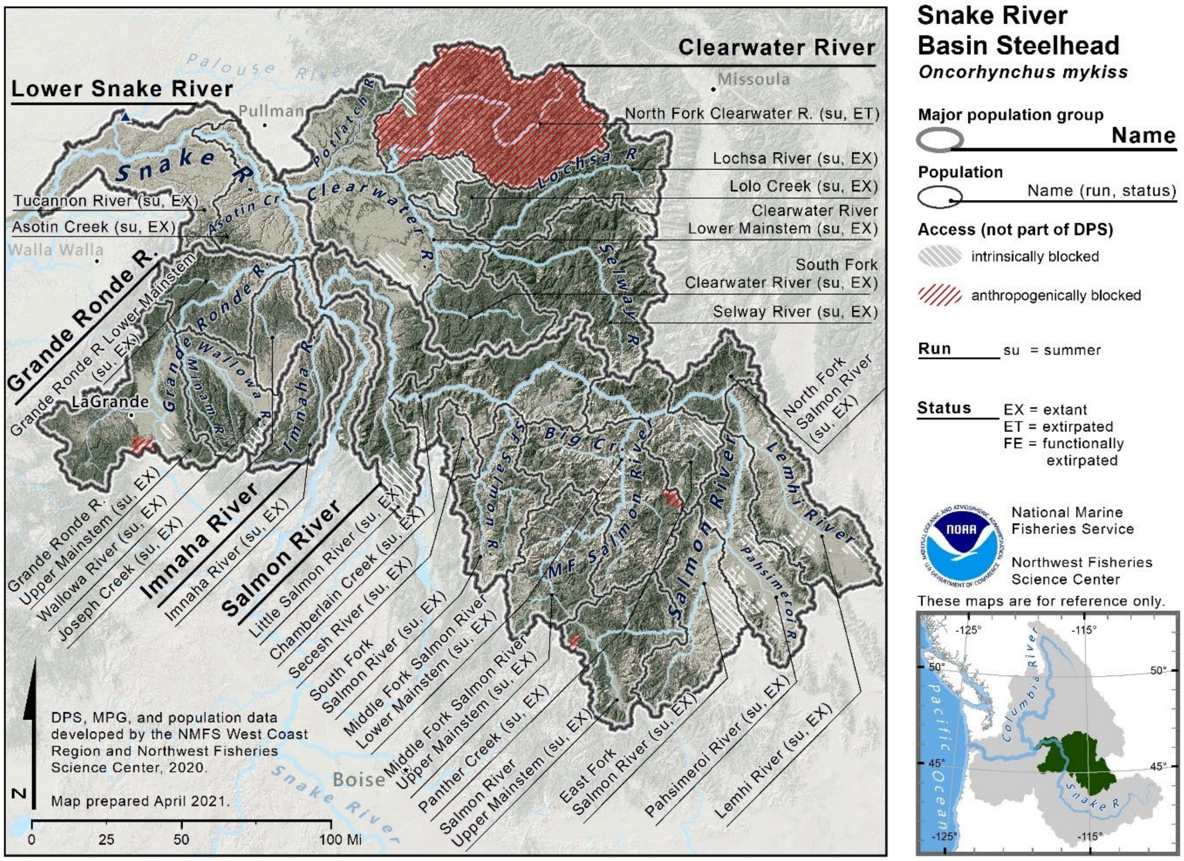

Figure 6. Snake River Basin Steelhead DPS spawning and rearing areas, illustrating natural populations and MPGs (Ford 2022).

O. mykiss exhibit perhaps the most complex suite of life-history traits of any species of Pacific salmonid. They can be anadromous or freshwater resident, and under some circumstances, yield offspring of the opposite form. Steelhead are the anadromous form. A non-anadromous form of *O. mykiss* (rainbow trout) co-occurs with the anadromous form in this DPS, and juvenile life stages of the two forms can be very difficult to differentiate. Steelhead can spend up to 7 years in fresh water prior to smoltification, and then spend up to 3 years in salt water prior to first spawning. This species can also spawn more than once (iteroparous), whereas all other species of *Oncorhynchus,* except *O. clarkii,* spawn once and then die (semelparous). Snake River steelhead migrate a substantial distance from the ocean (up to 1,500 km) and use high-elevation tributaries (typically 1,000–2,000 m above sea level) for spawning and juvenile rearing. Snake River steelhead occupy habitat that is considerably warmer and drier (on an annual basis) than other steelhead DPSs.

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

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 Snake River Steelhead DPS currently remains at “moderate” risk of extinction (Ford 2022). The additional monitoring programs instituted in the early 2000s have significantly improved the ability to assess viability of the DPS. This new information has resulted in an updated view of the relative abundance of natural-origin spawners and life-history diversity across the various populations. However, a great deal of uncertainty still remains regarding the relative proportion of hatchery fish in natural spawning areas near major hatchery release sites within individual populations.

There are five MPGs with extant populations: The Lower Snake River MPG (two populations); the Grande Ronde MPG (four populations); the Imnaha MPG (one population); the Clearwater MPG (five extant and one extirpated population); and the Salmon River MPG (12 populations). The Interior Columbia River Technical Recovery Team (ICTRT) has recommended that each MPG should include viable populations totaling at least half of the populations historically present, with all major life history groups represented (Ford 2022).

The ICTRT viability criteria adopted in the draft Snake River Management Unit Recovery Plans include spatial explicit criteria and metrics for both spatial structure and diversity. With one exception, spatial structure ratings for all of the Snake River Basin steelhead populations were low or very low risk, given the evidence for distribution of natural production with populations. The exception was the Panther Creek population, which was given a high-risk rating for spatial structure based on the lack of spawning in the upper sections. No new information was provided for the 2020 status update that would change those ratings (Ford 2022).

There are many factors that affect the abundance, productivity, spatial structure, and diversity of the Snake River Steelhead DPS. Factors that are thought to limit the DPS’s survival and recovery include: juvenile and adult survival through the FCRPS; the degradation and loss of estuarine areas that help the fish survive the transition between fresh and marine waters; spawning and rearing areas that have lost deep pools, cover, side-channel refuge areas, high quality spawning gravels; and interbreeding and competition with hatchery fish that, in some of the populations of interest, far outnumber natural-origin fish.

Steelhead were historically harvested in tribal and non-tribal gillnet fisheries, and in recreational fisheries in the mainstem Columbia River and its tributaries. Steelhead are still harvested in tribal fisheries and there is incidental mortality associated with mark-selective recreational and commercial fisheries. The majority of impacts on the summer run occur in tribal gillnet and dip net fishing targeting spring/summer-run Chinook salmon. Because of their larger size, the B-run fish are more vulnerable to gillnet gear. In recent years, total exploitation rates (exploitation rates are the sum of all harvest) on the A-run have been stable around 5 percent, while exploitation rates on the B-run have generally been in the range of 15-20 percent (NWFSC 2015).

Four out of the five MPGs are not meeting the specific objectives in the draft Snake River Recovery Plan, and the status of many individual populations remain uncertain. The additional monitoring programs instituted in the early 2000s to gain better information on natural-origin abundance and related factors have significantly improved the ability to assess status at a more detailed level. The new information has resulted in an updated view of the relative abundance of natural-origin spawners and life history diversity across the populations in the DPS. The more specific information on the distribution of natural returns among stock groups and populations indicates that differences in abundance/productivity status among populations may be more related to geography or elevation rather than the morphological forms (i.e., A-run versus B-run). However, a great deal of uncertainty still remains regarding the relative proportion of hatchery fish in natural spawning areas near major hatchery release sites within individual populations. Overall, the information analyzed for this viability review indicates that the Snake River Basin steelhead DPS remains at "moderate" risk of extinction, with viability largely unchanged from the prior review in 2015 (Ford 2022).

2.2.2. Rangewide Status of Critical Habitat

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

NMFS determines the rangewide status of critical habitat by examining the condition of its PBFs that were identified when critical habitat was designated. These features are essential to the conservation of the listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration and foraging). An example of some PBFs are below. These are often similar among listed salmon and steelhead; specific differences can be found in the critical habitat designation for each species (Table 8).

- Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development.

- 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.

- 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.

- 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.

- 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.

- Offshore marine areas with water-quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.

The status of critical habitat is based primarily on a watershed-level analysis of conservation value that focused on the presence of ESA-listed species and physical features that are essential to the species' conservation. NMFS organized information at the 5th field hydrologic unit code (HUC) watershed scale because it corresponds to the spatial distribution and site fidelity scales of salmon and steelhead populations (McElhany et al. 2000b). The analysis for the 2005 designations of salmon and steelhead species was completed by Critical Habitat Analytical Review Teams (CHARTs) that focused on large geographical areas corresponding approximately to recovery domains (NMFS 2005c). Each watershed was ranked using a conservation value attributed to the quantity of stream habitat with physical and biological features (PBFs; also known as primary and constituent elements (PCEs), the present condition of those PBFs, the likelihood of achieving PBF potential (either naturally or through active restoration), support for rare or important genetic or life history characteristics, support for abundant populations, and support for spawning and rearing populations. In some cases, our understanding of these interim conservation values has been further refined by the work of technical recovery teams and other recovery planning efforts that have better explained the habitat attributes, ecological interactions, and population characteristics important to each species.

The HUCs that have been identified as critical habitat for these species are largely ranked as having high conservation value. Conservation value reflects several factors: (1) how important the area is for various life history stages, (2) how necessary the area is to access other vital areas of habitat, and (3) the relative importance of the populations the area supports relative to the overall viability of the ESU or DPS. No CHART reviews have been conducted for the three Snake River Salmon ESUs, but have been done for both the Snake River and mid-Columbia steelhead DPSs. The Snake River Steelhead DPS's range includes 291 watersheds. The CHART assigned low, medium, and high conservation value ratings to 14, 43, and 230 watersheds, respectively (NMFS 2005a). They also identified 4 watersheds that had no conservation value.

The following are the major factors limiting the conservation value of critical habitat for Snake River steelhead:

- Agriculture
- Channel modifications/diking
- Dams
- Forestry
- Fire activity and disturbance
- Grazing
- Irrigation impoundments and withdrawals,
- Mineral mining
- Recreational facilities and activities management
- Exotic/ invasive species introductions

Also, refer to the Mitchell Act Biological Opinion (NMFS 2017a) for a detailed description of how critical habitat has been designated by NMFS.

2.2.2.1. Critical Habitat in Interior Columbia: Snake River Basin, Idaho

Critical habitat has been designated in the Interior Columbia (IC) recovery domain, which includes the Snake River Basin, for the Snake River Spring/Summer-run Chinook Salmon ESU, Snake River Fall-run Chinook Salmon ESU, Snake River Sockeye Salmon ESU, and Snake River Basin Steelhead DPS (Table 8). In the Snake River Basin, some watersheds with PCEs for steelhead (Upper Middle Salmon, Upper Salmon/Pahsimeroi, MF Salmon, Little Salmon, Selway, and Lochsa Rivers) are in good-to-excellent condition with no potential for improvement. Additionally, several Lower Snake River watersheds in the Hells Canyon area, straddling Oregon and Idaho, are in good-to-excellent condition with no potential for improvement (NMFS 2016a). While critical habitat is in good-to-excellent condition, the Snake River Spring/Summer-run Chinook Salmon ESU (Table 12) and the Snake River Basin Steelhead DPS remain at moderate to high risk for extinction.

Habitat quality in tributary streams in the IC recovery domain varies from excellent in wilderness and road-less areas to poor in areas subject to heavy agricultural and urban development. Critical habitat throughout much of the IC recovery domain has been degraded by intense agriculture, alteration of stream morphology (i.e., through channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining, and urbanization. Reduced summer stream flows, impaired water quality, and reduction of habitat complexity are common problems for critical habitat in developed areas, including those within the IC recovery domain (NMFS 2016a).

Habitat quality of migratory corridors in this area have been severely affected by the development and operation of the FCRPS dams and reservoirs in the mainstem Columbia River, Bureau of Reclamation tributary projects, and privately-owned dams in the Snake River basin. Hydroelectric development has modified natural flow regimes of the rivers, resulting in higher water temperatures, changes in fish community structure that lead to increased rates of piscivorous and avian predation on juvenile salmon and steelhead, and delayed migration for both adult and juvenile salmonids. Physical features of dams, such as turbines, also kill out-migrating fish. In-river survival is inversely related to the number of hydropower projects encountered by emigrating juveniles. Additionally, development and operation of extensive irrigation systems and dams for water withdrawal and storage in tributaries have altered hydrological cycles (NMFS 2016a).

Many stream reaches designated as critical habitat are listed on Idaho's Clean Water Act Section 303(d) list for water temperature. Many areas that were historically suitable rearing and spawning habitat are now unsuitable due to high summer stream temperatures. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water for agricultural or municipal use all contribute to elevated stream temperatures. Furthermore, contaminants, such as insecticides and herbicides from agricultural runoff and heavy metals from mine waste, are common in some areas of critical habitat (NMFS 2016a). They can negatively impact critical habitat and the organisms associated with these areas.

2.3. Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02).

2.3.1. Action Area for Snake River Fall-run Chinook Salmon

For the purposes of this analysis, the action area includes the vicinity of hatchery, acclimation facilities, and release areas in the Snake, Grande Ronde, and Clearwater River Basins as well as areas within those basins where fall-run Chinook salmon spawn and rear.

The Action Area for this analysis has changed from the 2018 Biological Opinion (NMFS 2018e) in the following ways:

1. The Action Area will be expanded to include the movement of the Pittsburg Landing subyearling release from the Snake River into the Salmon River 10 miles upstream of the IPC program release at Hammer Creek.
2. The Action Area will also extend further into the Grande Ronde Basin, to include the shifting of release location from Cougar Creek, WA to the Big Canyon Acclimation Facility (ODFW) located on Deer Creek (a tributary to the Wallowa River), OR.

In determining whether to extend the action area further downstream, NMFS considered the following: Releases from the proposed programs constitute approximately 27% of all hatchery salmon and steelhead released into the Snake Basin. As ecological interactions are possible with listed Snake River spring/summer-run Chinook salmon, sockeye salmon, and steelhead juveniles, the Action Area will include the mainstem Snake River downstream to the Columbia River confluence. Other areas outside the Snake River Basin where juvenile salmon generated from the hatchery programs may co-occur with listed salmon and steelhead will not be included. Considering the small proportion (~5%) of fish from the proposed programs in the total numbers of hatchery fish in the Columbia River mainstem downstream from the Snake River confluence and ocean, NMFS does not believe it is possible to meaningfully measure, detect, or evaluate the effects of those juvenile interactions in the mainstem Columbia River and near ocean due to the low likelihood or magnitude of such interactions in locations outside the action area and their associated effects (Section 2.5.2.3).

Adult fish from Snake River fall-run Chinook salmon hatchery programs are occasionally found in hatchery traps and on the spawning grounds of listed Chinook salmon ESUs in the Columbia Basin and in California (Milks 2012). However, the numbers of Snake River fall-run Chinook salmon are low and the straying pattern displays no regular pattern temporally or spatially. Any effect the stray fish would have would be very small. Thus, we do not extend the Action Area to these areas.

The Action Area resulting from this analysis includes the Salmon River release sites downstream to the confluence of the Snake River, the Snake River from the confluence of the Salmon River downstream to Ice Harbor Dam, as well as the area downstream of the Clearwater and the Grande Ronde Rivers releases. The extent to which we believe the effects of the Proposed Action can be detected is from the area downstream of the release sites to Ice Harbor Dam. We did not extend the action area beyond Ice Harbor Dam to the estuary/plume because the action area, as defined, represents the area in which the effects of the action can be meaningfully detected. The Mitchell Act Biological Opinion (NMFS 2024b) considered the effects of hatchery fish in the estuary and ocean and found that subyearling Chinook salmon and coho salmon are the most likely hatchery fish to have effects in these areas due to their long residence times and relatively high predation rates, respectively. Only subyearling Chinook salmon are released into the Action Area. This suggests that the likelihood of detecting effects from the hatchery steelhead releases on natural-origin fish below Ice Harbor Dam has already been examined to the best of our ability.

2.3.2. Action Area for Southern Resident Killer Whales

“Action area” means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action” (50 CFR 402.02).

The action area for Southern Resident Killer Whales (SRKW) is different than the action area for Snake River fall-run Chinook salmon described above as there are no effects of flow management that directly affect SRKWs. Rather, there is an indirect link to SRKWs from effects on Chinook salmon and Chinook salmon spawning and rearing habitat in the Snake River, Clearwater and Grande Ronde River basins because Chinook salmon are a primary prey for SRKWs in the Pacific Ocean. This indirect link results in effects in the Pacific Ocean where SRKWs feed on concentrations of adult Chinook salmon (Hanson et al. 2021; NMFS 2021a). This action area for SRKWs is the section of the ocean where there is species overlap between Snake River fall-run Chinook salmon and SRKWs. The exact boundaries of this area cannot be precisely defined based upon current information; however, the action area where SRKWs and Chinook salmon from the Snake River overlap includes coastal waters ranging from the mouth of the Columbia River down to Southern Oregon and up to Southeast Alaska (Weitkamp 2010). This portion of the action area also includes coastal critical habitat for SRKWs (86 FR 41668; August 2, 2021).

2.4. Environmental Baseline

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultations, and the impact of State or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

2.4.1. RM&E Activities

Juvenile monitoring activities, although not part of this Proposed Action, are critical to understanding the status of the Snake River Fall-run Chinook Salmon ESU. Some juvenile monitoring activities operated by NPT have previously been permitted under a former ESA §10 scientific research permit #1134 issued to the Nez Perce Tribe, (NPT 2007). Monitoring under the permit occurs in the Clearwater River and the lower reaches of the South Fork Clearwater and Selway Rivers using snorkel surveys, seine, fyke net, trawl, purse seine, minnow trap, electrofishing, and screw traps. In general, juvenile fall-run Chinook salmon will be observed trapped, handled, tagged, and released during monitoring activities. Snake River spring/summer-run Chinook salmon and Snake River steelhead will also be observed trapped, handled, tagged, and released during monitoring activities. A detailed description of methods, locations, and number of fish taken is found in the NPT HGMP (NPT 2011) and incorporated here by reference and in supplementary material provided by NPT (Vogel 2012). Juvenile monitoring (smolt trapping) also occurs in the Tucannon River. In general, juvenile fall-run Chinook salmon will be trapped, handled (and possibly PIT tagged), and released during smolt trapping operations. Snake River spring/summer-run Chinook salmon and Snake River steelhead are also trapped, handled, tagged, and released at the Tucannon River smolt trap, both of which have been consulted and permitted previously under ESA section 10 permit #18024 and permit #18025. In addition, the monitoring of natural-origin juveniles conducted by the USFWS and USGS is covered annually under ESA Determination USGS-34. Permitted activities include seining and PIT tagging of juveniles and adult redd counts and carcass recovery, but is adaptable to new activities as well. All of the above-mentioned juvenile monitoring activities are not part of this Proposed Action, but they are critical to informing population status.

2.4.2. Habitat Restoration Activities

Since the 1990s, when salmonid populations began to be listed under the ESA, organizations have coordinated, developed, and implemented various habitat restoration activities in the subbasins within the Snake River Basin. The focus of these projects has been to reduce the effects of ecological concerns (limiting factors) that impact the environment, which may influence salmonid VSP metrics (Section 2.5.1). In particular, NMFS believes that these habitat restoration projects will benefit the viability of the affected populations by improving abundance, productivity, and spatial structure.

Intensive habitat restoration has been underway since the state of Washington's Salmon Recovery Act of 1998 in the Snake River region. NMFS has streamlined the implementation of restoration activities throughout the Snake River region by completing several programmatic ESA section 7 consultations that cover projects implemented that are specifically designed to improve fish habitat (NMFS 2012c). Since the initiation of restoration implementation, significant work has been done to remove fish passage barriers, unscreened irrigation diversions, minimize fine sediments, and plant riparian buffers. Between 1999 and 2012 in the Snake River Salmon Recovery Region, 52 fish passage barriers were removed or modified, 526 irrigation diversions were properly screened, in-stream flow increased by 81.8 cubic feet per second through efficiency and leases, channel complexity increased by 13.49 miles, 121,730 acres of upland agriculture best management practices were increased to reduce erosion, 262 river miles of riparian habitat was restored, and 7.26 river miles of stream channel confinement was reduced according to the Snake River Salmon Recovery Board. The removal of barriers opened over 229 miles of habitat and the placement of screens has reduced juvenile salmonid injury and mortality. All of these efforts have substantially altered the environmental baseline and will continue to do so into the future.

2.4.3. 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 2024b). The baseline includes all federally authorized hydropower projects, including projects with licenses issued by the Federal Energy Regulatory Commission, the Federal Columbia River Power System, and other developments that have undergone ESA §7 consultations. Here, we summarize some key impacts on salmon and steelhead habitat in the Snake River Basin.

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 mainstem dams on the mainstem Snake and Columbia Rivers (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)

Many floodplains in the Middle and Lower Snake River watersheds have been altered by channelization to reduce flooding and by conversion of land to agricultural and residential uses. Flood control structures (i.e., dikes) have been constructed on several streams and rivers. These have accelerated surface water runoff and decreased groundwater recharge, contributing to lower summer stream flows. Groundwater withdrawals and surface water diversion for irrigation have also modified natural groundwater recharge and discharge patterns. Most irrigation water withdrawals occur during the summer dry months when precipitation is lowest and demand for water is the greatest. Road construction, overgrazing, and vegetation removal in floodplain areas have also caused bank erosion, resulting in wide channels that increase the severity of low summer flows. Primary water quality concerns for salmonids in Snake River tributaries include high water temperatures, which can cause direct mortality or thermal passage barriers, and high sediment loads, which can cause siltation of spawning beds.

While harmful land-use practices continue in some areas, many land management activities, including forestry practices, have fewer impacts on salmonid habitat due to raised awareness and less invasive techniques. For example, timber harvest on public land has declined drastically since the 1980s. Current harvest techniques (e.g., the use of mechanical harvesters and forwarders) and silvicultural prescriptions (i.e., thinning and cleaning) require little, if any, road construction and produce much less sediment.

2.4.4. Changing Environmental Conditions

One factor affecting the status of ESA-listed species considered in this opinion, and aquatic habitat at large, is changing environmental conditions. Changes in environmental conditions is likely to play an increasingly important role in determining the abundance and distribution of ESA-listed species, and the conservation value of designated critical habitats, in the Pacific Northwest. These changes will not be spatially homogeneous across the Pacific Northwest. Major ecological realignments are already occurring in response to the changing environmental conditions (IPCC 2022). Long-term trends in warming have continued at global, national and regional scales. Global surface temperatures in the last decade (2010s) were estimated to be 1.09 °C higher than the 1850-1900 baseline period, with larger increases over land ~1.6 °C compared to oceans ~0.88 (IPCC 2021). The vast majority of this warming has been attributed to anthropogenic releases of greenhouse gases (IPCC 2021). Globally, 2014-2022 were all in the top 10 warmest years on record both on land and in the ocean (2022 was the 5th warmest)(NOAA NCEI 2022). Events such as the 2013-2016 marine heatwave (Jacox et al. 2018) have been attributed directly to anthropogenic warming in the annual special issue of Bulletin of the American Meteorological Society on extreme events (Herring et al. 2018). Global warming and anthropogenic loss of biodiversity represent profound threats to ecosystem functionality (IPCC 2022). These two factors are often examined in isolation, but likely have interacting effects on ecosystem function.

Updated projections of the changing environmental conditions are similar to or greater than previous projections (IPCC 2021). NMFS is increasingly confident in our projections of changes to freshwater and marine systems because every year brings stronger validation of previous predictions in both physical and biological realms. Retaining and restoring habitat complexity, access to climate refuges (both flow and temperature) and improving growth opportunity in both

freshwater and marine environments are strongly advocated in the recent literature (Siegel and Crozier 2020).
Changing environmental conditions is systemic, influencing freshwater, estuarine, and marine conditions. Other systems are also being influenced by changing climatic conditions. Literature reviews on the impacts of the changes in environmental conditions on Pacific salmon (Crozier 2011; 2012; 2013; 2014; 2015; 2016; 2017; Crozier and Siegel 2018; Siegel and Crozier 2019; 2020) have collected hundreds of papers documenting the major themes relevant for salmon. Here we describe habitat changes relevant to Pacific salmon and steelhead, prior to describing how these changes result in the varied specific mechanisms impacting these species in subsequent sections.

Changing environmental conditions effects on salmon and steelhead

In freshwater, year-round increases in stream temperature and changes in flow will affect physiological, behavioral, and demographic processes in salmon, and change the species with which they interact. For example, as stream temperatures increase, many native salmonids face increased competition with more warm-water tolerant invasive species. Changing freshwater temperatures are likely to affect incubation and emergence timing for eggs, and in locations where the greatest warming occurs may affect egg survival, although several factors impact intergravel temperature and oxygen (e.g., groundwater influence) as well as sensitivity of eggs to thermal stress (Crozier et al. 2019). Changes in temperature and flow regimes may alter the amount of habitat and food available for juvenile rearing, and this in turn could lead to a restriction in the distribution of juveniles, further decreasing productivity through density dependence. For migrating adults, predicted changes in freshwater flows and temperatures will likely increase exposure to stressful temperatures for many salmon and steelhead populations, and alter migration travel times and increase thermal stress accumulation for ESUs or DPSs with early-returning (i.e. spring- and summer-run) phenotypes associated with longer freshwater holding times (Fitzgerald et al. 2020; Crozier et al. 2021). Rising river temperatures increase the energetic cost of migration and the risk of *en route* or pre-spawning mortality of adults with long freshwater migrations, although populations of some ESA-listed salmon and steelhead may be able to make use of cool-water refuges and run-timing plasticity to reduce thermal exposure (Keefer et al. 2018; Barnett et al. 2020).

Synchrony between terrestrial and marine environmental conditions (e.g., coastal upwelling, precipitation and river discharge) has increased in spatial scale causing the highest levels of synchrony in the last 250 years (Black et al. 2018). A more synchronized climate combined with simplified habitats and reduced genetic diversity may be leading to more synchrony in the productivity of populations across the range of salmon (Braun et al. 2016). For example, salmon productivity (recruits/spawner) has also become more synchronized across Chinook populations from Oregon to the Yukon (Kilduff et al. 2015; Dorner et al. 2018). In addition, Chinook salmon have become smaller and younger at maturation across their range (Ohlberger et al. 2018). Other Pacific salmon species (Stachura et al. 2014) and Atlantic salmon (Olmos et al. 2020) also have demonstrated synchrony in productivity across a broad latitudinal range.

At the individual scale, climate impacts on salmon in one life stage generally affect body size or timing in the next life stage and negative impacts can accumulate across multiple life stages (Healey 2011; Wainwright and Weitkamp 2013; Gosselin et al. 2021). Changes in winter precipitation will likely affect incubation and/or rearing stages of most populations. Changes in the intensity of cool season precipitation, snow accumulation, and runoff could influence migration cues for fall, winter and spring adult migrants, such as coho and steelhead. Egg survival rates may suffer from more intense flooding that scours or buries redds. Changes in hydrological regime, such as a shift from mostly snow to more rain, could drive changes in life history, potentially threatening diversity within an ESU (Beechie et al. 2006). Changes in summer temperature and flow will affect both juvenile and adult stages in some populations, especially those with yearling life histories and summer migration patterns (Crozier and Zabel 2006; Crozier et al. 2010; Crozier et al. 2019).

At the population level, the ability of organisms to genetically adapt to changing environmental conditions depends on how much genetic variation currently exists within salmon populations, as well as how selection on multiple traits interact, and whether those traits are linked genetically. While genetic diversity may help populations respond to changes in environmental conditions, the remaining genetic diversity of many populations is highly reduced compared to historic levels. For example, Johnson et al. (2018), compared genetic variation in Chinook salmon from the Columbia River Basin between contemporary and ancient samples. A total of 84 samples determined to be Chinook salmon were collected from vertebrae found in ancient middens and compared to 379 contemporary samples. Results suggest a decline in genetic diversity, as demonstrated by a loss of mitochondrial haplotypes as well as reductions in haplotype and nucleotide diversity. Genetic losses in this comparison appeared larger for Chinook from the mid-Columbia than those from the Snake River Basin. In addition to other stressors, modified habitats and flow regimes may create unnatural selection pressures that reduce the diversity of functional behaviors (Sturrock et al. 2020). Managing to conserve and augment existing genetic diversity may be increasingly important with more extreme environmental change (Anderson et al. 2015), though the low levels of remaining diversity present challenges to this effort (Freshwater et al. 2019). Salmon historically maintained relatively consistent returns across variation in annual weather through the portfolio effect (Schindler et al. 2015), in which different populations are sensitive to different climate drivers. Applying this concept to changing environmental conditions, Anderson et al. (2015) emphasized the additional need for populations with different physiological tolerances. Loss of the portfolio increases volatility in fisheries, as well as ecological systems, as demonstrated for Fraser River and Sacramento River stock complexes (Freshwater et al. 2019; Munsch et al. 2022).

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. In contrast, others are habitat-specific, such as stream flow variation in freshwater, sea level rise in estuaries, and upwelling in the ocean. How changes in environmental conditions will affect each stock or population of salmon also varies widely depending on the level or extent of change, the rate of change, and the unique life history characteristics of different natural populations (Crozier et al. 2008). 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).

In the Status of Listed Species, Section 2.2.1, we identified local-scale climate effects as a limiting factor for the majority of the species. Given this Proposed Action (Section 1.3) and Action area (Section 2.3), we may expect direct changes in environmental condition effects of increased water temperature on fish physiology, temperature-induced changes to stream flow patterns, and alterations to freshwater food webs.

2.4.5. Artificial Propagation

A more comprehensive discussion of hatchery programs in the Snake River Basin can be found in our opinion on Mitchell Act-funded programs (NMFS 2024b). In summary, because most programs are ongoing, the effects of each are reflected in the most recent status of the species (Ford 2022), and was summarized in Section 2.2.1 of this opinion. 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. A new role for hatcheries emerged during 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 can also help improve viability by supplementing natural population abundance and expanding spatial distribution. However, hatchery supplementation's long-term benefits and risks remain untested (Christie et al. 2014).

All salmon and steelhead hatcheries in the action area were built to mitigate hydroelectric development from dam construction and operation. The major hatchery programs are funded through the Lower Snake River Compensation Plan (LSRCP), BPA, IPC, Army Corp of Engineers (COE), and USFWS. Moreover, over the last few decades, hatcheries have been increasingly used for population conservation.

The LSRCP was authorized by the Water Resource Development Act of 1976 (90 Stat. 2917) to offset fish and wildlife losses resulting from the construction and operation of the four lock and dam projects on the lower 150 miles of the Snake River in SE Washington. Nine major LSRCP hatchery facilities are located in the Snake Basin. The IDFG operates four hatcheries in Idaho, the Oregon Department of Fish and Wildlife (ODFW) operates three in Oregon, the Washington Department of Fish and Wildlife (WDFW) operates one hatchery complex in Washington, and the USFWS operates one and co-manages another with the Nez Perce Tribe in Idaho. The Nez Perce Tribe, Confederated Tribes of the Umatilla Indian Reservation, and Shoshone-Bannock Tribes operate satellite facilities that collect broodstock and provide juvenile acclimation and release for several LSRCP hatcheries.

In addition to the LSRCP facilities, four hatcheries in Idaho are funded by IPC as mitigation for losses caused by the three Hells Canyon Complex dams (Hells Canyon, Oxbow, and Brownlee). IDFG operates these facilities. The COE funds the operation of one major hatchery as mitigation for the losses caused by the construction of Dworshak Dam and the total blockage of the North Fork Clearwater River. The USFWS and Nez Perce Tribe co-operate this facility. BPA directly funds the Nez-Perce Tribal Hatchery Project (NPTH) and three other hatchery programs as mitigation for the effects of the Federal Columbia River Power System through its Fish and Wildlife Program. The USFWS directly funds Kooskia Hatchery, which the Nez Perce Tribe operates.

Currently, almost all aspects of hatchery programs—most importantly, the numbers, locations, and marking of fish released—are incorporated into the *U.S. v. Oregon* Management Agreement.

Production of all species discussed in this Opinion may be increased, decreased, or relocated by the *U.S. v. Oregon* parties, pursuant to applicable program authorizations.

2.4.6. Harvest

For thousands of years, Native Americans have fished for salmon, steelhead, and other species, in the tributaries and mainstem of the Columbia River for ceremonial, subsistence, and economic purposes. Various gears and methods were used, including hoop and dip nets at cascades such as Celilo and Willamette Falls, to spears, weirs, and traps (usually in smaller streams and headwater areas). Commercial fishing developed rapidly with the arrival of European settlers and the advent of canning technologies in the late 1800s. The development of non-Indian fisheries began circa 1830, and by 1861, commercial fishing was an important economic activity. Fishing pressure, especially in the late nineteenth and early twentieth centuries, has long been recognized as a key factor in the decline of Columbia River salmon runs (NRC 1996).

The year-to-year harvest management in the Columbia River Basin is under a 10-year management agreement established by the parties to the *U.S. v. Oregon* litigation (D. Or., No. 68-513). The most recent agreement was signed in February 2018, and harvest and hatchery effects were considered as part of the associated Biological Opinion (NMFS 2018d), for which we provide a brief discussion here. Table 15 shows the expected take limits for species discussed in this opinion for treaty Indian and non-Indian fisheries under the *U.S. v. Oregon* Management Agreement.

Table 15. Expected incidental take (as proportion of total run-size) of listed anadromous salmonids for non-tribal and treaty tribal fisheries under the *U.S. v. Oregon* Management Agreement

ESU		Take Limits (%)	Treaty Indian (%)	Non-Indian (%)
Snake River fall-run Chinook Salmon		31.29	11.6 – 23.04	5.9 – 8.25
Snake River spring/summer-run Chinook Salmon		5.5 – 17.07	5.0 – 15.0	0.5 – 2.0
Snake River Basin Steelhead	**A-Run Component**	4.03	3.5 – 8.2	1.0 – 1.8
	B-Run Component	17.04	3.4 – 15.04	1.5 – 2.0
Snake River Sockeye Salmon		6.0 – 8.08	2.8 – 7.0	0.0 – 1.0

The hatchery programs primarily contribute to fall-run Chinook salmon fisheries in the mainstem Snake and Columbia Rivers and terminal areas. The 2018-2027 *U.S. v. Oregon* Management Agreement defines mainstem Columbia River harvest rates on a sliding scale. This abundance-based sliding-scale harvest rate[4] in the mainstem is based on natural-origin fall-run Chinook salmon projected to return to the Snake River basin. Harvest share in terminal areas is defined as

[4]Sliding-scale harvest rates increase as the projected return of natural-origin fish increases.

the number of returning hatchery adults minus the number of adults needed for broodstock. The harvest share is split equally between treaty and non-treaty fisheries. Non-treaty fisheries are marked selective, and fisheries target hatchery-origin fish, while treaty fisheries are not selective. Impacts on natural-origin fish are managed based on a sliding scale of abundance of natural-origin fish.

The following sections outline the various fisheries that occur in the Action Area that may affect listed species. There are no fisheries that are part of the Proposed Action (see Section 1.3).

Fall-run Chinook Salmon Fisheries

Snake River fall-run Chinook salmon are caught in ocean and in-river fisheries. Ocean fisheries occur outside the action area (from Alaska to California) but are reviewed here to provide a more comprehensive overview of harvest affecting the status of this species. The total ocean fishery exploitation rate averaged 46% from 1986 to 1991, and 31% from 1992 to 2006. Since 1996, ocean fisheries have been required, through ESA consultation, to achieve a 30% reduction in the average exploitation rate observed during the 1988 to 1993 base period. Snake River fall-run Chinook salmon are also caught in fall-run fisheries in the Columbia River, with most impacts occurring in non-Indian and treaty fisheries from the river mouth to McNary Dam. These fisheries have been subject to ESA constraints since 1992, and since 1996 have been limited to a total harvest rate of 31.29%. This represents a 30% reduction in the 1988 to 1993 base period harvest rate. Columbia River fisheries have a similar 30% base-period reduction standard. Total harvest mortality for the combined ocean and in-river fisheries can be expressed as exploitation rates. The total exploitation rate for Snake River fall-run Chinook salmon has declined greatly since the ESA listing. Total exploitation rates averaged 75% from 1986 to 1991, and 45% from 1992 to 2006.

The fall-run Chinook salmon fishery in the Snake River basin typically takes place from September through October with a closing date of no later than November 31st. Similar to spring/summer-run Chinook salmon and steelhead fisheries, the non-tribal fisheries have selectively targeted hatchery fish with a clipped adipose fin in the past. Since 2019, in addition to the adipose-clipped fall-run Chinook salmon fishery, a recreational fishery of adipose-intact fall-run Chinook salmon is authorized (IDFG 2019). Tribal fisheries target both hatchery and natural-origin fish regardless of external marking, meaning there is no incidental take of the target species for their fisheries. An average of approximately 7.6% of the Snake River Fall-run Chinook Salmon ESU is killed in fisheries above LGR (Table 16).

Table 16. The number of ESA-listed natural-origin fall-run Chinook salmon encountered and incidentally killed (catch and release mortality is estimated at 10 percent of those caught) in fall-run Chinook salmon fisheries from 2017-2022. The Shoshone-Bannock Tribes currently do not participate in Snake River fall-run Chinook salmon fisheries.

Fishery Manager	Average Encounter	Average Mortality	Average natural-origin estimated escapement above LGR	% Average natural-origin mortality above LGR
IDFG	566	379	6,514	5.8

NPT	122	120	6,514	1.8

Sources: (Powell 2024; Young 2025b)

Spring/Summer-run Chinook Salmon Fisheries

The spring/summer-run Chinook salmon fisheries in the Snake basin typically occur from late April through July. The non-tribal fisheries selectively target hatchery fish with a clipped adipose fin. Tribal fisheries target both hatchery and natural-origin fish regardless of external marking, meaning there is no incidental take of the target species for their fisheries. Table 17 below shows that an average of ~ 4.7 percent of the Snake River Spring/Summer-run Chinook Salmon ESU is killed by fisheries. This may be an overestimate of the percentage impact because the above LGR natural-origin return estimate does not include those fish that return to tributaries of the Snake River below LGR (e.g., Tucannon River).

Table 17. The number of ESA-listed natural-origin spring/summer-run Chinook salmon encountered and incidentally killed (catch and release mortality is estimated at 10 percent of those caught) in fisheries from 2017-2023.

Fishery Manager	Average Incidental Mortality take Authorization	Average Encounter	Average Mortality	Average natural-origin estimated escapement above LGR	% Average natural-origin incidental mortality above LGR
IDFG	91	465	47	7,680	.5
SBT[1]	Not Applicable	121	121		1.6
NPT[1]	Not Applicable	203	203		2.6

Sources: (Croy 2024; Powell 2024; Young 2025b)

[1]In this fishery, there is no incidental mortality of natural-origin fish; all fish, regardless of origin, are intentionally harvested.

There are no incidental encounters or mortality of Snake River steelhead, fall-run Chinook salmon or sockeye salmon during spring/summer-run Chinook salmon fisheries. The reasons are that the fishery does not open until after the steelhead run, and the fishery closes prior to the arrival of fall-run Chinook salmon in the Snake Basin. Sockeye salmon are not impacted by the fisheries because IDFG tracks sockeye migration and attempts to close the fishery as sockeye begin to arrive in the fishing areas. Additionally, sockeye salmon typically do not strike at lures used by recreational anglers fishing for spring/summer-run Chinook salmon.

Steelhead Fisheries

Steelhead fisheries above LGR typically occur from September through March of the following year. Although steelhead bound for Idaho enter the Columbia River from about June 1 through October 1 each year, a portion of the run spends the winter in the Columbia and Snake Rivers downstream of LGR and migrates into Idaho in the spring of the following year. Similar to spring/summer-run Chinook salmon fisheries, the non-tribal fisheries selectively target hatchery fish with a clipped adipose fin. Tribal fisheries target both hatchery and natural-origin fish regardless of external marking, meaning there is no incidental take of the target species for their fisheries. Table 18 below shows that an average of ~ 5.6 percent of the Snake River steelhead DPS is killed annually in fisheries above LGR. This may be an overestimate of the percentage impact because the above LGR natural-origin return estimate only includes Idaho-bound stocks (Clearwater and Salmon MPGs).

Table 18. The number of ESA-listed natural-origin steelhead encountered and killed in fisheries from 2017-2023.

Fishery Manager	Average Encounter	Average Mortality	Average natural-origin estimated escapement above LGR	% Average natural-origin mortality above LGR
IDFG[1]	8,666	433[1]	12,447	3.6
SBT	< 100	< 100		0.8
NPT	146	147		1.2

Sources: (Croy 2024; Powell 2024; Young 2025b)
[1]For the state fishery, all mortality of natural-origin fish is incidental (catch and release mortality), and is estimated at 5 percent of those caught.

Table 19. The number of ESA-listed natural-origin fall-run Chinook salmon encountered and incidentally killed (catch and release mortality is estimated at 10 percent of those caught) in steelhead fisheries from 2017-2022.

Fishery Manager	Average Encounter	Average Mortality	Average natural-origin estimated escapement above LGR	% Average natural-origin mortality above LGR
IDFG	39	4[1]	5,923	0.07
SBT	0	0		0
NPT	These numbers are included in Table 16 above			

Sources: (Croy 2024; Powell 2024; Young 2025b)
[1]For the state fishery, all mortality of natural-origin fish is incidental (catch and release mortality), and is estimated at 5 percent (or 14 mortalities) of those caught

Other Fisheries

In some years, Idaho opens a kokanee salmon fishery in Redfish Lake to help offset intra-specific competition in Redfish Lake between resident kokanee and sockeye salmon. From 2014 to 2022, IDFG estimates that an average of 0.32 percent of the sockeye salmon population in Redfish Lake was incidentally harvested in this fishery (IDFG 2023). Because kokanee and sockeye salmon are phenotypically indistinguishable, 23 percent of the unclipped fish caught are assumed to be sockeye salmon since they represent 23 percent of the *O. nerka* population (IDFG 2023).

2.4.7. Other Actions Included in this Baseline

Congress established the Pacific Coastal Salmon Recovery Fund (PCSRF) to help protect and recover salmon and steelhead populations and their habitats (NMFS 2007b). The states of Washington, Oregon, California, Idaho, and Alaska, and the Pacific Coastal and Columbia River Tribes receive PCSRF appropriations from NMFS each year. The fund supplements existing state, tribal, and local programs to foster the development of Federal-state-tribal-local partnerships in salmon and steelhead recovery. The PCSRF has made substantial progress in achieving program goals, as indicated in annual Reports to Congress, workshops, and independent reviews.

Information relevant to the Environmental Baseline is also discussed in detail in Chapter 5 of the Supplemental Comprehensive Analysis (SCA), and the related 2008 FCRPS Biological Opinion (NMFS 2008f). Chapter 5 of the SCA (NMFS 2008b) and related portions of the FCRPS Opinion provide an analysis of the effects of past and ongoing human and natural factors on the current status of the species, their habitats and ecosystems, within the entire Columbia River Basin. Relevant information is also discussed in the updated 2020 FCRPS Biological Opinion (NMFS 2020b).

2.5. Effects of the Action

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action but that are not part of the action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 CFR 402.02). In our analysis, which describes the effects of the Proposed Action, we considered the factors set forth in 50 CFR 402.17(a) and (b).

This section describes the effects of the Proposed Action, independent of the Environmental Baseline and Cumulative Effects. Section 2.5.1 summarizes the methodology and best scientific information NMFS follows for analyzing hatchery effects, followed by Section 2.5.2, which describes the methodology's application and analysis of the Proposed Action itself.

2.5.1. 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 the best available science (Hard et al. 1992; McElhany et al. 2000b; NMFS 2004a; 2005b; Jones Jr. 2006; NFMS 2008; NMFS 2011c). For Pacific salmon, NMFS evaluates extinction processes and effects of the Proposed Action beginning at the population scale (McElhany et al. 2000b). NMFS defines population performance measures in terms of natural-origin fish and four key parameters or attributes: abundance, productivity, spatial structure, and diversity, and then relates the effects of the Proposed Action at the population scale to the MPG level and ultimately to the survival and recovery of an entire ESU or DPS.

Because of the potential for circumventing the high rates of early mortality typically experienced in the wild, artificial propagation may be useful in recovering listed salmon species. However, artificial propagation entails risks and opportunities for salmon conservation (Hard et al. 1992). A Proposed Action is analyzed for positive and negative effects on the attributes defining 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, serving as a source population for repopulating unoccupied habitats, increasing spatial distribution, and conserving genetic resources. Conversely, a hatchery program managed without adequate consideration can affect a listing determination by reducing the 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 the effects it would be expected to have on ESA-listed species and designated critical habitat, based on the best scientific information available. This allows for quantification (wherever possible) of the effects of the six factors of hatchery operation on each listed species at the population level (in Section 2.5.2), 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 (Section 2.6).

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 designated critical habitat depends on six factors. These factors are:

(1) the hatchery program does or does not remove fish from the natural population and use them for hatchery broodstock
(2) hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities
(3) hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas, migratory corridors, 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 each affected population's current risk level for abundance, productivity, spatial structure, and diversity; (2) the role or importance of the affected natural populations in salmon ESU or steelhead DPS recovery; (3) the target viability for the affected natural populations; and (4) the Environmental Baseline, including the factors currently limiting population viability.

2.5.2. Effects of the Proposed Action

This section describes the effects of the Proposed Action, independent of the environmental baseline and cumulative effects. Under the ESA, "effects of the action" means the direct and indirect effects of an action on critical habitat and on the individuals within a population and how these affect the VSP parameters for the natural population(s) that make up the species, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are caused by the Proposed Action and are later in time, but still are reasonably certain to occur.

The methodology and best scientific information NMFS follows for analyzing hatchery effects is summarized in Section 2.5, and then application of the methodology and analysis of the Proposed Action itself follows in Section 2.5.2 Effects of the Proposed Action that are expected to occur later in time (i.e., just after the timeframe of the Proposed Action) are included in the analysis in this opinion to the extent they can be meaningfully evaluated. In Section 2.2, the Proposed Action, the status of ESA-protected species and designated critical habitat, the environmental baseline, and the cumulative effects of future state and private activities within the Action Area that are reasonably certain to occur are analyzed comprehensively to determine whether the Proposed Action is likely to appreciably reduce the likelihood of survival and recovery of ESA-protected species or result in the destruction or adverse modification of their designated critical habitat.

2.5.2.1. Factor 1. The hatchery program does or does not remove fish from the natural population and use them for hatchery broodstock

Because the proposed action is limited to funding and operations of fall-run Chinook salmon hatchery programs, this factor does not directly affect spring/summer-run Chinook salmon, steelhead, or sockeye salmon in this proposed action because none of the proposed hatchery programs propagate these species and, therefore, do not remove these species for use as hatchery broodstock. Impacts to these species as an incidental effect of broodstock operations are discussed under Factor 2 (see Section 2.5.2.2.3, below).

Analysis of this factor for Snake River Fall-run Chinook Hatchery programs was first completed in the 2012 Biological Opinion (NMFS 2012d) under the *Fish Removal* section (Section 2.4.3.), as well as the *U.S. v. Oregon* Biological Opinion (NMFS et al. 2018). The analysis was unchanged for the 2018 Snake River Fall-run Chinook Salmon Biological Opinion (NMFS 2018e). There is an increase in broodstock needed for the new Proposed Action which would remain within the limits defined in the permits as well as the take analyzed in the 2012

Biological Opinion. Under the proposed action up to 4,150 adults or jacks[5] fall-run Chinook salmon would be collected annually as broodstock for these four programs. All of these hatchery programs are integrated and utilize natural-origin fall-run Chinook salmon in their broodstock. The Proposed Action in this current Biological Opinion includes the same percentage (20%) of natural-origin broodstock removed for these integrated hatchery programs as stated in the permit #16115-2R. A brief summary of these effects is given here.

The removal of adult salmon from the natural system for the purposes of artificial production can result in benefits to the stock in question but also carry inherent risks that need to be considered. These may include demographic risks posed by removing productive individuals from depressed populations. The removal of reproductive individuals from a depressed population can raise the population's risks for further reductions in abundance and extinction through demographic stochasticity: a natural tendency for salmon and steelhead populations at low abundance to be highly variable and possibly going to zero (NFMS 2008). Hatchery programs can serve an important conservation role when habitat conditions in freshwater depress juvenile survival or when access to spawning and rearing habitat is blocked. Under circumstances like these and in the short-term, the demographic risks of extinction of such populations likely exceed genetic and ecological risks to natural-origin fish that would result from hatchery supplementation (NFMS 2008). A well-designed artificial propagation program can increase the total abundance of both hatchery and wild fish and potentially reduce the short-term demographic risk. However, for populations without such extreme risks of extinction, other viability considerations assume relatively greater importance, such as fitness loss through domestication.

At very low abundance numbers, populations may experience a decrease in reproductive success because of factors such as the inability to efficiently find mates, random demographic effects (the variation in individual reproduction becomes important), changes in predator-prey interactions, and other "Allee" effects. In such cases, the risk of removing members for broodstock is increased. At present, low abundance is not a concern in this population, with recent (2018 to 2023) natural-origin adult returns to LGR averaging 6,932 (range 6,140-8,068) and total adult returns to LGR averaging 29,113 (range 16,073-43,963). Broodstock needs for all components of the Snake River fall-run Chinook salmon hatchery program, including the LFH on-station releases, the FCAP, the IPC program, and the NPTH program, as well as for run reconstruction would require about 6,000 total fish.

Unintentional mortality due to handling and holding in the process of collecting broodstock may result in up to 15% of the total fish used for broodstock, and up to 1% of the total run. This full four-program collection action represents a significant proportion of the total run passing over LGR Dam. However, current limits on the total natural-origin returning adults that can be collected for broodstock are set at up to 20% of the return. Additionally, hatchery fish and a smaller number of natural-origin fish may be collected at the LFH trap annually.

The total number of fall-run Chinook salmon removed from the natural system to perpetuate these hatchery programs has ranged from less than 1,000 during the early years of the program to

[5] For purposes of this Biological Opinion, adults and jacks include all fall-run Chinook salmon that include fall-run Chinook salmon that have spent at least 1 year in the ocean. Post-season reporting will be based on estimated ocean age.

over 5,000 in recent years. The vast majority of these collected fish are hatchery-origin returns. In addition, many of the returning natural-origin fish collected for the program may be descendants of the hatchery program. Collecting a high percentage of NORs is not considered detrimental to this single-population ESU because it primarily affects abundance and the Minimum Abundance Thresholds (MAT) have been exceeded in recent years. So, when there is a high abundance of NORs, there is little risk of depleting the natural origin population above LGR. Long-term positive trends in total population abundance, natural spawner abundance, and spawner utilization in the production areas above LGR indicate total population levels significantly higher than the threshold for demographic risk concern.

Furthermore, collecting a higher number of NORs allows for the population-level percentage of natural-origin fish in the broodstock, referred to as proportion of natural influence (PNI), to increase (see Section 2.5.2.2 for the full genetic analysis). NOR adults are targeted to be included in the brood at a rate of 30%, with no more than 20% of the estimated total natural-origin run collected (Section 1.3.3). The inclusion of NORs in the broodstock improves the genetic makeup of the hatchery fish being released in low-return years, which would decrease the genetic threat to the population while maintaining a spawning population above LGR, as further explained in Factor 2. In low return years, when abundance concerns are generally prioritized over genetic effects concerns, including NORs in the broodstock will allow abundance goals to be met while also alleviating some of the genetic concerns. However, collection would decrease during low return years. While the current natural-origin returns appear to be just below the TRT minimum abundance thresholds for a "large" population, the genetic concerns outweigh the concerns associated with removing natural-origin adults for broodstock. In addition, the annual abundance of natural-origin Snake River fall-run Chinook salmon has substantially increased since the 1990s, which means that it is unlikely that the removal of natural-origin fish for broodstock for this program has negatively affected population abundance, and we do not expect it to during the duration of the permit term. Moreover, since many of the natural-origin returns may be offspring from the hatchery program, it is unlikely that broodstock collection of natural-origin adults will have a negative effect on the abundance of this single-population ESU. Thus, the genetic (diversity) and abundance impacts on the natural-origin population will be minimal, resulting in an overall negligible effect.

2.5.2.2. Factor 2. Hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities

NMFS first evaluated genetic effects from Snake River fall-run Chinook salmon hatchery programs in the 2012 Biological Opinion (NMFS 2012d) and subsequently evaluated expected genetic effects associated with program modifications that included the 1) relocation of annual releases (one million subyearling Chinook salmon) from the Hells Canyon reach of the Snake River to the Salmon River, and 2) replacement of 450,000 yearling Chinook salmon with the release of 1.4 million subyearlings (NMFS 2018e). The relocation of releases from Hells Canyon to the Salmon River was intended to serve as a first step toward the creation of a natural production emphasis area (NPEA), consistent with the preferred recovery scenario for Snake River fall-run Chinook salmon (NMFS 2017f). The replacement of yearling releases with subyearling releases was intended to produce hatchery-origin (HOR) salmon that more closely resemble natural-origin (NOR) Snake River fall-run Chinook salmon with respect to juvenile life history. NMFS (2017f) had previously recognized these actions as important for the recovery of this population.

In the following section, we evaluate likely genetic effects from the Proposed Action in the context of current operations, which have been shaped in part by recent hatchery management changes. Briefly, our findings indicate that hatchery programs continue to pose a genetic risk to the NOR component of Snake River fall-run Chinook salmon, but such risk has been considerably reduced from previous levels since both the inception of the program and previous analyses conducted by (NMFS 2018e). The planned program changes in the Proposed Action are expected to further alleviate genetic risk to local populations from the hatchery programs. Please refer to Section 6 of the appendix for a generalized description of the potential genetic effects associated with hatchery programs.

This section also considers ecological and adult collection effects. These are relevant for spring/summer-run Chinook, steelhead, and sockeye salmon because the programs considered here do not propagate these species. The overall effect of this factor on these species is negligible, as discussed below.

2.5.2.2.1. Genetic interactions between hatchery- and natural-origin adults

Genetic interactions between hatchery fish released pursuant to the proposed action and spring/summer-run Chinook salmon, steelhead, or sockeye salmon do not occur, since these species are not produced by the proposed hatchery programs, and this factor only concerns direct effects from interbreeding, which is limited or altogether prevented through distinct spatiotemporal distributions during spawning or other reproductive barriers.

Although hatchery operations have made significant contributions toward increasing the abundance of salmon in this ESU since it was first listed as "threatened" under the ESA (Table 9), genetic risks posed by hatchery operations, as discussed in Section 6, must be considered and managed within limits. Specifically, three categories of genetic risk are particularly relevant to Snake River fall-run Chinook salmon and associated hatchery programs: hatchery-influenced selection, within ESU diversity, and outbreeding effects.

Hatchery-influenced selection and within ESU diversity

Generally speaking, artificial spawning and hatchery rearing can alter a wide range of traits in a cultured salmon species, including adult run timing (Hoffnagle et al. 2008; Tillotson et al. 2019), age at maturity (Hankin et al. 2009; Larsen et al. 2019), egg size (Heath et al. 2003; Beacham 2010), and more (Perry et al. 2021; Cogliati et al. 2023). Such changes may have genetic or environmental causes, and the underlying processes may be intentional or incidental. Since these programs are integrated, some bi-directional gene flow is intentional, so as to retain the genetic variation that underpins adaptions to the local natural environment within the composite population as represented by the PNI metric described in this section.

In several ways, previously established program goals and operation guidelines have limited genetic risks from Snake River fall-run Chinook salmon hatchery programs. First, bi-directional gene flow between HOR and NOR components of the population is monitored and managed to limit the effects of domestication selection on the natural productivity of Snake River fall-run Chinook salmon. Second, the intentional selection of older and larger fish for broodstock in the Snake River fall-run Chinook salmon hatchery program more closely emulates processes of sexual selection that occur in naturally spawning salmon populations. Lastly, the iterative transition to release juvenile hatchery salmon as subyearlings rather than as yearling smolts serve to more closely mimic the natural life history of Snake River fall-run Chinook salmon and may have important transgenerational effects on behavior and productivity through epigenetic mechanisms. We expect the proposed action to continue managing effects in the same way, with potentially increased effectiveness resulting from the proposed operational changes.

Managed gene flow

As Ford (2002) described, disparate selection regimes in natural and artificial environments can negatively affect the fitness of a cultured species when it reproduces in the wild. Indeed, many studies have demonstrated that HOR salmon (and steelhead) experience lower fitness when they spawn in the wild relative to their NOR conspecifics (Christie et al. 2014; Koch and Narum 2021). As might be expected, interbreeding between HOR and NOR salmon generally tends to negatively impact the fitness of the latter (Araki and Schmid 2010; Ford et al. 2016a; Sard et al. 2016; Shedd et al. 2022), and such genetic interactions may contribute to lower productivity for naturally spawning populations that contain a high proportion of HOR spawners (Chilcote et al. 2011). As described by Paquet et al. (2011), the negative effects of domestication selection on mean fitness and productivity can be alleviated by limiting gene flow from HOR salmon (into the naturally spawning component of the population) and increasing gene flow from NOR salmon (into the hatchery component of the population). The combined effects of bi-directional gene flow between the naturally spawning and artificially spawned components of the population can be described as the Proportionate Natural Influence (PNI):

$$PNI = \frac{pNOB}{pNOB + pHOS}$$

where pNOB represents the proportion of NOR salmon integrated with the hatchery broodstock and pHOS represents the proportion of HOR salmon in the naturally spawning population. Respectively, pNOB and pHOS represent gene flow from NOR and HOR salmon. It is expected that as PNI increases, the mean fitness of fish that spawn in the wild will also increase (Paquet et al. 2011).

Generally, a PNI > 0.67 is recommended to adequately limit genetic risks from an integrated hatchery program, as it represents the naturally spawning component having roughly double the influence of the hatchery component on the population. A minimum target is >.50 and above. However, it is important to recognize that one objective for Snake River fall-run Chinook salmon hatchery programs is to "return hatchery fish to spawn naturally to increase the abundance of the naturally spawning population" (NMFS 2017f). Snake River fall-run Chinook salmon have experienced a drastic increase in abundance since hatchery supplementation began (Figure 7), and it is, therefore, reasonable to conclude that hatchery programs are achieving their goal of boosting abundance and contributing to the species' recovery. Elevated pHOS is, of course, an inherent consequence of hatchery supplementation, and relatively high pHOS is expected to persist in this population with continued hatchery supplementation, albeit at lower levels in reaches with less hatchery influence. Recent estimates of pHOS for naturally spawning Snake River fall-run Chinook salmon are presented in Table 20.

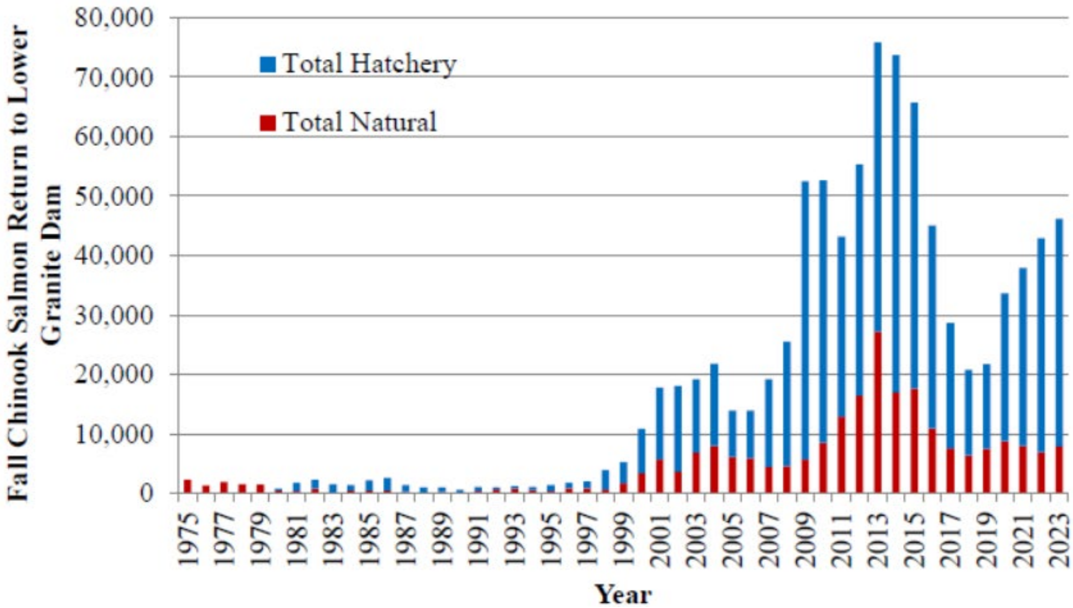

Figure 7. Total hatchery and natural Snake River fall-run Chinook salmon returns to Lower Granite Dam from 1975 through 2023. Natural-origin returns prior to August 18 not included (Young et al. 2024).

In the context of hatchery program objectives and associated high pHOS levels, hatchery operators have attempted to increase PNI by managing toward a 30% pNOB target. Related, NMFS (2018e) has previously required a 5-year mean pNOB of 15% or greater. Estimates of pNOB, obtained through run reconstruction methods and with parental-based tag (PBT) data, indicate that hatchery operators have regularly met or exceeded NMFS's pNOB requirement, despite a decline in recent years. Table 20 presents annual estimates of pHOS, pNOB, and PNI for the years 2010-2023, and these values are plotted in Figure 8.

As can be seen in Figure 8, interannual variation in PNI is largely driven by variation in pNOB, as pHOS remains relatively constant. Notably, pHOS in the Hells Canyon reach above its confluence with the Salmon River, was estimated at 0.61 in 2023 (USGS & IPC, unpublished data), a markedly lower value than the overall pHOS estimate (0.79) above LGR shown in Table 20. This finding offers encouraging evidence that previous actions taken to reduce pHOS in the NPEA are having their desired effect. Nevertheless, overall pHOS above LGR remains consistently high, such that near-term efforts to increase PNI and reduce genetic risk are most likely to be achieved through increases to pNOB in Snake River fall-run Chinook salmon hatchery programs.

Table 20. For Snake River fall-run Chinook salmon in years 2010-2023, the proportion of hatchery-origin salmon arriving at Lower Granite Dam (LGR), the proportion of natural-origin salmon integrated into broodstock (pNOB) used by Washington Department of Fish and Wildlife (WDFW) hatcheries, Nez Perce Tribal (NPT) hatcheries, and both programs combined, and pHOS above LGR following broodstock collection and harvest. The far-right column provides estimates for the proportionate natural influence (PNI) for Snake River fall-run Chinook salmon. Parental-based tag (PBT) data were used to estimate pHOS and pNOB for the years 2022-2023 and 2018-2023, respectively. Earlier estimates for these metrics were performed with standard run reconstruction methods as described by (Young et al. 2024).

Brood Year	Proportion HOR arriving at LGR	WDFW pNOB	NPT pNOB	Total pNOB	Above LGR pHOS	PNI
2010	0.84	0.14	0.15	0.14	0.82	0.15
2011	0.70	0.22	0.31	0.24	0.65	0.27
2012	0.70	0.25	0.42	0.30	0.66	0.31
2013	0.64	0.21	0.35	0.25	0.59	0.30
2014	0.77	0.22	0.29	0.24	0.74	0.25
2015	0.73	0.15	0.18	0.16	0.70	0.19
2016	0.76	0.35	0.35	0.35	0.71	0.33
2017	0.74	0.34	0.39	0.35	0.70	0.33
2018	0.69	0.37	0.35	0.37	0.66	0.36
2019	0.65	0.38	0.44	0.40	0.63	0.39
2020	0.74	0.32	0.30	0.31	0.72	0.30
2021	0.79	0.26	0.25	0.25	0.76	0.25
2022	0.84	0.20	0.23	0.20	0.81	0.20
2023	0.83	0.17	0.19	0.18	0.79	0.19

Figure 8. The proportion of hatchery-origin salmon on spawning grounds (pHOS) above Lower Granite Dam (top) the proportion of natural-origin salmon used in hatchery broodstocks (pNOB; middle), and the proportionate natural influence (PNI; bottom) for Snake River fall-run Chinook salmon (2010-2023). Fish used as broodstock or harvested are not included in estimated pHOS, and pNOB is estimated with data from both WDFW and NPT hatchery facilities. Whenever available, parental-based tag (PBT) data were used to estimate pHOS (2022-2023) and pNOB (2018-2023). Earlier estimates were performed with standard run reconstruction methods as described by (Young et al. 2024).

Broodstock selection

Non-selective ("random") artificial spawning of broodstock, which is often practiced by salmon hatchery operators, carries the potential to forgo beneficial effects from sexual selection that occur in nature, and which typically favor larger, more fecund individuals (Fleming and Gross 1994; Hankin et al. 2009; Chen et al. 2023). To address this potential issue, WDFW and NPT developed size-selective criteria for Snake River fall-run Chinook salmon broodstock and began implementation in 2010. These selection criteria, described in NPT (2011) and WDFW et al. (2011), favor spawning of age-4 and age-5 fish and select against spawning of younger age classes. The full effects of this management approach are not yet well understood, but implementation has contributed to a drastic (97%) reduction in the broodstock contribution from precocial, 0-salt fish since 2009 (Figure 9). This change from previous hatchery practices is likely to mimic the mating system of naturally spawning Snake River fall-run Chinook salmon more closely and thereby reduce unintended artificial selection for younger age at maturity (Hankin et al. 1993; McKinney et al. 2021; Chen et al. 2023). We expect this practice to continue and to repeat the effects of limiting precocial fish.

Juvenile age at release and outmigration

Snake River fall-run Chinook salmon typically express a subyearling outmigration life history (Connor et al. 2005; NMFS 2017f), but hatchery programs have previously released up to 15% of their juvenile production as yearling smolts (NMFS 2018e). This practice was adopted to achieve higher survival rates for juvenile hatchery fish (Connor et al. 2004; WDFW et al. 2011). Yet the tradeoff between benefits from higher survival rates and possible risks from artificial selection on juvenile life history has been the topic of ongoing discussion among hatchery operators, and the continued practice of yearling releases has been questioned by USFWS (2011) and NMFS (2017f). Hatchery fish released as yearling smolts are larger and thus more likely than subyearlings to compete with or prey upon juvenile fish during their out-migration.

In response to this concern, NMFS (2018e) analyzed the likely effects of a 50% proposed reduction to the number of yearling releases, an action that was subsequently implemented in concert with an increase in the number of juvenile hatchery fish released as subyearlings. Implementing the current Proposed Action would altogether discontinue the release of Snake River fall-run Chinook hatchery salmon as yearlings, with a commensurate increase to the number of hatchery salmon released as subyearlings. The appropriate number of subyearlings to be released in compensation for discontinuation of yearling releases was determined through the methods of Bumgarner et al. (2022), which determined that the release of 1.15 million subyearlings could provide a similar number of adult returns as the 450,000-yearlings currently released (and proposed to be discontinued), while at the same time lessening competition and predation risks from juvenile hatchery fish during their out-migration.

The genetic effects of this proposed change are uncertain but likely beneficial. Waples et al. (2017) reported substantial heritability for growth rate in Snake River fall-run Chinook salmon, as well as an association between the juvenile life history of spawners and the growth rate of their progeny. The authors observed that the offspring of Chinook salmon that had been released as yearlings had higher growth rates than the offspring of parents that had been released as subyearlings (Waples et al. 2017). These findings suggest that epigenetic mechanisms could be responsible for transmitting artificially selected juvenile behaviors across generations of Snake River fall-run Chinook salmon. While the ultimate effects of such processes remain unclear, any potential genetic risks associated with yearling releases will be alleviated through the Proposed Action.

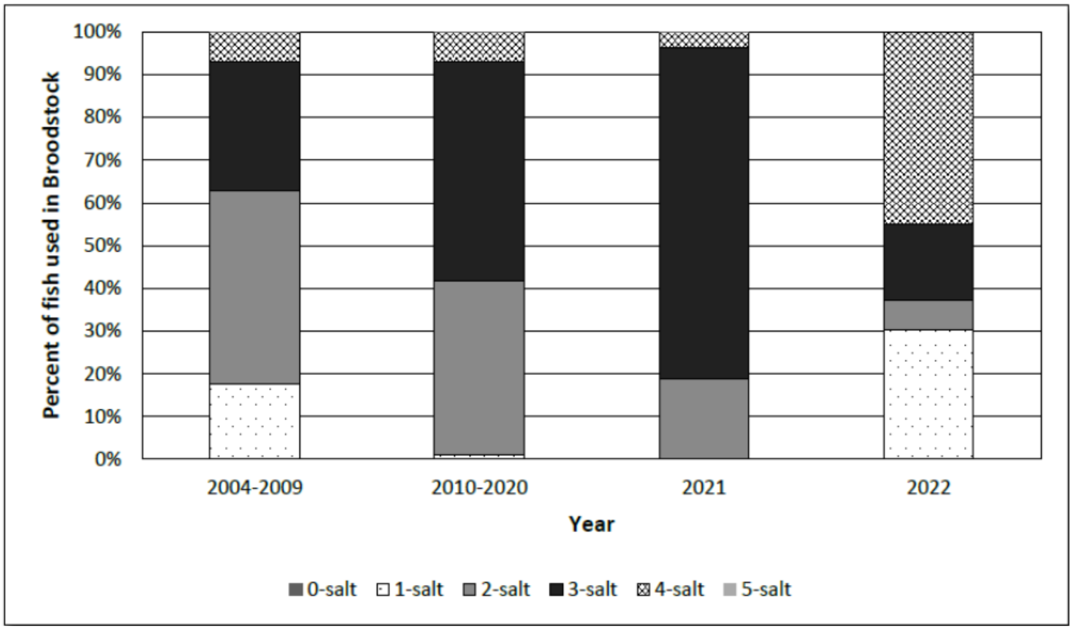

Figure 9. Percentages of salt ages (years spent in salt water) of fall-run Chinook salmon spawned at Lyons Ferry Hatchery before and after changes to broodstock selection protocols (Fortier and Herr 2024).

Outbreeding effects and among ESU diversity

Here, we analyze the effect of the Snake River fall-run Chinook salmon on other salmon populations due to straying and the effect posed to the Snake River Fall-run Chinook Salmon ESU by inclusion as broodstock of stray fish from other hatchery programs.

Straying from Snake River fall-run Chinook salmon Hatchery Programs

The level of straying outside the Snake River by HOR Snake River fall-run Chinook salmon was previously analyzed and found to be low and within acceptable standards (<5%; see (Grant 1997)) by NMFS (2018e). Bond et al. (2017) examined passive integrated transponder (PIT) tag data to investigate factors affecting stray rates for fall-run Chinook salmon released from Lyons Ferry, Nez Perce Tribal, and other hatcheries. They found that when juvenile fall-run Chinook salmon were barged down the river, instead of volitional outmigration, the likelihood of entering non-natal tributaries as adults greatly increased. However, their results also indicated a low level of straying overall. Of 18,463 adult fish with adequate PIT tag detections to allow inference, only 152 permanently strayed into lower Columbia River tributaries (most often into the lower Deschutes River), and only 196 strayed into upper Columbia River tributaries, suggestive of a 1.9% stray rate over the ten years of their study.

Pearsons and Miller (2023) used coded-wire tag (CWT) data from 1999-2018, expanded for tagging and sampling rates, to estimate the "recipient population stray rate" for upper Columbia River Chinook salmon populations. Their findings indicated that Snake River fall-run Chinook salmon constituted <1% of naturally spawning Chinook salmon populations in the upper Columbia River (Figure 10). Collectively, available information indicates that strays from Snake River fall-run Chinook salmon hatchery programs pose no serious genetic risk to potential recipient populations or among ESU genetic diversity.

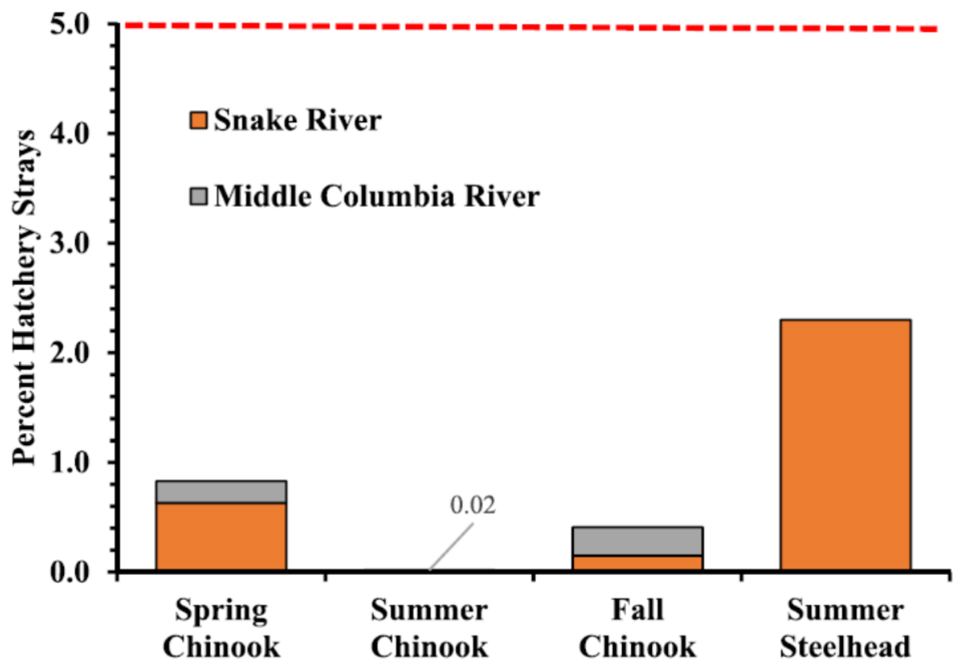

Figure 10. Mean percent hatchery stray Chinook Salmon and steelhead observed in the upper Columbia River basin from other regions of the Columbia River basin from 2014 to 2018 (Pearsons and Miller 2023).

Inclusion of strays into the Snake River fall-run Chinook salmon Hatchery Programs

A small proportion of the fall-run Chinook salmon that arrive at Lower Granite Dam originate from populations outside the Snake River Fall-run Chinook Salmon ESU. Such strays can often be identified through coded-wire or parental-based (genetic) tags. Young et al. (2024) reported that in 2023, an estimated 3.9% of fall-run Chinook salmon that arrived at LGR from August 18 to November 15 were identified as strays from other populations (Table 21).

Table 21. The number of hatchery- and natural-origin (HOR and NOR) Snake River fall-run Chinook salmon (SRFC) and out-of-basin strays that arrived at Lower Granite Dam in 2023 (August 18-November 15). Adapted from (Young et al. 2024).

Origin	Age	Females	Males	Jacks	Total

				(<57 cm)	
HOR SRFC	2	0	78	237	315
	3	138	1,028	132	1298
	4	2,813	2,898	12	5723
	5	452	108	0	560
NOR SRFC	2	0	186	1,531	1717
	3	1,074	4,631	138	5843
	4	16,696	10,016	17	26729
	5	1,443	712	0	2155
Out-of-Basin Strays	2	0	14	15	29
	3	0	131	25	156
	4	634	658	0	1292
	5	204	48	0	252

The use of out-of-basin strays for broodstock in Snake River fall-run Chinook salmon hatcheries is generally avoided so as to preserve ESU genetic diversity and limit potentially detrimental outbreeding effects. However, NMFS (2018e) has previously allowed the inclusion of up to 5% contribution to broodstock from out-of-basin strays, as needed to meet hatchery egg-take goals. Actual use of strays in broodstock has typically been maintained well below 5% (Table 22). Including strays in the hatchery broodstock presents little if any genetic risk to Snake River fall-run Chinook salmon.

Table 22. Inclusion of out-of-basin strays in the Lyons Ferry Hatchery Snake River fall-run Chinook salmon program, 2007-2022. Adapted from Fortier and Herr (2024).

Year	Total number of matings	Matings with stray males	Matings with stray females	Stray x Stray matings	Percent of matings with strays
2007	1,458	3	7	0	0.70%
2008	1,309	1	0	0	0.10%
2009	1,293	0	1	0	0.10%
2010	1,238	3	9	0	1.00%
2011	1,251	0	6	0	0.50%
2012	1,184	0	1	0	0.10%
2013	1,240	6	59	1	5.20%
2014	1,162	0	0	0	0.00%
2015	1,200	0	24	0	1.90%
2016	1,210	0	0	0	0.00%
2017	1,285	1	0	0	0.10%
2018	1,253	0	0	0	0.00%
2019	1,151	5	4	0	0.80%
2020	1,107	4	2	0	0.50%

2021	1,216	3	8	0	0.90%
2022	1,232	0	4	0	0.30%
Mean	1,237	1.6	7.8	0.06	0.01%

Our analysis concludes that, given the objectives of the programs, hatchery-influenced selection is adequately limited through integration of natural-origin fish into the hatchery broodstock at pNOB > 0.15 (Figure 8). Regular adherence with the established pNOB limit also serves to conserve within-ESU genetic diversity associated with adaptation to the natural environment. Very low contribution levels of out-of-basin strays into the hatchery broodstock (Table 22) provide further evidence that within-ESU genetic diversity is being preserved through current management practices. Lastly, the low level of straying by (< 5%) and low pHOS from (< 2%) Snake River fall-run Chinook salmon hatchery programs indicate that fish from these programs pose little-to-no outbreeding depression risk to ESA-listed species

In summation, the overall genetic effects resulting from the hatchery programs described in the Proposed Action do not constitute a serious threat to the Snake River Fall-run Chinook Salmon ESU.

2.5.2.2.2. Ecological interactions between hatchery- and Natural-Origin Adults

Hatchery-origin fish can have ecological effects on natural-origin fish when they compete for spawning sites, superimpose redds, and/or contribute marine-derived nutrients to freshwater areas.

Nutrient contribution

To the extent that hatcheries contribute additional fish to the ecosystem, hatchery operations can have positive ecological effects. For example, when anadromous salmonids return to spawn, regardless of their origin, they transport marine-derived nutrients stored in their bodies to freshwater and terrestrial ecosystems. Their carcasses provide a food source for juvenile salmonids and other fishes, aquatic invertebrates, and terrestrial animals, and their decomposition supplies nutrients that can increase primary and secondary productivity (Kline et al. 1990; Gresh et al. 2000; Wipfli et al. 2003). As a result, the growth and survival of juvenile salmonids may increase in response to greater nutrient availability (Johnston et al. 1990; Larkin and Slaney 1996; Quinn and Peterson 1996; Bradford et al. 2000).

Salmon and steelhead are essential transporters of marine-derived nutrients, such as phosphorous, into the freshwater and terrestrial systems through the decomposition of fish carcasses (Cederholm et al. 2000). Increased phosphorus can benefit salmonids because it is typically a limiting nutrient for the growth of organisms that salmon prey upon. For example, growth rates in *Daphnia* (a prey source for salmonids) have been shown to increase with increased phosphorus in the algae (Boersma et al. 2009). This means that an increase in phosphorus in the ecosystem could provide a larger prey mass for salmonids.

The propagation and release of fish from Snake River fall-run Chinook salmon hatchery programs could add an estimated 1,279 kg (Table 23) of phosphorus annually into the environment in addition to what is typically added to the system by NOR fish. Relative to the phosphorous delivery estimated by NMFS (2018e) under current conditions, this represents an annual increase of 217 kg. However, this is likely an overestimation of nutrients to be added to the system because HOR returns are subject to removal through harvest, broodstock collection, and gene flow management. Regardless, these added HOR fish are likely to deliver beneficial nutrients to the system, beyond what could be expected without implementation of the Proposed Action, even at the current level of nutrient contribution.

Table 23. Total phosphorous imported by adult returns from the proposed hatchery programs per year based on the equation: $\boldsymbol{I_t = A_t \times m_A \times P_A}$, where $\boldsymbol{I}$ represents the annual import of phosphorus by adult salmon into the freshwater, $\boldsymbol{t}$ represents the year, $\boldsymbol{A_t}$ is the total number of adult spawners in year $\boldsymbol{t}$, $\boldsymbol{m_A}$ represents the mean mass of an individual adult, and $\boldsymbol{P_A}$ is the proportion of phosphorus in the body of adults (Scheuerell and Williams 2005).

All program releases by life stage	$\# \, smolt \, release \times smolt \, to \, adult \, survival = A_t$	Number of adults, A_t	Adult Mass (kg), m_A[1]	Concentration of phosphorous (kg/adult), P_A[2]	Phosphorus imported (kg/year), I_t
6.8 million subyearlings	6.8 million × ~0.009	61,200	5.5	0.0038	1,279

[1]5.5 kg was used as the mean mass of adult Chinook salmon from the Snake River basin (Peery et al. 2003)
[2]Moore and Schindler (2004) assume 0.38% mass-specific concentrations of phosphorus in adults

Spawning site competition and redd superimposition

According to the program HGMPs (NPT 2011; Washington Department of Fish and Wildlife et al. 2011), run and spawn timing between HOR and NOR Snake River fall-run Chinook is very similar. Therefore, HOR fish that make it onto spawning grounds may compete with NOR fall-run Chinook salmon for spawning sites, and redd superimposition may also occur. These integrated hatchery programs produce HOR fish intended to spawn with NOR fish to supplement the NOR population. As described in Factor 1, Section 2.5.2.1, the natural Snake River fall-run Chinook salmon population remains over the abundance threshold for a "Large" population. Because of this, there is likely adequate habitat for both NOR and HOR returns to spawn without experiencing a harmful level of competition for spawning sites or superimposition.

Regardless, relocating hatchery releases from the Pittsburg Landing site of the Snake River to the Salmon River is expected to build upon the intent of the NPEA, and reduce redd site competition and superimposition in the lower Hells Canyon reach. Moreover, the upriver relocation of HOR releases to the Big Canyon site of the Grande Ronde River can be expected to expand the distribution of the species into areas with less competition from or interactions with NOR fish. These changes are expected to reduce interactions between HOR and NOR salmon on natural spawning grounds in the Snake River, as well as reduce local pHOS in select river reaches.

There is unlikely to be negative effects from spawning site competition or redd superimposition between HOR fall-run Chinook salmon and the other three listed species (Table 24). This is because their spawn timings largely do not overlap; therefore, there is limited opportunity for these potential ecological interactions to occur. It is possible that HOR fall-run Chinook salmon could compete with NOR spring/summer-run Chinook salmon because there is a slight overlap in spawn timings in October. However, the single-population Snake River fall-run Chinook salmon only geographically overlaps with a portion of the Snake River spring/summer-run Chinook salmon. This overlap primarily occurs in the South Fork of the Salmon River and affects both the Salmon River MPG and the Little Salmon River MPG. However, Snake River fall-run Chinook salmon spawn in the mainstem rivers, while Snake River spring/summer-run Chinook salmon spawn in tributaries. Because of these spatial, temporal, and life history differences, we expect the effects from spawning site competition and redd superimposition between HOR fall-run Chinook salmon and Snake River spring/summer-run Chinook salmon to be minimal. Hatchery operators are familiar with identifying morphological differences between fall-run and spring/summer-run Chinook salmon, and it is highly unlikely that they would use incorrect species for broodstock purposes. Ongoing PBT genetic analyses will indicate any spawning overlap between fall-run and spring/summer-run Chinook salmon, which could determine levels of spawning site competition and redd superimposition between species.

Table 24. Run and spawn timing of Snake River fall-run Chinook salmon, steelhead, spring/summer-run Chinook salmon, and sockeye salmon

Species		Run timing	Spawning
Fall-run Chinook salmon		late-August to November	mid-October to mid-December
steelhead		September to November	March to June
spring/summer-run Chinook salmon		March to mid-August	late July to October
sockeye salmon	resident life form I	NA	late-fall
	resident life form II: kokanee	NA	late-summer to early-fall
	anadromous	mid-summer	late-fall

Source: IDFG website, http://fishandgame.idaho.gov

The overall ecological effects from adult HOR fish on listed salmon and steelhead are likely to be negligible. The effects of nutrient contribution in the form of marine-derived nutrients will be slightly positive to listed species, which does not constitute a measurable change to VSP criteria. In addition, and the effects of spawning site competition and redd superimposition will be negligible and will not affect VSP criteria.

2.5.2.2.3. Encounter of listed species at adult collection facilities

Hatchery operators may incidentally encounter ESA-listed salmonids at adult collection facilities. These encounters may cause handling-related stress or mortality to fish from sorting, holding, and handling. Therefore, the operation of these facilities poses potential incidental harm to Snake River fall-run Chinook salmon not intended for broodstock, steelhead, spring/summer-run Chinook salmon, and sockeye salmon. However, incidental lethal take is limited during trapping with a <1% mortality rate for listed species. This threat is minimized by collecting, processing, and passing fish within 24 hours of initial trapping.

Snake River Fall-run Chinook salmon

Adult collection facilities may affect fall-run Chinook salmon in a number of ways. Handling these fish may result in stress and/or physical injury, which could lead to short-term or long-term post-release mortality. Long-term mortality is difficult to observe and estimate; therefore, only immediate mortality events have been recorded as mortalities with a <1% (38 fish) mortality rate during trapping at the adult collection facilities.

This analysis was first completed in the 2012 Biological Opinion (NMFS 2012d) under the *Fish Removal* section (Section 2.4.3) as well as the *U.S. v. Oregon* Biological Opinion (NMFS et al. 2018). The new Proposed Action does not result in any additional incidental effects on listed species from what was previously analyzed by NMFS (2018e). This is because broodstock handling and collection methods at adult collection facilities are the same as what was proposed in the 2012 and 2018 NMFS Biological Opinions.

2.5.2.3. Factors 3. Hatchery-origin fish and the progeny of naturally spawning hatchery-origin fish in juvenile rearing areas and migratory corridors

NMFS also analyzes the potential for competition and predation when the progeny of naturally spawning hatchery fish and hatchery releases share juvenile rearing areas and migratory corridors. This factor can have effects on the productivity VSP parameter (Section 2.5) of the natural population. The effect of this factor ranges from negligible to negative. See Section 6 for a description of the full range of effects due to competition and predation.

The prior analysis was covered in the 2012 Biological Opinion (NMFS 2012d) under the *Fish Removal* section (Section 2.4.3.), the *U.S. v. Oregon* Biological Opinion (NMFS et al. 2018), and the former 2018 Snake River Fall-run Chinook Salmon Biological Opinion (NMFS 2018e). The Proposed Action proposes an increase of 1,150,000 subyearlings, to make up for eliminating the remaining yearling releases. The increased release numbers are spread across the Snake River, Grand Ronde, and Clearwater River Basins. The increase in subyearlings comes from four specific releases within the ESU boundaries and is analyzed for this factor. The first change is the increase of 200,000 subyearlings at the Big Canyon Acclimation Facility (NPT) on the Clearwater. The second change is the return of the Couse Creek direct release site accounting for 600,000 subyearlings being released at Couse Creek on the Snake River. The third change is increasing the Cougar Creek by 300,000 subyearlings and moving the release to the Big Canyon Acclimation facility (ODFW) on Deer Creek. The last change is switching the Lyons Ferry release to a subyearling release, and increasing it by 50,000 totaling 500,000 subyearlings. The production totals an increase in 1,150,000 subyearlings across the four locations, but this analysis factors in the total fish released at each release location. Additional changes were made to release sites under the current Proposed Action. However, the new release numbers were comparable to the 2018 releases. Therefore, these effects were likely maximized in past operations, the ecological analyses of which can be found in the prior Snake River Fall-run Chinook Salmon Biological Opinion (NMFS 2012d; 2018e) and the *U.S. v. Oregon* Biological Opinion (NMFS

2018d). These documents provide an in-depth description of competition and predation effects from all of the juvenile releases.

We include our Action Area down to Ice Harbor Dam on the Snake River because we can only reasonably expect to detect effects of hatchery-origin fish in juvenile rearing areas and the migratory corridor down to Ice Harbor Dam. Overall, the effects of Factor 3 on all listed species analyzed in this Biological Opinion are considered negative.

2.5.2.3.1. Hatchery release competition and predation effects

In an effort to better understand the aggregate competition and predation effects, NMFS used the PCD (Predation, competition, disease) Risk model (Pearsons and Busack 2012) to simulate predation and competition on natural-origin salmon, sockeye, and steelhead juveniles from the additional 1,150,00 fish released within the Snake, Clearwater, and Grande Ronde basin. As discussed in more detail in Section 6, outputs from the PCDRisk model should not be considered estimates of the actual predation and competition effects on natural-origin salmon and steelhead from hatchery-origin juveniles because the PCDRisk model is not a total simulation of ecological interactions between hatchery and wild fish. Nonetheless, the simulations are helpful in that they give an example of the magnitude of interactions that could occur under a certain set of assumptions. Parameter values used in the model runs are shown in Table 25, Table 26, and Table 27.

We assumed a 100 percent population overlap between hatchery-origin fall-run Chinook salmon juveniles and all natural-origin species (juveniles) present for our model runs. The release of the additional 1,150,000 subyearlings could potentially overlap with natural-origin Chinook and sockeye salmon and steelhead in the Snake River, Clearwater, and Grande Ronde Basins. However, we acknowledge that a 100 percent population overlap in microhabitats is likely a considerable overestimation. In addition, our model does not assess effects on age-0 steelhead because steelhead spawn from March to June with a peak from April to May in the Action Area (Busby et al. 1996). Thus, it is unlikely that any age-0 steelhead would have emerged in time to interact with the hatchery steelhead smolts as they migrate downstream.

Table 25. Parameters in the PCDRisk model that are the same across all programs. All values from HETT (2014) unless otherwise noted

Parameter	Value
Habitat complexity	0.1
Population overlap	1.0
Habitat segregation	0.3 for Chinook salmon; 0.6 for all other species
Dominance mode	3
Piscivory	0.0023 for Chinook salmon; 0 for all other species

Maximum encounters per day	3
Predator: prey length ratio for predation	0.25[1]
Average temperature across release sites	11.9°C, 10.8°C, 8.1°C[2]

[1] (Daly et al. 2009)
[2] USGS gages accessed for Snake River (13317660), Clearwater (13340000), and the Grande Ronde (1331500)

Table 26. Age and average size of listed natural-origin salmon and steelhead encountered by juvenile hatchery fish after release.

<table>
<tr><th>Species</th><th>Age Class</th><th>Size in mm (SD)</th></tr>
<tr><td rowspan="2">Chinook salmon</td><td>0</td><td>55 (10)</td></tr>
<tr><td>1</td><td>91 (11)</td></tr>
<tr><td rowspan="2">Steelhead</td><td>1</td><td>71 (10)</td></tr>
<tr><td>2</td><td>128 (30)</td></tr>
<tr><td rowspan="2">Sockeye Salmon[1]</td><td>1</td><td>86 (7)</td></tr>
<tr><td>2</td><td>128 (8)</td></tr>
</table>

[1] For the sockeye salmon runs, we assumed that a maximum of 61,000 natural-origin outmigrants in the model. We also assumed an age class composition of 13% “age two” fish and 87% “age one” fish (Leth 2017; Rabe 2017)

Table 27. Hatchery fish parameter values for the PCDRisk model. Model runs for release At Big Canyon Acclimation Facility (ODFW), Couse Creek, and Big Canyon Acclimation Facility (NPT) to Lower Granite Dam (LGD). And then aggregated with Lyons Ferry Hatchery (LFH) to Ice Harbor Dam (ICH).

<table>
<tr><th rowspan="2">Release site</th><th rowspan="2">Proposed Release numbers with 10% overage buffer</th><th rowspan="2">Size in mm (SD)</th><th colspan="4">Survival rate</th><th colspan="4">Travel (Residence) Time in median days</th></tr>
<tr><th>Release site to LGD[1]</th><th>LGD to LFH[1,2]</th><th>LFH to LOMO[1,2]</th><th>LOMO to ICH[1]</th><th>Release site to LGD[1]</th><th>LGD to LFH[1,2]</th><th>LFH to LOMO[1]</th><th>LOMO to ICE[1]</th></tr>
<tr><td>LFH (on Station)</td><td>550,000</td><td>103 (20)</td><td>N/A</td><td>N/A</td><td rowspan="3">0.95</td><td rowspan="3">0.87</td><td>N/A</td><td>N/A</td><td rowspan="3">1.4</td><td rowspan="3">4</td></tr>
<tr><td>Big Canyon Acclimation (ODFW)</td><td>550,000</td><td>103 (20)</td><td>0.33[3]</td><td rowspan="2">0.87</td><td>19[3]</td><td rowspan="2">3.8</td></tr>
<tr><td>Big Canyon Acclimation (NPT)</td><td>440,000</td><td>103 (20)</td><td>0.79</td><td>14</td></tr>
</table>

Couse Creek	660,000	103 (20)	0.47				17			

Sources: (Bumgarner 2017; NMFS 2017e)
[1] LGD stands for Lower Granite Dam; LOMO stands for Lower Monumental Dam; ICH stands for Ice Harbor Dam.
[2] All releases upstream of LGD are aggregated at LGD; LFH aggregated with all releases at LFH.
[3]Due to limited data available, survival rate and travel time from the prior release within the Grande Ronde were used as a proxy for the new acclimated release at the Big Canyon Acclimation Facility (ODFW).

Based on the data in Table 27, our model results show that the largest effect hatchery-origin Chinook salmon are likely to have is on natural-origin steelhead, followed by their effect on natural-origin Chinook (all runs) (Table 28). The maximum numbers of fish lost to a combination of predation and competition by hatchery-released juveniles are also shown in Table 28 and would not change if more natural-origin fish were present throughout the Action Area because we ran the model with natural-origin fish numbers at the point where all possible hatchery fish interactions are exhausted at the end of each day. The exception to this model result is for sockeye salmon because we have natural-origin abundance data for the one sockeye population that the Proposed Action may affect, which demonstrates that, from 2006-2016, the maximum number of natural-origin sockeye salmon produced was ~61,000. Thus, we used this value in the model along with the actual proportions of each age class (87 percent age-1, and 13 percent age-2) available (Kozfkay 2017).

These model effects shown as juvenile and adult equivalent fish lost can also be represented as a travel-time standard for a year-to-year measurement. This can be accomplished by taking a five-year running median travel time of hatchery-origin fall-run Chinook salmon outmigrants to reach Ice Harbor Dam after release
Table 27) beginning in year 2025. Once this is accomplished, you can compare the five-year running medians across a given five-year time frame (e.g., 2025 to 2029). If travel times exceed the five-year median by five or more days in at least three of the five years used to establish the median, this indicates that the effects (including take estimates) may be greater than our existing estimates suggest. These travel time values are easily measurable using PIT tags, screw traps, or other juvenile monitoring techniques and are linked to the current model estimates.

The number of each species that pass over LGR is 14,194 for natural-origin Chinook salmon (Table 16 and Table 17, both fall-run and spring/summer-runs combined), 12,447 for steelhead (Table 18), and 973 for both hatchery and natural sockeye salmon (DART, 10-year average from 2015-2024 accessed February 5, 2025). These would equate to a potential loss of <2.0 percent of all the potential adult returns from competition and predation during the juvenile life stage. In addition, these negative effects are spread out over the various populations comprising the various Snake River ESUs/DPSs, including the unlisted spring/summer-run Chinook salmon originating from the Clearwater sub-basin. In addition, most of the ecological effects on natural-origin ESA-listed salmon and steelhead were predicted to occur via competition. Based on the assumptions used in NMFS' simulations applying the PCD Risk model, ecological impacts from the release of the additional 1,150,000 hatchery-origin subyearlings included in this Proposed Action is negligible.

Table 28. Maximum possible numbers and percent of natural-origin salmon and steelhead lost to competition and predation with hatchery-origin fall-run Chinook salmon released from the Proposed Action

Program	Chinook	Steelhead[2]	Sockeye
	Competition[1]	Competition[1]	Competition[1]
Release Location to LGD			
Big Canyon (ODFW) to LGD	11796	10028	513
Couse Creek to LGD	11191	9779	474
Big Canyon (NPT) to LGD	9176	7923	408
LGD to LFH			
LGD to LFH	2923	2953	132
LFH to Ice Harbor Dam			
LFH to LOMO	745	774	34
LOMO to ICH	2916	2928	132
Total Juveniles Lost	**38757**	**34385**	**1693**
SAR[3]	0.41	0.88	0.5
Adult Equivalents	**159**	**303**	**8**

[1] Competition as used here is the number of natural-origin fish lost to competitive interactions assuming that all competitive interactions that result in body weight loss are applied to each fish until death occurs (i.e., when a fish loses 50% of its body weight). This is not reality, but does provide a maximum mortality estimate using these parameter values. Moreover, the model showed that steelhead and sockeye are not expected to be prey items for the program hatchery fish so only competition is reported

[2] For these runs, we only used "age two" steelhead in the model, because "age one" fish are not likely to occur at that reach (Busby et al. 1996)

[3] SAR stands for "smolt-to-adult survival". Data sources for rates: (NMFS 2017e).

The PCD Risk model is designed to characterize a maximum possible scenario, and as such is highly unlikely to reflect the actual levels of effects. Similar to using models for biological systems elsewhere, this model cannot possibly account for all the variables that could influence competition and predation of hatchery juveniles on natural juveniles. For example, the model assumes that if a hatchery fish is piscivorous and its stomach capacity allows the fish to consume prey, it will be natural-origin prey. The reality is that hatchery-origin fish could choose to eat a wide variety of invertebrates, other fish species (e.g., shad, minnows), and other hatchery-origin fish in addition to natural-origin smolts. However, we believe that with this model we are estimating a worst-case estimate for the effects on natural-origin juveniles to the best of our ability.

Residual hatchery fall-run Chinook salmon are not explicitly accounted for in our current model. Residualization occurs when a juvenile remains in the river environment, rather than migrating to the ocean, in which case the amount of competitive interactions increases for any residual fish. However, the applicants have proposed actions that are expected to minimize their ecological and genetic impacts. Recent data exists that residualism may occur as a result of hatchery rearing and has been measured in some Upper Columbia River hatchery programs (NMFS 2017d). Therefore, comanagers will measure, and NMFS will interpret the residual effects resulting from this Proposed Action. The comanagers will measure this through visual observation at pre-release sampling, and the percentage of fall-run Chinook salmon that are precociously mature prior to release will be recorded and calculated. This visual observation will be relied on as part of the Proposed Action, but has only occurred for the LFH portions of these programs thus far. Table 29 shows the extent of precocious maturation observed at LFH over the most recent five-year period where data was available. However, the NPT has not previously utilized visual observation. The Proposed Action includes conducting visual observations during pre-release sampling to estimate the likely extent of residualism. NMFS must consider evidence from other programs to understand the potential outcomes of this sampling.

There are recent, relevant studies that have measured precocial maturation as result of hatchery rearing. In particular, one study found Chinook salmon mini-jack rates range from 19 to 57 percent of observed juveniles from hatchery programs that used Hood River and Carson stock (Spangenberg et al. 2015), located downstream in the Mid-Columbia ecological province. We do not expect precocial maturation rates to be this high in the fall-run Chinook salmon programs because these results largely reflect environmental conditions not observed in the Snake River Basin. This is because recent data from LFH (Table 29) suggests that no fall-run Chinook salmon have expressed precocial maturation during pre-release sampling.

Based on informal communications with co-managers, a review of LFH data (Table 29), and the best available science, we estimate that no more than five percent of observed hatchery fish should express precocial maturation for the LFH program. A five-year running average will be used to determine these effects in the future for the LFH program. This is the first time that the NPT hatchery program has utilized visual observations to estimate the amount of precocious fish in their hatchery release groups; therefore, no data exists to understand what has been done in the past. While we expect results to be similar to LFH (Table 29), this may be implemented in the future after we have assessed results.

Table 29. Numbers of precocious maturation observed during pre-release sampling at Lyons Ferry Hatchery (McGuan 2025)

Brood Year	# Precocious	Total sampled	Total released	% Precocious
Yearlings				
2019	0	425	400124	0
2020	0	305	433895	0
2021	0	424	434010	0
2022	0	215	469043	0
2023[1]	N/A	N/A	452332	N/A
Subyearlings				
2019	0	426	695038	0
2020	0	423	559654	0
2021	0	205	517161	0

2022	0	424	765331	0
2023	0	412	566294	0

[1]Fish were released early due to a botulism outbreak and were not sampled.

2.5.2.3.2. Naturally-produced progeny competition

Naturally spawning hatchery-origin Chinook salmon are likely to be less efficient at reproduction than their natural-origin counterparts (Christie et al. 2014). However, the progeny of such hatchery-origin spawners are still likely to make up a sizable portion of the juvenile fish population. This is a desired result of the integrated recovery programs. There is no reason to expect the offspring of naturally spawning hatchery-origin adults to behave differently from those of natural-origin parents. Therefore, the only expected effect of this added production is a density-dependent response of decreasing growth and potential exceedance of habitat capacity. Population status trends monitored through life cycle modeling may suggest this response and will be measured in the future. Overall, these actions have a slight negative effect.

NMFS expects that the monitoring efforts will detect negative effects before they reach problematic levels, and we include language in the Incidental Take Statement (ITS; Section 2.9) to ensure that appropriate monitoring takes place.

2.5.2.3.3. Disease

The risk of pathogen transmission to natural-origin salmon and steelhead is negligible for these Chinook salmon programs. Please refer to Table 30 for information on pathogen incidences at hatchery facilities over the last six years. Despite these detections/outbreaks with pathogens that could be transmitted to natural-origin salmon and steelhead, all are easily treatable (if necessary), controlled by NPT and WDFW's Fish Health Laboratory, and are endemic to the Columbia Basin. Therefore, there is little risk of native pathogen transmission and no risk of non-native pathogen transmission to ESA-listed natural-origin fish.

Table 30. Pathogen information over the most recent six years of data at facilities where Snake River fall-run Chinook salmon are reared, acclimated, or spawned.

Program	Years	Life Stage	Pathogen detected	Treatment or control regime	Epidemic?	Exotic pathogen detection
Nez Perce Tribal Hatchery Complex[1]	2018	Juvenile	*Flavobacterium branchiophilum*	Chloramine-T	No	No
		Adult	*Renibacterium salmoninarum*	No treatment		
	2019	Juvenile	*Flavobacterium branchiophilum*	Chloramine-T	No	No
		Adult	*Aeromonas salmonicida*	Formalin		
			Renibacterium salmoninarum	No Treatment		
	2020	Juvenile	*Flavobacterium branchiophilum*	Chloramine-T	No	No
		Adult	*Aeromonas salmonicida*	Formalin		
			Renibacterium salmoninarum	No Treatment		
	2021	Juvenile	*Flavobacterium branchiophilum*	Chloramine-T	No	No

		Adult	*Renibacterium salmoninarum*	No Treatment		
	2022	Juvenile	*Flavobacterium branchiophilum*	Chloramine-T	No	No
		Adult	*Renibacterium salmoninarum*	No Treatment		
	2023	Juvenile	*Flavobacterium branchiophilum*	Chloramine-T	No	No
		Adult	*Renibacterium salmoninarum*	No Treatment		
Lyons Ferry Hatchery	2018	Juvenile	*None*	No treatment	No	No
		Adult	*Renibacterium salmoninarum*			
	2019	Juvenile	*Ichthyophthirius multifiliis*	Formalin drip treatment for Juveniles. No treatment for adults.	No	No
		Adult	*Renibacterium salmoninarum*			
	2020	Juvenile	*None*	No treatment	No	No
		Adult	*Renibacterium salmoninarum*			
	2021	Juvenile	*None*	No treatment	No	No
		Adult	*Renibacterium salmoninarum*			
	2022	Juvenile	*None*	No treatment	No	No
		Adult	*Renibacterium salmoninarum*			
	2023	Juvenile	*None*	No treatment	No	No
		Adult	*Renibacterium salmoninarum*			
Irrigon Fish Hatchery[2]	2018	Juvenile	*Flavobacterium psychrophilum* *Aeromonad-pseudomonad septicemia*	No treatment	No	No
		Adult	*Renibacterium salmoninarum*			
	2019	Juvenile	*Flavobacterium psychrophilum* *Aeromonad-pseudomonad septicemia*	No treatment	No	No
		Adult	*Renibacterium salmoninarum*			
	2020	Juvenile	*Flavobacterium psychrophilum* *Aeromonad-pseudomonad septicemia* *Hexamita*	Aquaflor Medicated Feed (CWD) 3% Epsom Salt Feed (Hexamita) for juveniles, no treatment for adults	No	No
		Adult	*Renibacterium salmoninarum*			
	2021	Juvenile	*Flavobacterium psychrophilum* *Aeromonad-pseudomonad septicemia*	Aquaflor Medicated Feed (APS)	No	No
		Adult	*Renibacterium salmoninarum*			
	2022	Juvenile	*Flavobacterium psychrophilum* *Aeromonad-pseudomonad septicemia*	No treatment	No	No
		Adult	*Renibacterium salmoninarum*			
	2023	Juvenile	*Flavobacterium psychrophilum* *Aeromonad-pseudomonad septicemia*	No treatment	No	No
		Adult	*Renibacterium salmoninarum*			

Source: (Herr 2024; Schmidt 2024; Johnson 2025)
[1] Includes fish reared at the North Lapwai Valley, Cedar Flats, and Lukes Gulch Acclimation Facilities
[2] Includes fish reared for releases at Grande Ronde and Salmon River

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

NMFS analyses the incidental effects of the proposed research, monitoring, and evaluation (RM&E) on listed species. This factor can also affect the natural-origin population's productivity VSP parameter (Section 2.5).

The monitoring and evaluation activities directly related to the Snake River Hatchery programs are part of a more significant effort to determine the overall status of the Snake River Fall-run Chinook Salmon ESU. Because the intent is to improve our understanding of listed population status, the information gained through these studies outweigh the associated low risks to the populations detailed below. Only a small proportion of the population is likely to be encountered during these efforts, resulting in an overall negligible effect of RM&E on the Snake River fall-run Chinook salmon population. The effects on Snake River spring/summer-run Chinook salmon, sockeye, and steelhead are also negligible.

Many RM&E projects exist within the Snake basin, which include spawning surveys, electrofishing, tissue sampling, hook-and-line angling, marking, tagging, anesthetization, snorkel surveys and juvenile trapping activities. RM&E used specifically for Snake River fall-run Chinook salmon includes the marking and tagging of juvenile fish, PBT sampling, and a mixture of seining and angling to count, tag and sample juveniles as they emigrate through the Federal hydropower system (Table 31). Mortality within the juvenile RM&E efforts is very low (>1%) with the highest mortality seen this past year at 0.6 percent (Table 31). Currently, the survival rate of these juveniles out of Clearwater is only 25 percent (Young 2024), making it difficult to generate an accurate Smolt-to-Adult return estimate (SAR). The Fish Passage Center, along with the Nez Perce Tribe, is proposing to increase the tagging effort to help better track fish passage through the hydropower system, as well as increase the reliability of data and returns of Snake River fall-run Chinook salmon (Table 32).

In general, it has been found that PIT tags have very little effect on the growth, mortality, and behavior of the fish (NMFS 2012d). Very early studies on the effects of PIT tags have shown that there is no long-term effect on growth or survival (Prentice and Park 1984; Prentice et al. 1987; Hockersmith et al. 2000). However, more recent studies have shown that actually PIT tagged fish might have a higher mortality than originally estimated (Knudsen et al. 2009). While the effects of PIT tags on fish are still not fully understood, protocols are put in place to limit potential mortality. The potential of lethal or sub-lethal effects on ESA-listed salmon would be minimized by the following protocols: (1) keeping the fish in water to the maximum extent possible during sampling and processing procedures, (2) ensuring adequate circulation and replenishment of water in holding units, and (3) not handling the fish when water temperatures exceed 70 degrees Fahrenheit.

Table 31. Number of Juvenile Snake River fall-run Chinook salmon captured, tagged, and released as part of the Nez Perce Tribal monitoring efforts in accordance with Permit 11615-2R.

Year	Number of juveniles handled, sampled, or tagged	Mortality	% Mortality
2019	3064	4	0.13%
2020	1962	0	0
2021[1]	NA	NA	NA
2022	4505	19	0.42%
2023[1]	NA	NA	NA
2024	5712	35	0.6%

[1]Data unavailable for 2021 and 2023.
Source: (NPT 2019; 2020; 2022; 2024)

Table 32. Number of Juvenile fall-run Chinook salmon handled/tagged and that incidentally die due to handling/tagging during juvenile monitoring efforts.

Trap Site	Fish Origin	Average; min and max of actual handling/tagging (mortality)	Proposed handling/tagging (mortality)	Average survival to LGR (%)	Adult equivalents (mortality)
Clearwater	Natural	3811; 1962-5712 (12; 0-35)	20000 (325)	0.25%	36(1)

Source: (NPT 2019; 2020; 2022; 2024; Young 2025a)

Moreover, adult weir trapping activities that exist as a result of hatchery operations are likely to include take of listed species. Please refer to the Proposed Action (Section 1.3) regarding broodstock collection activities and the direct take of sockeye salmon. During broodstock collection, RM&E activities also take place that are in addition to meeting broodstock goals and in support of other HGMP-listed activities. These RM&E activities include capture, marking, tagging, taking tissue samples, and releasing live animals. In addition, other fish not directly intended for "take" may be incidentally caught, at which point RM&E activities may be utilized. Other than the incidental encounters of spring/summer-run Chinook, mentioned, there is likely to be no effect of the activities on other listed species. This is because steelhead and sockeye salmon are separated spatially and/or temporally from this activity, and have not been encountered previously.

2.5.2.5. Factor 5. Construction, operation, and maintenance of facilities that exist because of the hatchery programs

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. This analysis considers 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. This factor can potentially affect a population's abundance, productivity, and spatial structure VSP parameters (Section 2.5). The effect of this factor ranges from negligible to negative. We anticipate that any effects from routine hatchery maintenance would not result in any deviation beyond normal fish behavioral responses to environmental disturbances, in adherence with NMFS criteria.

The operation and maintenance of facilities associated with hatchery programs included in the Proposed Action would have a negligible effect on ESA-listed species and critical habitat. These effects were all previously considered in the 2012 Biological Opinion (NMFS 2012d), the previous Snake River Fall-run Chinook salmon 2018 Biological Opinion (NMFS 2018e), the *U.S. v. Oregon* Biological Opinion (NMFS et al. 2018), and the Four Lower Snake River Steelhead Salmon Hatchery Programs Biological opinion (NMFS 2017c), which are summarized below. Please refer to the previous Biological Opinions for additional details on facility effects on ESA-listed salmon and steelhead.

The Proposed Action includes the construction of one new acclimation facility located on the Salmon River in Idaho. This new acclimation facility requires the use of surface water diverted from the Salmon River. However, it stays within the range of surface water withdrawals/diversions recorded at the other acclimation facilities used within the program. The Proposed Action also includes the use of the Big Canyon Acclimation Facility (ODFW) on Deer Creek, a tributary of the Wallowa River in Oregon. This acclimation facility is currently in use for Steelhead and is covered under the Four Lower Snake River Steelhead Hatchery Programs Biological Opinion (NMFS 2017c). The Big Canyon acclimation facility does not require any new construction and will only be used as an acclimation and release facility for Snake River fall-run Chinook salmon. The activities covered in the 2017 Biological Opinion for the Big Canyon acclimation facility are the same as they would be to include Snake River fall-run Chinook salmon.

The operation of Russell Bar Acclimation Facility is currently in the pre-consultation phase. However, the construction of the new acclimation facility will be covered in a different consultation. The new facility will be an acclimation site for the acclimation and release of Snake River fall-run Chinook salmon. The facility is proposing to use surface water exclusively from the Salmon River. All the water diverted from the river (minus evaporation) would be returned after it circulated through the facility. Therefore, the only potentially impacted river segment would be the short distance between the water intake and discharge structures. The effect will likely be difficult to measure, and the habitat available to ESA-listed salmonids would not change perceptibly.

The best management practices regarding specific water withdrawal, screening criteria, facility upgrades, maintenance activities, and NPDES permit information for each hatchery facility are described in the Proposed Action (Section 1.3). These best management practices will limit effects on ESA-listed salmonids and their associated critical habitat. Therefore, the Lyons Ferry Hatchery, Nez Perce Tribal Hatchery, Irrigon Hatchery, Pittsburg Landing Acclimation Facility, Big Canyon Acclimation Facility (NPT), Big Canyon Acclimation Facility (ODFW), Captain John Rapids Acclimation Facility, Luke's Gulch Acclimation Facility, Sweetwater Springs Satellite Facility, Cedar Flats Acclimation Facility, North Lapwai Valley Acclimation Facility, and the newly proposed Russell Bar Acclimation Facility will have a small negative effect on listed salmon and steelhead as described in the 2012 Biological Opinion (NMFS 2012d), the 2018 Biological Opinion (NMFS 2018e), the *U.S. v. Oregon* Biological Opinion (NMFS et al. 2018) and the Four Lower Snake River Steelhead Hatchery Programs Biological Opinion (NMFS 2017c).

The Proposed Action proposes minor changes in water withdrawals from the current operations of the hatcheries described in the 2012 Biological Opinion (NMFS 2012d), 2018 Biological Opinion (NMFS 2018e), and the *U.S. v. Oregon* Biological Opinion (NMFS et al. 2018). The current surface water withdrawals measured in the maximum percent of flow diversions (in cubic feet per second (cfs) from hatchery facility operations are shown in Table 33. The Nez Perce Tribal hatchery increased its amount of surface water used from 4.5 cfs to 6.8 cfs (Table 7) but still kept the same diversion percentage used for fall-run Chinook salmon (Table 33). The maximum percent of flow divergence is highest at the Big Canyon Acclimation Facility (ODFW), where roughly 50-60% of the total streamflow in Deer Creek is diverted between the intake and outfall of the facility, a distance of about 0.2km (NMFS 2017c). After the outfall, Deer Creek continues to flow at full rate into the Wallowa River. The only affected segment of the creek would be the short distance between the water intake and the outfall of the facility. In addition, the North Lapwai Valley Acclimation Facility diverts up to 2.2% of the total streamflow in the Lapwai River during the acclimation period (early April to the end of June). This would leave 63 cfs remaining in the River at its maximum effect. NMFS does not expect this to have a measurable effect on ESA-listed salmon or steelhead in the river, nor does it expect to perceptibly alter the available habitat utilized by ESA-listed salmonids.

Dewatering of redds or preventing natural-origin fish movement has not been observed at any facility under the Proposed Action when water flows are limited by hatchery operations during “low-flow" periods. Moreover, all facilities have been approved for compliance with the most recent NMFS’ 2011 screening criteria (NMFS 2011a). These criteria ensure that the mesh or slot-size in the screening material and the approach velocity of water toward the intake screening meet standards that reduce the risk of both entrainment and impingement of listed juvenile salmonids. Upon review, hatchery operators will prioritize repairs and upgrades into the future. Moreover, facilities are routinely observed for any signs that screens are not effectively excluding fish from intakes. Thus, we do not anticipate effects on listed salmon and steelhead from water intake structures. Note that, because changing in environmental condition trends indicate that juveniles may out-migrate earlier, the risk of dewatering juvenile rearing habitat when flows are at their lowest under likely changes in climate conditions, is reduced even further (Dittmer 2013).

Table 33. Average streamflow (in cfs) measured from April 1st to June 30th,[1], maximum daily water usage per facility, and calculated range of maximum percent flow divergence from facility operations.

Program	Average streamflow (in cfs)	Maximum daily surface water use (in cfs)	% flow divergence
LFH and Irrigon Hatchery[2]	N/A		
Pittsburg Landing	22843 (USGS gage #13290460 on Snake River)	4.5	<0.1%
Russell Bar Acclimation Facility[3]	22933 (USGS gage # 13317000 on Salmon River)	4.5-5.6	<0.1%
Big Canyon Acclimation Facility (NPT)	21467 (USGS gage #13341050 on Clearwater River)	4.5	<0.1%
Big Canyon Acclimation Facility (ODFW)	5-6[4]	3.0	50-60%
Capitan John Rapids Acclimation Facility	51657 (USGS gage #13334300 on Snake River)	5.6	<0.1%
Sweetwater Springs Satellite[5] Facility	N/A		
Lukes Gulch Acclimation Facility	2830 (USGS gage #13338500 on SF Clear Water River)	2.2	<0.1%
Cedar Flats Acclimation Facility	8427 (USGS gage #13336500 on Selway River)	2.2	<0.1%
NPTH	22167 (USGS gage #13342500 on Clearwater River)	13.4	<0.1%
North Lapwai Valley Acclimation Facility	65 (USGS gage #13342450 on Lapwai Creek)	1.4	<2.2%

[1]Acclimation facilities and are only for a few months during juvenile releases, so water use is only calculated during juvenile releases.
[2] Not Applicable because it is a well water supplied facility where no surface water is used
[3] The Russell Bar Acclimation Facility is currently under construction and all values are estimates based on other facilities.
[4] No USGS gage available, data provided by ODFW (Harrod 2024)
[5] Not Applicable due to no surface water used. Spring water is used in place of surface water.

The total facility discharges proportionally small volumes of water with waste (predominantly biological waste) into a larger water body, which results in temporary, very low, or undetectable levels of contaminants. General effects of various biological waste in hatchery effluent are summarized in (NMFS 2004b), though the biological waste is not likely to have a detectable effect on listed species because of an abatement pond that reduces the biological waste, as well as the small volume of effluent compared to the stream flow.

Therapeutic chemicals used to control or eliminate pathogens (i.e., formaldehyde, sodium chloride, iodine, potassium permanganate, hydrogen peroxide, antibiotics), can also be present in hatchery effluent. However, these chemicals are not likely to be problematic for ESA-listed species because they are quickly diluted beyond manufacturer's instructions when added to the total effluent and again after discharge into the recipient water body. Therapeutants are also used periodically, and not constantly during hatchery rearing. In addition, many of them break down quickly in the water and/or are not likely to bioaccumulate in the environment. For example, formaldehyde readily biodegrades within 30 to 40 hours in stagnant waters. Similarly, potassium permanganate would be reduced to compounds of low toxicity within minutes Aquatic organisms are also capable of transforming formaldehyde through various metabolic pathways into non-toxic substances, preventing bioaccumulation in organisms (EPA 2015).

Hatchery maintenance activities may also displace juvenile fish through noise and instream activity as well as exposing fish to brief pulses in sediment may alter the routine movement of juvenile fish. These activities may result in short-term displacement (within the normal range of fish behaviors in response to noise or a periodic habitat disturbance). Still, it is unlikely that long-term displacement will occur. The Proposed Action includes best management practices that limit the type, timing, and magnitude of allowable instream activities. These practices would likely limit potential short-term effects and would not result in a measurable effect.

The hatchery facilities (Table 33) are either operated under NPDES permits or do not need an NPDES permit because rearing levels in the acclimation pond are below permit minimums. To the extent that permits are current and on file, the effects of operations are in the baseline, but for the sake of analysis, we consider them here. Facility effluent is monitored to ensure compliance with permit requirements. Though compliance with NPDES permit conditions is not an assurance that effects will not occur to ESA-listed salmonids, the facilities use the water specifically to rear ESA-listed Chinook salmon, and juveniles are directly exposed to effluent levels in the hatchery facilities. Those juveniles have a low mortality during hatchery residence. This suggests that the effects of effluent do not affect the hatchery-reared juveniles. It stands to reason that the same effluent, which is further diluted once discharged, will not have a measurable impact on natural-origin salmon populations in the area.

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

Fisheries are not a part of the Proposed Action. However, there are fisheries that exist because of the Proposed Action. The fall-run Chinook salmon fishery on the Snake River meets the “but for” test, meaning the fishery would not occur “but for” the Proposed Action. While NMFS can analyze the effects of this fishery, we are not authorizing it through this consultation. Fisheries catching Snake River fall-run Chinook salmon in the mainstem Columbia River and the Pacific Ocean would exist with or without the Proposed Action and have previously been evaluated in separate biological opinions (NMFS 2012c; 2015a; 2018c).

The Snake River Fall-run Chinook Salmon Hatchery program is a unique case, that due to the success of the hatchery program, a fishery was created in 2019 after the completion of the 2018 Biological Opinion (IDFG 2019). The fishery allows sport fishing for adipose-intact and mark selective fall-run Chinook salmon. The fall-run Chinook salmon fishery is authorized separately of the proposed action, and is not covered in this Biological opinion.

Two aspects of fisheries are potentially relevant to NMFS’ analysis of hatchery program effects. One is where fisheries exist because of the Proposed Action (i.e., the fishery is an interrelated and interdependent action to the hatchery), and listed natural-origin species are inadvertently and incidentally taken in those fisheries. These fisheries would negatively affect the abundance VSP parameter of the affected populations (Section 2.5). The other scenario involves utilizing fisheries to harvest hatchery fish associated with the Proposed Action, including ESA-listed hatchery-origin salmon and/or steelhead, preventing them from spawning naturally. The effects of these fisheries can vary from positive to negative.

Hatchery programs can produce more fish than are used for the conservation and recovery of an ESU. They can play an important role in fulfilling tribal trust and treaty harvest obligations, and non-treaty sustainable fisheries objectives. In accordance with the approved harvest plan for ESUs listed as threatened, NMFS will, where appropriate, exercise its authority under Section 4(d) of the ESA to allow the harvest of ESA-listed hatchery fish that are surplus to the conservation and recovery needs of an ESU (NMFS 2005b). In any event, fisheries are strictly regulated based on ESA-authorized management, including catch and release take allowance.

For a detailed description of enumerated encounters during and the effects of fisheries that exist because of hatchery programs, refer to Section 2.4.6 and see Table 34 below. Based on these detailed descriptions, the effects of fisheries on ESA-listed natural-origin fall-run Chinook salmon, spring/summer-run Chinook salmon, sockeye, and steelhead, are negative.

Table 34. Expected incidental take (as a proportion of total run-size) of listed anadromous salmonids for non-tribal and treaty tribal fisheries under the *U.S. v. Oregon* Management Agreement (NMFS 2018d)

ESU		Take Limits (%)	Treaty Indian (%)	Non-Indian (%)
Snake River fall-run Chinook Salmon		31.29	11.6 – 23.04	5.9 – 8.25
Snake River spring/summer-run Chinook Salmon		5.5 – 17.07	5.0 – 15.0	0.5 – 2.0
Snake River Basin Steelhead	**A-Run Component**	4.03	3.5 – 8.2	1.0 – 1.8
	B-Run Component	17.04	3.4 – 15.04	1.5 – 2.0
Snake River Sockeye Salmon		6.0 – 8.08	2.8 – 7.0	0.0 – 1.0

2.5.2.7. Effects of the Action on Critical Habitat

This consultation analyzed the Proposed Action for its effects on designated critical habitat and has determined that the operation of the hatchery programs will have a negligible effect on PCEs in the Action Area and may have an overall beneficial effect in the Action Area. 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 the 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.

Other PCEs likely affected in the Action Area would be water quantity and water quality associated with water withdrawals and effluent return. Proposed surface water diversions for rearing juvenile fish include strict criteria for diverting water from the river and will not have any discernible effect or result in any adverse modification to critical habitat concerning freshwater spawning, rearing, and migration conditions. This is because the facilities typically divert a small proportion of the water source, water use is non-consumptive, and the distance over which water is diverted is relatively small (Table 7, Table 33, and Section 2.5.2.5). In addition, all hatchery facilities have current NPDES permits, and effluent would be monitored to ensure compliance with permit requirements. All chemicals used for sanitation and for treatment of diseases would be diluted to manufacturer's instructions prior to release into the main water body.

Operation and maintenance activities would include pump maintenance, debris removal from intake and outfall structures, building maintenance, and ground maintenance. 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. This opinion does not consider semi-routine maintenance (e.g., construction of facilities or reconstruction of in-river hatchery structures) and would require separate consultation.

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 to distinguish between the action area's future environmental conditions caused by changes in environmental conditions that are properly part of the environmental baseline vs. cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described earlier in the discussion of environmental baseline (Section 2.4).

For the purpose of this analysis, the Action Area is that part of the Snake River Basin described in the Section 2.3. To the extent ongoing activities have occurred in the past and are currently occurring, their effects are included in the Environmental Baseline (whether they are federal, state, tribal, or private). To the extent those same activities are reasonably certain to occur in the future (and are tribal, state, or private), their future effects are included in the cumulative effect's analysis. This is the case even if the ongoing Tribal, state, or private activities may become the subject of section 10(a)(1)(B) incidental take permits in the future. The effects of such activities are treated as cumulative effects unless and until an opinion has been issued.

State, Tribal, and local governments have developed plans and initiatives to benefit listed species and these plans must be implemented and sustained in a comprehensive manner for NMFS to consider them "reasonably foreseeable" in its analysis of cumulative effects. The Recovery Plan for Snake River Sockeye Salmon (NMFS 2015) is such a plan, and it describes, in detail, the ongoing and proposed Federal, state, Tribal, and local government actions that are targeted to reduce known threats to ESA-listed salmon and steelhead in the Snake River Basin. Such future state, tribal, and local government actions will likely be in the form of legislation, administrative rules, or policy initiatives, land use, and other types of permits, and that government actions are subject to political, legislative, and fiscal uncertainties. A full discussion of cumulative effects can also be found in the 2008 and 2020 FCRPS Biological Opinion (NMFS 2008c; 2020b), the Mitchell Act Biological Opinion (NMFS 2017a, (NMFS 2024b)), and the *U.S. v. Oregon* Biological Opinion (NMFS et al. 2018). The effects of these opinions are relevant to this Action Area.

Further discussion of cumulative effects for the Columbia River Basin can be found in our Biological Opinion on the funding of Mitchell Act hatchery programs. These actions include activities to help restore and protect habitat, restore access and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites. In summary, likely, the type and extent of salmon and steelhead hatchery programs and the numbers of fish released in the analysis area and throughout the Columbia River Basin generally will change over time. Although adverse effects will continue, these changes are likely to reduce effects such as competition and predation on natural-origin salmon and steelhead compared to current levels, especially for those species that are listed under the ESA. This is because all salmon and steelhead hatchery and harvest programs funded and operated by non-Federal agencies and Tribes in the Columbia River Basin have to undergo review under the ESA to ensure that listed species are not jeopardized and that "take" under the ESA from salmon and steelhead hatchery programs is minimized or avoided. Where needed, reductions in effects on listed salmon and steelhead are likely to occur through:

- Hatchery monitoring information
- 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
- Decreased use of isolated hatchery programs
- Increased use of integrated hatchery programs for conservation purposes
- Incorporation of new research results and improved best management practices for hatchery operations
- Creation of wild fish-only areas
- Changes in hatchery production levels
- Increased use of marking of hatchery-origin fish
- Improved estimates of natural-origin salmon and steelhead abundance for abundance-based fishery management.

Overall, we anticipate that these cumulative actions will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area; however, we anticipate these activities will be mindful of ESA-listed species and will perhaps be less harmful than would have otherwise occurred in the absence of the current body of scientific work that has been established for anadromous fish. In general, we think the level of adverse effects will be lower than in the recent past and much lower than in the more distant past. NMFS anticipates that available scientific information will continue to grow and Tribal, public, and private support for salmon recovery will remain high. This will continue to fuel state and local habitat restoration and protection actions as well as hatchery, harvest, and other reforms likely to improve fish survival.

2.7. INTEGRATION AND SYNTHESIS

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

NMFS considered the baseline effects and species status, where we determined that abundance, productivity, and diversity were the critical parameters concerning the Snake River fall-run Chinook salmon population, consistent with the recovery plan's identification of limiting factors. The cumulative effects consist primarily of ongoing hatchery programs, harvest, hydropower, habitat, and other forms of development that have reduced habitat and productivity (Section 2.6). Over time, NMFS expects the Proposed Action to provide a net benefit to the Snake River Fall-run Chinook Salmon ESU by reducing the hatchery-selective influences the population has endured in the past.

2.7.1. Listed Species

2.7.1.1. Snake River Fall-run Chinook Salmon ESU

The best available information indicates that the risk rating for the lower-mainstem Snake River fall-run Chinook salmon population within the Snake River Fall-run Chinook Salmon ESU is "viable"; however, it remains designated as threatened (Ford 2022). Based on the VSP parameters (section 6), the overall risk rating is low for abundance and productivity and moderate for spatial structure and diversity. The most significant limiting factor to this population is low diversity from the relatively high proportion of hatchery-origin adult recruits to the spawning population (i.e., pHOS levels) in all major natural spawning areas (Ford 2022). Moreover, the Snake River Fall-run Chinook Salmon Recovery Plan (NMFS 2017f) requires the population to meet or exceed the minimum requirements for a "highly viable" population. Given the current Proposed Action, which continues to move releases from the Snake River to the Salmon River, the Proposed Action makes testing the preliminary feasibility of the NPEA, Scenario C of the Snake River Fall-run Chinook Recovery Plan (NMFS 2017f), possible.

Our Environmental Baseline analysis considers the effects of the four H's (i.e., hydropower, changes in habitat (both beneficial and adverse), harvest, and hatcheries) on this ESU. Although all four factors have been attributed to declining ESA-listed populations within the Columbia River basin, their adaptive management has continued to reduce their adverse effects. All factors have also seen improvements in the how they are managed/operated. As we continue to deal with a changing environmental condition, management of these factors may also alleviate some of the potential adverse effects on VSP parameters (abundance, productivity, diversity, and spatial structure) covered in Section 6 (e.g., through hatcheries serving as a genetic reserve for natural populations).

The Proposed Action may impose continued genetic and ecological effects on the Snake River Fall-run Chinook Salmon ESU, influencing the population's abundance, productivity, and diversity parameters. The comanagers can effectively limit genetic effects compared to past years of hatchery operations by controlling the Proportion of Natural Influence in the natural spawning population (PNI) by minimizing the proportion of hatchery-origin adults spawning naturally (pHOS) and by integrating natural-origin adults (incorporated proportionately) into the program broodstock (pNOB). In addition, ecological effects can be minimized through mainstem Columbia and Snake River basin Tribal and non-tribal harvest fisheries that target Snake River fall-run Chinook salmon hatchery-origin adults, thereby reducing the number of hatchery adults recruited to the naturally spawning populations. Adult management operations also trap hatchery (HOR) and natural-origin returning (NOR) adults at adult collection facilities located within the Snake River basin (LGR, NPTH, and LFH). Moreover, these hatchery releases are subject to very high direct harvest rates from tribal and non-tribal fisheries throughout the Columbia River mainstem below the confluence of the Snake River.

With the relocation of the IPC subyearling release group to the Salmon River, starting in 2018 NMFS (2018c), the estimated pHOS in the Hells Canyon reach of the Snake River has dropped below the basin-wide pHOS estimate. This is based on PBT data analysis on adult returns in Hells Canyon and returns to Lower Granite Dam located on the Snake River (USGS & IPC unpublished data) (NPT 2024a). Accordingly, genetic effects in the Hells Canyon reach are likely less than previously described (NMFS 2012d) and may partially explain the broad patterns of increasing natural production (Hance et al. 2024). The proportion of NOR adults incorporated into hatchery broodstocks (pNOB) has also increased since previously described by NMFS (2012d); (2018e), regularly exceeding the 15% goal established by NMFS (2017f) and exceeding the hatchery operators' 30% goal in 2018, 2019, and 2020 (Fortier and Herr 2024). These results further indicate a noteworthy reduction of genetic (domestication) effects and may improve the mean fitness and productivity of naturally spawning Snake River fall-run Chinook salmon. The Proposed Action completely replaces the yearling release of hatchery fall-run Chinook salmon with subyearling releases and introduces a broodstock size selection technique for larger, older broodstock. These management approaches will help mitigate the negative effects typically associated with hatchery programs. Overall, the combined genetic effects from the proposed hatchery programs will not have a substantial negative effect on the diversity of the Snake River Fall-run Chinook Salmon ESU. These reductions in genetic effects indicate significant enhancements to the hatchery operations relative to past practices. While genetic effects will continue, they can be expected to better protect diversity and foster productivity of the Snake River fall-run Chinook salmon population.

Ecological effects on natural-origin juvenile Chinook salmon associated with releases from the hatchery programs equates to a loss of up to one percent of the adult natural-origin Chinook salmon in the Snake River basin passing through LGR (Section 2.5.2.3) as a result of predation and competition. This includes the effects on both the Snake River spring/summer-run and Fall-run Chinook Salmon ESUs because the analyses combined all Chinook salmon effects in the model. This percentage is likely even smaller because the analysis did not account for potential predation on hatchery program fish by other hatchery program fish in the Snake River Basin (Section 2.5.2.3). Overall, this relatively small loss is unlikely to affect the abundance or productivity of either the spring/summer-run or fall-run Chinook Salmon ESUs in the Snake River.

Added to the Species' Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or Tribal activities not involving Federal activities within the Action Area. The recovery plan for this ESU (NMFS 2017f) describes the ongoing and proposed Federal, state, Tribal, and local government actions that are targeted to reduce known threats to the ESA-listed Snake River fall-run Chinook salmon. Such actions are improving habitat conditions and hatchery and harvest practices to protect ESA-listed sockeye salmon, and NMFS expects this trend to continue, ultimately improving the abundance, diversity, and productivity of natural populations. Spatial structure is not likely to be affected by the proposed hatchery programs.

The effects of facilities operations and broodstock collection are small and localized. While RM&E requires handling a substantial portion of the juvenile and adult population, the broodstock collection is an essential component of the action, and information gained from conducting the work is essential for understanding the effects of the hatchery program on natural-origin fall-run Chinook salmon populations. The comanagers will monitor effects, and NMFS will determine whether decreased productivity, diversity, or abundance of natural-origin fish may necessitate more aggressive adult management and/or reconsideration of hatchery program size in the future to limit impacts on these VSP parameters in these ESUs (Section 6).

The effects of the fishery on Snake River fall-run Chinook salmon is low due to the allowable mortality rate schedule. The fishery is not directed at any particular age or size of the run and thus poses low to very low risk to selective change in natural process or selective impacts to biological characteristics of the Snake River Fall-run Chinook Salmon ESU (IDFG 2019). The harvest rate schedule developed by the States in this document for Snake River fall-run Chinook salmon follows an abundance-based framework, similar to the approach taken in the *U.S v. Oregon* Management Agreement (U.S. v. Oregon 2018). The harvest rate schedule is set in a way to provide higher harvest rates when abundance is high enough to accommodate the increased harvest and to provide reduced harvest rates, when numbers are lower.

In summary, NMFS considered the baseline effects and the status of the species, where we found that abundance, productivity, and diversity were the critical problems, consistent with the Snake River recovery plan's identification of limiting factors. The effects of the action are limited to a small impact on abundance, productivity, and diversity as a result of the hatchery releases, but over time, the Proposed Action will provide benefits to the ESU. The cumulative effects consist primarily of ongoing hatchery programs, harvest, hydropower, agriculture, and other forms of development that have reduced habitat and productivity (Section 2.4). Taken together, these activities are not likely to appreciably reduce the survival and recovery of ESA-listed Snake River Fall-run Chinook Salmon ESU.

2.7.1.2. Snake River Spring/Summer-run Chinook Salmon ESU, Steelhead DPS, and Sockeye Salmon ESU

The proposed action's effects on these ESUs and DPS are confined to ecological impacts, RM&E, and broodstock collection. The abundance and productivity of the ESA-listed natural-origin populations within the action area are particularly noteworthy concerns. Adverse ecological effects on natural-origin adults are minor because of the differences in the spatial and temporal overlap of these three species with the hatchery-origin Snake River fall-run Chinook salmon. Natural-origin juveniles may experience more significant effects due to the overlap in outmigration timing; however, we expect less than 1% of juveniles to be affected.

Added to the Species' Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or Tribal activities not involving Federal activities within the Action Area. The recovery plans for each ESU describes the ongoing and proposed state, Tribal, and local government actions targeted to reduce known threats to ESA-listed salmon and steelhead. Such actions are improving habitat conditions, and hatchery and harvest practices to protect listed salmon ESUs, and DPSs with NMFS expecting this trend to continue.

Our Environmental Baseline analysis considers the effects of hydropower, changes in habitat (both beneficial and adverse), harvest, and hatcheries on these ESUs and DPS. Although all have contributed to these populations' listings, all three factors have also seen improvements in how they are actively managed and operated. As we continue to deal with the changing environmental conditions, adaptive management strategies will alleviate some potential adverse effects on VSP parameters covered in Section 6.

NMFS considered the baseline effects and the status of the species, determining that abundance, productivity, and diversity were the critical parameters impacted. This aligns with the Snake River recovery plan's identification of limiting factors. Although the Proposed Action has a limited effect on abundance, productivity, and diversity, the increase in hatchery production over time will yield positive benefits.

The cumulative effects consist primarily of ongoing hatchery programs, harvest, hydropower, agriculture, and other forms of development that have reduced habitat and productivity. The effects of the Proposed Action, when added to activities described above, are not likely to appreciably reduce the survival and recovery of ESA-listed, Spring/Summer-run Chinook Salmon ESU, Sockeye Salmon ESU, or Snake River Steelhead DPS.

The best available information indicates that the Spring/Summer-run Chinook Salmon ESU and the Snake River Steelhead DPS are at high risk and remain threatened (Ford 2022). The Snake River Sockeye Salmon ESU is at high risk and remains endangered (Ford 2022).

2.7.1.2.1. Snake River Spring/Summer-run Chinook Salmon

The effects of our Proposed Action on Snake River spring/summer-run Chinook salmon will occur incidental to the collection of adult Snake River fall-run Chinook salmon for broodstock and during RM&E activities. In addition, ecological effects may occur because of the overlap in outmigration timing. These effects can result in changes to the abundance and productivity of the natural-origin Snake River spring/summer-run Chinook salmon population within the South Fork, Middle Fork, and Upper Salmon River MPGs (Table 12). NMFS has determined these effects are low to negligible to the MPGs and the ESU as a whole.

Incidental effects of broodstock collection activities targeting Snake River fall-run Chinook salmon on natural-origin adult spring/summer-run Chinook salmon are minimal since the temporal overlap between the two populations occurs only in the latter portion of the Snake River spring/summer-run Chinook salmon run (March to early August) (Table 24). During the Snake River fall-run Chinook salmon broodstock collection season (late August through November), the mortality rate for fish handling is low (NMFS 2019a). Given this and the low incidence of spring/summer individuals being handled, it is expected to have a minimal effect on the population's demographic abundance. Monitoring will occur as part of the Snake River spring/summer-run Chinook salmon Hatchery Program (NMFS 2019a).

However, Snake River spring/summer-run Chinook salmon natural-origin juveniles may experience a more considerable effect because of the overlap in outmigration timing coinciding with the Snake River fall-run Chinook salmon scheduled program releases. NMFS has determined that the potential demographic loss to the ESUs is not expected to noticeably reduce the productivity of these natural-origin populations in the Snake River basin. This effect would equate to a potential loss of one percent of the natural-origin adult return from competition and predation during the juvenile life stage (section 2.5.2.3.1). The co-managers will monitor these effects, and NMFS will determine whether decreased productivity or abundance of natural-origin fish may necessitate reconsideration of hatchery program size in the future to limit the effects of the Proposed Action on these VSP parameters for this ESU (Section 6). Thus, there is very little incidental effect on Snake River Spring/Summer-run Chinook Salmon ESU, and it is unlikely that these activities would lead to a decrease in the abundance, productivity, spatial structure, or diversity of the ESU.

After considering the status of each population, the species' current viability status, the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, Tribal, or private projects, NMFS concludes that the effects of the Proposed Action will not appreciably reduce the likelihood of survival and recovery of this ESA-listed ESU.

2.7.1.2.2. Snake River Basin Steelhead

The effects of the Proposed Action on the Snake River steelhead DPS are limited to the incidental collection of natural-origin Snake River steelhead DPS adults during the Snake River fall-run Chinook salmon program's broodstock collection activities, during RM&E activities, and in addition, ecological effects associated with the Snake River fall-run Chinook salmon program's juvenile releases overlapping with natural-origin Snake River steelhead DPS juvenile's outmigration timing. These effects may result in changes to the abundance and productivity of the various natural-origin Snake River steelhead populations within the Salmon

River DPS (Table 14); however, NMFS has determined the effects are low to negligible to the DPS.

Incidental effects to Snake River steelhead of broodstock collection activities targeting fall-run Chinook salmon are negligible. Steelhead are incidentally captured throughout the majority of the run during fall-run broodstock collection, with the occasional capture of juveniles during monitoring operations, and from competition among juveniles during outmigration. Trapping and handling at the Lower Granite trap is may handle up to 30% of the entire run annually; however, the mortality rate is very low, because nearly all fish that are captured and released for monitoring activities are known to recover shortly after handling with no long-term ill effects (NMFS 2012d). Because steelhead are not a target species, they are released unharmed. Direct monitoring and collection would only occur as part of other programs authorized separately (NMFS 2017c; 2019b; 2020a).

Due to the overlap of the Snake River fall-run Chinook salmon and Snake River Steelhead runs, the impact will occur through the majority of the run, but will not disproportionally impact any specific segment of the ESU and will have a limited impact on spatial structure or diversity. The low mortality rate is likely to equate to a very low impact on abundance, and likely no measurable impact on productivity. Thus, there is low to negligible incidental effect on Snake River Basin Steelhead, and it is unlikely that these activities would lead to a decrease in the abundance, productivity, spatial structure, or diversity of the DPS.

After considering the status of each population, the current viability status of the species, the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the effects of the Proposed Action will not appreciably reduce the likelihood of survival and recovery of this ESA-listed DPS in the wild.

2.7.1.2.3. Snake River Sockeye Salmon

The effects of the Proposed Action on the Snake River Sockeye Salmon ESU will occur incidental to the collection of Snake River fall-run Chinook salmon for broodstock and during RM&E activities. In addition, ecological effects can occur because of the potential overlap in outmigration timing. These effects may result in changes to the abundance and productivity of the various natural-origin fish populations within the Salmon River MPG (Table 13); however, NMFS believes the impacts are negligible to the MPG as a whole.

Effects on Snake River sockeye salmon due to broodstock collection activities targeting Snake River fall-run Chinook salmon are low to negligible because of the differences in spatial and temporal overlap between the two returning adult populations. Snake River fall-run Chinook salmon enter the lower Snake River basin at the end of August, and adults are no longer observed at the LGR adult ladder by the end of October/beginning of November. Snake River sockeye salmon enter the lower Snake River starting in mid-summer and are no longer observed at the LGR trap in late summer (Table 24) at the beginning of the fall-run Chinook salmon observance at LGR. Because sockeye are a Non-Target Taxa (NTT), they are released unharmed if any are encountered during broodstock collection operations. In addition, trap operators would ensure all weirs/traps associated with the hatchery program minimize or eliminate stress, injury, or mortality to ESU-listed salmon and steelhead.

The Proposed Action may also affect the Snake River sockeye salmon natural-origin juveniles during their seasonal outmigration coinciding with the Snake River fall-run Chinook salmon program releases. Juvenile releases are expected to account for less than a 1% loss of sockeye adult return equivalents (Section 2.5.2.3). Sockeye salmon also utilize different habitat from Chinook salmon and spend very little time rearing in the migration corridor (NMFS 2015b). In addition, sockeye are known to be exclusively planktivorous, mostly eating zooplankton minimizing competition and predation effects on natural-origin salmonids and steelhead (Burgner 1987; NMFS 2015b; 2017b). NMFS has determined the effects to be negligible on Snake River sockeye salmon abundance.

Effects related to direct monitoring and collection (RM&E) would only occur as part of the Snake River sockeye salmon section 10(a)(1)(A) permits 1454-2R and 1455-2Rauthorized separately (NMFS 2023). The continued operation of previously authorized RM&E activities has a negligible incidental effect on the Snake River Sockeye Salmon ESU (in addition to the effects identified in NMFS 2023 and considered here as part of the environmental baseline), and it is unlikely that these activities would lead to a decrease in the abundance, productivity, spatial structure, or diversity of the ESU.

After considering the status of each population, the species' current viability status, the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, Tribal, or private actions, NMFS concludes that the effects of the Proposed Action will not appreciably reduce the likelihood of survival and recovery of this ESA-listed ESU in the wild.

2.7.2. Critical Habitat

The hatchery water diversion and the discharge pose a negligible effect on designated critical habitat in the Action Area (Section 2.5.2.7). Existing hatchery facilities have not contributed to altered channel morphology and stability, reduced and degraded floodplain connectivity, excessive sediment input, or the loss of habitat diversity. The operation of the weirs and other hatchery facilities may impact migration PBFs due to delay at these structures and possible rejection. However, the number of natural-origin adults delayed is expected to be low and the delay would be for only a short period. Rejection of weirs and other facilities is also expected to be low, since the weir is operated to reduce harmful effects during handling and to minimize passage delay. Thus, the impact on the spawning, rearing, and migration PBFs will be negligible in scale, and will not appreciably diminish the capability of the critical habitat to satisfy the essential requirements of the species.

Changes in environmental conditions may have some effects on critical habitat as discussed in Section 2.4.4. With continued losses in snowpack and increasing water temperatures, it is possible that increases in the density and residence time of fish using cold-water refugia could result in increases in ecological interactions between hatchery and natural-origin fish of all life stages, with unknown but likely small effects. Within the Action Area, the rising air and water temperatures poses a concern to returning hatchery-origin and natural-origin salmonids.

2.8. CONCLUSION

After reviewing and analyzing the current status of each ESA-listed species, the designated critical habitat, the Environmental Baseline within the Action Area, the effects of the Proposed Action, the effects of other activities caused by the Proposed Action, and the cumulative effects, it is NMFS' biological opinion that the Proposed Action is not likely to jeopardize the continued existence of the Snake River Fall-run Chinook Salmon ESU, the Snake River Spring/Summer-run Chinook Salmon ESU, the Snake River Sockeye Salmon ESU and the Snake River Steelhead DPS or destroy or adversely modify their designated critical habitat.

2.9. INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulation 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 results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering (50 CFR 17.3). Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. "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[6]

However, NMFS also expects that incidental take of ESA-listed salmonids is reasonably certain to occur as a result of the Proposed Action for the following factors.

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

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

Effects of hatchery-origin fish on the genetics of natural-origin fish can occur through a reduction in genetic diversity, outbreeding depression, and hatchery-influenced selection (i.e. domestication). Take can also occur through ecological interactions between hatchery and

[6] The primary form of take on ESA-listed fall-run Chinook salmon is direct take under the Proposed Action and the issuance of the (two) Section 10 Authorizations for the hatchery programs. That take is therefore not incidental to the Proposed Action and not covered here.

natural-origin adults; specifically, spawning site competition and redd superimposition. These genetic and ecological effects cannot be directly measured because it is not possible to observe gene flow between hatchery and natural-origin adults in a reliable way.

To monitor and manage genetic effects from the Snake River Fall-run Chinook salmon hatchery programs, NMFS will rely on a single surrogate take indicator: the proportion of natural-origin spawners used in hatchery broodstock (pNOB). This metric is rationally connected to incidental take in the form of genetic effects because pNOB most effectively describes the level of natural influence experienced by the composite (hatchery- and natural-origin) population. In other words, higher pNOB reduces take by limiting the influence of hatchery selection (i.e. domestication) imposed on the natural spawning population when hatchery-origin fish, or their offspring, spawn in the wild. The surrogate take indicator, pNOB, has been and can be reliably measured and monitored through analysis of PBT samples, as described in the Proposed Action (Section 1.3). Take associated with adult genetic and ecological effects will be considered to have been exceeded if a consecutive running five-year mean of pNOB is less than 0.15 or 15% (Section 2.5.2.2).

ESA-listed salmon and steelhead, including Snake River spring/summer-run Chinook salmon, fall-run Chinook salmon, and sockeye salmon and steelhead, will also be taken as a result of the capture and handling associated with operation of the adult trap. Please see Table 35 below for NMFS' limits on the extent of incidental take from broodstock collection activities.

Table 35. Incidental take of Snake River spring/summer-run Chinook salmon, Snake River sockeye salmon, and Snake River steelhead during Snake River fall-run Chinook salmon broodstock collection

Species	Take Activity	Location[2]	Number handled annually	Number killed annually
Spring/summer-run Chinook salmon - adipose fin intact	Capture, handle, release	LGR	300 adults	2% of number handled, up to 6 Adults
Spring/summer-run Chinook salmon – adipose fin clipped[1]	Capture, handle, transport, kill	From LGR	Up to 10 Adults	Up to 10 Adults[3]
Steelhead – adipose fin intact [1]	Capture, handle, release	LGR	Up to 30 % of the entire annual adult return, based on post-season estimates, up to 15,000[4]	Up to 0.5 % of those captured and handled. Maximum of 75 Adults[4]
Steelhead – adipose fin clipped	Capture, handle, release	LGR	Up to 30 % of the entire annual adult return, based on post-season estimates, up to 36,000[5]	Up to 0.5 % of those captured and handled. Maximum of 180 Adults[5]
Steelhead – adipose fin clipped	Capture, handle, release	SF Clearwater weir	2 % of the SF Clearwater River adult return, based on post-season estimates, up to 400 adults	Up to 0.5% of those captured and handled. Maximum of 2 Adults
Steelhead – adipose fin intact [1]	Capture, handle, 21-day hold, and release	LFH	Up to 10 Adults	20% of those held, up to 2 Adults
Steelhead – adipose fin in- tact and adipose fin clipped[1]	Capture, handle, release	NPTH	Up to 10 Adults	2 Adults[3]
Sockeye	Capture, handle, release	LGR	2% of the entire annual adult return, based on post-season estimates up to 60	0.5 % of those captured, up to 2 mortalities

[1]While still ESA-listed, adipose fin-clipped hatchery fish may be exempted from ESA section 9 take prohibitions using an approved ESA authorization; in this case, the final approval of the HGMP(s) submitted by the comanagers that are the subject of this consultation.
[2]Lower Granite Trap operates between August 18 and November 21 annually, the LFH trap operates between September 17 and December 1 annually, and both the Nez Perce Tribal Hatchery and the South Fork Clearwater weir operates between October 1 and December 1 annually.
[3]Numbers are provided here for reference, though under NMFS Hatchery Listing Policy (70 FR 37194) adipose fin-clipped salmon and steelhead are either unlisted or already determined to be in excess of recovery needs through the final approval of the HGMP(s) submitted by the comanagers that are the subject of this consultation.
[4] Based on a return of 50,000 adults, which is close to the highest abundance since 2015 (45,789)
[5] Based on a return of 120,000 adults, which is close to the highest abundance since 2015 (114,848)

Factor 3: Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas

Incidental take of ESA-listed salmon and steelhead are expected to occur in the form of interactions between juvenile hatchery and natural-origin fish in juvenile rearing and migratory areas. This form of take concerns interactions (predation, competition, or pathogen transmission, collectively referred to as ecological interactions) between juvenile salmon and steelhead and juvenile hatchery fish. This occurs as smolts emigrate from hatcheries and acclimation ponds and likely transit through the migratory fresh, brackish, and marine waters of the Action Area or as hatchery fish residualize and remain behind. However, it is difficult to quantify this take because ecological interactions cannot be observed directly. NMFS will, therefore, rely on a series of surrogate take indicators, each which will apply as described below. These surrogates all work in conjunction with each other.

Timing Surrogate: The first take surrogate is the date of release. This standard has a rational connection to the amount of take expected from ecological interactions, because the potential for adverse ecological interactions increases as more overlap occurs between hatchery and natural-origin fish, specifically hatchery-origin subyearling fish, for the reasons discussed in Section 2.5.2.3. For this take surrogate, NMFS considers that the incidental take associated with the release date will have been exceeded if hatchery subyearling smolts are released before May 1st. For releases that may occur prior to May 1st, the operator must first seek and obtain NMFS concurrence that the early release will not increase the temporal overlap with natural-origin fish. The location of a release is associated with the travel time expected to reach LGD for releases upstream of LGD and Ice Harbor Dam for releases from Lyons Ferry Hatchery. If NMFS receives information that the emigration of most natural-origin juveniles has shifted to a later time, NMFS will revisit this take surrogate or its associated timing to determine whether the take levels analyzed in this Opinion have been exceeded.

Production Levels: The second take surrogate is compliance with the production levels. As the number of smolts released increases, so does the extent of potential interaction, so exceeding the expected production levels would increase the incidental take beyond the levels analyzed in this Opinion. NMFS recognizes that production targets are often not met, and occasionally exceeded, and thus the take limits described below give some flexibility to program managers, though in general we expect the managers to manage to the target and only use the buffers when necessary.

The choice of location for the release also determines the extent of potential interaction, and the Opinion's assessment of take is based on the release locations below. Any change to the release location could exacerbate incidental take, unless NMFS gives prior authorization to a change based on an expectation of improved performance.

The limits imposed through these surrogates are as follows:

- Any release of smolts in numbers that exceed the annual maximum program release number (110% of the proposed release numbers) identified below in Table 36 will be considered to have exceeded the expected incidental take through ecological interactions, unless NMFS has determined otherwise.

Table 36. Proposed production target and maximum annual production levels for each release site the Snake River Fall-run Chinook Salmon Hatchery Program.

Hatchery Program	Hatchery Program Operator(s)	Proposed Production Target Limit	Annual Maximum Production Level
Snake River Fall-run Chinook salmon	WDFW, NPT, ODFW, IPC	6,800,000	7,480,000

Residualism: Finally, take may occur through ecological interactions where hatchery fish residualize and remain in freshwater. This, too, cannot be reliably observed and quantified; therefore, NMFS will rely on a take surrogate consisting of the proportion of hatchery-origin fish that are visually identified as precocially mature prior to release by sampling a subset of the release. This standard has a rational connection to the amount of take expected from ecological interactions because precocious fish are more likely to residualize after release from the hatchery, which would place them in contact with natural-origin fish of a size that makes them vulnerable to predation. This take surrogate can be reliably measured and monitored by assessing precocious maturation rates before each proposed releases.

The incidental take through residualization will be exceeded if the percent of releases that are determined to be precocially mature exceeds 5% in any one year or if the 5-year average exceeds 3% at any time.

These surrogates can be reliably measured and monitored through the enumeration and tracking of release dates and numbers for hatchery salmon and steelhead. Each of these surrogates represents an independent threshold, meaning that exceedance of any one of these surrogates would result in the applicable program having exceeded the incidental take limits included in this statement, potentially necessitating the reinitiation of consultation.

Factor 4: Research, Monitoring, and Evaluation that exists because of the hatchery program

Listed salmonids will also be taken as a result of RM&E activities, specifically through capturing, handling, marking, and tagging. Mortality rate is expected to be no more than 3% of total percent of fish handled. Please see Table 37 below for incidental take information from Factor 4.

Table 37. Take of Snake River spring/summer-run Chinook salmon, steelhead, and sockeye salmon for monitoring activities not directly related to fish culture.

Species and Life stage	Take Activity	Capture Method and Location	Total Number Handled annually	Number marked/tagged annually	Total Number Killed annually
Juvenile SR spring/summer-run	Capture/Mark, Tag, Sample,	Seines, fyke nets, trawls, and purse seines in Lower Snake,	1,500 (6 mortalities)	100 (misidentified) (1 mortality)	7

Chinook salmon - adipose fin in-tact	Tissue/Release Live Animal	Lower Salmon, Grande Ronde, and Imnaha			
Juvenile SR steelhead – adipose fin in-tact	Capture/Mark, Tag, Sample, Tissue/Release Live Animal	Seines, fyke nets, trawls, and purse seines Lower Snake, Lower Snake, Clearwater, Grande Ronde, and Imnaha	500 (2 mortalities)	0 (0 mortalities)	2
Juvenile SR steelhead – adipose fin in-tact	Capture/Mark, Tag, Sample, Tissue/Release Live Animal	Screw Traps Clearwater River	300 (2 mortalities)	0 (0 mortalities)	2
Adult SR steelhead – adipose fin in-tact	Adult fall-back	Screw Trap Clearwater River	70 (10 mortalities)	0	10

2.9.2 Effect of the Take

NMFS determined in the effects analysis for this Biological Opinion, that the amount or extent of anticipated take, coupled with other effects of the Proposed Action, is not likely to result in jeopardy to the Snake River Sockeye Salmon ESU, Snake River Spring/Summer-run Chinook Salmon ESU, and Snake River Basin Steelhead DPS, or result in the destruction or adverse modification of their designated critical habitat.

2.9.2. Reasonable and Prudent Measures

"Reasonable and prudent measures" refer to those actions the Director considers necessary or appropriate to minimize the impact of the incidental take on the species (50 CFR 402.02).

NMFS concludes that the following reasonable and prudent measures are necessary and appropriate to minimize incidental take. NMFS, BPA, and the USFWS (i.e., LSRCP) must ensure that:

1. Each Action Agency shall ensure that operator activities are consistent with each agency's portion of the Proposed Action. BPA shall ensure that NPT's activities are consistent with the BPA-funded portion of the Proposed Action. USFWS shall ensure that WDFW and ODFW's activities are consistent with the LSRCP-funded portion of the Proposed Action. NMFS shall ensure that the section 10(a)(1)(A) permits for the Snake River Stock fall-run Chinook salmon Nez Perce Tribal Hatchery (permit #16615-2R) and the FCAP/WDFW Lyons Ferry/ODFW/Idaho Power Company Hatchery (permit #16607-2R) programs shall operate as described in the Proposed Action. The applicants shall implement the hatchery programs and operate the hatchery facilities, including monitoring, as described in the Proposed Action (Section 1.3) and in the submitted HGMPs.
2. NMFS shall ensure that the applicants provide reports to NMFS' Sustainable Fisheries Division (SFD) annually for all hatchery programs, and associated RM&E.

2.9.3. Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, the Federal Action Agency must comply (or must ensure that any applicant complies) with the following terms and conditions. NMFS has a continuing duty to monitor the impacts of incidental take and entities must report the progress of the Proposed Action and its impact on the species as specified in this incidental take statement (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse.

1. BPA, USFWS, and NMFS shall take the following measures to ensure that applicants adhere to the activities as described in the Proposed Action:

    a. Review and approve the NPT's, WDFW's, and ODFW's activities as described in the annual contracts to ensure they are consistent with the BPA, and LSRCP funded portions of the Proposed Action. NMFS will review annual reports and ensure that IPC activities are consistent with the IPC funded portions of the Proposed Action. These include Research, Monitoring and Evaluation activities as described in the Proposed Action.

2. The applicants shall provide reports to SFD annually for their respective programs, including associated RM&E. All reports and required notifications are to be submitted electronically to the NMFS, West Coast Region, Sustainable Fisheries Division, Anadromous Hatcheries South Branch. The current point of contact for document submission is Andreas Raisch (andreas.raisch@noaa.gov, 503-230-5405).

    a. An annual RM&E report(s) is submitted by applicants no later than May 15th, two years following the monitoring and evaluation activities (i.e., surveys conducted in 2025, report due in May 2027) to NMFS. However often, the majority of information will be reported earlier and in tandem with other monitoring reports (e.g. Run Reconstruction Annual report). These annual reports will include:

        i. A calculation of quantifiable encounter and mortality take for each species across all HGMP activities.
        ii. Hatchery Environmental Monitoring Reporting (for all programs and operations covered in this Biological Opinion unless specified)
            1. Number, hatchery/natural composition, age structure (total and saltwater), and dates of collection of broodstock.
            2. Numbers: fish per pound (fpp), dates, locations, and tag/mark information of released fish.
            3. Mean length and Coefficient of Variation immediately prior to release.
            4. Survival rates of hatchery-origin salmon life stages (green egg to smolt).
            5. Disease occurrence at facilities and the acclimation sites.
            6. Any problems that may have arisen during hatchery activities.

7. Any unforeseen effects on ESA-listed fish.
8. The number and species of listed fish encountered at each adult collection location, and the number that die.
9. Distribution of hatchery- and listed natural-origin spawners in several natural spawning areas (based on PBT sampling and carcass surveys if technically feasible).
10. pHOS, pNOB, (based on run reconstruction at LGR, PBT sampling, and carcass surveys) in the upper Snake River in the Hells Canyon reach.

iii. Natural Environmental Monitoring Reporting (for all programs unless specified)

1. The number of returning hatchery and natural-origin adults and age composition (total and saltwater).
2. Smolt-to-Adult survival rate.
3. The contribution of fish from these programs into other populations (including out-of-basin tributaries)
4. Post-release:
    i. Out-of-basin migration timing as the median travel time of juvenile hatchery-origin salmon from the release sites to Ice Harbor Dam (for releases from Lyons Ferry Hatchery) or LGD (for releases occurring upstream of LGD) in days.
    ii. Release timing for each release group.
    iii. Production levels for each release group
    iv. Residual rates for each release group.
5. Mean length, Coefficient of Variation, number, and age at outmigration of natural-origin juveniles during RM&E activities.

2.10. Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of 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 identified three conservation recommendation appropriate to the Proposed Action:

1. *Continue to prioritize Snake River fall-run Chinook salmon natural population monitoring.*

   This information is essential to understanding the status of the Snake River Fall-run Chinook Salmon ESU. The Recovery Plan (NMFS 2017f) outlines three potential recovery scenarios, each consistent with the basic set of viability objectives use by the ICTRT. Natural population monitoring information is necessary to evaluate each of the VSP parameters and test the viability of the three potential recovery scenarios.

2. *Investigate the level of subpopulation structure present in naturally-spawning aggregations of Snake River fall-run Chinook salmon.*

   Both the ongoing release of hatchery-origin Chinook salmon at acclimation sites, and the natural propensity of salmon to home to release sites or natal streams, should favor the development of genetic structure within Snake River fall-run Chinook salmon. This structure could factor significantly in the viability of the population (NMFS 2017a), and warrants investigation.

3. *Explore new methods to increase the proportion of natural-origin adults used in Snake River fall-run Chinook salmon hatchery broodstocks.*

   The level of genetic risk posed by hatchery operations to Snake River fall-run Chinook salmon can be measured through the proportionate natural influence (PNI) of the population. Data indicate that for this population, PNI varies primarily in function of the proportion of natural-origin fish used in the hatchery broodstock (pNOB), underscoring the value of identifying methods to increase pNOB and thereby alleviate genetic risk to the population.

2.11. RE-INITIATION OF CONSULTATION

This concludes formal consultation on the authorization, funding, and operation of the Snake River fall-run Chinook salmon Hatchery Programs in the Snake, Clearwater and Grande Ronde River basins.

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

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, including the operation of weirs and traps, and RM&E in support of the hatchery programs, are occurring from the operation of the proposed 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.

2.12. "Not Likely to Adversely Affect" Determinations

NMFS concludes that the Proposed Action is not likely to adversely affect the species or critical habitat of the species listed in Table 8. The applicable standard to find that a Proposed Action is "not likely to adversely affect" ESA listed species or critical habitat is that all of the effects of the action are expected to be discountable, insignificant, or completely beneficial. Beneficial effects are contemporaneous positive effects without any adverse effects on the species. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Discountable effects are extremely unlikely to occur. The information NMFS considered in making these determinations is summarized below.

2.12.1. Marine Mammals

We assessed potential effects to ESA-listed marine mammals from this action. In this assessment the following DPS was determined to incur beneficial effects as a result of the Proposed Action. The following DPS is affected by the Proposed Action in marine waters, as the species does not occur in freshwater areas.

2.12.1.1. Southern Resident Killer Whales

2.12.1.1.1. Status and Occurrence

The SRKW DPS was listed as endangered under the ESA in 2005 (70 FR 69903, November 18, 2005) and the final recovery plan was completed in 2008 (NMFS 2008d). Several factors identified in the recovery plan for SRKWs may be limiting their recovery. The primary threats include quantity and quality of prey, toxic chemicals that accumulate in top predators, and disturbance from sound and vessels. It is likely that multiple threats are acting together to impact the whales. Although it is not clear which threat or threats are most significant to the survival and recovery of SRKWs, all of the threats identified are potential limiting factors in their population dynamics (NMFS 2008d). A 5-year review under the ESA completed in 2021 concluded that SRKWs should remain listed as endangered and includes recent information on the population, threats, and new research results and publications (NMFS 2021b).

The SRKW DPS consists of three pods (J, K, and L) that inhabit coastal waters off Washington, Oregon, and Vancouver Island, Canada, and are known to travel as far south as central California and as far north as Southeast Alaska (NMFS 2008d; Hanson et al. 2013; Carretta et al. 2023). Seasonal movements are likely tied to migration of their primary prey, salmon. During the spring, summer, and fall months, SRKWs spend a substantial amount of time in the inland waterways of the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound (Bigg 1982; Ford et al. 2000; Krahn et al. 2002; Hauser et al. 2007; Olson et al. 2018; NMFS 2021b; Ettinger et al. 2022; Thornton et al. 2022). During fall and early winter, SRKWs, and J pod in particular, expand their routine movements into Puget Sound, likely to take advantage of chum, coho, and Chinook salmon runs (Osborne 1999; Hanson et al. 2010; Ford et al. 2016b; Olson et al. 2018). Although seasonal movements are somewhat predictable, there can be large inter-annual variability in arrival time and days present in inland waters from spring through fall, with late arrivals and fewer days present in recent years (NMFS 2021b; Ettinger et al. 2022).

Land- and vessel-based opportunistic and survey-based visual sightings, satellite tracking, and passive acoustic research have provided an updated estimate of the whales' coastal range. In recent years, several sightings and acoustic detections of SRKWs have been obtained off the Washington, Oregon, and California coasts in the winter and spring (Hanson et al. 2010; Hanson et al. 2013; Hanson et al. 2017; Emmons et al. 2021; NMFS 2021a). Satellite-linked tag deployments in the winter indicate that K and L pods use the coastal waters along Washington, Oregon, and California during non-summer months (Hanson et al. 2017; NMFS 2021a), while J pod occurred frequently near the western entrance of the Strait of Juan de Fuca but spent relatively little time in other outer coastal areas. A full description of the geographic area occupied by SRKW can be found in the biological report that accompanies the final critical habitat rule (NMFS 2021a).

SRKWs consume a variety of fish species (22 species) and one species of squid (Ford et al. 1998; Ford et al. 2000; Ford and Ellis 2006; Hanson et al. 2010; Ford et al. 2016b), but salmon are identified as their primary prey. The diet of SRKWs is the subject of ongoing research, including direct observation of feeding, scale and tissue sampling of prey remains, and fecal sampling. The diet data suggest that SRKWs are consuming mostly larger (i.e., generally age 3 and up) Chinook salmon (Ford and Ellis 2006). Chinook salmon is their primary prey despite the much lower abundance in comparison to other salmonids in some areas and during certain time periods. Scale and tissue sampling from May to September in inland waters of Washington and British Columbia, Canada, indicate that their diet consists of a high percentage of Chinook salmon (monthly proportions as high as >90%) (Hanson et al. 2010; Ford et al. 2016b). Ford et al. (2016b) confirmed the importance of Chinook salmon to SRKWs in the summer months using DNA sequencing from whale feces. Salmon and steelhead made up to 98% of the inferred diet, of which almost 80% were Chinook salmon. Coho salmon and steelhead are also found in the diet in inland waters in spring and fall months when Chinook salmon are less abundant (Ford et al. 1998; Ford and Ellis 2006; Hanson et al. 2010; Ford et al. 2016b).

Prey remains and fecal samples collected in inland and coastal waters during October through May indicate Chinook salmon and chum salmon are primary contributors of the whales' diet during the fall, winter, and spring months as well, including hatchery salmon (Hanson et al. 2021). Analysis of prey remains and fecal samples sampled during the winter and spring in coastal waters indicated the majority of prey samples were Chinook salmon (approximately 80% of prey remains and 67% of fecal samples were Chinook salmon), with a smaller number of steelhead, chum salmon, and halibut detected in prey remain samples and foraging on coho, chum, steelhead, big skate, and lingcod detected in fecal samples (Hanson et al. 2021). The occurrence of K and L pods off the Columbia River in March suggests the importance of Columbia River spring runs of Chinook salmon in their diet (Hanson et al. 2013). Chinook salmon genetic stock identification from samples collected in winter and spring in coastal waters included 12 U.S. west coast stocks, and over half the Chinook salmon consumed originated in the Columbia River (Hanson et al. 2021).

At the time of the 2024 population census, there were 73 SRKWs counted in the population. Since the census was completed, a new calf was born in L pod but did not survive, an adult male has died, and a J Pod calf was born keeping the population at 73. The abundance estimate for this stock of killer whales is a direct count of individually identifiable animals, and as such serves as both a best estimate of abundance and a minimum estimate of abundance. The NWFSC continues to evaluate changes in fecundity and mortality rates. Population projections using survival and fecundity rates from a recent five-year period (2017–2021) project a downward trend over the next 25 years (NMFS 2021b). Recent genomic analyses indicate that the SRKW population has greater inbreeding and carries a higher load of deleterious mutations than do Alaska resident or transient killer whales, and that inbreeding depression is likely impacting the survival and growth of the population (Kardos et al. 2023). These factors likely contribute to the SRKW population's poor status.

Critical Habitat

In November 2006, NMFS designated critical habitat for the SRKW DPS (71 FR 69054, November 29, 2006). This designation includes approximately 2,500 square miles of Puget Sound, including three specific areas: 1) the Summer Core Area in Haro Strait and waters around the San Juan Islands; 2) Puget Sound; and 3) the Strait of Juan de Fuca. Areas with water less than 20 feet deep are not included in the designation. Three physical or biological essential features were identified: (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality and availability to support individual growth, reproduction and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging.

In September 2021, NMFS revised the critical habitat designation for the SRKW DPS by designating six additional coastal critical habitat areas along the U.S. West Coast (86 FR 41668, August 2, 2021). The revision added to the existing critical habitat approximately 15,910 square miles of marine waters between the 6.1-meter and 200-meter depth contours from the U.S.-Canada border to Point Sur, California. The same physical or biological essential features were identified for coastal critical habitat (listed above), and each coastal area contains all three physical or biological essential features identified in the 2006 designation.

2.12.1.1.2. Potential for Proposed Action Effects

The Proposed Action is expected to make a small increase in the amount of Chinook salmon prey available to SRKWs in their critical habitat, which would positively affect the whales and their critical habitat. We do not expect any impacts to SRKWs via other effects pathways, such as vessel or noise disturbance, or water quality impacts.

As described previously in the Environmental Baseline for salmon and steelhead (NMFS 2024a), hatchery production of salmonids has occurred for over a hundred years. There are over 300 hatchery programs in Washington, Oregon, California, and Idaho that produce and release juvenile salmon that migrate through coastal and inland waters of the action area. Many of these fish contribute to both fisheries and the SRKW prey base in coastal waters of the action area.

NMFS has completed Section 7(a)(2) consultations on more than two hundred hatchery programs (Doremus and Friedman 2021). A detailed description of the effects of these hatchery programs can be found in the site-specific ESA and NEPA documents for programs referenced in Appendix B of the Prey Increase Program Biological Opinion (NMFS 2024a). These effects are further described in Appendix C of NMFS (2018d), which is incorporated here by reference. Additionally, a description of the effects of hatchery production implemented with federal funds to increase SRKW prey is described in Alternative 2 of the prey program FEIS (NMFS 2024d). Currently, hatchery production is a significant component of the salmon prey base within the range of SRKWs (Barnett-Johnson et al. 2007; NMFS 2008b). Prey availability has been identified as a threat to SRKW recovery, and we expect the existing hatchery programs to continue benefiting SRKWs by contributing to their prey base.

Chinook salmon aged 3+ are the preferred prey of SRKWs year-round (Ford et al. 1998; Ford and Ellis 2006; Hanson et al. 2010; Ford et al. 2016b; Hanson et al. 2021). Genetic studies from fecal and predation event remains have identified Chinook salmon stocks consumed by SRKWs during different seasons in inland and coastal portions of their range (Hanson et al. 2010; Ford et al. 2016b; Hanson et al. 2021). These studies have informed a list of priority prey stocks that are important to SRKWs (NOAA Fisheries and WDFW 2018). While these studies have not assessed whether the fish consumed come from wild or hatchery populations, all available evidence suggests that SRKWs consume both wild and hatchery Chinook salmon, given the high proportion of hatchery-origin fish in the priority stocks that were identified. The abundance of the Puget Sound Chinook salmon ESU, the top priority prey stocks for SRKW, comprises a minimum[7] of 77% hatchery produced fish, on average (NMFS 2024a). In the Columbia River, a minimum of 50% of the abundance is made up of hatchery fish (NMFS 2024a). Based on the contribution of hatchery fish to these preferred prey stock groups, it is extremely likely that hatchery fish are a main component of the SRKW diet.

Chinook salmon have the highest value of total energy content compared to other salmonids because of their larger body size and higher energy density (O'Neill et al. 2014), likely the reason for their preference in the SRKW diet. Studies have identified a trend in declining body size and age structure in Chinook salmon along the west coast (Ohlberger et al. 2018; Ohlberger et al. 2019). This trend is evident in both hatchery- and natural-origin fish, and is evident even in natural Chinook salmon populations that are not exposed to hatchery fish, such as in western Alaska (Ohlberger et al. 2018). Given that smaller fish have a lower total energy value than larger ones (O'Neill et al. 2014), this trend suggests that SRKWs may need to eat more Chinook salmon – hatchery- and natural-origin – to meet their daily metabolic needs as compared to historically. The cause of this trend is uncertain, size-selective removals from predation or fishing practices, or evolutionary shifts. Given all of this information, we do not expect any negative effects to SRKWs from the proposed action in terms of changes to the proportion of hatchery- and natural-origin fish or priority prey stock composition, or the size of Chinook salmon available as prey.

As described in the proposed action, 6.8 million smolts will be released from various hatcheries around the Snake River and Grande Ronde River Basin (Figure 2). The total adult equivalents of all the proposed hatchery program releases are 49,640 adult Chinook salmon (based on the average SAR return value of .73 to LGR). Between 2016 and 2020, in the Southwest West Coast Vancouver Island region, October (pre-fishing) Chinook salmon abundances ranged from approximately 527,210 to 628,543 fish; North of Falcon abundance ranged from 633,225 to 781,476 fish; Oregon coast abundance ranged from 408,739 to 596,483 and California coast

[7] These percentages are based on the percentage of marked versus unmarked fish from FRAM validation runs 2009-2020. While mass marking is largely in effect in these areas, there are several unclipped hatchery programs (and a couple wild marking programs in the Columbia), leading these percentages to be underestimates of the proportion of hatchery fish.

abundance ranged from 211,895 to 505,310 (NMFS 2024c). The average total Chinook salmon abundance from these locations was approximately 2,122,435 fish. Therefore, an increase of approximately 49,640 adult Chinook salmon due to the proposed action would equate to about 2.3% increase in the total estimated ocean abundance that may be available to SRKW.

Importantly, the expected increases in Chinook salmon abundance due to the proposed action are not expected to jeopardize other listed Chinook salmon ESUs. The primary risks of the Proposed Action to natural-origin Chinook salmon include genetic and ecological effects, broodstock collection, and progeny of naturally-spawning hatchery salmon. Moderate risk to Chinook salmon comes from ecological interactions with hatchery salmon (including competition and predation). Additionally, most hatchery facilities employ best management practices to minimize risks to natural-origin salmon. Our assessment of these risks supports our conclusion that the effects of the proposed action on natural-origin Chinook salmon is sufficiently low that no adverse effects to SRKW in terms of reduced quantity or quality of Chinook prey over the long term are expected.

In summary, given that the Proposed Action is beneficial to SRKWs in that more prey is expected to be available throughout the range of SRKWs, there are no negative effects expected to SRKWs, and that ESA-listed Chinook salmon ESUs are not jeopardized, the Proposed Action is therefore not likely to adversely affect SRKWs.

Critical Habitat

In addition to the effects to the DPS discussed above, the Proposed Action affects critical habitat designated for SRKWs. We do not expect the Proposed Action to impact the water quality or passage features of critical habitat because hatchery production occurs in-river and does not affect the water quality or passage conditions within SRKW critical habitat. The Proposed Action has the potential to affect the quantity and availability of prey in critical habitat.

The percent prey increases presented above is an estimate based on the production levels being proposed in the Proposed Action (6.8 million smolts). However, the ocean abundance of adult Chinook salmon is dependent on the level of Chinook salmon observed in a given year. For example, variable ocean conditions are a major driver of ocean salmon abundances which can vary widely from year to year. As such, percent prey increases due to the Proposed Action may be smaller in years when ocean abundance is high (i.e., marine survival is high for salmon across all stocks). Accordingly, the benefits of the proposed hatchery production to SRKWs may be much higher in low abundance years.

We would not expect any impacts from the Proposed Action on prey quality with respect to levels of harmful contaminants. We also do not expect any impacts on prey quality with respect to size of Chinook salmon. As discussed above, size and age structure of Chinook salmon has substantially changed across the Northeast Pacific Ocean since the 1970s (Ohlberger et al. 2018). Therefore, SRKWs would need to consume more salmon in order to meet their caloric needs as a result of a decrease in average size of older Chinook salmon, as compared to previous years when Chinook salmon were larger. Across most of the west coast, adult Chinook salmon (ocean ages 4 and 5) are becoming smaller, the size of age 2 fish are generally increasing, and most of the Chinook salmon populations from Oregon to Alaska have shown declines in the proportions of age 4- and 5-year-olds and an increase in the proportion of 2-year-olds (i.e., the mean age in populations has declined over time) (Ohlberger et al. 2018). Strength of trends varied by region. Ohlberger et al. (2019) found that reasons for this shift may be largely due to direct effects from size-selective removal by resident killer whales and fisheries, followed by evolutionary changes toward these smaller sizes and early maturation. Therefore, we would not expect the current level of hatchery production to appreciably decrease Chinook salmon size (i.e., quality) thereby reducing the conservation value of the prey feature.

As described above, the increase in Chinook salmon abundance due to the Proposed Action is not expected to jeopardize ESA-listed Chinook salmon ESUs. There are also no negative effects to SRKW critical habitat expected due to the Proposed Action. As such, the Proposed Action is beneficial to SRKW prey in both coastal and inland critical habitat, and therefore is not likely to adversely affect SRKW critical habitat.

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

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 associated physical, chemical, and biological 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 may result from actions occurring within EFH or outside of it and may include direct, indirect, site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) 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 (50 CFR 600.905(b)).

3.1. ESSENTIAL FISH HABITAT AFFECTED BY THE PROPOSED ACTION

The Proposed Action is the issuance of permits as implemented by operators of the Snake River fall-run Chinook salmon Hatchery Program as described in Section 1.3. The Action Area (Section 2.3) includes habitat described as EFH for Chinook salmon (PFMC 2014a; 2014b) within the Snake River Basin. Because EFH has not been described for steelhead or sockeye salmon, the analysis is restricted to the effects of the Proposed Action on EFH for Chinook salmon.

As described by (PFMC 2014b), the freshwater EFH for Chinook 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. HAPCs 1 and 3 are potentially affected by the Proposed Action.

3.2. ADVERSE EFFECTS ON ESSENTIAL FISH HABITAT

The Proposed Action has small effects on the major components of EFH. The HAPCs that are potentially being affected are the complex channels and floodplain habitat in and around the hatchery facilities as well as the spawning habitat in the Snake, Clearwater, and Grande Ronde River Basins.

As described in Section 2.5.2.5, water withdrawal for hatchery operations can adversely affect salmon by reducing streamflow, impeding migration, or reducing other stream-dwelling organisms that could serve as prey for juvenile salmonids. Water withdrawals can also kill or injure juvenile salmonids through impingement upon inadequately designed intake screens or by entrainment of juvenile fish into the water diversion structures. The proposed hatchery programs include designs to minimize each of these effects. In general, water withdrawals are small enough in scale that changes in flow would be undetectable, and impacts would not occur.

The PFMC (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 hatchery programs might have on natural populations of Chinook salmon (Section 2.5.2.2; Section 6). The effects on steelhead and sockeye salmon are typically much smaller, due to the species-specific nature of many of the interactions and relatively small overlap in habitat usage by these species. Ecological effects of juvenile and adult hatchery-origin fish on natural-origin fish are discussed in Sections 2.5.2.2 and 2.5.2.3. Hatchery fish returning to the Snake River Basin are expected to largely spawn and rear near the hatchery and not compete for space with sockeye salmon or steelhead. Some fall-run Chinook salmon from the programs would stray into other rivers but not in numbers that would exceed the carrying capacities of natural production areas, or that would result in increased incidence of disease or predators. Predation by adult hatchery fall-run Chinook salmon on juvenile natural-origin Chinook and sockeye salmon as well as steelhead has been analyzed in Section 2.5.2.3. Predation and competition by juvenile hatchery fall-run Chinook salmon on juvenile natural-origin Chinook or sockeye salmon or steelhead is small (Section 2.5.2.3) because these fish out-migrate relatively quickly and at sizes that limit these types of interactions.

NMFS has determined that the Proposed Action is likely to adversely affect EFH for Pacific salmon, specifically through water withdrawal for hatchery operations, and genetic and ecological interactions of the hatchery-reared fish with natural fish in the natural environment, affecting complex channels and floodplain habitat, and spawning habitat.

3.3. Essential Fish Habitat Conservation Recommendations

NMFS determined that the following conservation recommendations are necessary to avoid, minimize, mitigate, or otherwise offset the impact of the Proposed Action on EFH.

For each of the potential adverse effects of the Proposed Action on EFH for Pacific salmon, NMFS believes that the Proposed Action, as described in the HGMP Addendum (NPT et al. 2024) and the ITS (Section 2.9), includes the best approaches to avoid or minimize those adverse effects. The Reasonable and Prudent Measures and Terms and Conditions included in the ITS associated with ecological interactions constitute NMFS recommendations to address potential EFH effects. NMFS, USFWS, and BPA shall ensure that the ITS, including Reasonable and Prudent Measures and implementing Terms and Conditions, are carried out.

Fully implementing these EFH conservation recommendations would protect, by avoiding or minimizing the adverse effects described in section 3.2, above, for Pacific Coast salmon.

3.4. STATUTORY RESPONSE REQUIREMENT

As required by section 305(b)(4)(B) of the MSA, the Federal Agency must provide a detailed response in writing to NMFS within 30 days after receiving an EFH conservation recommendation. 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)).

3.5. SUPPLEMENTAL CONSULTATION

NMFS, USFWS, and BPA must reinitiate EFH consultation with NMFS if the Proposed Action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH conservation recommendations (50 CFR 600.920(l)).

4. Data Quality Act Documentation and Pre-Dissemination Review

The Data Quality Act (DQA) specifies three competent 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 DQA, and certifies that this opinion has undergone pre-dissemination review.

4.1. Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users are NMFS, BPA, LSRCP, and the program operators and their co-operators. Other interested users could include the NPT, CFTUIR, IDFG, ODFW, and WDFW. Individual copies of this opinion were provided to the NPT, CFTUIR, IDFG, ODFW, WDFW, IPC, BPA and the LSRCP. The document will be available within 2 weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. The format and naming adhere to conventional standards for style.

4.2. Integrity

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

4.3. Objectivity

Information Product Category: Natural Resource Plan

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

Best Available Information: This consultation and supporting documents use the best available information, as described in the references section. The analyses in this Biological Opinion and EFH consultation contain more background on information sources and quality.

Referencing: All supporting materials, information, data, and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA and MSA implementation, and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

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6. APPENDIX: EFFECTS OF HATCHERY PROGRAMS ON SALMON AND STEELHEAD POPULATIONS: REFERENCE DOCUMENT FOR NMFS ESA HATCHERY CONSULTATIONS (REVISED MAY 2023)[8]

NMFS applies available scientific information, identifies the types of circumstances and conditions that are unique to individual hatchery programs, then refines the range in effects for a specific hatchery program. Our analysis of a Proposed Action addresses six factors:

(1) The hatchery program does or does not remove fish from the natural population and use them for hatchery broodstock
(2) Hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities
(3) Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas, the migration corridor, estuary, and ocean
(4) Research, monitoring, and evaluation (RM&E) that exist because of the hatchery program
(5) Operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program
(6) Fisheries that would not exist but for the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds

Because the purpose of biological opinions is to evaluate whether proposed actions pose unacceptable risk (jeopardy) to listed species, much of the language in this appendix addresses risk. However, we also consider that hatcheries can be valuable tools for conservation or recovery, for example when used to prevent extinction or conserve genetic diversity in a small population, or to produce fish for reintroduction.

The following sections describe each factor in detail, including as appropriate, the scientific basis for and our analytical approach to assessment of effects. The material presented in this Appendix is only scientific support for our approach; social, cultural, and economic considerations are not included. The scientific literature on effects of salmonid hatcheries is large and growing rapidly. This appendix is thus not intended to be a comprehensive literature review, but rather a periodically updated overview of key relevant literature we use to guide our approach to effects analysis. Because this appendix can be updated only periodically, it may sometimes omit very recent findings, but should always reflect the scientific basis for our analyses. Relevant new information not cited in the appendix will be cited in the other sections of the opinion that detail our analyses of effects.

In choosing the literature we cite in this Appendix; our overriding concern is our mandate to use "best available science". Generally, "best available science" means recent peer-reviewed journal articles and books. However, as appropriate we cite older peer-reviewed literature that is still relevant, as well as "gray" literature. Although peer-review is typically considered the "gold standard" for scientific information, occasionally there are well-known and popular papers in the

[8] This version of the appendix supersedes all earlier dated versions and the NMFS (2012e) standalone document of the same name.

peer-reviewed literature we do not cite because we question the methodology, results, or conclusions. In citing sources, we also consider availability, and try to avoid sources that are difficult to access. For this reason, we generally avoid citing master's theses and doctoral dissertations, unless they provide unique information.

6.1. Factor 1. The hatchery program does or does not remove fish from the natural population and use them for hatchery broodstock

A primary consideration in analyzing and assessing effects for broodstock collection is the origin and number of fish collected. The analysis considers whether broodstock are of local origin and the biological benefits and risks of using ESA-listed fish (natural or hatchery-origin) for hatchery broodstock. It considers the maximum number of fish proposed for collection and the proportion of the donor population collected for hatchery broodstock. "Mining" a natural population to supply hatchery broodstock can reduce population abundance and spatial structure.

6.2. Factor 2. Hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural and hatchery fish and adult collection facilities

There are three aspects to the analysis of this factor: genetic effects, ecological effects, and encounters at adult collection facilities. We present genetic effects first. For the sake of simplicity, we discuss genetic effects on all life stages under factor 2.

6.2.1. Genetic effects

6.2.1.1. Overview

Based on currently available scientific information, we generally view the genetic effects of hatchery programs as detrimental to the ability of a salmon population's ability to sustain itself in the wild. We believe that artificial breeding and rearing is likely to result in some degree of change of genetic diversity and fitness reduction in hatchery-origin. Hatchery-origin fish can thus pose a risk to diversity and to salmon population rebuilding and recovery when they interbreed with natural-origin fish. However, conservation hatchery programs may prevent extinction or accelerate recovery of a target population by increasing abundance faster than may occur naturally (Waples 1999). Hatchery programs can also be used to create genetic reserves for a population to prevent the loss of its unique traits due to catastrophes (Ford et al. 2011b).

We recognize that there is considerable debate regarding aspects of genetic risk. The extent and duration of genetic change and fitness loss and the short- and long-term implications and consequences for different species (i.e., for species with multiple life-history types and species subjected to different hatchery practices and protocols) remain unclear and should be the subject of further scientific investigation. As a result, we believe that hatchery intervention is a legitimate and useful tool to alleviate short-term extinction risk, but otherwise managers should seek to limit interactions between hatchery and natural-origin fish and implement hatchery practices that harmonize conservation with the implementation of treaty Indian fishing rights and other applicable laws and policies (NMFS 2011b). We expect the scientific uncertainty surrounding genetic risks to be reduced considerably in the next decade due to the rapidly increasing power of genomic analysis (Waples et al. 2020).

Four general processes determine the genetic composition of populations of any plant or animal species (e.g., Falconer and MacKay 1996):

- Selection- changes in genetic composition over time due to some genotypes being more successful at survival or reproduction (i.e., more fit) than others
- Migration- individuals, and thus their genes, moving from one population to another
- Genetic drift- random loss of genetic material due to finite population size
- Mutation- generation of new genetic diversity through changes in DNA

Mutations are changes in DNA sequences that are generally so rare[9] that they can be ignored for relatively short-term evaluation of genetic change, but the other three processes are considerations in evaluating the effects of hatchery programs on the productivity and genetic diversity of natural salmon and steelhead populations. Although there is considerable biological interdependence among them, we consider three major areas of genetic effects of hatchery programs in our analyses (Figure 11):

- Within-population genetic diversity
- Among-population genetic diversity/outbreeding
- Hatchery-influenced selection

The first two areas are well-known major concerns of conservation biology (e.g., Frankham et al. 2010; Allendorf et al. 2013), but our emphasis on hatchery-influenced selection— what conservation geneticists would likely call “adaptation to captivity” (Allendorf et al. 2013, pp. 408-409)— reflects the fairly unique position of salmon and steelhead among ESA-listed species. In the case of ESA-listed Pacific salmon and steelhead, artificial propagation in hatcheries has been used as a routine management tool for many decades, and in some cases the size and scope of hatchery programs has been a factor in listing decisions.

In the sections below, we discuss these three major areas of risk, but preface this with an explanation of some key terms relevant to genetic risk. Although these terms may also be listed in a glossary in the biological opinion to which this appendix accompanies, we felt that it was important to include them here, as this appendix may at times be used as a stand-alone document.

[9] For example, the probability of a random base substitution in a DNA molecule in coho salmon is .000000008 (Rougemont et al. 2020).

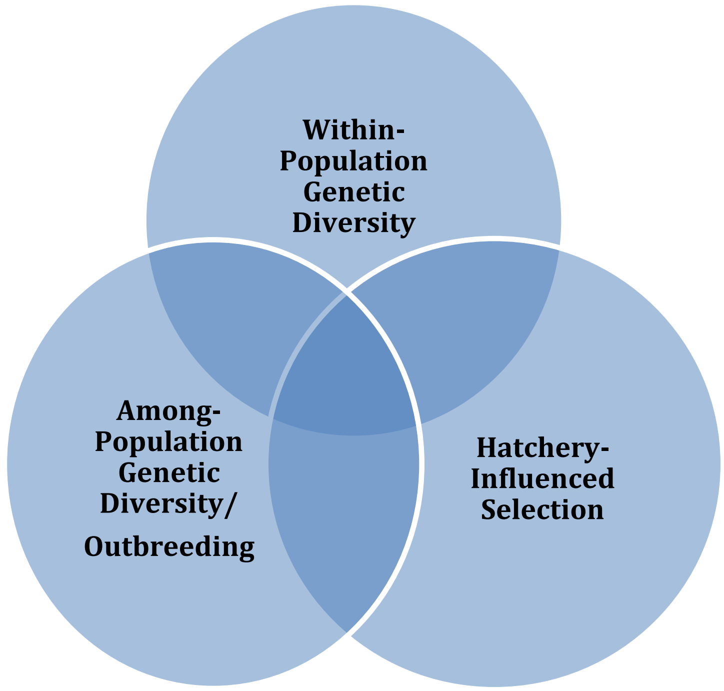

Figure 11. Major categories of hatchery program genetic effects analyzed by NMFS

6.2.1.1.1. Key Terms

The terms "wild fish" and "hatchery fish" are commonly used by the public, management biologists, and regulatory biologists, but their meaning can vary depending on context. For genetic risk assessment, more precise terminology is needed. Much of this terminology, and further derivatives of it, is commonly attributed to the Hatchery Scientific Review Group (HSRG), but were developed in 2004 technical discussions between the HSRG and scientists from the Washington Department of Fish and Wildlife (WDFW) and the Northwest Indian Fisheries Commission (HSRG 2009b).

- **Hatchery-origin (HO)**- refers to fish that have been reared and released by a hatchery program, regardless of the origin (i.e., from a hatchery or from spawning in nature) of their parents. A series of acronyms has been developed for subclasses of HO fish:

    - **Hatchery-origin recruits (HOR)** – HO fish returning to freshwater as adults or jacks. Usage varies, but typically the term refers to post-harvest fish that will either spawn in nature, used for hatchery broodstock, or surplused.

    - **Hatchery-origin spawners (HOS)**- hatchery-origin fish spawning in nature. A very important derivative term, used both in genetic and ecological risk, is **pHOS,** the proportion of fish on the spawning grounds of a population consisting of HO fish. pHOS is the expected maximum genetic contribution of HO spawners to the naturally spawning population.

- **Hatchery-origin broodstock (HOB)**- hatchery-origin fish that are spawned in the hatchery (i.e., are used as broodstock). This term is rarely used.

- **Natural-origin (NO)**- refers to fish that have resulted from spawning in nature, regardless of the origin of their parents. A series of acronyms parallel to those for HO fish has been developed for subclasses of NO fish:

    - **Natural-origin recruits (NOR)** – NO fish returning to freshwater as adults or jacks. Usage varies, but typically the term refers to post-harvest fish that will either spawn in nature or used for hatchery broodstock.

    - **Natural-origin spawners (NOS)**- natural-origin fish spawning in nature.

    - **Natural-origin broodstock (NOB)**- natural-origin fish that are spawned in the hatchery (i.e., are used as broodstock). An important derivative term is **pNOB**, the proportion of a hatchery program's broodstock consisting of NO fish.

Hatchery programs are designated as either as "integrated" or "segregated". In the past these terms have been described in various ways, based on purpose (e.g., conservation or harvest) or intent with respect to the genetic relationship between the hatchery fish and the natural population they interact with. For purposes of genetic risk, we use simple functional definitions based on use of natural-origin broodstock:

- **Integrated hatchery programs**- programs that intentionally incorporate natural-origin fish into the broodstock at some level (i.e., pNOB > 0)

- **Segregated hatchery programs**- programs that do not intentionally incorporate natural-origin fish into the broodstock (i.e., pNOB = 0)

6.2.1.2. Within-population diversity effects

Within-population genetic diversity is a general term for the quantity, variety, and combinations of genetic material in a population (Busack and Currens 1995). Within-population diversity is gained through mutations or gene flow from other populations (described below under outbreeding effects) and is lost primarily due to genetic drift. In hatchery programs diversity may also be lost through biased or nonrepresentational sampling incurred during hatchery operations, particularly broodstock collection and spawning protocols.

6.2.1.2.1. Genetic drift

Genetic drift is random loss of diversity due to population size. The rate of drift is determined not by the census population size (N_c), but rather by the effective population size (N_e). The effective size of a population is the size of a genetically "ideal" population (i.e., equal numbers of males and females, each with equal opportunity to contribute to the next generation) that will display as much genetic drift as the population being examined (e.g., Falconer and MacKay 1996; Allendorf et al. 2013).[10]

This definition can be baffling, so an example is useful. A commonly used effective-size equation is $Ne = 4 * N_m * N_f/(N_m + N_f)$, where N_m and N_f are the number of male and female parents, respectively. Suppose a steelhead hatchery operation spawns 5 males with 29 females. According to the equation, although 34 fish were spawned, the skewed sex ratio made this equivalent to spawning 17 fish (half male and half female) in terms of conserving genetic diversity because half of the genetic material in the offspring came from only 5 fish.

Various guidelines have been proposed for what levels of N_e should be for conservation of genetic diversity. A long-standing guideline is the 50/500 rule (Franklin 1980; Lande and Barrowclough 1987): 50 for a few generations is sufficient to avoid inbreeding depression, and 500 is adequate to conserve diversity over the longer term. One recent review (Jamieson and Allendorf 2012) concluded the rule still provided valuable guidance; another (Frankham et al. 2014) concluded that larger values are more appropriate, basically suggesting a 100/1000 rule. See Frankham et al. (2010) for a more thorough discussion of these guidelines.

Although *Ne* can be estimated from genetic or demographic data, often-insufficient information is available to do this, so for conservation purposes it is useful to estimate effective size from census size. As illustrated by the example above, N_e can be considerably smaller than N_c. This is typically the case. Frankham et al. (2014) suggested a N_e/N_c range of ~0.1-0.2 based on a large review of the literature on effective size. For Pacific salmon populations over a generation, Waples (2004) arrived at a similar range of 0.05-0.3.

In salmon and steelhead management, effective size concerns are typically dealt with using the term effective number of breeders (N_b) in a single spawning season, with per-generation N_e equal to the generation time (average age of spawners) times the average N_b *(Waples 2004)*. We will use N_b rather than N_e where appropriate in the following discussion.

Hatchery programs, simply by virtue of being able to create more progeny than natural spawners are able to, can increase N_b in a fish population. In very small populations, this increase can be a benefit, making selection more effective and reducing other small-population risks (e.g., Lacy 1987; Whitlock 2000; Willi et al. 2006). Conservation hatchery programs can thus serve to protect genetic diversity; several programs, such as the Snake River sockeye salmon program, are important genetic reserves. However, hatchery programs can also directly depress N_b by three principal pathways:

- Removal of fish from the naturally spawning population for use as hatchery broodstock. If a substantial portion of the population is taken into a hatchery, the hatchery becomes responsible for that portion of the effective size, and if the operation fails, the effective size of the population will be reduced (Waples and Do 1994).

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[10] There are technically two subcategories of N_e: inbreeding effective size and variance effective size. The distinction between them is usually not a concern in our application of the concept.

- Mating strategy used in the hatchery. N_b is reduced considerably below the census number of broodstock by using a skewed sex ratio, spawning males multiple times (Busack 2007), and by pooling gametes. Pooling milt is especially problematic because when milt of several males is mixed and applied to eggs, a large portion of the eggs may be fertilized by a single male (Gharrett and Shirley 1985; Withler 1988). This problem can be avoided by more structured mating schemes such as 1-to-1 mating. Factorial mating schemes, in which fish are systematically mated multiple times, can be used to increase N_b (Fiumera et al. 2004; Busack and Knudsen 2007) over what would be achievable with less structured designs. Considerable benefit in N_b increase over what is achievable by 1-to-1 mating can be achieved through a factorial design as simple as a 2 x 2 (Busack and Knudsen 2007).

- Ryman-Laikre effect. On a per-capita basis, a hatchery broodstock fish can often contribute many more progeny to a naturally spawning population than a naturally spawning fish can contribute This difference in reproductive contribution causes the composite N_b to be reduced, which is called a Ryman-Laikre (R-L) effect (Ryman and Laikre 1991; Ryman et al. 1995). The key factors determining the magnitude of the effect are the numbers of hatchery and natural spawners, and the proportion of natural spawners consisting of hatchery returnees.

The initial papers on the R-L effect required knowledge of N_b in the two spawning components of the population. Waples et al. (2016) have developed R-L equations suitable for a wide variety of situations in terms of knowledge base. A serious limitation of any R-L calculation however, is that it is a snapshot in time. What happens in subsequent generations depends on gene flow between the hatchery broodstock and the natural spawners. If a substantial portion of the broodstock are NO fish, the long-term effective size depression can be considerably less than would be expected from the calculated per-generation N_b.

Duchesne and Bernatchez (2002), Tufto and Hindar (2003), and Wang and Ryman (2001) have developed analytical approaches to deal with the effective-size consequences of multiple generations of interbreeding between HO and NO fish. One interesting result of these models is that effective size reductions caused by a hatchery program can easily be countered by low levels of gene flow from other populations. Tufto (2017) recently provided us with R code (R Core Team 2019) updates to the Tufto and Hindar (2003) method that yield identical answers to the Duchesne and Bernatchez (2002) method, and we use an R (R Core Team 2019) program incorporating them to analyze the effects of hatchery programs on effective size.

Inbreeding depression, another N_e-related phenomenon, is a reduction in fitness and survival caused by the mating of closely related individuals (e.g., siblings, half-siblings, cousins). Related individuals are genetically similar and produce offspring characterized by low genetic variation, low heterozygosity, lower survival, and increased expression of recessive deleterious mutations (Frankham et al. 2010; Allendorf et al. 2013; Rollinson et al. 2014; Hedrick and Garcia-Dorado 2016). Lowered fitness due to inbreeding depression exacerbates genetic risk relating to small population size and low genetic variation which further shifts a small population toward extinction (Nonaka et al. 2019). The protective hatchery environment masks the effects of inbreeding which becomes apparent when fish are released into the natural environment and experience decreased survival (Thrower and Hard 2009). Inbreeding concerns in salmonids related to hatcheries have been reviewed by Wang et al. (2002) and Naish et al. (2007).

N_e affects the level of inbreeding in a population, as the likelihood of mating between close relatives is increased in populations with low numbers of spawners. Populations exhibiting high levels of inbreeding are generally found to have low N_e (Dowell Beer et al. 2019). Small populations are at increased risk of both inbreeding depression and genetic drift (e.g., Willi et al. 2006). Genetic drift is the stochastic loss of genetic variation, which is most often observed in populations with low numbers of breeders. Inbreeding exacerbates the loss of genetic variation by increasing genetic drift when related individuals with similar allelic diversity interbreed (Willoughby et al. 2015).

Hatchery populations should be managed to avoid inbreeding depression. If hatcheries produce inbred fish which return to spawn in natural spawning areas the low genetic variation and increased deleterious mutations can lower the fitness, productivity, and survival of the natural population (Christie et al. 2014). A captive population, which has been managed so genetic variation is maximized and inbreeding is minimized, may be used for a genetic rescue of a natural population characterized by low genetic variation and low Ne.

6.2.1.2.2. Biased/nonrepresentational sampling

Even if effective size is large, the genetic diversity of a population can be negatively affected by hatchery operations. Although many operations aspire to randomly use fish for spawning with respect to size, age, and other characteristics, this is difficult to do. For example, male Chinook salmon that mature precociously in freshwater are rarely if ever used as broodstock because they are not captured at hatchery weirs. Pressure to meet egg take goals is likely responsible for advancing run/spawn timing in at least some coho and Chinook salmon hatcheries (Quinn et al. 2002; Ford et al. 2006). Ironically, random mating, a common spawning guideline for conservation of genetic diversity has been hypothesized to be effectively selecting for younger, smaller fish (Hankin et al. 2009).

The sampling examples mentioned thus far are more or less unintentional actions. There are also established hatchery practices with possible diversity consequences that are clearly intentional. A classic example is use of jacks in spawning, where carefully considered guidelines range from random usage to near exclusion of jacks (e.g., Seidel 1983; IDFG et al. 2020). Another is the deliberate artificial selection in the hatchery of summer and winter steelhead to smolt at one year of age, which has resulted in early spawning stocks of both ecotypes (Crawford 1979).

Another source of biased sampling is non-inclusion of precocious males in broodstock. Precociousness, or early male maturation, is an alternative reproductive tactic employed by Atlantic salmon (Baglinière and Maisse 1985; Myers et al. 1986), Chinook salmon (Bernier et al. 1993; Larsen et al. 2004), coho salmon (Iwamoto et al. 1984; Silverstein and Hershberger 1992), steelhead (Schmidt and House 1979; McMillan et al. 2012) , sockeye salmon (Ricker 1959), as well as several salmonid species in Asia and Europe (Dellefors and Faremo 1988; Kato 1991; Munakata et al. 2001; Morita et al. 2009).

Unlike anadromous males and females that migrate to the ocean to grow for a year or more before returning to their natal stream, precocious males generally stay in headwater reaches or migrate shorter distances downstream (Larsen et al. 2010) before spawning. They are orders of magnitude smaller than anadromous adults and use a 'sneaker' strategy to spawn with full size anadromous females (Fleming 1996). Precocious males are typically not subject to collection as broodstock, because of either size or location. Thus, to the extent this life history is genetically determined, hatchery programs culturing species that display precociousness unintentionally select against it.

The examples above illustrate the overlap between diversity effects and selection. Selection, natural or artificial, affects diversity, so could be regarded as a subcategory of within-population diversity. Analytically, here we consider specific effects of sampling or selection on genetic diversity. Broodstock collection or spawning guidelines that include specifications about non-random use of fish with respect to age or size, spawn timing, etc. (e.g., Crawford 1979) are of special interest. We consider general non-specific effects of unintentional selection due to the hatchery that are not related to individual traits in Section 6.2.1.4.

6.2.1.3. Among-population diversity/ Outbreeding effects

Outbreeding effects result from gene flow from other populations into the population of interest. Gene flow occurs naturally among salmon and steelhead populations, a process referred to as straying (Quinn 1997; Keefer and Caudill 2012; Westley et al. 2013). Natural straying serves a valuable function in preserving diversity that would otherwise be lost through genetic drift and in re-colonizing vacant habitat, and straying is considered a risk only when it occurs at unnatural levels or from unnatural sources.

Hatchery fish may exhibit reduced homing fidelity relative to NO fish (Grant 1997; Quinn 1997; Jonsson et al. 2003; Goodman 2005), resulting in unnatural levels of gene flow into recipient populations from strays, either in terms of sources or rates. Based on thousands of coded-wire tag (CWT) recoveries, Westley et al. (2013) concluded that species propagated in hatcheries vary in terms of straying tendency: Chinook salmon > coho salmon > steelhead. Also, within Chinook salmon, "ocean-type" fish stray more than "stream-type" fish. However, even if hatchery fish home at the same level of fidelity as NO fish, their higher abundance relative to NO fish can cause unnaturally high gene flow into recipient populations.

Rearing and release practices and ancestral origin of the hatchery fish can all play a role in straying (Quinn 1997). Based on fundamental population genetic principles, a 1995 scientific workgroup convened by NMFS concluded that aggregate gene flow from non-native HO fish from all programs combined should be kept below 5 percent (Grant 1997), and this is the recommendation NMFS uses as a reference in hatchery consultations. It is important to note that this 5 percent criterion was developed independently and for a different purpose than the HSRG's 5% pHOS criterion that is presented in Section 6.2.1.4.

Gene flow from other populations can increase genetic diversity (e.g., Ayllon et al. 2006), which can be a benefit in small populations, but it can also alter established allele frequencies (and co-adapted gene complexes) and reduce the population's level of adaptation, a phenomenon called outbreeding depression (Edmands 2007; McClelland and Naish 2007). In general, the greater the geographic separation between the source or origin of hatchery fish and the recipient natural population, the greater the genetic difference between the two populations (ICBTRT 2007), and the greater potential for outbreeding depression. For this reason, NMFS advises hatchery action agencies to develop locally derived hatchery broodstock.

In addition, unusual high rates of straying into other populations within or beyond the population's MPG, salmon ESU, or a steelhead DPS, can have a homogenizing effect, decreasing intra-population genetic variability (e.g., Vasemagi et al. 2005), and increasing risk to population diversity, one of the four attributes measured to determine population viability (McElhany et al. 2000a). The practice of backfilling — using eggs collected at one hatchery to compensate for egg shortages at another—has historically a key source of intentional large-scale "straying". Although it now is generally considered an unwise practice, it still is common.

There is a growing appreciation of the extent to which among-population diversity contributes to a "portfolio" effect (Schindler et al. 2010), and lack of among-population genetic diversity is considered a contributing factor to the depressed status of California Chinook salmon populations (Carlson et al. 2011; Satterthwaite and Carlson 2015). Eldridge et al. (2009) found that among-population genetic diversity had decreased in Puget Sound coho salmon populations during several decades of intensive hatchery culture.

As discussed in Section 6.2.1.4, pHOS[11] is often used as a surrogate measure of gene flow. Appropriate cautions and qualifications should be considered when using this proportion to analyze outbreeding effects.

- Adult salmon may wander on their return migration, entering and then leaving tributary streams before spawning (Pastor 2004). These "dip-in" fish may be detected and counted as strays, but may eventually spawn in other areas, resulting in an overestimate of the number of strays that potentially interbreed with the natural population (Keefer et al. 2008). On the other hand, "dip-ins" can also be captured by hatchery traps and become part of the broodstock.

- Strays may not contribute genetically in proportion to their abundance. Several studies demonstrate little genetic impact from straying despite a considerable presence of strays in the spawning population (e.g., Saisa et al. 2003; Blankenship et al. 2007). The causes of poor reproductive success of strays are likely similar to those responsible for reduced productivity of HO fish in general; e.g., differences in run and spawn timing, spawning in less productive habitats, and reduced survival of their progeny (Reisenbichler and McIntyre 1977; Leider et al. 1990; Williamson et al. 2010).

[11] It is important to reiterate that, as NMFS analyzes them, outbreeding effects are a risk only when the HO fish are from a *different* population than the NO fish.

6.2.1.4. Hatchery-influenced selection effects

Hatchery-influenced selection (often called domestication[12]), the third major area of genetic effects of hatchery programs that NMFS analyses, 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 HO fish. These differing selection pressures can be a result of differences in environments or a consequence of protocols and practices used by a hatchery program.

Hatchery-influenced selection can range from relaxation of selection that would normally occur in nature, to selection for different characteristics in the hatchery and natural environments, to intentional selection for desired characteristics (Waples 1999), but in this section, for the most part, we consider hatchery-influenced selection effects that are general and unintentional. Concerns about these effects, often noted as performance differences between HO and NO fish have been recorded in the scientific literature for more than 60 years (Vincent 1960, and references therein).

Genetic change and fitness reduction in natural salmon and steelhead due to hatchery-influenced selection depends on:

- The difference in selection pressures presented by the hatchery and natural environments. Hatchery environments differ from natural environments in many ways (e.g., Thorpe 2004) Some obvious ones are food, density, flows, environmental complexity, and protection from predation.

- How long the fish are reared in the hatchery environment. This varies by species, program type, and by program objective. Steelhead, coho and "stream-type" Chinook salmon are usually released as yearlings, while "ocean-type" Chinook, pink, and chum salmon are usually released at younger ages.

- The rate of gene flow between HO and NO fish, which is usually expressed as pHOS for segregated programs and PNI for integrated programs.

All three factors should be considered in evaluating risks of hatchery programs. However, because gene flow is generally more readily managed than the selection strength of the hatchery environment, current efforts to control and evaluate the risk of hatchery-influenced selection are currently largely focused on gene flow between NO and HO fish.[13] Strong selective fish culture with low hatchery-wild interbreeding can pose less risk than relatively weaker selective fish culture with high levels of interbreeding.

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[12] We prefer the term "hatchery-influenced selection" or "adaptation to captivity" (Fisch et al. 2015) to "domestication" because in discussions of genetic risk in salmon "domestication" is often taken as equivalence to

[13] Gene flow between NO and HO fish is often interpreted as meaning actual matings between NO and HO fish. In some contexts, it can mean that. However, in this document, unless otherwise specified, gene flow means contributing to the same progeny population. For example, HO spawners in the wild will either spawn with other HO fish or with NO fish. NO spawners in the wild will either spawn with other NO fish or with HO fish. But all these matings, to the extent they are successful, will generate the next generation of NO fish. In other words, all will contribute to the NO gene pool.

6.2.1.4.1. Relative Reproductive Success Research

Although hundreds of papers in the scientific literature document behavioral, morphological and physiological differences between NO and HO fish, the most frequently cited research has focused on RRS of HO fish compared to NO fish determined through pedigree analysis. The influence of this type of research derives from the fact that it addresses fitness, the ability of the fish to produce progeny that will then return to sustain the population. The RRS study method is simple: genotyped NO and HO fish are released upstream to spawn, and their progeny (juveniles, adults, or both) are sampled genetically and matched with the genotyped parents. In some cases, multiple-generation pedigrees are possible.

RRS studies can be easy to misinterpret (Christie et al. 2014) for at least three reasons:

- RRS studies often have little experimental power because of limited sample sizes and enormous variation among individual fish in reproductive success (most fish leave no offspring and a few leave many). This can lead to lack of statistical significance for HO:NO comparisons even if a true difference does exist. Kalinowski and Taper (2005) provide a method for developing confidence intervals around RRS estimates that can shed light on statistical power.

- An observed difference in RRS may not be genetic. For example, Williamson et al. (2010) found that much of the observed difference in reproductive success between HO and NO fish was due to spawning location; the HO fish tended to spawn closer to the hatchery. Genetic differences in reproductive success require a multiple generation design, and only a handful of these studies are available.

- The history of the natural population in terms of hatchery ancestry can bias RRS results. Only a small difference in reproductive success of HO and NO fish might be expected if the population had been subjected to many generations of high pHOS (Willoughby and Christie 2017).

For several years, the bulk of the empirical evidence of fitness depression due to hatchery-influenced selection came from studies of species that are reared in the hatchery environment for an extended period— one to two years—before release (Berejikian and Ford 2004). Researchers and managers wondered if these results were applicable to species and life-history types with shorter hatchery residence, as it seemed reasonable that the selective effect of the hatchery environment would be less on species with shorter hatchery residence times (e.g., RIST 2009). Especially lacking was RRS information on “ocean-type” Chinook. Recent RRS work on Alaskan pink salmon, the species with the shortest hatchery residence time has found very large differences in reproductive success between HO and NO fish (Lescak et al. 2019; Shedd et al. 2022). The RRS was 0.42 for females and 0.28 for males (Lescak et al. 2019). This research suggests the “less residence time, less effect” paradigm should be revisited.

Collectively, some RRS results are now available for all eastern Pacific salmon species except sockeye salmon. Note that this is not an exhaustive list of references:

- Coho salmon (Theriault et al. 2011; Neff et al. 2015)
- Chum salmon (Berejikian et al. 2009)
- "Ocean-type" Chinook salmon (Anderson et al. 2012; Sard et al. 2015; Evans et al. 2019)
- "Stream-type" Chinook salmon (Ford et al. 2009; Williamson et al. 2010; Ford et al. 2012; Hess et al. 2012; Ford et al. 2015; Janowitz-Koch et al. 2018)
- Steelhead (Araki et al. 2007; Araki et al. 2009; Berntson et al. 2011; Christie et al. 2011)
- Pink salmon (Lescak et al. 2019; Shedd et al. 2022)

Although the size of the effect may vary, and there may be year-to-year variation and lack of statistical significance, the general pattern is clear: HO fish have lower reproductive success than NO fish.

As mentioned above, few studies have been designed to detect unambiguously a genetic component in RRS. Two such studies have been conducted with steelhead and both detected a statistically significant genetic component in steelhead (Araki et al. 2007; Christie et al. 2011; Ford et al. 2016a), but the two conducted with "stream-type" Chinook salmon (Ford et al. 2012; Janowitz-Koch et al. 2018) have not detected a statistically significant genetic component.

Detecting a genetic component of fitness loss in one species and not another suggests that perhaps the impacts of hatchery-influenced selection on fitness differs between Chinook salmon and steelhead.[14] The possibility that steelhead may be more affected by hatchery-influenced selection than Chinook salmon by no means suggest that effects on Chinook are trivial, however. A small decrement in fitness per generation can lead to large fitness loss.

6.2.1.4.2. Hatchery Scientific Review Group (HSRG) Guidelines

Key concepts concerning the relationship of gene flow to hatchery-influenced selection were developed and promulgated throughout the Pacific Northwest by the Hatchery Scientific Review Group (HSRG), a congressionally funded group of federal, state, tribal, academic, and unaffiliated scientists that existed from 2000 to 2020. Because HSRG concepts have been so influential regionally, we devote the next few paragraphs to them.

The HSRG developed gene-flow guidelines based on mathematical models developed by Ford (2002) and by Lynch and O'Hely (2001). Guidelines for segregated programs are based on pHOS, but guidelines for integrated programs also include PNI, which is a function of pHOS and pNOB. PNI is, in theory, a reflection of the relative strength of selection in the hatchery and natural environments; a PNI value greater than 0.5 indicates dominance of natural selective forces.

[14] This would not be surprising. Although steelhead are thought of as being quite similar to the "other" species of salmon, genetic evidence suggests the two groups diverged well over 10 million years ago (Crête-Lafrenière et al. 2012).

The HSRG guidelines (HSRG 2009a) vary according to type of program and conservation importance of the population. The HSRG used conservation importance classifications that were developed by the Willamette/Lower Columbia Technical Recovery Team (McElhany et al. 2003).[15] (Table 38). In considering the guidelines, we equate "primary" with a recovery goal of "viable" or "highly viable", and "contributing" with a recovery goal of "maintain". We disregard the guidelines for "stabilizing", because we feel they are inadequate for conservation guidance.

Table 38. HSRG gene flow guidelines (HSRG 2009a).

	Program classification	
Population conservation importance	**Integrated**	**Segregated**
Primary	**PNI $\geq$ 0.67 and pHOS $\leq$ 0.30**	**pHOS $\leq$ 0.05**
Contributing	**PNI $\geq$ 0.50 and pHOS $\leq$ 0.30**	**pHOS $\leq$ 0.10**
Stabilizing	**Existing conditions**	**Existing conditions**

Although they are controversial, the HSRG gene flow guidelines have achieved a considerable level of regional acceptance. They were adopted as policy by the Washington Fish and Wildlife Commission (WDFW 2009), and were recently reviewed and endorsed by a WDFW scientific panel, who noted that the "…HSRG is the primary, perhaps only entity providing guidance for operating hatcheries in a scientifically defensible manner…" (Anderson et al. 2020). In addition, HSRG principles have been adopted by the Canadian Department of Fisheries and Oceans, with very similar gene-flow guidelines for some situations (Withler et al. 2018)[16].

The gene flow guidelines developed by the HSRG have been implemented in areas of the Pacific Northwest for at most 15 years, so there has been insufficient time to judge their effect. They have also not been applied consistently, which complicates evaluation. However, the benefits of high pNOB (in the following cases, 100 percent) has been credited with limiting genetic change and fitness loss in supplemented Chinook populations in the Yakima (Washington) (Waters et al. 2015) and Salmon (Idaho) (Hess et al. 2012; Janowitz-Koch et al. 2018) basins.

Little work toward developing guidelines beyond the HSRG work has taken place. The only notable effort along these lines has been the work of Baskett and Waples (2013), who developed a model very similar to that of Ford (2002), but added the ability to impose density-dependent survival and selection at different life stages. Their qualitative results were similar to Ford's, but the model would require some revision to be used to develop guidelines comparable to the HSRG's.

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[15] Development of conservation importance classifications varied among technical recovery teams (TRTs); for more information, documents produced by the individual TRT's should be consulted.

[16] Withler et al. (2018) noted a non-genetic biological significance to a pHOS level of 30%. Assuming mating is random with respect to origin (HO or NO) in a spawning aggregation of HO and NO fish, NOxNO matings will comprise the majority of matings only if pHOS is less than 30%.

NMFS has not adopted the HSRG gene flow guidelines per se. However, at present the HSRG guidelines are the only scientifically based quantitative gene flow guidelines available for reducing the risk of hatchery-influenced selection. NMFS has considerable experience with the HSRG guidelines. They are based on a model (Ford 2002) developed by a NMFS geneticist, they have been evaluated by a NMFS-lead scientific team (RIST 2009), and NMFS scientists have extended the Ford model for more flexible application of the guidelines to complex situations (Busack 2015) (Section 6.2.1.4.3).

At minimum, we consider the HSRG guidelines a useful screening tool. For a particular program, based on specifics of the program, broodstock composition, and environment, we may consider a pHOS or PNI level to be a lower risk than the HSRG would but, generally, if a program meets HSRG guidelines, we will typically consider the risk levels to be acceptable. However, our approach to application of HSRG concepts varies somewhat from what is found in HSRG documents or in typical application of HSRG concepts. Key aspects of our approach warrant discussion here.

6.2.1.4.2.1. PNI AND SEGREGATED HATCHERY PROGRAMS

The PNI concept has created considerable confusion. Because it is usually estimated by a simple equation that is applicable to integrated programs, and applied in HSRG guidelines only to integrated programs, PNI is typically considered to be a concept that is relevant only to integrated programs. This in turn has caused a false distinction between segregated and integrated programs in terms of perceptions of risk. The simple equation for PNI is:

$PNI \approx pNOB / (pNOB + pHOS)$.

In a segregated program, pNOB equals zero, so by this equation PNI would also be zero. You could easily infer that PNI is zero in segregated programs, but this would be incorrect. The error comes from applying the equation to segregated programs. In integrated programs, PNI can be estimated accurately by the simple equation, and the simplicity of the equation makes it very easy to use. In segregated programs, however, a more complicated equation must be used to estimate PNI. A PNI equation applicable to both integrated and segregated programs was developed over a decade ago by the HSRG (HSRG 2009b, equation 9), but has been nearly completed ignored by parties dealing with the gene flow guidelines:

$$PNI \approx \frac{h^2 + (1.0 - h^2 + \omega^2) * pNOB}{h^2 + (1.0 - h^2 + \omega^2) * (pNOB + pHOS)},$$

where h^2 is heritability and ω^2 is the strength of selection in standard deviation units, squared. Ford (2002) used a range of values for the latter two variables. Substituting those values that created the strongest selection scenarios in his simulations (h^2 of 0.5 and ω^2 of 10), which is appropriate for risk assessment, results in:

$$PNI \approx \frac{0.5 + 10.5 * pNOB}{0.5 + 10.5 * (pNOB + pHOS)}$$

HSRG (2004) offered additional guidance regarding isolated programs, stating that risk increases dramatically as the level of divergence increases, especially if the hatchery stock has been selected directly or indirectly for characteristics that differ from the natural population. More recently, the HSRG concluded that the guidelines for isolated programs may not provide as much protection from fitness loss as the corresponding guidelines for integrated programs (HSRG 2014). This can be easily demonstrated using the equation presented in the previous paragraph: a pHOS of 0.05, the standard for a primary population affected by a segregated program, yields a PNI of 0.49, whereas a pHOS of 0.024 yields a PNI of 0.66, virtually the same as the standard for a primary population affected by an integrated program.

6.2.1.4.2.2. THE EFFECTIVE PHOS CONCEPT

The HSRG recognized that HO fish spawning naturally may on average produce fewer adult progeny than NO spawners, as described above. To account for this difference, the HSRG (2014) defined *effective* pHOS as:

$$pHOS_{eff} = (RRS * HOS_{census}) / (NOS + RRS * HOS_{census}),$$

where RRS is the reproductive success of HO fish relative to that of NO fish. They then recommend using this value in place of $pHOS_{census}$ in PNI calculations.

We feel that adjustment of census pHOS by RRS for this purpose should be done not nearly as freely as the HSRG document would suggest because the Ford (2002) model, which is the foundation of the HSRG gene-flow guidelines, implicitly includes a genetic component of RRS. In that model, hatchery fish are expected to have RRS < 1 (compared to natural fish) due to selection in the hatchery. A component of reduced RRS of hatchery fish is therefore already incorporated in the model and by extension the calculation of PNI. Therefore, reducing pHOS values by multiplying by RRS will result in underestimating the relevant pHOS and therefore overestimating PNI. Such adjustments would be particularly inappropriate for hatchery programs with low pNOB, as these programs may well have a substantial reduction in RRS due to genetic factors already incorporated in the model.

In some cases, adjusting pHOS downward may be appropriate, particularly if there is strong evidence of a non-genetic component to RRS. Wenatchee spring Chinook salmon (Williamson et al. 2010) is an example case with potentially justified adjustment by RRS, where the spatial distribution of NO and HO spawners differs, and the HO fish tend to spawn in poorer habitat. However, even in a situation like the Wenatchee spring Chinook salmon, it is unclear how much of an adjustment would be appropriate.

By the same logic, it might also be appropriate to adjust pNOB in some circumstances. For example, if hatchery juveniles produced from NO broodstock tend to mature early and residualize (due to non-genetic effects of rearing), as has been documented in some spring Chinook salmon and steelhead programs, the “effective” pNOB might be much lower than the census pNOB.

It is important to recognize that PNI is only an approximation of relative trait value, based on a model that is itself very simplistic. To the degree that PNI fails to capture important biological information, it would be better to work to include this biological information in the underlying models rather than make ad hoc adjustments to a statistic that was only intended to be a rough guideline to managers. We look forward to seeing this issue further clarified in the near future. In the meantime, except for cases in which an adjustment for RRS has strong justification, we feel that census pHOS, rather than effective pHOS, is the appropriate metric to use for genetic risk evaluation.

6.2.1.4.2.3. GENE FLOW GUIDELINES IN PHASES OF RECOVERY

In 2012 the HSRG expanded on the original gene flow guidelines/standards by introducing the concept of recovery phases for natural populations (HSRG 2012), and then refined the concept in later documents (HSRG 2014; 2015; 2017). They defined and described four phases:

1. Preservation
2. Re-colonization
3. Local adaptation
4. Fully restored

The HSRG provided guidance on development of quantitative "triggers" for determining when a population had moved (up or down) from one phase to another. As explained in HSRG (2015), in the preservation and re-colonization phase, no PNI levels were specified for integrated programs (Table 38). The emphasis in these phases was to "Retain genetic diversity and identity of the existing population". In the local adaptation phase, when PNI standards were to be applied, the emphasis shifted to "Increase fitness, reproductive success and life history diversity through local adaptation (e.g., by reducing hatchery influence by maximizing *PNI*)". The HSRG provided additional guidance in HSRG (2017), which encouraged managers to use pNOB to "…the extent possible…" during the preservation and recolonization phases.

Table 39. HSRG gene flow guidelines/standards for conservation and harvest programs, based on recovery phase of impacted population (Table 2 from HSRG 2015).

Natural Population		Hatchery Broodstock Management	
Designation	Status	Segregated	Integrated
Primary	Fully Restored	pHOS<5%	PNI>0.67
	Local Adaptation	pHOS<5%	PNI>0.67
	Re-colonization	pHOS<5%	Not Specified
	Preservation	pHOS<5%	Not Specified
Contributing	Fully Restored	pHOS<10%	PNI>0.50
	Local Adaptation	pHOS<10%	PNI>0.50
	Re-colonization	pHOS<10%	Not Specified
	Preservation	pHOS<10%	Not Specified
Stabilizing	Fully Restored	Current Condition	Current Condition
	Local Adaptation	Current Condition	Current Condition
	Re-colonization	Current Condition	Current Condition
	Preservation	Current Condition	Current Condition

We have two concerns regarding the phases of recovery approach. First, although the phase structure is intuitively appealing, no scientific evidence was presented the HSRG for existence of the phases. Second, while we agree that conservation of populations at perilously low abundance may require prioritization of demographic over genetic concerns, we are concerned that high pHOS/low PNI regimes imposed on small recovering populations may prevent them from advancing to higher recovery phases.[17] A WDFW scientific panel reviewing HSRG principles and guidelines reached the same conclusion (Anderson et al. 2020). In response, the HSRG in issued revised guidance for the preservation and recolonization phases (HSRG 2020):

1. *Preservation – No specific pHOS or PNI recommendations, but hatchery managers are encouraged to use as many NOR brood as possible. In some cases (e.g., very low R/S values at low spawner abundances or low intrinsic productivity), it may be preferable to use all available NORs in the hatchery brood and allow only extra hatchery-origin recruits (HORs) to spawn naturally.*

2. *Recolonization – No specific pHOS or PNI recommendations, but managers are encouraged to continue to use some NOR in broodstock (perhaps 10-30 percent of NORs), while allowing the majority of NORs to spawn naturally.*

6.2.1.4.3. Extension of PNI modeling to more than two population components

The Ford (2002) model considered a single population affected by a single hatchery program—basically two population units connected by gene flow—but the recursion equations underlying

[17] According to Andy Appleby, past HSRG co-chair, the HSRG never intended this guidance to be interpreted as total disregard for pHOS/PNI standards in the preservation and recovery phases (Appleby 2020).

the model are easily expanded to more than two populations (Busack 2015). This has resulted in tremendous flexibility in applying the PNI concept to hatchery consultations.

A good example is a system of genetically linked hatchery programs, an integrated program in which in which returnees from a (typically smaller) integrated hatchery program are used as broodstock for a larger segregated program, and both programs contribute to pHOS (Figure 12). It seems logical that this would result in less impact on the natural population than if the segregated program used only its own returnees as broodstock, but because the two-population implementation of the Ford model did not apply, there was no way to calculate PNI for this system.

Extending Ford's recursion equations (equations 5 and 6) to three populations allowed us to calculate PNI for a system of this type. We successfully applied this approach to link two spring Chinook salmon hatchery programs: Winthrop NFH (segregated) and Methow FH (integrated). By using some level of Methow returnees as broodstock for the Winthrop program, PNI for the natural population could be increased significantly[18](Busack 2015). We have since used the multi-population PNI model in numerous hatchery program consultations in Puget Sound and the Columbia basin, and have extended to it to include as many as ten hatchery programs and natural production areas.

[18] Such programs can lower the effective size of the system, but the model of Tufto (Section 6.2.1.3) can easily be applied to estimate this impact.

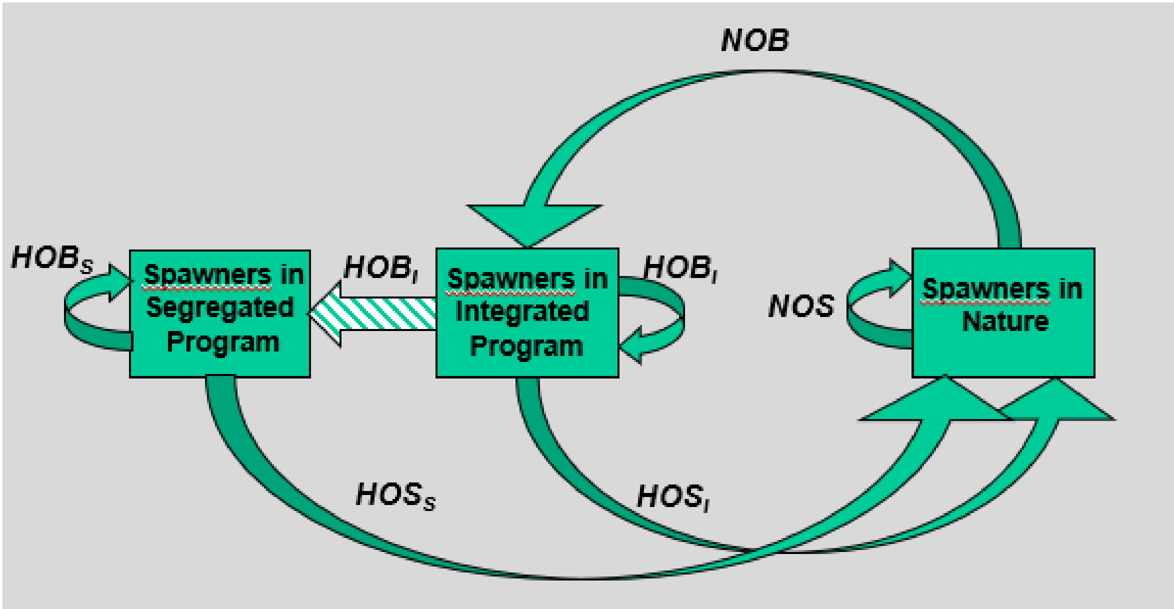

Figure 12. Example of genetically linked hatchery programs. The natural population is influenced by hatchery-origin spawners from an integrated (HOS_I) and a segregated program (HOS_S). The integrated program uses a mix of natural-origin (NOB) and its own returnees (HOB_I) as broodstock, but the segregated uses returnees from the integrated program (HOB_I above striped arrow) as all or part of its broodstock, genetically linking the two programs. The system illustrated here is functionally equivalent to the HSRG's *(HSRG 2014)* "stepping stone" concept.

6.2.1.4.4. California HSRG

Another scientific team was assembled to review hatchery programs in California and this group developed guidelines that differed somewhat from those developed by the "Northwest" HSRG (California HSRG 2012). The California team:

- Felt that truly isolated programs in which no HO returnees interact genetically with natural populations were impossible in California, and was "generally unsupportive" of the concept of segregated programs. However, if programs were to be managed as isolated, they recommend a pHOS of less than 5 percent.

- Rejected development of overall pHOS guidelines for integrated programs because the optimal pHOS will depend upon multiple factors, such as "the amount of spawning by NO fish in areas integrated with the hatchery, the value of pNOB, the importance of the integrated population to the larger stock, the fitness differences between HO and NO fish, and societal values, such as angling opportunity."

- Recommended that program-specific plans be developed with corresponding population-specific targets and thresholds for pHOS, pNOB, and PNI that reflect these factors. However, they did state that PNI should exceed 50 percent in most cases, although in supplementation or reintroduction programs the acceptable pHOS could be much higher than 5 percent, even approaching 100 percent at times.

- Recommended for conservation programs that pNOB approach 100 percent, but pNOB levels should not be so high they pose demographic risk to the natural population by taking too large a proportion of the population for broodstock.

6.2.2. Ecological effects

Ecological effects for this factor (i.e., hatchery fish and the progeny of naturally spawning hatchery fish on the spawning grounds) refer to effects from competition for spawning sites and redd superimposition, contributions to marine-derived nutrients, and the removal of fine sediments from spawning gravels. Ecological effects on the spawning grounds may be positive or negative.

To the extent that hatcheries contribute added fish to the ecosystem, there can be positive effects. For example, when anadromous salmonids return to spawn, hatchery-origin and natural-origin alike, they transport marine-derived nutrients stored in their bodies to freshwater and terrestrial ecosystems. Their carcasses provide a direct food source for juvenile salmonids and other fish, aquatic invertebrates, and terrestrial animals, and their decomposition supplies nutrients that may increase primary and secondary production (Kline et al. 1990; Piorkowski 1995; Larkin and Slaney 1996; Gresh et al. 2000; Murota 2003; Quamme and Slaney 2003; Wipfli et al. 2003). As a result, the growth and survival of juvenile salmonids may increase (Hager and Noble 1976; Bilton et al. 1982; Holtby 1988; Ward and Slaney 1988; Hartman and Scrivener 1990; Johnston et al. 1990; Larkin and Slaney 1996; Quinn and Peterson 1996; Bradford et al. 2000; Bell 2001; Brakensiek 2002).

Additionally, studies have demonstrated that perturbation of spawning gravels by spawning salmonids loosens cemented (compacted) gravel areas used by spawning salmon (e.g., (Montgomery et al. 1996). The act of spawning also coarsens gravel in spawning reaches, removing fine material that blocks interstitial gravel flow and reduces the survival of incubating eggs in egg pockets of redds.

The added spawner density resulting from hatchery-origin fish spawning in the wild can have negative consequences, such as increased competition, and potential for redd superimposition. Although males compete for access to females, female spawners compete for spawning sites. Essington et al. (2000) found that aggression of both sexes increases with spawner density, and is most intense with conspecifics. However, females tended to act aggressively towards heterospecifics as well. In particular, when there is spatial overlap between natural-and hatchery-origin spawners, the potential exists for hatchery-derived fish to superimpose or destroy the eggs and embryos of ESA-listed species. Redd superimposition has been shown to be a cause of egg loss in pink salmon and other species (e.g., Fukushima et al. 1998).

6.2.3. Adult Collection Facilities

The analysis also considers the effects from encounters with natural-origin fish that are incidental to broodstock collection. Here, NMFS analyzes effects from sorting, holding, and handling natural-origin fish in the course of broodstock collection. Some programs collect their broodstock from fish voluntarily entering the hatchery, typically into a ladder and holding pond, while others sort through the run at large, usually at a weir, ladder, or sampling facility. The more a hatchery program accesses the run at large for hatchery broodstock – that is, the more fish that are handled or delayed during migration – the greater the negative effect on natural- and hatchery-origin fish that are intended to spawn naturally and on ESA-listed species. The information NMFS uses for this analysis includes a description of the facilities, practices, and protocols for collecting broodstock, the environmental conditions under which broodstock collection is conducted, and the encounter rate for ESA-listed fish.

NMFS also analyzes the effects of structures, either temporary or permanent, that are used to collect hatchery broodstock, and remove hatchery fish from the river or stream and prevent them from spawning naturally, on juvenile and adult fish from encounters with these structures. NMFS determines through the analysis, for example, whether the spatial structure, productivity, or abundance of a natural population is affected when fish encounter a structure used for broodstock collection, usually a weir or ladder.

6.3. Factor 3. Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas, the migratory corridor, estuary, and ocean (Revised June 1, 2020)

NMFS also analyzes the potential for competition, predation, and disease when the progeny of naturally spawning hatchery fish and hatchery releases share juvenile rearing areas.

6.3.1. Competition

Competition and a corresponding reduction in productivity and survival may result from direct or indirect interactions. Direct interactions occur when hatchery-origin fish interfere with the accessibility to limited resources by natural-origin fish, and indirect interactions occur when the utilization of a limited resource by hatchery fish reduces the amount available for fish from the natural population (Rensel et al. 1984). Natural-origin fish may be competitively displaced by hatchery fish early in life, especially when hatchery fish are more numerous, are of equal or greater size, take up residency before natural-origin fry emerge from redds, and residualize. Hatchery fish might alter natural-origin salmon behavioral patterns and habitat use, making natural-origin fish more susceptible to predators (Hillman and Mullan 1989; Steward and Bjornn 1990). Hatchery-origin fish may also alter natural-origin salmonid migratory responses or movement patterns, leading to a decrease in foraging success by the natural-origin fish (Hillman and Mullan 1989; Steward and Bjornn 1990). Actual impacts on natural-origin fish thus depend on the degree of dietary overlap, food availability, size-related differences in prey selection, foraging tactics, and differences in microhabitat use (Steward and Bjornn 1990).

Several studies suggest that salmonid species and migratory forms that spend longer periods of time in stream habitats (e.g., coho salmon and steelhead) are more aggressive than those that outmigrate at an earlier stage (Hutchison and Iwata 1997). The three least aggressive species generally outmigrate to marine (chum salmon) or lake (kokanee and sockeye salmon) habitats as post-emergent fry. The remaining (i.e., more aggressive) species all spend one year or more in stream habitats before outmigrating. Similarly, Hoar (1951) did not observe aggression or territoriality in fry of early migrants (chum and pink salmon), in contrast to fry of a later migrating species (coho salmon) which displayed high levels of both behaviors. Hoar (1954) rarely observed aggression in sockeye salmon fry, and observed considerably less aggression in sockeye than coho salmon smolts. Taylor (1990) found that Chinook salmon populations that outmigrate as fry are less aggressive than those that outmigrate as parr, which in turn are less aggressive than those that outmigrate as yearlings.

Although *intraspecific* interactions are expected to be more frequent/intense than *interspecific* interactions (e.g., Hartman 1965; Tatara and Berejikian 2012), this apparent relationship between aggression and stream residence appears to apply to *interspecific* interactions as well. For example, juvenile coho salmon are known to be highly aggressive toward other species (e.g., Stein et al. 1972; Taylor 1991). Taylor (1991) found that coho salmon were much more aggressive toward size-matched *ocean*-type Chinook salmon (early outmigrants), but only moderately more aggressive toward size-matched *stream*-type Chinook salmon (later outmigrants). Similarly, the findings of Hasegawa et al. (2014) indicate that masu salmon (*O. masou*) , which spend 1 to 2 years in streams before outmigrating, dominate and outcompete the early-migrating chum salmon.

A few exceptions to this general stream residence-aggression pattern have been observed (e.g., Lahti et al. 2001; Young 2003; Hasegawa et al. 2004; Young 2004), but all the species and migratory forms evaluated in these studies spend one year or more in stream habitat before outmigrating. Other than the Taylor (1991) and Hasegawa et al. (2014) papers noted above, we are not aware of any other studies that have looked specifically at interspecific interactions between early-outmigrating species (e.g., sockeye, chum, and pink salmon) and those that rear longer in streams.

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

A proportion of the smolts released from a hatchery may not migrate to the ocean but rather reside for a time near the release point. These non-migratory smolts (residuals) may compete for food and space with natural-origin juvenile salmonids of similar age (Bachman 1984; Tatara and Berejikian 2012). Although this behavior has been studied and observed most frequently in hatchery steelhead, residualism has been reported as a potential issue for hatchery coho and Chinook salmon as well (Parkinson et al. 2017). Adverse impacts of residual hatchery Chinook and coho salmon on natural-origin salmonids can occur, especially given that the number of smolts per release is generally higher than for steelhead; however, residualism in these species has not been as widely investigated as it has in steelhead. Therefore, for all species, monitoring of natural stream areas near hatchery release points may be necessary to determine the potential effects of hatchery smolt residualism on natural-origin juvenile salmonids.

The risk of adverse competitive interactions between hatchery- and natural-origin fish can be minimized by:

- Releasing hatchery smolts that are physiologically ready to migrate. Hatchery fish released as smolts emigrate seaward soon after liberation, minimizing the potential for competition with juvenile natural-origin fish in freshwater (Steward and Bjornn 1990; California HSRG 2012)
- Rearing hatchery fish to a size sufficient to ensure that smoltification occurs
- Releasing hatchery smolts in lower river areas, below rearing areas used by natural-origin juveniles
- Monitoring the incidence of non-migratory smolts (residuals) after release and adjusting rearing strategies, release location, and release timing if substantial competition with natural-origin juveniles is likely

Critical information for analyzing competition risk is quality and quantity of spawning and rearing habitat in the action area,[19] 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.

6.3.2. Predation

Predation is another potential ecological effect of hatchery releases. Predation, either direct (consumption by hatchery fish) or indirect (increases in predation by other predator species due to enhanced attraction), can result from hatchery fish released into the wild. Here we consider predation by hatchery-origin fish, by the progeny of naturally spawning hatchery fish, and by birds and other non-piscine predators attracted to the area by an abundance of hatchery fish.

Hatchery fish originating from egg boxes and fish planted as non-migrant fry or fingerlings can prey upon fish from the local natural population during juvenile rearing. Hatchery fish released at a later stage that are more likely to migrate quickly to the ocean, can still prey on fry and fingerlings that are encountered during the downstream migration. Some of these hatchery fish do not emigrate and instead take up residence in the stream where they can prey on stream-rearing juveniles over a more prolonged period, as discussed above. The progeny of naturally spawning hatchery fish also can prey on fish from a natural population and pose a threat.

[19] "Action area," in ESA section 7 analysis documents, means all areas to be affected directly or indirectly by the action in which the effects of the action can be meaningfully detected and evaluated.

Predation may be greatest when large numbers of hatchery smolts encounter newly emerged fry or fingerlings, or when hatchery fish are large relative to natural-origin fish (Rensel et al. 1984). Due to their location in the stream, size, and time of emergence, newly emerged salmonid fry are likely to be the most vulnerable to predation. Their vulnerability is greatest immediately upon emergence from the gravel and then decreases as they move into shallow, shoreline areas (USFWS 1994). Emigration out of important rearing areas and foraging inefficiency of newly released hatchery smolts may reduce the degree of predation on salmonid fry (USFWS 1994).

Some reports suggest that hatchery fish can prey on fish that are as large as 1/2 their length (Hargreaves and LeBrasseur 1986; Pearsons and Fritts 1999; HSRG 2004 and references therein), but other studies have concluded that salmonid predators prey on fish up to 1/3 their length (Horner 1978; Hillman and Mullan 1989; Beauchamp 1990; Cannamela 1992; CBFWA 1996; Daly et al. 2009). Hatchery fish may also be less efficient predators as compared to their natural-origin conspecifics, reducing the potential for predation impacts (Sosiak et al. 1979; Bachman 1984; Olla et al. 1998).

Size is an important determinant of how piscivorous hatchery-origin fish are. Keeley and Grant (2001) reviewed 93 reports detailing the relationship between size and piscivory in 17 species of stream-dwelling salmonids. *O. mykiss* and Pacific salmon were well represented in the reviewed reports. Although there is some variation between species, stream-dwelling salmonids become piscivorous at about 100 mm FL, and then piscivory rate increases with increasing size. For example:

- For 140 mm fish, 15 percent would be expected to have fish in their diet but would not be primarily piscivorous; 2 percent would be expected to be primarily piscivorous (> 60 percent fish in diet).
- For 200 mm fish, those figures go to 32 percent (fish in diet) and 11 percent (primarily piscivorous).

The implication for hatchery-origin fish is pretty clear: larger hatchery-origin fish present a greater predation risk because more of them eat fish, and more of them eat primarily fish.

There are two key measures that hatchery programs can implement to reduce or avoid the threat of predation:

- Ensuring that a high proportion of the hatchery fish are fully smolted. Juvenile salmon tend to migrate seaward rapidly when fully smolted, limiting the duration of interaction between hatchery- and natural-origin fish present within and downstream of release areas.
- Releasing hatchery smolts in lower river areas near river mouths and below upstream areas used for stream-rearing young-of-the-year naturally produced salmon fry, thereby reducing the likelihood for interaction between the hatchery and naturally produced fish.

The two measures just mentioned will reduce minimize residualism as well as predation. The following measures can also help minimize residualism:

- Allowing smolts to exit the hatchery facility volitionally rather than forcing them out

- Ensuring that hatchery rearing regimes and growth rates produce fish that meet the minimum size needed for smolting, but are not so large as to induce desmoltification or early maturation

- Removing potential residuals based on size or appearance before release. This is likely impractical in most cases

6.3.3. Disease

The release of hatchery fish, as well as hatchery effluent, into juvenile rearing areas can lead to pathogen transmission; and contact with chemicals, or altering environmental conditions (e.g., dissolved oxygen) can result in disease outbreaks. Fish diseases can be subdivided into two main categories:

- Infectious diseases are those caused by pathogens such as viruses, bacteria, and parasites.
- Noninfectious diseases are those that cannot be transmitted between fish and are typically caused by environmental factors (e.g., low dissolved oxygen), but can also have genetic causes.

Pathogens can be categorized as exotic or endemic. For our purposes, exotic pathogens are those that have little to no history of occurrence within the boundaries of the state where the hatchery program is located. For example, *Oncorhynchus masou* virus (OMV) would be considered an exotic pathogen if identified anywhere in Washington state because it is not known to occur there. Endemic pathogens are native to a state, but may not be present in all watersheds.

In natural fish populations, the risk of disease associated with hatchery programs may increase through a variety of mechanisms (Naish et al. 2007), discussed below:

- Introduction of exotic pathogens
- Introduction of endemic pathogens to a new watershed
- Intentional release of infected fish or fish carcasses
- Continual pathogen reservoir
- Pathogen amplification

The last two terms above require some explanation. A continual pathogen reservoir is created when a standing crop of susceptible hosts keeps the pathogen from burning itself out. For example, stocking certain susceptible strains of trout can ensure that the pathogen is always present. Pathogen amplification occurs when densities of pathogens that are already present increase beyond baseline levels due to hatchery activities. A good example is sea lice in British Columbia (e.g., Krkošek 2010). The pathogen is endemic to the area and is normally present in wild populations, but salmon net pens potentially allow for a whole lot more pathogen to be produced and added to the natural environment.

Continual pathogen reservoir and pathogen amplification can exist at the same time. For example, stocked rainbow trout can amplify a naturally occurring pathogen if they become infected, and if stocking occurs every year, the stocked animals also can act as a continual pathogen reservoir.

Pathogen transmission between hatchery and natural fish can occur indirectly through hatchery water influent/effluent or directly via contact with infected fish. Within a hatchery, the likelihood of transmission leading to an epizootic (i.e., disease outbreak) is increased compared to the natural environment because hatchery fish are reared at higher densities and closer proximity than would naturally occur. During an epizootic, hatchery fish can shed relatively large amounts of pathogen into the hatchery effluent and ultimately, the environment, amplifying pathogen numbers. However, few, if any, examples of hatcheries contributing to an increase in disease in natural populations have been reported (Steward and Bjornn 1990; Naish et al. 2007). This lack of reporting is because both hatchery and natural-origin salmon and trout are susceptible to the same pathogens (Noakes et al. 2000), which are often endemic and ubiquitous (e.g., *Renibacterium salmoninarum,* the cause of Bacterial Kidney Disease).

Several state, federal, and tribal fish health policies, in some cases combined with state law, limit the disease risks associated with hatchery programs (IHOT 1995; ODFW 2003; USFWS 2004; NWIFC and WDFW 2006). Specifically, the policies govern the transfer of fish, eggs, carcasses, and water to prevent the spread of exotic and endemic pathogens. For example, the policy for Washington (NWIFC and WDFW 2006) divides the state into 14 Fish Health Management Zones[20] (FHMZs), and specifies requirements for transfers within and across FHMZs. Washington state law lists pathogens for which monitoring and reporting is required (regulated pathogens), and the Washington Department of Fish and Wildlife typically requires monitoring and reporting for additional pathogens. Reportable pathogen occurrence at a Washington hatchery is communicated to the state veterinarian, but also to fish health personnel at a variety of levels: local, tribal, state, and federal.

For all pathogens, both reportable and non-reportable, pathogen spread and amplification are minimized through regular monitoring (typically monthly) removing mortalities, and disinfecting all eggs. Vaccines may provide additional protection from certain pathogens when available (e.g., *Vibrio anguillarum*). If a pathogen is determined to be the cause of fish mortality, treatments (e.g., antibiotics) will be used to limit further pathogen transmission and amplification. Some pathogens, such as *infectious hematopoietic necrosis virus* (IHNV), have no known treatment. Thus, if an epizootic occurs for those pathogens, the only way to control pathogen amplification is to cull infected individuals or terminate all susceptible fish. In addition, current hatchery operations often rear hatchery fish on a timeline that mimics their natural life history, which limits the presence of fish susceptible to pathogen infection and prevents hatchery fish from becoming a pathogen reservoir when no natural fish hosts are present.

[20] Puget Sound consists of five FHMZs, the Columbia basin only 1.

In addition to the state, federal, and tribal fish health policies, disease risks can be further minimized by preventing pathogens from entering the hatchery through the treatment of incoming water (e.g., by using ozone), or by leaving the hatchery through hatchery effluent (Naish et al. 2007). Although preventing the exposure of fish to any pathogens before their release into the natural environment may make the hatchery fish more susceptible to infection after release into the natural environment, reduced fish densities in the natural environment compared to hatcheries likely reduces the risk of fish encountering pathogens at infectious levels (Naish et al. 2007).

Treating the hatchery effluent reduces pathogen amplification, but does not reduce disease outbreaks within the hatchery caused by pathogens present in the incoming water supply. Another challenge with treating hatchery effluent is the lack of reliable, standardized guidelines for testing or a consistent practice of controlling pathogens in effluent (LaPatra 2003). However, hatchery facilities located near marine waters likely limit freshwater pathogen amplification downstream of the hatchery without human intervention because the pathogens are killed before transmission to fish when the effluent mixes with saltwater.

Noninfectious diseases are typically caused by environmental factors (e.g., low dissolved oxygen). Hatchery facilities routinely use a variety of chemicals for treatment and sanitation purposes. Chlorine levels in the hatchery effluent, specifically, are monitored with a National Pollutant Discharge Elimination System (NPDES) permit administered by the Environmental Protection Agency. Other chemicals are discharged in accordance with manufacturer instructions. The NPDES permit also requires regular monitoring of settleable and unsettleable solids, temperature, and dissolved oxygen in the hatchery effluent to ensure compliance with environmental standards and to prevent fish mortality.

In contrast to infectious diseases, which typically are manifest by a limited number of life stages and over a protracted time period, non-infectious diseases caused by environmental factors typically affect all life stages of fish indiscriminately and over a relatively short time period. Because of the vast literature available on rearing of salmon and trout in aquaculture, one group of non-infectious diseases that are expected to occur rarely in current hatchery operations are those caused by nutritional deficiencies

6.3.4. Ecological Modeling

While competition, predation, and disease are important effects on consider, they are events which can rarely, if ever, be observed and directly measured. However, these behaviors have been established to the point where NMFS can model these potential effects on the species based on known factors that lead to competition or predation occurring. In our Biological Opinions, we use the Predation, Competition, and Delayed Mortality (PCD) Risk model version 4.1.0 based on Pearsons and Busack (2012). PCD Risk is an individual-based model that simulates the potential number of ESA-listed natural-origin juveniles lost to competition, predation, and delayed mortality (from disease, starvation, etc.) due to the release of hatchery-origin juveniles in the freshwater environment.

The PCD Risk model has undergone considerable modification since 2012 to increase supportability, reliability, transparency, and ease of use. Notably, the current version no longer operates as a compiled FORTRAN program in a Windows environment. The current version of the PCD Risk model (Version 4.1.0) is an R package (R Core Team 2019). A macro-enabled Excel workbook is included as an interface to the model that is used as a template for creating model scenarios, running the model, and reporting results. Users with knowledge of the R programming language have flexibility to develop and run more complex scenarios than can be created by the Excel template. The current model version no longer has a probabilistic mode for defining input parameter values. We also further refined the model by allowing for multiple hatchery release groups of the same species to be included in a single run.

There have also been a few recent modifications to the logic and parameterization of the model. The first was the elimination of competition equivalents and replacement of the disease function with a delayed mortality parameter. The rationale behind this change was to make the model more realistic; competition rarely directly results in death in the model because it takes many competitive interactions to suffer enough weight loss to kill a fish. Weight loss is how adverse competitive interactions are captured in the model. However, fish that lose competitive interactions and suffer some degree of weight loss are likely more vulnerable to mortality from other factors such as disease or predation by other fauna such as birds or bull trout. Now, at the end of each run, the competitive impacts for each fish are assessed, and the fish has a probability of delayed mortality based on the competitive impacts. This function will be subject to refinement based on research. For now, the probability of delayed mortality is equal to the proportion of a fish's weight loss. For example, if a fish has lost 10 percent of its body weight due to competition and a 50 percent weight loss kills a fish, then it has a 20 percent probability of delayed death, (0.2 = 0.1/0.5).

Another change in logic was to the habitat segregation parameter to make it size-independent or size-dependent based on hatchery species. Some species, such as coho salmon, are more aggressive competitors than other species, such as chum and sockeye salmon. To represent this difference in behavior more accurately in the model, for less aggressive species such as chum and sockeye salmon, hatchery fish segregation is random, whereas for more aggressive species, segregation occurs based on size, with the largest fish eliminated from the model preferentially.

6.3.5. Acclimation

One factor that can affect hatchery fish distribution and the potential to spatially overlap with natural-origin spawners, and thus the potential for genetic and ecological impacts, is the acclimation (the process of allowing fish to adjust to the environment in which they will be released) of hatchery juveniles before release. Acclimation of hatchery juveniles before release increases the probability that hatchery adults will hone back to the release location, reducing their potential to stray into natural spawning areas.

Acclimating fish for a time also allows them to recover from the stress caused by the transportation of the fish to the release location and by handling. Dittman and Quinn (2008) provide an extensive literature review and introduction to homing of Pacific salmon. They note that, as early as the 19th century, marking studies had shown that salmonids would home to the stream, or even the specific reach, where they originated. The ability to home to their home or "natal" stream is thought to be due to odors to which the juvenile salmonids were exposed while living in the stream (olfactory imprinting) and migrating from it years earlier (Dittman and Quinn 2008; Keefer and Caudill 2014). Fisheries managers use this innate ability of salmon and steelhead to home to specific streams by using acclimation ponds to support the reintroduction of species into newly accessible habitat or into areas where they have been extirpated (Quinn 1997; Dunnigan 1999; YKFP 2008).

Dittman and Quinn (2008) reference numerous experiments that indicated that a critical period for olfactory imprinting is during the parr-smolt transformation, which is the period when the salmonids go through changes in physiology, morphology, and behavior in preparation for transitioning from fresh water to the ocean (Hoar 1976; Beckman et al. 2000). Salmon species with more complex life histories (e.g., sockeye salmon) may imprint at multiple times from emergence to early migration (Dittman et al. 2010). Imprinting to a particular location, be it the hatchery, or an acclimation pond, through the acclimation and release of hatchery salmon and steelhead is employed by fisheries managers with the goal that the hatchery fish released from these locations will return to that particular site and not stray into other areas (Fulton and Pearson 1981; Quinn 1997; Hard and Heard 1999; Bentzen et al. 2001; Kostow 2009; Westley et al. 2013). However, this strategy may result in varying levels of success in regards to the proportion of the returning fish that stray outside of their natal stream. (e.g., (Kenaston et al. 2001; Clarke et al. 2011).

Increasing the likelihood that hatchery salmon and steelhead home to a particular location is one measure that can be taken to reduce the proportion of hatchery fish in the naturally spawning population. When the hatchery fish home to a particular location, those fish can be removed (e.g., through fisheries, use of a weir) or they can be isolated from primary spawning areas. Factors that can affect the success of acclimation as a tool to improve homing include:

- Timing acclimation so that a majority of the hatchery juveniles are going through the parr-smolt transformation during acclimation
- A water source distinct enough to attract returning adults
- Whether hatchery fish can access the stream reach where they were released
- Whether the water quantity and quality are such that returning hatchery fish will hold in that area before removal and/or their harvest in fisheries.

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

NMFS analyzes proposed research, monitoring, and evaluation (RM&E) activities associated with proposed hatchery programs for their effects on listed species and designated critical habitat. Such activities include, but are not limited to, the following:

- Observation during surveying (in-water or from the bank)
- Collecting and handling (purposeful or inadvertent)
- Sampling (e.g., the removal of scales and tissues)
- Tagging and fin-clipping, and observing the fish (in-water or from the bank)

Some RM&E actions may capture fish, induce injury, cause behavioral changes, and affect redds. Any negative effects from RM&E are weighed against the value of new information, particularly information that tests key assumptions and that reduces uncertainty. NMFS also considers the overall effectiveness of the RM&E program. There are five factors that we consider when assessing the beneficial and negative effects of hatchery RM&E:

- Status of the affected species and effects of the proposed RM&E on the species and on designated critical habitat
- Critical uncertainties concerning effects on the species
- Performance monitoring to determine the effectiveness of the hatchery program at achieving its goals and objectives
- Identifying and quantifying collateral effects
- Tracking compliance of the hatchery program with the terms and conditions for implementing the program.

After assessing the proposed hatchery RM&E, and before making any recommendations to the action agency(s), NMFS considers the benefit or usefulness of new or additional information, whether the desired information is available from another source, the effects on ESA-listed species, and cost. The following subsections describe effects on listed fish species associated with typical RM&E activities and risk mitigation measures.

6.4.1. Observing

For some activities, listed fish and redds of listed fish are observed in-water (e.g., by snorkel surveys, wading surveys, or observation from the banks). Direct observation is the least disruptive method for determining a species' presence/absence and estimating its relative numbers. Effects of direct observation are also generally the shortest-lived and least harmful of the research activities discussed in this section because a cautious observer can effectively obtain data while only slightly disrupting fish behavior and causing minimal to no disturbance to redds. Fish frightened by the turbulence and sound created by observers are likely to seek temporary refuge in deeper water, or behind/under rocks or vegetation. In extreme cases, some individuals may leave a particular pool or habitat type and then return when observers leave the area. These avoidance behaviors are expected to be in the range of normal predator and disturbance behaviors, and are typically not expected to significantly disrupt normal behavioral patterns or create the likelihood of injury.

Redds may be observed or encountered during some RM&E activities. Trained and knowledgeable surveyors are typically aware of risk reduction measures, such as not walking on redds, avoiding disturbance to nearby sediments and gravel, affording disturbed fish time and space to reach cover, and minimizing time present.

6.4.2. Capturing/handling

Any physical handling or psychological disturbance is known to be stressful to fish (Sharpe et al. 1998). Primary contributing factors to stress and death from handling are excessive doses of anesthetic, differences in water temperatures (between the river and holding vessel), dissolved oxygen conditions, the amount of time fish are held out of the water, and physical trauma. Stress increases rapidly if the water temperature exceeds 18ºC or dissolved oxygen is below saturation. Fish transferred to holding tanks can experience trauma if care is not taken in the transfer process, and fish can experience stress and injury from overcrowding in traps if the traps are not emptied regularly. Decreased survival can result from high stress levels, and may also increase the potential for vulnerability to subsequent challenges (Sharpe et al. 1998).

NMFS has developed general guidelines to reduce impacts when collecting listed adult and juvenile salmonids (NMFS 2000; 2008a) that have been incorporated as terms and conditions into section 7 opinions and section 10 permits for research and enhancement. Additional monitoring principles for supplementation programs have been developed by Galbreath et al. (2008).

6.4.3. Fin clipping and tagging

Many studies have examined the effects of fin clips on fish growth, survival, and behavior. Although the results of these studies vary somewhat, it appears that generally fin clips do not alter fish growth (Brynildson and Brynildson 1967; Gjerde and Refstie 1988). Mortality among fin-clipped fish is variable, but can be as high as 80 percent (Nicola and Cordone 1973). In some cases, though, no significant difference in mortality was found between clipped and un-clipped fish (Gjerde and Refstie 1988; Vincent-Lang 1993). The mortality rate typically depends on which fin is clipped. Recovery rates are generally higher for adipose- and pelvic-fin-clipped fish than for those that have clipped pectoral, dorsal, or anal fins (Nicola and Cordone 1973), probably because the adipose and pelvic fins are not as important as other fins for movement or balance (McNeil and Crossman 1979). However, some work has shown that fish without an adipose fin may have a more difficult time swimming through turbulent water (Reimchen and Temple 2003; Buckland-Nicks et al. 2011).

In addition to fin clipping, two commonly available tags are available to differentially mark fish: passive integrated transponder (PIT) tags, and coded-wire tags (CWTs). PIT tags consist of small radio transponders that transmit an ID number when interrogated by a reader device.[21] CWTs are small pieces of wire that are detected magnetically and may contain codes[22] that can be read visually once the tag is excised from the fish.

PIT tags are inserted into the body cavity of the fish just in front of the pelvic girdle. The tagging procedure requires that the fish be captured and extensively handled. Thus, tagging needs to take place where there is cold water of high quality, a carefully controlled environment for administering anesthesia, sanitary conditions, quality control checking, and a recovery tank.

Most studies have concluded that PIT tags generally have very little effect on growth, mortality, or behavior. Early studies of PIT tags showed no long-term effect on growth or survival (Prentice and Park 1984; Prentice et al. 1987; Rondorf and Miller 1994). In a study between the tailraces of Lower Granite and McNary Dams (225 km), Hockersmith et al. (2000) concluded that the

[21] The same technology, more commonly called RFID (radio frequency identification), is widely used in inventory control and to tag pets.
[22] Tags without codes are called blank wire tags (BWTs).

performance of yearling Chinook salmon was not adversely affected by orally or surgically implanted sham radio tags or PIT tags. However, (Knudsen et al. 2009) found that, over several brood years, PIT tag induced smolt-adult mortality in Yakima River spring Chinook salmon averaged 10.3 percent and was at times as high as 33.3 percent.

CWTs are made of magnetized, stainless-steel wire and are injected into the nasal cartilage of a salmon and thus cause little direct tissue damage (Bergman et al. 1968; Bordner et al. 1990). The conditions under which CWTs should be inserted are similar to those required for PIT tags. A major advantage to using CWTs is that they have a negligible effect on the biological condition or response of tagged salmon (Vander Haegen et al. 2005); however, if the tag is placed too deeply in the snout of a fish, it may kill the fish, reduce its growth, or damage olfactory tissue (Fletcher et al. 1987; Peltz and Miller 1990). This latter effect can create problems for species like salmon because they use olfactory clues to guide their spawning migrations (Morrison and Zajac 1987).

Mortality from tagging is both acute (occurring during or soon after tagging) and delayed (occurring long after the fish have been released into the environment). Acute mortality is caused by trauma induced during capture, tagging, and release—it can be reduced by handling fish as gently as possible. Delayed mortality occurs if the tag or the tagging procedure harms the animal. Tags may cause wounds that do not heal properly, may make swimming more difficult, or may make tagged animals more vulnerable to predation (Howe and Hoyt 1982; Matthews and Reavis 1990; Moring 1990). Tagging may also reduce fish growth by increasing the energetic costs of swimming and maintaining balance.

6.4.4. Masking

Hatchery actions also must be assessed for risk caused by masking effects, defined as when hatchery fish included in the Proposed Action are not distinguishable from other fish. Masking undermines and confuses RM&E, and status and trends monitoring. Both adult and juvenile hatchery fish can have masking effects. When presented with a proposed hatchery action, NMFS analyzes the nature and level of uncertainties caused by masking, and whether and to what extent listed salmon and steelhead are at increased risk as a result of misidentification in status evaluations. The analysis also considers the role of the affected salmon and steelhead population(s) in recovery and whether unidentifiable hatchery fish compromise important RM&E.

6.5. FACTOR 5. CONSTRUCTION, OPERATION, AND MAINTENANCE, OF FACILITIES THAT EXIST BECAUSE OF THE HATCHERY PROGRAM

The construction/installation, operation, and maintenance of hatchery facilities can alter fish behavior and can injure or kill eggs, juveniles, and adults. These actions can also degrade habitat function and reduce or block access to spawning and rearing habitats altogether. Here, NMFS analyzes changes to: riparian habitat, channel morphology, habitat complexity, in-stream substrates, and water quantity and quality attributable to operation, maintenance, and construction activities. NMFS also confirms whether water diversions and fish passage facilities are constructed and operated consistent with NMFS criteria.

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

There are two aspects of fisheries that are potentially relevant to NMFS' analysis:

1) Fisheries that would not exist but for the program that is the subject of the Proposed Action, and listed species are inadvertently and incidentally taken in those fisheries.
2) Fisheries that are used as a tool to prevent the hatchery fish associated with the HGMP, including hatchery fish included in an ESA-listed salmon ESU or steelhead DPS, from spawning naturally.