**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 Chinook Salmon Hatchery Programs, ESA section 10(a)(1)(A) permits, numbers 16607–2R and 16615–2R

NMFS Consultation Numbers: WCR-2018-9988

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

Program Operators: 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 Determinations:

| **ESA-Listed Species** | **Status** | **Is Action Likely to Adversely Affect Species or Critical Habitat?** | **Is Action Likely To Jeopardize the Species?** | **Is Action Likely To Destroy or Adversely Modify Critical Habitat?** |
|---|---|---|---|---|
| Snake River fall Chinook salmon (*Oncorhynchus tshawytscha*) | Threatened | Yes | No | No |
| Snake River spring/summer Chinook salmon (*O. tshawytscha*) | Threatened | Yes | No | No |
| Snake River steelhead (*O.mykiss*) | Threatened | Yes | No | No |
| Snake River sockeye salmon (*O. nerka*) | Endangered | Yes | No | No |

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

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

Issued By: FOR
Barry Thom
Regional Administrator

Date: 8/13/2018

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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 Section 2 and 3, below.

### 1.1.Background

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

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

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

Pursuant to sections 7(a)(2) of the Endangered Species Act (ESA) and associated regulations at 50 CFR 223.203(b)(6), the National Marine Fisheries Service (NMFS) is reviewing a series of salmonid hatchery programs to determine whether the programs meet the regulatory requirements, including a finding that they will not appreciably reduce the likelihood of survival and recovery of threatened salmon or steelhead. If NMFS finds that the requirements are met, NMFS will issue section 10(a)(1)(A) permits and the prohibitions of ESA §9 will not apply to the take by the hatchery programs of threatened salmonids.

NMFS describes a hatchery program as a group of fish that have a separate purpose and that may have independent spawning, rearing, marking, and release strategies (NMFS 2008a). The operation and management of every hatchery program is unique in time, and specific to an identifiable stock and its native habitat (Flagg et al. 2004). NMFS defines integrated hatchery programs as those that are reproductively connected or "integrated" with a natural population, promote natural selection over artificial selection in the hatchery, and contain genetic resources that represent the ecological and genetic diversity of a species.

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 Fall 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 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) | April 10, 2018 | WDFW | LSRCP[3] | Integrated Recovery |
| Fall Chinook Acclimation Project (FCAP) | | NPT | *TBD*[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. 2018). All HGMPs were previously submitted in 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 will fund FCAP O&M and M&E until 2019. LSRCP will fund FCAP O&M starting in 2019. Funding for Snake River fall Chinook 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 2.10.4 Terms and Conditions.

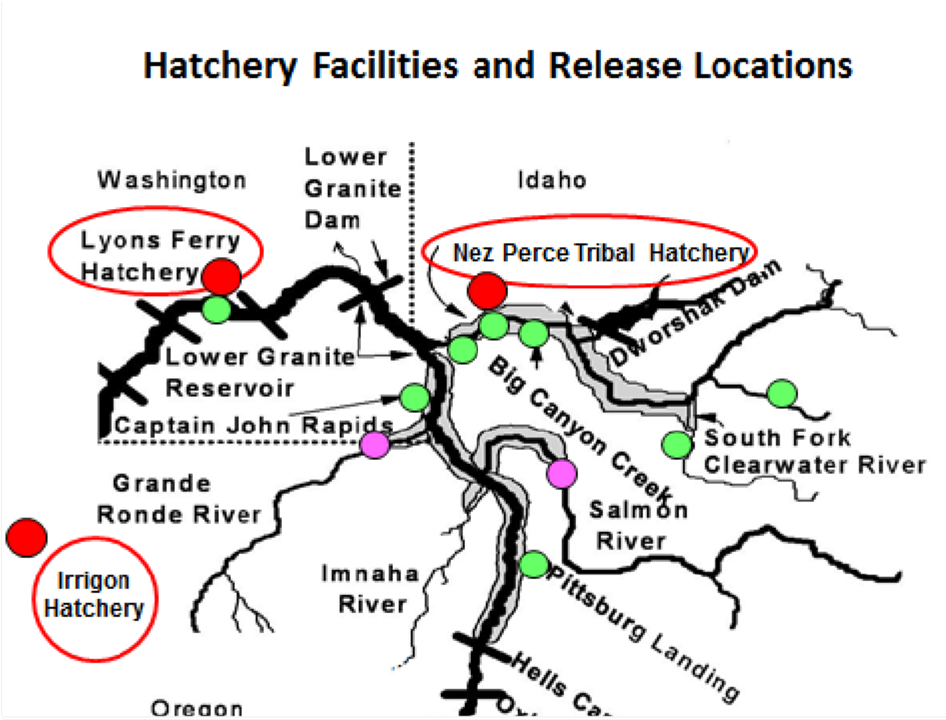


**Figure 1. Hatchery facilities (Red dot = main hatchery facility, Green dot = acclimation facility/acclimated release, Purple dot = direct stream release) in the Snake Basin included in the Proposed Action.**

This Biological Opinion evaluates NMFS' proposed issuance of two ten year section 10(a)(1)(A) permit actions that may affect Snake River fall Chinook salmon, Snake River spring/summer 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 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 2012a) and accompanying section 10(a)(1)(A) permits (numbers 16607 and 16615) (NMFS 2012b). 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). With respect to designated critical habitat, the following analysis relied only on the statutory provisions of the ESA, and not on the regulatory definition of "destruction or adverse modification" at 50 CFR 402.02. It is based on information provided in the applications for the proposed permits, published and unpublished scientific information on the biology and ecology of salmon and steelhead in the action area, and other sources of information.

## 1.2. Consultation History

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

A new opinion was completed on March 29, 1999, after Upper Columbia River (UCR) steelhead were listed under the ESA (62 FR 43937, August 18, 1997) and following the expiration of the previous opinion on December 31, 1998 (NMFS 1999). That opinion concluded that Federal and non-Federal hatchery programs jeopardize Lower Columbia River (LCR) steelhead and Snake River steelhead protected under the ESA and described RPAs necessary to avoid jeopardy. Those measures and conditions included restricting the use of non-endemic steelhead for hatchery broodstock and limiting stray rates of non-endemic salmon and steelhead to less than 5% of the annual natural population in the receiving stream. Soon after, NMFS reinitiated consultation when LCR Chinook salmon, UCR spring Chinook salmon, Upper Willamette Chinook salmon, Upper Willamette steelhead, Columbia River chum salmon, and Middle Columbia steelhead were added to the list of endangered and threatened species (Smith 1999).

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

The increase in ESA listings during the mid to late 1990s triggered a period of investigation, planning, and reporting across multiple jurisdictions and this served to complicate, at least from a resources and scheduling standpoint, hatchery consultations. A review of Federal funded hatchery programs ordered by Congress was underway at about the same time that the 2000 Federal Columbia River Power System (FCRPS) opinion was issued by NMFS. The Northwest Power and Conservation Council (Council) was asked to develop a set of coordinated policies to guide the future use of artificial propagation, and RPA 169 of the FCRPS opinion called for the completion of NMFS-approved hatchery operating plans (i.e., HGMPs) by the end of 2003. The RPA required the Action Agencies to facilitate this process, first by assisting in the development of HGMPs, and then by helping to implement identified hatchery reforms. Also at this time, a new *United States v. Oregon* (*U.S. v. Oregon*) Management Agreement, which included goals for hatchery management, was under negotiation and new information and science on the status and recovery goals for salmon and steelhead was emerging from Technical Recovery Teams (TRTs). Work on HGMPs under the FCRPS opinion was undertaken in cooperation with the Council's Artificial Production Review and Evaluation process, with CRFMP negotiations, and with ESA recovery planning (Foster 2004; Jones Jr. 2002). HGMPs were submitted to NMFS under RPA 169; however, many were incomplete and, therefore, were not found to be sufficient for ESA consultation.

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

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

Because it was aware of the scope and complexity of ESA consultations facing the co-managers and hatchery operators, NMFS offered substantial advice and guidance to help with the consultations. In September 2008, NMFS announced its intent to conduct a series of ESA consultations and that "from a scientific perspective, it is advisable to review all hatchery programs (i.e., Federal and non-Federal) in the UCR affecting ESA-listed salmon and steelhead concurrently" (Walton 2008). In November 2008, NMFS expressed again, the need for re-evaluation of UCR hatchery programs and provided a "framework for ensuring that these hatchery programs are in compliance with the Federal Endangered Species Act." (Jones Jr. 2008). NMFS also "promised to share key considerations in analyzing HGMPs" and provided those materials to interested parties in February 2009 (Jones Jr. 2009).

On April 28, 2010 (Walton 2010), NMFS issued a letter to "co-managers, hatchery operators, and hatchery funding agencies" that described how NMFS "has been working with co-managers throughout the Northwest on the development and submittal of fishery and hatchery plans in compliance with the Federal ESA." NMFS stated, "In order to facilitate the evaluation of hatchery and fishery plans, we want to clarify the process, including consistency with *U.S. v.*

*Oregon*, habitat conservation plans and other agreements…." With respect to "Development of Hatchery and Harvest Plans for Submittal under the ESA," NMFS clarified: "The development of fishery and hatchery plans for review under the ESA should consider existing agreements and be based on best available science; any applicable multiparty agreements should be considered, and the submittal package should explicitly reference how such agreements were considered. In the Columbia River, for example, the *U.S. v. Oregon* agreement is the starting place for developing hatchery and harvest plans for ESA review…."

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 Chinook 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 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 $16^{th}$-$17^{th}$ (USFWS 2017). Symposium presentations reviewed research, monitoring, and evaluation results over the length of the previous Biological Opinion and associated permits (NMFS 2012a). 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 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.

An important development since the 2012 consultation was completion of a Snake River fall Chinook salmon recovery plan (NMFS 2017d). 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). The creation of an NPEA in Scenario C dealt with genetic risks to the population in an innovative way. An NPEA is essentially 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) informed the preliminary feasibility of the NPEA and such a scenario may be possible with the current reprogramming of the IPC Hells Canyon releases to the Salmon River. Even though these releases were relocated in an attempt to increase survival rates for that component of the program, an ancillary benefit may be an opportunity to evaluate the concept of an NPEA. A second key feature of this Proposed Action relative to current operations is the 50% reduction in the release of yearling Chinook salmon, which includes conversion of all the current yearling acclimated groups released above Lower Granite Dam to subyearlings.

### 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. 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 federal Proposed Actions we are considering in this opinion:

- The Proposed Action for Bonneville Power Administration (BPA) is the funding of the O&M and M&E of the NPT hatchery program and components 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 LFH (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 Chinook salmon Nez Perce Tribal Hatchery (permit #16615) and the FCAP/WDFW Lyons Ferry/ODFW/Idaho Power Company Hatchery (permit #16607) programs. NMFS' issuance of the 10(a)(1)(A) permits would allow operation of hatchery related activities for these programs.

At the heart of these actions is the continued operation of the proposed Snake River fall 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 ESA-listed Snake River fall Chinook salmon as broodstock, making

[1] BPA will fund FCAP O&M and M&E until 2019. LSRCP will fund FCAP O&M starting in 2019. Funding for Snake River fall Chinook 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 2.10.4 Terms and Conditions.

these all integrated programs. The programs are funded as mitigation for losses of salmon caused by construction and operation of the Federal Lower Snake dams and mainstem Columbia dams, and by construction and operation of the Hells Canyon Complex dams owned and operated by the Idaho Power Company. The hatchery production from these programs is intended to be consistent with the ESA Recovery Plan for the Snake River Fall Chinook salmon Evolutionarily Significant Unit (ESU) (NMFS 2017d) and with the new 2018-2027 *U.S. v. Oregon* Management Agreement. 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 Idaho Power Company hatchery programs rearing and releasing Snake River fall 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. 2018). These programs were previously consulted on with NMFS (Consultation 2011/03947 and 2011/03948) and USFWS (Consultation 01EIF00-2012-F-0448) resulting in ESA section 10(a)(1)(A) permits #16607 and #16615. See **Table** 2 as well as 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 2012 Biological Opinion (NMFS 2012a).

Table 2. Past (*U.S. v. Oregon* Biological Opinion) and Proposed Action releases from production originating from LFH or NPTH.

| ***Lyons Ferry, Irrigon, Fall Chinook Acclimation Project Hatchery Production*** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Priority** | **Production Program 2008-2017 *U.S. v. Oregon* Management Agreement** | | | | | **Production Program 2018-2027 *U.S. v. Oregon* Management Agreement** | | | | |
| | **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 | 225K AdCWT<br>225K CWT | Lyons Ferry | 450,000 [1] | 1+ | On Station | 450K AdCWT |
| 2 | Lyons Ferry | 150,000 | 1+ | Pittsburg Landing | 70K AdCWT<br>80K CWT only | Lyons Ferry | 450,000 | 0+ | Captain John Rapids | 200K AdCWT<br>250K no clip |
| 3 | Lyons Ferry | 150,000 | 1+ | Big Canyon | 70K AdCWT<br>80K CWT only | Lyons Ferry | 450,000 | 0+ | Big Canyon | 200K AdCWT<br>250K no clip |
| 4 | Lyons Ferry | 150,000 | 1+ | Captain John Rapids | 70K AdCWT<br>80K CWT only | Lyons Ferry | 500,000 | 0+ | On Station | 200K AdCWT<br>300K no clip |
| 5 | Lyons Ferry | 200,000 | 0+ | On Station | 200K AdCWT | Lyons Ferry | 400,000 | 0+ | Pittsburg Landing | 200K AdCWT<br>200K no clip |
| 6 | Lyons Ferry | 500,000 | 0+ | Captain John Rapids | 100K AdCWT<br>100K CWT only<br>300K Unmarked | Lyons Ferry | 200,000 | 0+ | Captain John Rapids 2 | 200K AdCWT |
| 7 | Lyons Ferry | 500,000 | 0+ | Big Canyon | 100K AdCWT<br>100K CWT only<br>300K Unmarked | Lyons Ferry | 200,000 | 0+ | Big Canyon 2 | 200K AdCWT |
| 8 | Lyons Ferry | 200,000 | 0+ | Pittsburg Landing | 100K AdCWT<br>100K CWT only | Lyons Ferry | 200,000 | 0+ | Pittsburg Landing 2 | 200K AdCWT |
| 9 | Irrigon | 200,000 | 0+ | Salmon River | 200K AdCWT | Irrigon | 1,000,000 | 0+ | Salmon River | 200K AdCWT<br>800K no clip |
| 10 | Lyons Ferry | 200,000 | 0+ | Pittsburg Landing | 200K Unmarked | Irrigon | 200,000 | 0+ | Grande Ronde | 200K AdCWT |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | Lyons Ferry | 200,000 | 0+ | Captain John Rapids | 200K AdCWT | Lyons Ferry | 200,000 [3] | 0+ | On Station | 200K no clip |
| 12 | Irrigon | 200,000 | 0+ | Grande Ronde | 200K AdCWT | | | | | |
| 13 | Irrigon | 200,000 | 0+ | Salmon River | 200K Ad Only | | | | | |
| 14 | Irrigon | 200,000 | 0+ | Grande Ronde | 200K Unmarked | | | | | |
| 15 | Irrigon | 600,000 | 0+ | Salmon River | 600K Ad only | | | | | |
| Total | | 4,100,000 | | | | | 4,250,000 | | | |
| Clipped | | 2,335,000 | | | | | 2,250,000 | | | |
| Unclipped | | 1,765,000 | | | | | 2,000,000 | | | |
| ***Nez Perce Tribal Hatchery Production*** | | | | | | | | | | |
| 1 | NPTH | 500,000 | 0+ | On station | 100K AdCWT<br>200K CWT Only<br>200K Unmarked | NPTH | 500,000 | 0+ | On station | 100K AdCWT<br>400K no clip |
| 2 | NPTH | 200,000 | 0+ | Luke's Gulch | 100K AdCWT<br>100K CWT Only | NPTH | 350,000[4] | 0+ | Luke's Gulch | 100K AdCWT<br>250K no clip |
| | NPTH | 200,000 | 0+ | Cedar Flats | 100K AdCWT<br>100K CWT Only | NPTH | 350,000[4] | 0+ | Cedar Flats | 100K AdCWT<br>250K no clip |
| 3 | NPTH | 500,000 | 0+ | North Lapwai Valley | 100K AdCWT<br>200K CWT Only<br>200K Unmarked | NPTH | 200,000[5] | 0+ | North Lapwai Valley | 100K AdCWT<br>100K no clip |
| Total | | 1,400,000 | | | | | 1,400,000 | | | |
| Clipped | | 400,000 | | | | | 400,000 | | | |
| Unclipped | | 1,000,000 | | | | | 1,000,000 | | | |

[1]The parties agree during the term of the next agreement to re-evaluate and discuss the reduction and/or elimination of the yearling program at LFH
[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, and do not require an additional AdCWT group or PIT Tags.
[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.
[5] If environmental conditions preclude acclimation at North Lapwai Valley these fish will be released on station at NPTH

The 2012 Hatchery Biological Opinion compared to the 2018 *U.S. v. Oregon* Biological Opinion:

1) The 2018 *U.S. v. Oregon* Biological Opinion transferred the release location of IPC program from Hells Canyon Dam on the Snake River to the Salmon River and discontinuation of rearing at the IPC Oxbow Hatchery

The 2018 *U.S. v. Oregon* Biological Opinion (and the 2012 Biological Opinion) compared to this Proposed Action (these are minor changes and the Proposed Action is consistent with the 2018 *U.S. v. Oregon* management agreement production levels):

1) This Proposed Action transfers rearing for the entire IPC program from Oxbow and Umatilla hatcheries to Irrigon Hatchery
2) This Proposed Action prioritizes the release groups based on adult return/harvest performance including:
    a. Discontinuation of the Couse Creek direct stream release and moving fish from that group to the acclimation facility at Captain John Rapids

b. Reduction of release group from North Lapwai Valley and moving fish from that group to acclimation facilities in the upper Clearwater basin at Lukes Gulch (S.F. Clearwater River) and Cedar Flats (Selway River) to increase those releases.
c. Conversion of yearling releases above Lower Granite Dam (LGR) at the Fall Chinook Acclimation Project (FCAP) sites to subyearling production[2]. Because of expected lower smolt-to-adult rates in subyearlings compared to yearlings, the total number of smolts to be released by all programs has increased by 150,000.
d. The on-station release of subyearlings for the LFH program has increased from 200,000 to 700,000 subyearlings LGRand those fish will be partially reared in one of the large rearing lakes at LFH.
e. Total yearling production has been reduced from 900,000 to 450,000, all of which would occur at LFH below LGR.LGRTotal subyearling production increased from 4.6 million to 5.2 million.

3) This Proposed Action describes the marking of Snake River fall Chinook occurring under a comprehensive mark strategy (all programs). Changes to that strategy beginning in 2018 include:
    a. Each release site and group will have a representative 200,000 Ad/CWT mark, with the exception of all NPTH production releases which will be represented by 100,000 AD/CWT groups. The NPTH production release groups will be combined into upper basin (Lukes Gulch and Cedar Flats) and lower basin (NPTH on station and North Lapwai Valley) 200,000 Ad/CWT release groups as needed for evaluations. All broodstock fish will be genotyped, making all released fish identifiable through parentage-based tagging (PBT). PBT will be the dominant marking strategy.
    b. All CWT-only groups and Ad-clip only groups have been discontinued. If PBT alone is unable to meet harvest management requirements or estimate program performance, a double index tagged group or groups of fish (CWT only) may be implemented following technical agreement between NMFS, USFWS, and co-managers.

The four programs listed in Table 1 and
Table 2 are described individually in detail below. Descriptions include the purpose and goals as stated by the operators, history, facilities involved, broodstock collection activities, juvenile release strategies, and marking protocols. The HGMPs (NPT 2011; Washington Department of Fish and Wildlife et al. 2011) and Addendum (NPT et al. 2018) contain a considerable amount of detail on fish cultural methods beyond that presented in this section. Proposed and on-going basin wide research, monitoring, and evaluation activities are also described. Because of the complex history of Snake River fall 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. 2018) or from 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

[2] As a result, all releases above Lower Granite Dam will be subyearlings – the typical life history of natural-origin fall Chinook salmon.

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 in 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 operation of the fall 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.

This opinion will determine if the Proposed Actions comply with the provisions of section 7(a)(2) of the ESA. The duration of the Proposed Action is unlimited from the date of Opinion completion.

### 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& for the NPT Hatchery Program and components of the FCAP Program[3].

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[3] is included in the proposed action and is funded through the Lower Snake River Compensation Plan (LSRCP), which is managed by the USFWS.

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

### 1.3.2. Program Purpose and Type

Specific information regarding the hatchery program purpose and type of the four Snake River hatchery programs included in this proposed action are largely described in the October 2012 Snake River Fall Chinook Hatchery Programs Biological Opinion (NMFS 2012a) and ESA section 10(a)(1)(A) permits (NMFS 2012a). 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

[3]BPA will fund FCAP O&M and M&E until 2019. LSRCP will fund FCAP O&M starting in 2019. Future funding discussions regarding FCAP M&E and tagging will occur, but a future funder for this component of the program has not been identified. Please see Section 2.10.4 Terms and Conditions for more information regarding future funding decisions.

production is to meet mitigation, harvest, and conservation objectives, and is part of the LSRCP, a congressionally mandated program pursuant to PL 99-662. The purpose of the LSRCP is to replace salmon and steelhead lost by 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 program purpose and type.

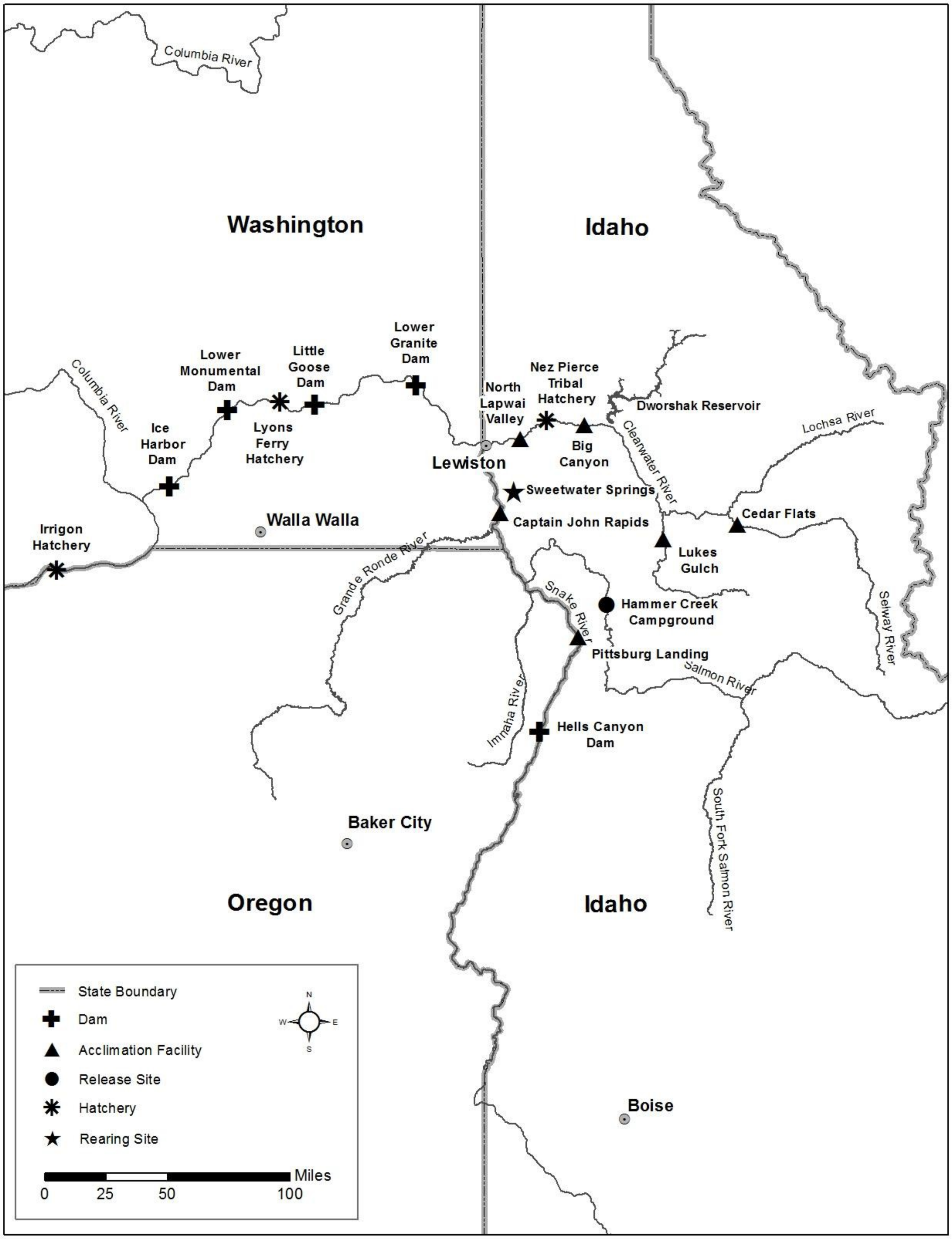


Figure 2. Map of Snake River fall Chinook salmon hatcheries and acclimation facilities (Gilmore 2018)

### 1.3.3. Proposed Hatchery Broodstock Collection Details

Broodstock collection will remain the same as described in the October 2012 Snake River Fall Chinook Hatchery Programs Biological Opinion and ESA section 10(a)(1)(A) permits (NMFS 2012a) 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 Lower Granite Dam trap. Trapping rates are adjusted as necessary based on estimated return strength of the run. Broodstock are 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. 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.

Annually, up to 4,010 adults or jacks[4] fall Chinook salmon are collected as broodstock for these four programs. Additionally, about 3,000 more Snake River fall Chinook salmon with CWT's may be collected for run-reconstruction purposes, and expansion of those CWT's to estimate returns to LGR. Collected broodstock are divided between LFH and NPTH, usually at a 70:30 ratio as agreed upon annually. Broodstock trapping objectives are for 2,960 adults (1,480 females) for LFH and 1,050 (525 females) for NPTH. Males may be used on multiple females so are not necessarily needed at a 1:1 rate and fewer may be collected.

Trapping protocols at LGR vary from year to year due to expected run size of fall Chinook, steelhead and coho salmon. 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).

Fish collected for broodstock are 100% electronically sampled and CWT's are decoded to identify origins before spawning. Those that can be identified as originating out-of-basin (though very uncommon) are typically 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 will be used to distinguish unmarked in-basin hatchery-origin fish from natural-origin and unmarked strays in the future (Section 1.3.6.1). Since 2016, all in-basin hatchery returns have been genetically identifiable. Any unmarked fish not assigned to in-basin hatchery returns will be assigned as natural-origin after the stray out-of-

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

basin component is estimated based on associated CWT's and PBT profiling. 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 matings are done with 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 older fish as broodstock, as compensation for overrepresentation of younger fish in previous years (NMFS 2012) 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 actually 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 Chinook Hatchery Programs Biological Opinion and ESA section 10(a)(1)(A) permits (NMFS 2012a) 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 components of the program in the interim since the HGMPs were submitted in 2011. The goal of these methods are 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 juvenile production, by hatchery facility of origin[5]. The grand total Snake River fall Chinook releases in the Snake River Basin from all hatchery programs and facilities is 450,000 yearlings and 5.2 million subyearlings on an average yearly basis. In addition, there is a 10% overage buffer of juvenile releases, whereby in a single year the operator 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 the minority of situations and annual operational adjustments, to maintain consistency with the proposed production levels and life stages, should be addressed during the development of the annual operation plan(s). Please refer to the previous 2012 Biological Opinion (NMFS 2012a) as well as the *U.S. v. Oregon* Management Agreement Biological Opinion (NMFS et al. 2018) for information regarding past releases.

[5] It is worth noting that, during the transition year (2019) from the previous 2008-2017 *U.S. v. Oregon* Management Agreement to the new 2018-2027 *U.S. v. Oregon* Management Agreement, production will not be as it is defined in Table 3 and Table 4. Because yearling production is largely being phased out into subyearling releases, this means that there will be an overlap in releases in 2019. For example, Brood Year 2017 yearlings from the FCAP program are not scheduled to be released until 2019. This combined with the new proposed subyearling releases from the 2018-2027 *U.S. v. Oregon* Management Agreement means that a total of 6.1 million Snake River fall Chinook salmon will be released in 2019 instead of the 5.65 million in the new production tables. This will be a single occurrence during the transition year in 2019, and we do not expect this will happen in the future.

**Table 3. Snake River fall Chinook salmon production for three of the hatchery programs in the Proposed Action (the Lower Snake River Compensation Program (LSRCP) at Lyons Ferry 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 | 450,000 | 1+ | On station | 450KAdCWT |
| 2 | Lyons Ferry | 450,000 | 0+ | Captain John | 200K AdCWT<br>250K no clip |
| 3 | Lyons Ferry | 450,000 | 0+ | Big Canyon | 200K AdCWT<br>250K no clip |
| 4 | Lyons Ferry | 500,000 | 0+ | On station | 200K AdCWT<br>300K no clip |
| 5 | Lyons Ferry | 400,000 | 0+ | Pittsburg Landing | 200K AdCWT<br>200K no clip |
| 6 | Lyons Ferry | 200,000 | 0+ | Captain John 2 | 200K AdCWT |
| 7 | Lyons Ferry | 200,000 | 0+ | Big Canyon 2 | 200K AdCWT |
| 8 | Lyons Ferry | 200,000 | 0+ | Pittsburg Landing 2 | 200K AdCWT |
| 9 | Irrigon | 1,000,000 | 0+ | Salmon River[2] | 200K AdCWT<br>800K no clip |
| 10 | Irrigon | 200,000 | 0+ | Grande Ronde River | 200K AdCWT |
| 11 | Lyons Ferry | 200,000 | 0+ | On station | 200K no clip |
| **TOTAL** | Yearlings | 450,000 | | | |
| | Subyearlings | 3,800,000 | | | |

[1]For all Snake River Fall Chinook 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]Beginning in 2018, the releases of subyearlings at Hells Canyon Dam will be moved to the Salmon River. Several Parties are actively participating in the re-licensing of Idaho Power Company's Hells Canyon Complex and its operations. Idaho Power Company's mitigation responsibilities, including production numbers and release locations are a subject of these discussions.

**Table 4. Snake River fall 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 | Life History | Release Location(s) | Marking[1] |
|---|---|---|---|---|---|
| 1 | 500,000 | 0+ | Standard | On station | 100K AdCWT<br>400K no clip |
| 2 | 350,000[2] | 0+ | Early-spawning | Luke’s Gulch | 100K AdCWT<br>250K no clip |
| | 350,000[2] | 0+ | Early-spawning | Cedar Flats | 100K AdCWT<br>250K no clip |

| | | | | | |
|---|---|---|---|---|---|
| 3 | 200,000[3] | 0+ | Standard | North Lapwai Valley | 100K AdCWT<br>100K no clip |
| **TOTAL** | 1,400,000 | Subyearlings | | | |

[1]For all Snake River Fall Chinook 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 Biological Opinion (NMFS 2012a). 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 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<br>-Grande Ronde River<br>-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 in the previous 2012 Biological Opinion (NMFS 2012a), with some exceptions. The *Snake River Fall Chinook Symposium* that took place on May 16$^{th}$-17$^{th}$, 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 6), will continue for all groups. In addition, the cooperators are exploring monitoring that will assess the effects of the change in release strategies on distribution of hatchery spawners into the Snake River. This assessment will utilize ongoing redd surveys and may include carcass recoveries. Currently, IPC is exploring a direct approach through carcass recovery and PBT analysis; however, technical feasibility issues remain to be resolved.

#### 1.3.6.1. RM&E Activities in Light of New Proposed Action

At present, Snake River fall Chinook salmon constitute a single-population ESU (NMFS 2005b), and approximately 75% of the fish in the population 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 difficult to quantify spawning, rearing, and productivity of natural-origin Snake River fall Chinook salmon. The same factors, coupled with logistic difficulties and management constraints, make evaluation of the effects of the hatchery programs on natural production of Snake River fall Chinook salmon very challenging. The previous Biological Opinion (NMFS 2012a) included significant RM&E effort from the co-managers to inform some of our gaps in knowledge regarding this single-population ESU. The co-manager organized *Snake River Fall Chinook Symposium* (USFWS 2017) served to review all of these findings.

Data from the past M&E effort associated with the 2012 Biological Opinion (NMFS 2012a) 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 Chinook salmon population (Section 2.6.2.2). The movement of 1 million fish (IPC release) from the Upper Snake area to the Salmon River as included the new *US v. Oregon* Management Agreement and accompanying Biological Opinion (NMFS et al. 2018) provides this opportunity. Analyses described in the *US v. Oregon* Management Agreement Biological Opinion in addition to analyses described in Section 2.6.2.2 indicate a general trend of reducing hatchery influence in the Upper Snake region. Thus, RM&E included in this Proposed Action, as well as data collected from natural production monitoring under the 2008 FCRPS Biological Opinion and its supplements (NMFS 2008b), will help inform the following RM&E objectives in light of the changes from the *US v. Oregon* Management Agreement Biological Opinion: general effect of the hatchery programs and the effect of the change in release location on the natural population.

Collectively, the M&E measures will provide important information that will guide future management of the Snake River fall Chinook salmon hatchery programs after the period of the permit is over. However, the measures vary in immediacy of results.

#### 1.3.6.2. RM&E Actions in this Biological Opinion

Because of the importance of Snake River fall Chinook salmon as a single-population ESU, 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 Snake River fall Chinook salmon is essential to the success of this hatchery program. Past efforts have been quite extensive and comprehensive compared to many other hatchery monitoring efforts in the Columbia Basin. The results of efforts were recently presented at the *Snake River Fall Chinook Symposium* that took place on May 16th-17th (USFWS 2017). Survival data presented in the Snake River Fall Chinook Performance Evaluation White Paper (Rosenberger et al. 2017) helped inform the program changes (movement of the Idaho Power Company releases in the Upper Snake River to an alternative release site in the Salmon River and the conversion of yearlings to subyearling releases above Lower Granite Dam), which is currently reflected in the new *US v. Oregon* Management Agreement and in this Proposed Action (Section 1.3.4). As mentioned previously, this also provides an opportunity to assess changes in hatchery influence in the upper Hells Canyon reach.

For this Proposed Action, ongoing monitoring activities, including standard production monitoring (Table 6), will continue for all groups. In addition, the cooperators are exploring monitoring that will assess the effects of the changes in release sites on the distribution of spawners in the Snake River. This assessment will utilize ongoing redd surveys and may include carcass recoveries. Currently, IPC is exploring a direct approach through carcass recovery and PBT analysis; however, technical feasibility issues remain to be resolved.

**Table 6. Standard RM&E activities, purpose, and implementers for all of the Snake River Fall Chinook programs (NPT et al. 2018)**

| Activity | Purpose | Implementers |
|---|---|---|
| Adult trapping and tissue sampling at Lower Granite Dam 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 of individual release groups. | WDFW, NPT, NMFS |
| 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 |
| Monitor health and condition of adult and juveniles associated with hatchery production | Track in hatchery fish health and perform prerelease sampling | WDFW, NPT, ODFW, USFWS |
| Harvest monitoring (related to the measurement of program goals) and continued marking of hatchery production: Adipose clipping, coded wire tagging, PIT Tagging and 100% marking of hatchery production via Parentage Based Tagging. | 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, NPT, PBT Sampling combined for CRITFC, IDFG and WDFW labs. |
| Complete run reconstruction. PBT sampling of LGR Run-at-Large a component piece | Adult escapement of both HOR and NOR to Snake Basin and pNOB in program. Estimates of in-river and overall survival from smolt to adult return. Contributes to estimation of overall mitigation benefit and survival by hatchery | WDFW, IPC, NPT, NMFS and CRITFC, IDFG and WDFW labs for PBT analysis. |

| | | |
|---|---|---|
| | release group. Estimations of strays to spawning ground. | |
| Redd counts across spawning areas (efforts include carcass sampling) | Adult spawning distribution and success. Informs natural population abundance and life-cycle modeling. | IPC, USFWS, USGS, NPT, WDFW |

#### 1.3.6.3. 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, broodstock needs for both hatcheries, and run reconstruction needs. 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 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 spatial distribution. Underwater camera observation of redds in deep water areas supplements aerial counts in the mainstem Snake 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 the same way as is age-structure.

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 Chinook salmon, as previously mentioned, relies on run-reconstruction using expansions based on tagging rate of fish recovered with CWTs or PBTs.

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

Abundance and distribution information on juveniles is limited. Abundance information of wild juveniles is not available for any spawning aggregate above LGR, but does exist for the Tucannon River spawning area, below LGR. Collection of juveniles occurs at three of the four Lower Snake River dams and fish guidance efficiencies are estimated. However, Snake River fall 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 and the Upper and Lower Snake River spawning aggregates, and the Tucannon River. However, estimates of survival for wild and NPTH subyearling production must be characterized by combining probability of emigration and survival, because a significant proportion emigrate as yearlings. Distribution and emigrant survival information is collected for the Clearwater River and for 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

All hatchery programs 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. If NMFS screening and passage criteria is 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 individual risk, program risk, and compliance concern. Modifications and upgrades will be based on the prioritized list and acted upon as funding becomes available. Additional facilities will be adopting 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
    - Be staged and fueled with appropriate distance from any water body
    - Be cleaned and free of vegetation before they are brought to the site

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

**Table 7. Facility water source and use for hatchery program operations as reported in the 2012 Biological Opinion (NMFS 2012a).**

| Hatchery Facility[1] | Total Facility Water Use (cfs) | Surface Water Used[1] (cfs) | Ground-water Used (cfs) | Water Source | Amount Used for Fall Chinook salmon (cfs) | Proportion Used for Fall 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 |
| Big Canyon Acclimation Facility | 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 |
| North Lapwai Valley Acclimation Facility | 5 | 1.4 | 3.6 | Ground-water and Lapwai Creek | 5 | 100 | Lapwai Creek | Yes | N/A |

[1]Oxbow Hatchery was included in the previous Biological Opinion; however, rearing at this facility will not be included in this Proposed Action and therefore it is not considered here.

## 1.4. Interrelated and Interdependent Actions

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 (50 CFR 402.02). NMFS has not identified any interdependent or interrelated activities associated with the proposed action.

Fisheries are not part of this Proposed Action. Although Snake River area state tributary fisheries have targeted adipose-clipped hatchery-origin returns from these programs in the past, harvest frameworks are managed separately from hatchery production, and are not solely tied to production numbers. Additionally, production and fishery implementation are subject to different legal mandates and agreements. Because the hatchery programs would likely exist whether or not these fisheries were in place, fisheries in these areas are considered a separate action.

There are also existing mainstem Columbia River and ocean fisheries that may catch fish from these programs. However, these mixed stock fisheries would exist with or without these programs, and are included in the Environmental Baseline as a result of them having been evaluated in the *U.S. v. Oregon* Biological Opinion (NMFS et al. 2018). The impacts of fisheries in the Action Area (Section 2.4) on these programs and, in particular, on ESA-listed salmonids returning to the Action Area (Section 2.4) for this opinion are included in the Environmental Baseline (Section 2.5).

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

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

### 2.1. Introduction to the Biological Opinion

Section 7(a)(2) of the ESA requires Federal agencies, in consultation with NMFS, 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. The jeopardy analysis considers both survival and recovery of the species. "To jeopardize the continued existence of a listed species" means to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of the species in the wild by reducing the reproduction, numbers, or distribution of that species or reduce the value of designated or proposed critical habitat (50 CFR 402.02).

This Biological Opinion relies on the definition of "destruction or adverse modification," which "means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features" (81 Fed. Reg. 7214, February 11, 2016).

The designations of critical habitat for the species considered in this opinion use the terms primary constituent element (PCE) or essential features. The new critical habitat regulations (81 Fed. Reg. 7414, February 11, 2016) replace 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.

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

The Endangered Species Act - section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation, NOAA's National Marine Fisheries Service's implementation of the Mitchell Act Final Environmental Impact Statement preferred alternative and administration of Mitchell Act hatchery funding (Mitchell Act Biological Opinion) (NMFS 2017b) that was completed by NMFS in 2017 has largely contributed to the status descriptions (Section 2.3), the description of the environmental baseline (Section 2.5), the description of the factors that are considered when analyzing hatchery effects (Section 2.6), as well as background information used to analyze the hatchery effects (Section 2.6.2) in this Biological Opinion. Information from the Mitchell Act Biological Opinion has either been incorporated by reference or descriptions have been taken directly or modified to suit this Biological Opinion. Moreover, the Endangered Species Act section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation for Snake River Fall Chinook Salmon Hatchery Programs, ESA section 10(a)(l)(A) permits, numbers 16607 and 16615 (NMFS 2012a) Biological Opinion has also largely contributed to the development of the Background (Section 1.1), Consultation History (Section 1.2), Proposed Action (Section 1.3), considerations for the development of the Action Area (Section 2.4), the Environmental Baseline (Section 2.5), and some of the analyses in the Effects of the Proposed Action (Section 2.6.2). Moreover, the new *U.S. v. Oregon* Management Agreement Biological Opinion (NMFS et al. 2018) contributed to the Background (Section 1.1), Consultation History (Section 1.2), Proposed Action (Section 1.3), considerations for the development of the Action Area (Section 2.4), the Environmental Baseline (Section 2.5), and some of the analyses in the Effects of the Proposed Action (Section 2.6.2) since the movement of the 1 million IPC releases were included in this Management Agreement and analysis.

## 2.2.Analytical Approach

*Range-wide status of the species and critical habitat*

This section describes the status of species and critical habitat that are the subject of this opinion. The status review starts with a description of the general life history characteristics and the population structure of the ESU/DPS, including the strata or major population groups (MPG) where they occur. NMFS has developed specific guidance for analyzing the status of salmon and steelhead populations in a “Viable Salmonid Population” (VSP) paper (McElhany et al. 2000). The VSP approach considers four attributes, the abundance, productivity, spatial structure, and diversity of each population (natural-origin fish only), as part of the overall review of a species’ status. For salmon and steelhead protected under the ESA, the VSP criteria therefore encompass the species’ “reproduction, numbers, or distribution” (50 CFR 402.02). In describing the range-wide status of listed species, NMFS reviews available information on the VSP parameters including abundance, productivity trends (information on trends, supplements the assessment of abundance and productivity parameters), spatial structure, and diversity. We also summarize available estimates of extinction risk that are used to characterize the viability of the populations and ESU/DPS, and the limiting factors and threats. To source this information, NMFS relies on viability assessments and criteria in technical recovery team documents, ESA Status Review updates, and recovery plans. We determine the status of critical habitat by examining its physical and biological features (also called “primary constituent elements” or PCEs). Status of the species and critical habitat are discussed in Section 3.1.

*Description of the environmental baseline*

The environmental baseline includes the past and present impacts of Federal, state, or private actions and other human activities in the Action Area on ESA-listed species. It includes the anticipated impacts of proposed Federal projects that have already undergone formal or early section 7 consultation and the impacts of state or private actions that are contemporaneous with the consultation in process. The environmental baseline is discussed in Section 2.5 of this opinion.

*Cumulative effects*

Cumulative effects, as defined in NMFS' implementing regulations (50 CFR 402.02), are the effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the Action Area. Future Federal actions that are unrelated to the Proposed Action are not considered because they require separate section 7 consultation. Cumulative effects are considered in Section 2.7 of this opinion.

*Integration and synthesis*

Integration and synthesis occurs in Section 2.8 of this opinion. In this step, NMFS adds the effects of the Proposed Action (Section 2.6.2) to the status of ESA protected populations in the Action Area under the environmental baseline (Section 2.5) and to cumulative effects (Section 2.7). Impacts on individuals within the affected populations are analyzed to determine their effects on the VSP parameters for the affected populations, and these are combined with the overall status of the strata/MGP to determine the effects on the ESA-listed species (ESU/DPS), which will be used to formulate the agency's opinion as to whether the hatchery action is likely to: (1) result in appreciable reductions in the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat.

*Jeopardy and adverse modification*

Based on the Integration and Synthesis analysis in Section 2.8, the opinion determines whether the proposed action is likely to jeopardize the survival and recovery of ESA-listed species or destroy or adversely modify designated critical habitat in Section 2.7.

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

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

## 2.3. Range-wide Status of the Species and Critical Habitat

This Opinion examines the status of each ESA listed species that would be affected by the Proposed Action as described in Table 8[6]. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status Section also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The

[6] ESA-listed bull trout (*Salvelinus confluentus*) are administered by the FWS. ESA compliance for bull trout is currently being addressed through a separate consultation with FWS.

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 current function of the essential physical and biological features that help to form that conservation value.

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

| Species | Listing Status | Critical Habitat | Protective Regulations |
|---|---|---|---|
| **Chinook salmon *(Oncorhynchus tshawytscha)*** | | | |
| Snake River fall-run | Threatened, 79 FR 20802, April 14, 2014 | 58 FR 68543, December 28, 1993 | 70 FR 37160, June 28, 2005 |
| Snake River spring/summer-run | Threatened, 79 FR[7] 20802, April 14, 2014 | 64 FR 57399, October 25, 1999 | 70 FR 37160, June 28, 2005 |
| **Sockeye salmon *(O. nerka)*** | | | |
| Snake River | Endangered, 79 FR 20802, April 14, 2014 | 70 FR 52630, September 2, 2005 | 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 37160, June 28, 2005 |

*"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 distinct population, 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 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 USFWS-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. The two Chinook salmon species listed in Table 8 each constitute an ESU (a salmon DPS) of the taxonomic species *Oncorhynchus tshawytscha*; Snake River Sockeye salmon constitute an ESU of the taxonomic species *Oncorhynchus nerka;* and the steelhead constitutes a DPS of the taxonomic species *Oncorhynchus mykiss*.

### 2.3.1. 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. These VSP criteria therefore encompass the species' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. When these parameters are collectively

[7] Citations to "FR" and "Fed. Reg." are citations to the Federal Register.

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. use the terms "population growth rate" and "productivity" interchangeably when referring to production over the entire life cycle. They also refer to "trend in abundance," which is the manifestation of long-term population growth rate.

"Spatial structure" refers both to the spatial distributions of individuals in the population and the processes that generate that distribution. A population's spatial structure depends fundamentally on accessibility to the habitat, on habitat quality and spatial configuration, and on the dynamics and dispersal characteristics of individuals in the population.

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

In describing the range-wide status of listed species, we rely on viability assessments and criteria in TRT documents and recovery plans, when available, that describe VSP parameters at the population, major population group (MPG), and species scales (i.e., salmon ESUs and steelhead DPSs). For species with multiple populations, once the biological status of a species' populations and MPGs have been determined, NMFS assesses the status of the entire species. Considerations for species viability include having multiple populations that are viable, ensuring that populations with unique life histories and phenotypes are viable, and that some viable populations are both widespread to avoid concurrent extinctions from mass catastrophes and spatially close to allow functioning as meta-populations.

#### 2.3.1.1. Life History and Status of Snake River Fall Chinook Salmon

On June 3, 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) and on April 14, 2014 (79 FR 20802) (Table 8). Critical habitat was designated on December 28, 1993 (58 FR 68543) (Table 8).

The Snake River fall 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). 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).**

| **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 2012a). 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 (NWFSC 2015).

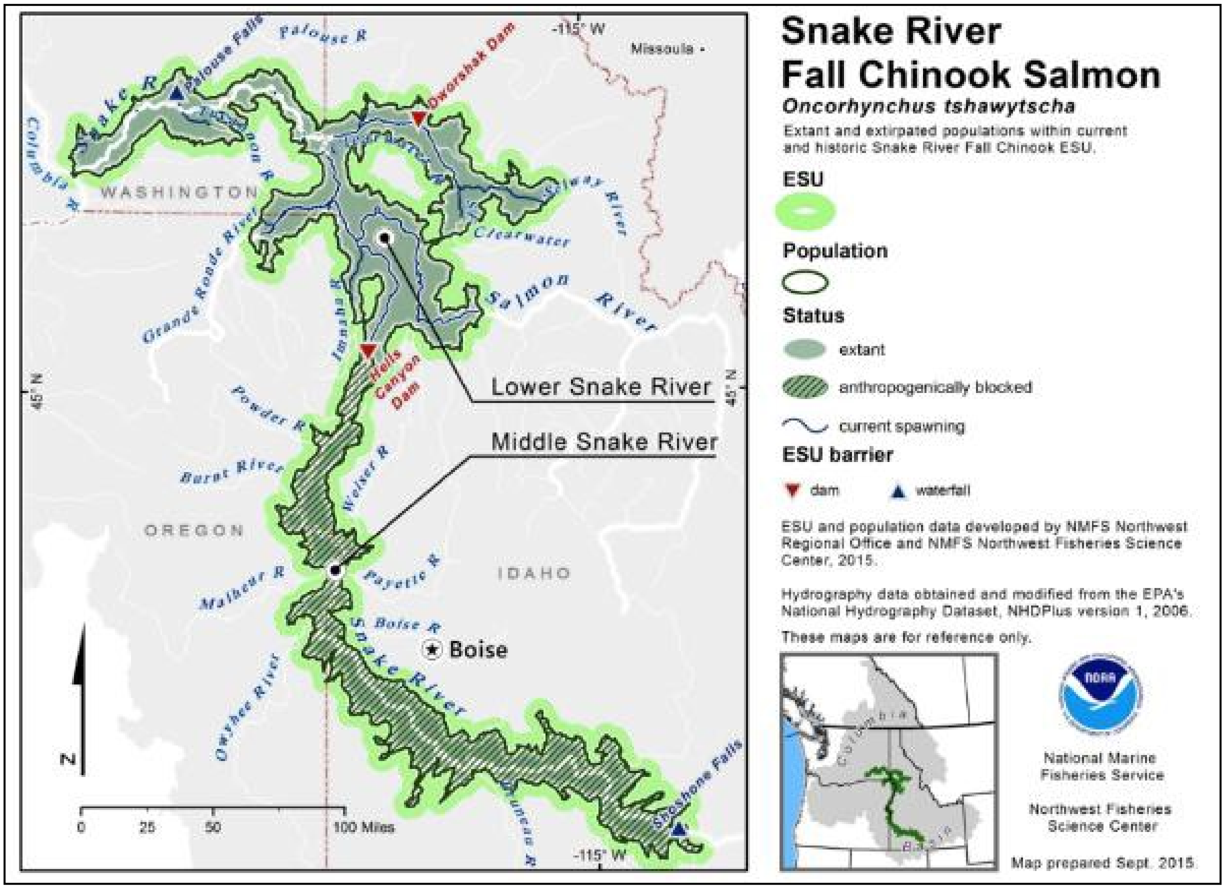


**Figure 3. Map of the Snake River Fall-Run Chinook Salmon ESU's spawning and rearing areas, illustrating populations and MPGs (NWFSC 2015).**

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 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 Lower Granite Dam 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 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 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 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. 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. 2005). 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 2012a).

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 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 2012a).

NMFS designated critical habitat for Snake River fall 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 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, which is based on a low risk rating for abundance/productivity, and a moderate risk rating for spatial structure/diversity (NWFSC 2015).

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), 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 in natural spawning areas, the potential for selective pressure imposed by current hydropower operations, and cumulative harvest impacts) contribute to the current rating level.

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 Chinook Recovery Plan (NMFS 2017d) 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 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 2017d) 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) currently levels of hatchery production are likely too high for long-term maintenance of acceptable productivity 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. 2011). Ocean conditions have also affected the status of this ESU. Ocean conditions affecting the survival of Snake River fall-run Chinook salmon were generally poor during the early part of the last 20 years (NMFS 2012a).

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 2012a).

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).

NMFS (2012a) 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 2012a).**

| Habitat Component | Primary Constituent Elements (PCEs) |
|---|---|
| Spawning and juvenile rearing areas | 1) spawning gravel<br>2) water quality<br>3) water quantity<br>4) cover/shelter<br>5) food (juvenile rearing)<br>6) riparian vegetation<br>7) space |

| | |
|---|---|
| Adult and juvenile migration corridors | 1) substrate<br>2) water quality<br>3) water quantity<br>4) water temperature<br>5) water velocity<br>6) cover/shelter<br>7) food (juvenile)<br>8) riparian vegetation<br>9) space<br>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.

#### 2.3.1.2. Life History and Status of Snake River Spring/Summer Chinook Salmon

On June 3, 1992, NMFS listed the Snake River spring/summer-run Chinook Salmon ESU as a threatened species (57 FR 23458). More recently, the threatened status was reaffirmed on June 28, 2005 (70 FR 37160) and on April 14, 2014 (79 FR 20802) (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 subbasins, as well as 11 artificial propagation programs (Jones Jr. 2015; NWFSC 2015). However, inside the geographic range of the ESU, there are a total of 19 hatchery spring/summer-run Chinook salmon programs currently operational (Jones Jr. 2015). Table 11 lists the natural and hatchery populations included (or excluded) in the ESU.

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

| **ESU Description** | |
|---|---|
| Threatened | Listed under ESA in 1992; updated in 2014 (see Table 8) |
| 5 major population groups | 28 historical populations (4 extant) |
| ***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, East Fork/Johnson Creek, South Fork Salmon River Mainstem, Little Salmon River |
| Middle Fork | Bear Valley, Marsh Creek, Sulphur Creek, Loon Creek, Camas Creek, Big Creek, Chamberlain Creek, Lower Middle Fork (MF) Salmon, Upper MF Salmon |

| | |
|---|---|
| Upper Salmon | Lower Salmon Mainstem, Lemhi River, Pahsimeroi River, Upper Salmon Mainstem, East Fork Salmon, Valley Creek, Yankee Fork, North Fork Salmon |
| ***Artificial production*** | |
| Hatchery programs included in ESU (11) | 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, Big Sheep Creek-Adult Spr/Sum out planting from Imnaha program, McCall Hatchery summer, Johnson Creek Artificial Propagation Enhancement summer, Pahsimeroi Hatchery summer, Sawtooth Hatchery spring. |

Twenty eight historical populations (4 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.

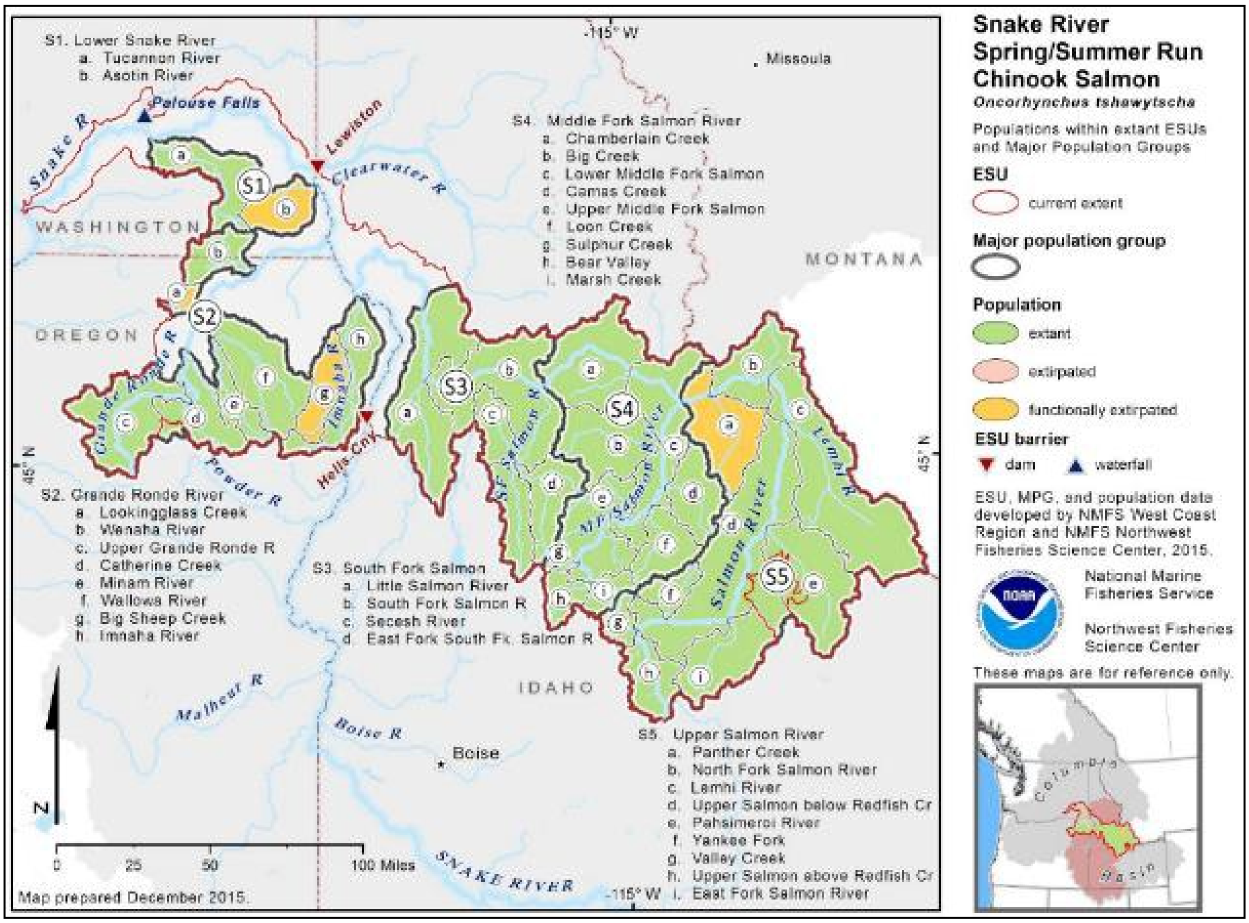


**Figure 4. Snake River Spring/Summer-Run Chinook Salmon ESU spawning and rearing areas, illustrating natural populations and MPGs (NWFSC 2015).**

The Snake River Spring/Summer Chinook Salmon ESU consists of “stream-type” Chinook salmon, which spend 2 to 3 years in ocean waters and exhibit extensive offshore ocean migrations (Myers et al. 1998). Chinook salmon return to the Columbia River from the ocean in early spring through August. Returning fish hold in deep mainstem and tributary pools until late summer, when they migrate up into tributary areas and spawn from mid- through late August. 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 Lower Granite Dam (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% of the returns from fish of natural-origin (NMFS 2012a).

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. Climate change is also recognized as a possible factor in Snake River salmon declines (NMFS 2012a; Scheuerell and Williams 2005; Tolimieri and Levin 2004).

**Abundance, Productivity, Spatial Structure, and Diversity**

Status of the species is determined based on VSP criteria including abundance, productivity, spatial structure, and diversity of its constituent natural populations (McElhany et al. 2000). 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.

There are four independent populations within the South Fork Salmon river Major Population Group (MPG). These include the South Fork Salmon River, Secesh River, East Fork of the South Fork Salmon River (Johnson Creek), and the Little Salmon River. The hatchery programs in this consultation directly affect the South Fork Salmon River, East Fork of the South Fork Salmon

River (Johnson Creek), and the Little Salmon River populations. The South Fork Salmon River population is required to meet viable status, while both the East Fork of the South Fork Salmon River (Johnson Creek) and Little Salmon River populations are considered “maintained” populations. In addition, the potential scenario identified by ICTRT calls for the Secesh population to be highly viable. The most recent status review by NMFS (NWFSC 2015) maintains that these populations are all at high risk.

### 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 began 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 2012a).

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 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 et al. 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 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.

### 2.3.1.3. Life History and Status of Snake River Steelhead

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* originating below natural and manmade impassable barriers in streams in the Snake River Basin of southeast Washington, northeast Oregon, and Idaho (NWFSC 2015). 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 12). This DPS consists of A-run steelhead, which are primarily returning to spawning areas beginning in the summer, and the B-run steelhead, which exhibit a larger body size and begin their migration in the fall (NMFS 2011a). Figure 5 shows a map of the current DPS and the MPGs within the DPS.

**Table 12. Snake River Basin Steelhead DPS description and MPGs (Jones Jr. 2015; NMFS 2012a; NWFSC 2015).**

| **DPS Description** | |
|---|---|
| Threatened | Listed under ESA as threatened in 1997; updated in 2014 (see Table 8) |
| 6 major population groups | 27 historical populations (3 extirpated) |
| ***Major Population Group*** | ***Populations*** |

| | |
|---|---|
| Grande Ronde | Joseph Creek, Upper Mainstem, Lower Mainstem, Wallowa River |
| Imnaha River | Imnaha River |
| Clearwater | Lower Mainstem River, North Fork Clearwater, Lolo Creek, Lochsa River, Selway River, South Fork Clearwater |
| Salmon River | Little Salmon/Rapid, Chamberlain Creek, Secesh River, South Fork Salmon, Panther Creek, Lower MF, Upper MF, North Fork, Lemhi River, Pahsimeroi River, East Fork Salmon, Upper Mainstem |
| Lower Snake | Tucannon River, Asotin Creek |
| Hells Canyon Tributaries | n/a |
| ***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 |

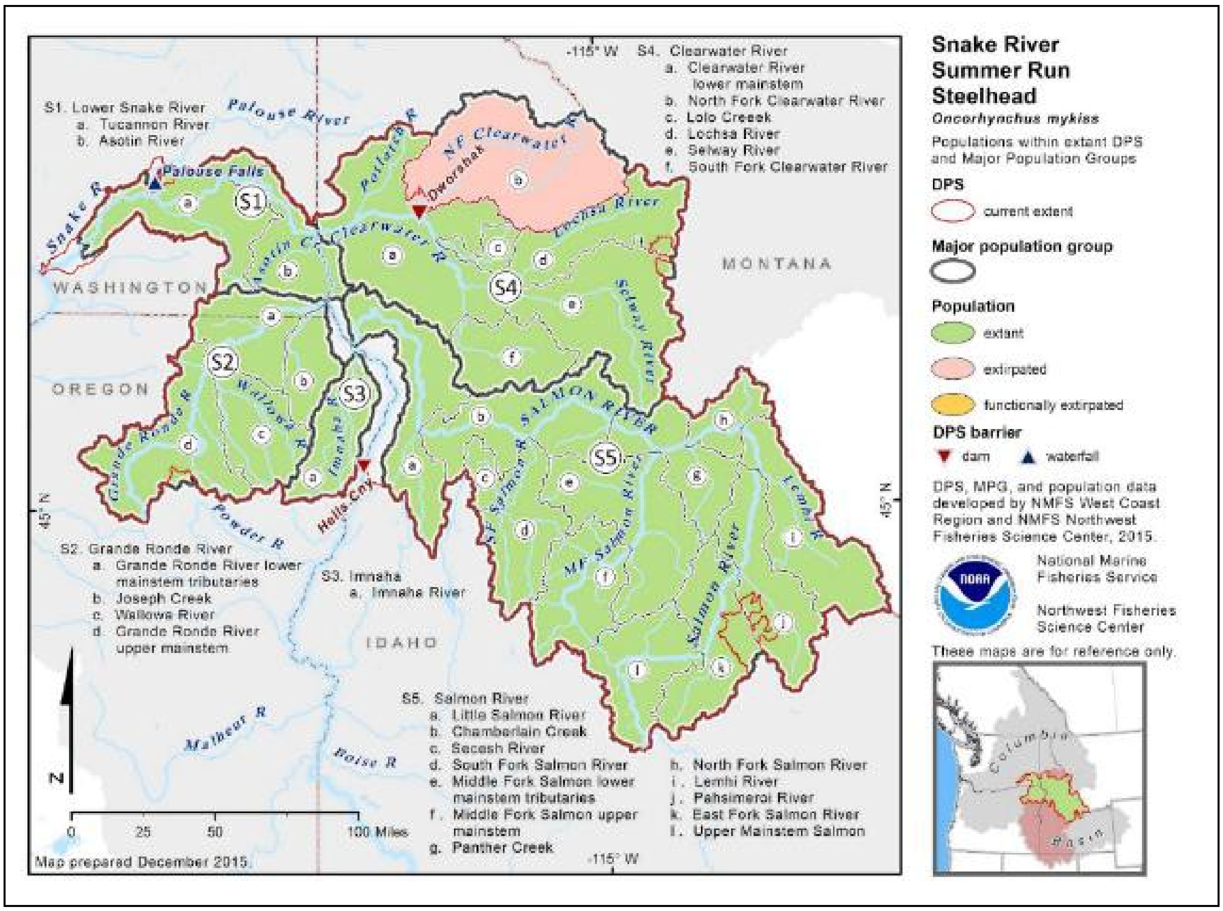


**Figure 5. Snake River Basin Steelhead DPS spawning and rearing areas, illustrating natural populations and MPGs (NWFSC 2015).**

*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* (redband 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 cutthroat trout (*O. clarkii)*, spawn once and then die (semelparous). Snake River steelhead are classified as summer-run because they enter the Columbia River from late June to October. After holding over the winter, summer steelhead spawn the following spring (March to May).

**Abundance, Productivity, Spatial Structure, and Diversity**

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the Snake River Basin Steelhead DPS, ranges from moderate to high risk and remains at threatened status. The most recent status update (NWFSC 2015) used new data (i.e., data from 2009 to 2014) to inform the analysis on this DPS. Additionally, ODFW has continued to refine sampling methods for various survey types, which has also led to more accurate data available for use. However, a great deal of uncertainty remains regarding the relative proportion of hatchery-origin fish in natural spawning areas near major hatchery release sites. Because of this, it is difficult to estimate changes in the DPS viability (NWFSC 2015).

Population-specific adult population abundance is generally not available for the Snake River Basin steelhead due to difficulties conducting surveys in much of their range. Evaluations in the 2015 status review were done using both a set of metrics corresponding to those used in prior BRT reviews, as well as a set corresponding to the specific viability criteria based on ICTRT recommendations for this DPS. The BRT level metrics were consistently done across all ESUs and DPSs to facilitate comparisons across domains. The most recent five year geometric mean abundance estimates for the two long term data series of direct population estimates (Joseph Creek and Upper Grande Ronde Mainstem populations) both increased compared to the prior review estimates; each of the populations increased an average of 2% per year over the past 15 years. Hatchery-origin spawner estimates for both populations continued to be low, and both populations are currently approaching the peak abundance estimates observed since the mid-1980s (NWFSC 2015).

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 2015 status update that would change those ratings (NWFSC 2015).

Updated information is available for two important factors that contribute to rating diversity risk under the ICTRT approach: hatchery spawner fractions and the life history diversity. At present, direct estimates of hatchery returns based on PBT analysis are available for the run assessed at LGR (IDFG 2015). Furthermore, information from the Genetic Stock Identification (GSI) assessment sampling provide an opportunity to evaluate the relative contribution of B-run returns within each stock group. No population fell exclusively into the B-run size category, although there were clear differences among population groups in the relative contributions of the larger B-run life history type (NWFSC 2015).

**Limiting Factors**

Factors that limit the DPS's survival and recovery include: juvenile and adult migration through the FCRPS; 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, cover, side-channel refuge areas, and high quality spawning gravels,: and interbreeding and competition with hatchery fish that 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 in 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 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%, while exploitation rates on the B-run have generally been in the range of 15-20% (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). A great deal of uncertainty still remains regarding the relative proportion of hatchery-origin fish in natural spawning areas near major hatchery release sites within individual populations. Overall, the information analyzed for the 2015 status review does not indicate a change in biological risk status since the status review in 2010 (NWFSC 2015).

#### 2.3.1.4. Life History and Status of Snake River Sockeye Salmon

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).

The ESU includes naturally spawned anadromous and residual sockeye salmon originating from the Snake River Basin in Idaho, as well as artificially propagated sockeye salmon from the Redfish Lake captive propagation program (Jones Jr. 2015) (Table 13).

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

| **ESU Description** | |
|---|---|
| Threatened | Listed under ESA in 1991; updated in 2014 (see Table 8) |
| 1 major population group | 5 historical populations (4 extirpated) |
| ***Major Population Group*** | ***Population*** |
| Sawtooth Valley Sockeye | Redfish Lake |
| ***Artificial production*** | |
| Hatchery programs included in ESU (1) | Redfish Lake Captive Broodstock |

The ICTRT treats Sawtooth Valley Sockeye salmon as the single MPG within the Snake River Sockeye Salmon ESU. The MPG contains one extant population (Redfish Lake) and two to four historical populations (Alturas, Petit, Stanley, and Yellowbelly Lakes) (NMFS 2015) (Figure 6). 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 2015). 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 outplanted to Pettit and Alturas lakes within the Sawtooth Valley for recolonization purposes (NMFS 2011a).

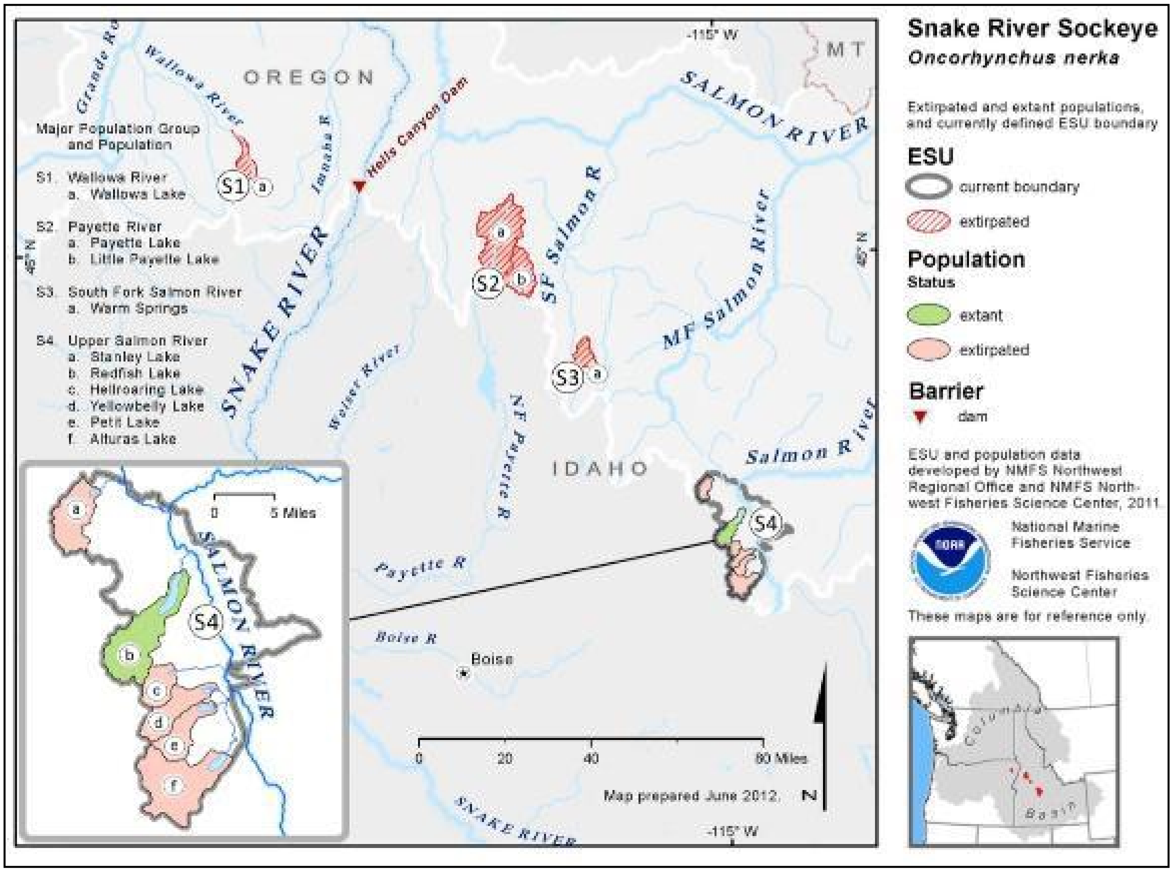

Figure 6. Map of the Snake River Sockeye Salmon ESU's spawning and rearing areas, illustrating populations and MPGs (NWFSC 2015).

While there are very few sockeye salmon currently following an anadromous life cycle in the Snake River, the small remnant run of the historical population migrates 900 miles downstream from the Sawtooth Valley through the Salmon, Snake, and Columbia Rivers to the ocean (Figure 6). After one to three years in the ocean, they return to the Sawtooth Valley as adults, passing once again through these mainstem rivers and through eight major federal dams, four on the Columbia River and four on the lower Snake River. Anadromous sockeye salmon returning to Redfish Lake in Idaho's Sawtooth Valley travel a greater distance from the sea, 900 miles, to a higher elevation (6,500 ft.) than any other sockeye salmon population. They are the southernmost population of sockeye salmon in the world (NMFS 2015).

**Abundance, Productivity, Spatial Structure, and Diversity**

Although the endangered Snake River Sockeye Salmon ESU has a long way to go before it will meet the biological viability criteria (i.e., indication that the ESU is self-sustaining and naturally producing and no longer qualifies as a threatened species), annual returns of sockeye salmon through 2013 show that more fish are returning than before initiation of the captive broodstock program, which began soon after the initial ESA listing.

Between 1999 and 2007, more than 355 adults returned from the ocean from captive brood releases – almost 20 times the number of natural-origin fish that returned in the 1990s, though this total is primarily due to large returns in the year 2000. Adult returns in the last six years have ranged from a high of 1,579 fish in 2014 (including 453 natural-origin fish) to a low of 257 adults in 2012 (including 52 natural-origin fish). Sockeye salmon returns to Alturas Lake ranged from one fish in 2002 to 14 fish in 2010. No fish returned to Alturas Lake in 2012, 2013, or 2014 (NMFS 2015).

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 Sawtooth Valley 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 outplanting and recolonization of the species historical range (NMFS 2015; NWFSC 2015).

Furthermore, there is evidence that the historical Snake River Sockeye Salmon ESU included a range of life history patterns, with spawning populations present in several of the small lakes in the Sawtooth Basin (NMFS 2015b). Historical production from Redfish Lake was likely associated with a lake shoal spawning life history pattern although there may have also been some level of spawning in Fish Hook Creek (NMFS 2015; NWFSC 2015). In NMFS' 2011 status review update for Pacific salmon and steelhead listed under the ESA , it was not possible to quantify the viability ratings for Snake River Sockeye salmon. Ford (2011) determined that the Snake River sockeye salmon 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 (NMFS 2012a).

In the most recent 2015 status update, NMFS determined that at this stage of the recovery efforts, the ESU remains at high risk for both spatial structure and diversity (NWFSC 2015). 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 2015). 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 high risk for spatial structure, diversity, abundance, and productivity (NWFSC 2015).

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

**Limiting Factors**

Factors that limit the ESU have been, and continue to be impaired mainstem and tributary passage, historical commercial fisheries, chemical treatment of Sawtooth Valley lakes in the 1950s and 1960s, poor ocean conditions, Snake and Columbia River hydropower system, and reduced tributary stream flows and high temperatures. 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 2015; NWFSC 2015). However, some limiting factors have improved since the listing. Fisheries are now better regulated through ESA constraints and management agreements, significantly reducing harvest-related mortality. Potential habitat-related threats to the fish, especially in the Sawtooth Valley, pose limited concern since most passage barriers have been removed and much of the natal lake area and headwaters remain protected. Hatchery-related concerns have also been reduced through improved management actions (NMFS 2015).

### 2.3.2. Range Wide Status of Critical Habitat

NMFS determines the range-wide 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. An example of some PBFs are listed below. These are often similar among listed salmon and steelhead; specific differences can be found in the critical habitat designation for each species (Table 8).

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

(5) Near-shore marine areas free of obstruction and excessive predation with: (i) Water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and (ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels;
(6) Offshore marine areas with water-quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.

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. 2000). 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 ESU's, 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:

- 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 2017b) for a detailed description of how critical habitat has been designated by NMFS.

#### 2.3.2.1. 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 2016).

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 2016).

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 2016).

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 2016). They can negatively impact critical habitat and the organisms associated with these areas.

## 2.4. Action Area

The “Action Area” means all areas to be affected directly or indirectly by the Proposed Action, in which the effects of the action can be meaningfully detected, measured, and evaluated (50 CFR 402.02). For the purposes of this analysis, the action area includes the vicinity of hatchery, acclimation facilities, and release areas in the Snake and Clearwater River Basins as well as areas within those basins where fall Chinook salmon spawn and rear.

The Action Area for this analysis has changed from the 2012 Biological Opinion (NMFS 2012a) in the following ways:

1. The Action Area will no longer include the facility effects at Oxbow Hatchery. Rearing of hatchery fall Chinook salmon has been discontinued at Oxbow Hatchery. The facility effects at Oxbow Hatchery were previously considered; however, because it was above Hells Canyon Dam (which is a total barrier to anadromous fish), they did not look at effects on listed species in that reach. In the new Proposed Action, the entire IPC program will operate out of Irrigon Hatchery. Irrigon Hatchery was included in the previous Action Area. Irrigon Hatchery is outside the Snake Basin; however, no fall Chinook salmon will be released at this site. Irrigon Hatchery will be included in the Action Area, but only for facility effects on Snake River fall Chinook salmon, as no impacts on other listed Snake River ESUs or DPSs are possible.
2. The Action Area will be expanded to include a new release location of the IPC program which was shifted from Hells Canyon Dam on the Snake River to a location of equal distance on the Salmon River. The Action Area will still include the Snake River below Hells Canyon Dam since the Snake River Fall Chinook ESU includes natural spawning in this reach, but it will also include a portion of the Salmon River downstream of where the new releases will take place, generally near the confluence of Whitebird Creek.

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 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 of fish from the proposed programs in the total numbers of 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 2.6.2.3).

Adult fish from Snake River fall 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 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 site 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 effects of the action can be meaningfully detected. The Mitchell Act Biological Opinion (NMFS 2017b) 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 and yearling Chinook salmon are released into the Action Area. This suggests that the likelihood of detecting effects from the releases of hatchery steelhead on natural-origin fish below Ice Harbor Dam have already been examined to the best of our ability.

The effects of the Proposed Action on Southern Resident Killer Whales (SRKW) was considered, but we ultimately determined not to extend the action area to include them because the total number of releases is not large enough for available information to detect an effect on Southern Resident Killer Whales. Snake River Fall Chinook salmon have been identified as a priority stock for the Southern Resident Killer Whales according to a new report from NMFS (NOAA and WDFW 2018). Despite this, the total adult equivalents of all of the proposed hatchery program releases is only 50,850 adult Chinook salmon (based on the average SAR return value of 0.9 to LGR). The Pacific Fisheries Management Council provides ocean abundance estimates for Chinook salmon that originate from the U.S. systems (PFMC 2016a). Between 2008 and 2016, escapement forecasts for Columbia River Chinook salmon stocks ranged from approximately 741,000 to 1,960,800 fish; Puget Sound stocks ranged from 150,600 to 269,800 fish; Washington coast stocks ranged from 65,500 to 115,900 fish, and Oregon and California coast stocks ranged from 142,200 to 1,651,800 fish. The average total Chinook salmon abundance from these sources was approximately 2,035,778 fish. Therefore, 50,850 adult Chinook salmon would be a small portion (or approximately 2.5%) of the total estimated ocean escapement that may be available to SRKW. Therefore, we did not find these proposed releases, which continue to support the escapement totals and do not cause take that would measurably reduce the SRKW prey base, to be a large enough proportion of the run to result in detectable effects which would justify extending the Action Area to include SRKW geographic ranges.

## 2.5. Environmental Baseline

In the Environmental Baseline section, NMFS describes what is affecting ESA-listed species and designated critical habitat in the Action Area before including any effects resulting from 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 and the anticipated impacts of all proposed federal projects in the Action Area that have already undergone formal or early section 7 consultation (50 CFR 402.02). The effects of future actions over which the Federal agency has discretionary involvement or control will be analyzed as ‘effects of the action.’

### 2.5.1. RM&E Activities

Juvenile monitoring activities, although not part of this Proposed Action, are critical to understanding the status of the Snake River Fall Chinook salmon ESU. Some juvenile monitoring activities operated by NPT have previously been permitted as parts of projects 4 and 5 under section 10 permit 1134 (NPT 2007). Monitoring 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 Chinook salmon will be observed trapped, handled, tagged and released during monitoring activities. Snake River spring/summer 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 Chinook salmon will be trapped, handled (and possibly PIT tagged), and released during smolt trapping operations. Snake River spring/summer 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 upon 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 Determinations USGS-7 and 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.

### 2.5.2. Recent 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 VSP metrics of salmonids (Section 2.6). 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 initiation of restoration implementation, significant work has been done to remove fish passage barriers, unscreened irrigation diversions, minimizing fine sediments, and planting 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.

### 2.5.3. 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 2017b). 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 (FCRPS), and other developments which have undergone ESA §7 consultation. Here, we summarize some of the key impacts on salmon and steelhead habitat in the Snake River Basin. We also outline historical developments with the FCRPS section 7 consultation.

**Key hydropower impacts on salmon and steelhead habitat in the Snake River**

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:

- Impediments to safe passage: 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);
- Decreased water quantity (i.e., flow) and changes in 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);
- Harmful increase in temperature in the reaches below the large mainstem storage projects (water quality and safe passage in the migration corridor)
- Harmful sediment transport and turbidity (water quality and safe passage in the migration corridor)
- Decreased total dissolved gas (water quality and safe passage in the migration corridor)
- Changes to food web dynamics, including both predators and prey (food/prey and safe passage in the migration corridor)
- Blocked habitat or habitat loss due to channelization, scouring flows, etc.

For a more detailed discussion of the impacts to listed species caused by hydropower operations in the action area, see the most recent FCRPS Biological Opinion in 2008 (NMFS 2008b).

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 a number of streams and rivers. These have accelerated surface water runoff and decreased groundwater recharge, contributing to lower summer stream flows. Natural groundwater recharge and discharge patterns have also been modified by groundwater pumpage and surface water diversion for irrigation. 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 removal of vegetation 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, now 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 and 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. The Federal Conservation Reserve and Enhancement Program (CREP) began in the 1990's.Under the CREP, highly erodible and other environmentally sensitive lands that have produced crops are converted to a long-term resource-conserving vegetative cover. Participants in the CREP are required to seed native or introduced perennial grasses or a combination of shrubs and trees with native shrubs and grasses.

**History of the FCRPS section 7 consultation**

Fourteen federal dam and reservoir projects within the Federal Columbia River Power System are operated as a coordinated water management system on the Columbia River and some of its major tributaries (referred to herein as the "FCRPS"). The continued operation and maintenance of the FCRPS is an ongoing action occurring in the action area, which has undergone multiple consultations. Therefore its continued existence and operation is considered a part of the environmental baseline. In 1992, NMFS and the FCRPS action agencies completed their first ESA section 7 consultation on the FCRPS, and NMFS issued a Biological Opinion. More than two decades of ESA consultations and ongoing litigation involving multiple diverse plaintiffs ─ including environmental organizations, river users, states, and tribes ─ have ensued. NMFS issued the most recent FCRPS Biological Opinion in 2008 (NMFS 2008b) and supplemented it in 2010 and 2014.

On May 4, 2016, the U.S. District Court for the District of Oregon ruled on litigation concerning the 2008 FCRPS Biological Opinion and its supplements. The court's order did not vacate the 2008 Biological Opinion or its supplements, but it did issue a remand requiring NMFS to develop a new Biological Opinion. It also ordered the Corps and the USBR to comply with the National Environmental Policy Act (NEPA).

In addition to the M&E activities described in the Proposed Action (Section 1.3), critical natural production monitoring actions conducted under the 2008 FCRPS Biological Opinion and its supplements (NMFS 2008b) help evaluate the status of this important and unique single-population ESU. This monitoring has dealt in part or entirely with the effects of the hatchery programs on the natural production of Snake River fall Chinook salmon.

### 2.5.4. Climate Change

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

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

These changes will not be spatially homogeneous across the entire Pacific Northwest. Low-lying areas are likely to be more affected. Climate change may have long-term effects that include, but are not limited to, depletion of important cold water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, premature emergence of fry, and increased competition among species (ISAB 2007). For a more detailed description of future climate change effects, refer to the Mitchell Act Biological Opinion (NMFS 2017b).

**Effects on salmon**

Climate change is predicted to cause a variety of impacts on Pacific salmon and their ecosystems (Crozier et al. (2008a); Martins et al. (2012); Mote et al. (2003); Wainwright and Weitkamp (2013)). The complex life cycles of anadromous fishes including salmon rely on productive freshwater, estuarine, and marine habitats for growth and survival, making them particularly vulnerable to environmental variation (Morrison et al. 2016). Ultimately, the effect of climate change on salmon and steelhead across the region will be determined by the specific nature, level, and rate of change and the synergy between interconnected terrestrial/freshwater, estuarine, nearshore and ocean environments.

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

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

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

In the Status of Listed Species, Section 2.3.1, 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 2.4), we may expect direct climate change effects of increased water temperature on fish physiology, temperature-induced changes to stream flow patterns, and alterations to freshwater food webs.

### 2.5.5. 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 2017b). In summary, because most programs are ongoing, the effects of each are reflected in the most recent status of the species, (NWFSC 2015) and were summarized in Section 2.3.1 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 be used to help improve viability by supplementing natural population abundance and expanding spatial distribution. However, the long-term benefits and risks of hatchery supplementation are still being tested (Christie et al. 2014). Therefore, fixing the factors limiting viability is essential for long-term viability.

All Snake River Fall Chinook hatchery programs are currently ongoing and have operated since the mid 1990's. However, there are some differences between how programs are currently being operated and what is being proposed in the Proposed Action, which is covered in Section 2.6.2. Moreover, the effects of the ongoing hatchery programs outline in the Proposed Action (Section 1.3) and included in the Environmental Baseline (Section 2.5) are analyzed in detail in the Effects of the Proposed Action (Section 2.6.2). This effects analysis of the Proposed Action is essential to making our jeopardy determination.

All salmon and steelhead hatcheries in the action area were built as mitigation for hydroelectric development from dam construction and operation. The major hatchery programs are funded through the LSRCP, BPA, IPC, 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 the four hatcheries in Idaho, Oregon Department of Fish and Wildlife (ODFW) operates three in Oregon, 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 of these 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). These facilities are operated by IDFG. The COE funds operation of one major hatchery as mitigation for the losses caused by construction of Dworshak Dam and total blockage of the North Fork Clearwater River. This facility is co-operated by the USFWS and NPT. BPA directly funds NPTH as well as three other hatchery programs as mitigation for effects of the Federal Columbia River Power System through its Fish and Wildlife Program. The USFWS directly funds Kooskia Hatchery, which is operated by the Nez Perce Tribe.

Currently almost all aspects of hatchery programs—most importantly numbers, locations, and marking of fish released—are regulated by 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. Changes to the Proposed Action, including increased production, may trigger reinitiation. Relocation of releases (e.g., Pittsburg Landing) to the Salmon River or a decrease in production from what is in the current Proposed Action may not trigger reinitiation, but may require additional discussion and analyses.

### 2.5.6. Harvest

For thousands of years, Native Americans have fished for salmon and steelhead, as well as other species, in the tributaries and mainstem of the Columbia River for ceremonial, subsistence, and economic purposes. A wide variety of gears and methods were used, including hoop and dip nets at cascades such as Celilo and Willamette Falls, to spears, weirs, and traps (usually in smaller streams and headwater areas). Commercial fishing developed rapidly with the arrival of European settlers and the advent of 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).

Currently, the year-to-year management of harvest in the Columbia Basin is under a 10-year management agreement established by the parties to *U.S. v. Oregon*, No. 68-513 (D. Or, 1968). The most recent agreement was signed in February, 2018, and harvest and hatchery effects were considered as part of the associated Biological Opinion (NMFS et al. 2018), for which we provide a brief discussion here. Table 14 shows the current 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 14. 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 Chinook** | | 31.29 | 11.6 – 23.04 | 5.9 – 8.25 |
| **Snake River spring/summer Chinook** | | 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** | | 6.0 – 8.08 | 2.8 – 7.0 | 0.0 – 1.0 |

The hatchery programs primarily contribute to fall Chinook salmon fisheries in the mainstem Snake and Columbia Rivers and terminal areas. The current 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[8] in the mainstem is based on natural-origin fall Chinook salmon projected to return to the Snake River basin. Harvest share in terminal areas is defined as 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 mark 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 1.4).

### Fall Chinook Salmon Fisheries

Snake River fall 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 Chinook salmon are also caught in fall 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 Chinook salmon has declined greatly since

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

the ESA listing. Total exploitation rates averaged 75% from 1986 to 1991, and 45% from 1992 to 2006.

The fall Chinook salmon fishery in the Snake River basin typically takes place from September through October. Similar to spring/summer Chinook salmon and steelhead fisheries, the non-tribal fisheries have selectively targeted 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. An average of approximately 4.5% of the Snake River Fall-run Chinook Salmon ESU is killed in fisheries above LGR (Table 15).

**Table 15. Number of ESA-listed natural-origin fall Chinook salmon encountered and incidentally killed (catch and release mortality is estimated at 10 percent of those caught) in fall Chinook salmon fisheries from 2011-2016. The Shoshone-Bannock Tribes currently do not participate in Snake River fall Chinook salmon fisheries.**

| Fishery Manager | Average Encounter | Average Mortality | Average natural-origin estimated escapement above LGR | % Average natural-origin mortality above LGR |
|---|---|---|---|---|
| IDFG | 853 | 85 | 10,819 | 0.8 |
| NPT | 400 | 397 | 10,819 | 3.7 |

Sources: (IDFG 2014; IDFG 2016a; IDFG 2017a; Oatman 2017a; Petrosky 2012; Petrosky 2013; Petrosky 2014)

**Spring/Summer Chinook Salmon Fisheries**

The spring/summer Chinook fisheries in the Snake River 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 16 below shows that an average of approximately 5% of the Snake River Spring/summer Chinook Salmon ESU is killed by fisheries. This may be an overestimate of the percentage impact because the 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 16. Number of ESA-listed natural-origin spring/summer Chinook salmon encountered and incidentally killed (catch and release mortality is estimated at 10 percent of those caught) in fisheries from 2011-2016.**

| 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 | 774 | 2,260 | 260 | 19,788 | 1.3 |

| | | | | | |
|---|---|---|---|---|---|
| SBT[1] | Not Applicable | 407 | 407 | 19,788 | 2.1 |
| NPT[1] | Not Applicable | 326 | 326 | 19,788 | 1.6 |

Sources: (Hurst 2017; IDFG 2014; IDFG 2016a; IDFG 2017a; Oatman 2017b; Petrosky 2012; Petrosky 2013; Petrosky 2014)
[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 Chinook salmon or sockeye salmon during spring/summer 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 Chinook salmon in the Snake Basin. Sockeye salmon are not encountered because they typically do not strike at lures used by recreational anglers fishing for 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 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 16 below shows that an average of ~ 4.1 % of the Snake River steelhead DPS is killed annually in fisheries above LGR. This may be an overestimate of the percentage impact because the LGR natural-origin return estimate does not include those fish that return to tributaries in the Snake River below LGR (e.g., Tucannon River).

**Table 17. Number of ESA-listed natural-origin steelhead encountered and killed in fisheries from 2011-2016.**

| Fishery Manager | Average Encounter | Average Mortality | Average natural-origin estimated escapement above LGR | % Average natural-origin mortality above LGR |
|---|---|---|---|---|
| IDFG[1] | 15,888 | 801[1] | 25,690 | 3.1 |
| SBT | < 100 | < 100 | 25,960 | 0.4 |
| NPT | 167 | 157 | 25,960 | 0.6 |

Sources: (Hurst 2017; IDFG 2014; IDFG 2016a; IDFG 2017a; Oatman 2017a; Petrosky 2012; Petrosky 2013; Petrosky 2014)
[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 18. Number of ESA-listed natural-origin fall Chinook salmon encountered and incidentally killed (catch and release mortality is estimated at 10 percent of those caught) in steelhead fisheries from 2011-2016.**

| Fishery Manager | Average Encounter | Average Mortality | Average natural-origin estimated escapement above LGR | % Average natural-origin mortality above LGR |
|---|---|---|---|---|
| IDFG | 281 | 28[1] | 10,819 | 0.3 |
| SBT | 0 | 0 | 10,819 | 0 |
| NPT | These numbers are included in the table on Fall Chinook fisheries below | | | |

Sources: (Hurst 2017; IDFG 2014; IDFG 2016a; IDFG 2017a; Oatman 2017a; Petrosky 2012; Petrosky 2013; Petrosky 2014)
[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 2016, an average of 0.5 percent of the sockeye salmon population in Redfish Lake were incidentally harvested in this fishery, assuming that sockeye salmon represent 29 percent of the *O. nerka* population (kokanee and sockeye salmon are phenotypically indistinguishable) (IDFG 2014; IDFG 2016a; IDFG 2017a).

### 2.5.7. Other Actions Included in the 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 funds from NMFS each year. The fund supplements existing state, tribal, and local programs to foster 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 2008c). Chapter 5 of the SCA (NMFS 2008d), 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.

## 2.6. Effects of the Action

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the species or critical habitat, 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 those that are caused by the Proposed Action and are later in time, but still are reasonably certain to occur.

### 2.6.1. Factors That Are Considered When Analyzing Hatchery Effects

NMFS has substantial experience with hatchery programs and has developed and published a series of guidance documents for designing and evaluating hatchery programs following best available science (Hard et al. 1992; Jones 2006; McElhany et al. 2000; Myers et al. 2004; NFMS 2008; NMFS 2004b; NMFS 2005c). For Pacific salmon, NMFS evaluates extinction processes and effects of the Proposed Action beginning at the population scale (McElhany et al. 2000). NMFS defines population performance measures in terms of natural-origin fish and four key parameters or attributes—abundance, productivity, spatial structure, and diversity—and then relates effects of the Proposed Action at the population scale to the MPG level and ultimately to the survival and recovery of an entire ESU or DPS.

Because of the potential for circumventing the high rates of early mortality typically experienced in the wild, artificial propagation may be useful in the recovery of listed salmon species. However, artificial propagation entails risks as well as opportunities for salmon conservation (Hard et al. 1992). A Proposed Action is analyzed for effects, positive and negative, on the attributes that define population viability: abundance, productivity, spatial structure, and diversity. The effects of a hatchery program on the status of an ESU or steelhead DPS and designated critical habitat "will depend on which of the four key attributes are currently limiting the ESU, and how the hatchery fish within the ESU affect each of the attributes" (70 FR 37215, June 28, 2005). The presence of hatchery fish within the ESU can positively affect the overall status of the ESU by increasing the number of natural spawners, by serving as a source population for repopulating unoccupied habitat and increasing spatial distribution, and by conserving genetic resources. Conversely, a hatchery program managed without adequate consideration can affect a listing determination by reducing adaptive genetic diversity of the ESU, and by reducing the reproductive fitness, productivity, and abundance of the ESU.

NMFS' analysis of the Proposed Action is in terms of effects it would be expected to have on ESA-listed species and on designated critical habitat, based on the best scientific information available. This allows for quantification (wherever possible) of the effects of the seven factors of hatchery operation on each listed species at the population level (in Section 2.6.2), 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 2.7).

Information that NMFS needs to analyze the effects of a hatchery program on ESA-listed species must be included in an HGMP. Draft HGMPs are reviewed by NMFS for their sufficiency before formal review and analysis of the Proposed Action can begin. Analysis of an HGMP or Proposed Action for its effects on ESA-listed species and on designated critical habitat depends on six factors. 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 corridor, estuary, and ocean
(4) RM&E that exists because of the hatchery program
(5) the operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program
(6) fisheries that exist because of the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds

NMFS analysis assigns an effect category for each factor (negative, negligible, or positive/beneficial) on population viability. The effect category assigned is based on: (1) an analysis of each factor weighed against the affected population(s) current risk level for abundance, productivity, spatial structure, and diversity; (2) the role or importance of the affected natural population(s) in salmon ESU or steelhead DPS recovery; (3) the target viability for the affected natural population(s) and; (4) the Environmental Baseline, including the factors currently limiting population viability. For more information on how NMFS evaluates each factor, please see Appendix A.

### 2.6.2. Effects of the Proposed Action

This section describes the effects of the Proposed Action, independent of the environmental baseline and cumulative effects.

The methodology and best scientific information NMFS follows for analyzing hatchery effects is summarized in Section 2.6 and then application of the methodology and analysis of the Proposed Action itself follows in Section 2.6.2. Effects of the Proposed Action that are expected to occur later in time (i.e., just after timeframe of the Proposed Action) are included in the analysis in this Opinion to the extent they can be meaningfully evaluated. In Section 2.8, 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.

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

*This factor does not apply to spring/summer 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 on these species as an incidental effect of broodstock operations are discussed under Factor 2 (see Section 2.6.2.2.3, below).*

This analysis was first completed in the 2012 Biological Opinion (NMFS 2012a) under the *Fish Removal* section (Section 2.4.3.) as well as the *U.S. v. Oregon* Biological Opinion (NMFS et al. 2018). There are no changes to the Proposed Action or the natural-population that would alter these analyses. Annually, up to 4,010 adults or jacks[9] fall Chinook salmon are collected as broodstock for these four programs. Additionally, about 3,000 more Snake River fall Chinook salmon with CWT's may be collected for run-reconstruction purposes, and expansion of the CWT's to estimate returns to LGR. All of these hatchery programs are integrated and utilize natural-origin fall Chinook salmon in their broodstock. The Proposed Action in this current Biological Opinion includes the same level of natural-origin broodstock removal for these integrated hatchery programs as the previous Proposed Action from 2012. In addition, Snake River fall Chinook salmon natural-origin returns over the length of the last permit have remained generally consistent (USFWS 2017) to what was analyzed in the previous Biological Opinion. 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 to 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 become important), changes in predator-prey interactions, and other "Allee" effects. At present, low abundance is not a concern in this population, with recent (2012 to 2017) natural-origin adult returns to LGR averaging 13,414 (range 6,930-20,638) and total adult returns to LGR averaging 44,930 (range 24,782-58,363). Broodstock total for all components of the Snake River fall 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 need about 6,000 fish. Unintentional mortality due to handling and holding may result in up to 15% of the total fish used for broodstock, and up to 1% of the total run. This full program collection represents a significant proportion of the total run passing over LGR Dam. However, current restrictions on the total natural-origin that can be

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

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 Chinook salmon removed from the natural system to perpetuate these hatchery programs is large. It has ranged from less than 1,000, during the early years of the program, to over five thousand 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 from the hatchery program. Collecting a high percentage of NORs is not considered detrimental to this single-population ESU, because the Minimum Abundance Thresholds have been exceeded in recent years. Long-term positive trends in total population abundance, natural spawner abundance, and spawner utilization in the production areas above LGR indicate total population levels that are significantly higher than would warrant demographic risk concern. Additionally, physical and biological limits, regarding total proportions of the run-at-large (20% maximum for Snake River fall Chinook salmon and 30% maximum for Snake River steelhead at the LGR trap-rate) that can be handled, sampled and/or collected for use as program broodstock, further reduce the demographic risk concerns for this population.

Furthermore, the collection of a higher percentage of NORs allows for the population level PNI to increase (see Section 2.6.2.2 for the full genetic analysis). Natural-origin return adults are targeted to be included in the brood at a rate of 30% with no more than 20% of the total natural origin return collected (Section 1.3.3). When NORs are very high, then there is little risk to deplete the natural-origin population above LGR.

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. 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 as well. 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 for removing natural-origin fish for broodstock at this point in time. In addition, the annual abundance of natural-origin Snake River Fall Chinook salmon has substantially increased since the 1990’s, which means that it is unlikely that the removal of natural-origin fish for broodstock for this program has negatively affected population abundance. 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 impact 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.

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

A genetic analysis was completed in the 2012 Biological Opinion (NMFS 2012a) under the *Genetic Effects* section (Section 2.4.4.). The Proposed Action from the *U.S. v. Oregon* Biological Opinion (NMFS et al. 2018) included the movement of the 1 million IPC releases from the Hells

Canyon reach into the Salmon River (Section 2.5). The updated genetic analysis below focuses primarily on two elements in the current Proposed Action that should have consequences in terms of genetic risk, compared to the program in place since 2012: the movement of the 1 million IPC releases from the Hells Canyon reach into the Salmon River, and the replacement of all yearling releases above LGR with subyearlings. Based on our current understanding of homing fidelity of Snake River fall Chinook salmon, the reprogramming of the IPC releases should lessen the effects of the hatchery programs in the upper Snake River area (above the Salmon River), and may serve as a first step toward creation of a natural production emphasis area as part of a recovery scenario (NMFS 2017d). This analysis is described in greater detail below, in Section 2.6.2.2.1. While this change in the Proposed Action should result in a substantial reduction in genetic risk relative to current conditions, it involves considerable uncertainty. However, it also potentially offers large benefits in terms of better understanding this salmon population, as well as providing critical information on the consequences of large-scale perturbations in hatchery/natural dynamics. In addition, the population is now being managed at a much higher PNI level than it was previously. Although the hatchery programs continue to pose risk, the level is considerably reduced from previous levels and at this point does not appear to pose a risk to the survival or recovery of Snake River fall Chinook salmon. Please refer to Appendix A (Section 5.2.1) for a more thorough description of potential genetic effects of hatchery programs.

Ecological and adult collection effects are also considered in this section. These are relevant for spring/summer Chinook, steelhead, and sockeye salmon because these proposed programs do not propagate these species. The overall effect of this factor on these species is negligible, as discussed below.

##### 2.6.2.2.1. Genetic interactions between hatchery- and natural-origin adults

*Genetic interactions between fish of the proposed action and spring/summer Chinook salmon, steelhead, or sockeye salmon do not occur, since these species are not produced by the proposed hatchery programs.*

Hatchery programs, while undoubtedly having the ability to increase abundance, may pose genetic risks to natural populations in several ways, as discussed in Appendix A Section 5.2.1. Three categories of risk are pertinent to the hatchery programs for Snake River fall Chinook salmon: hatchery-influenced selection, within-population diversity, and outbreeding effects.

**Hatchery-influenced selection**

The risk of hatchery-influenced selection posed to Snake River fall Chinook salmon from the large hatchery effort that is in place has been a concern for some time, primarily because of the high percentage of spawners that are hatchery returnees in a single-population ESU. Under the 2012 Proposed Action (NMFS 2012a), although there was uncertainty about both factors, we concluded that the proportion of hatchery-origin fish on the spawning grounds (pHOS), coupled with the proportion of natural-origin fish in the broodstocks (pNOB), led to a proportionate natural influence (PNI) that averaged approximately 7%. This is a considerably lower PNI value than we would ordinarily consider appropriate for a population of high conservation value, especially one that is the sole extant population in a listed ESU. The PNI recommended by the

HSRG for such a population, for example, is 67%[10]. Although it is not a hatchery-influenced selection concern per se, we also were concerned that the broodstock collection protocols, typically collection only at LGR, would limit conservation or development of subpopulation structure, posing a diversity risk.

[10] NMFS considers the gene flow standards (pHOS and PNI) promulgated by the HSRG as useful metrics to be used with other information. NMFS may, based on program specifics, consider a given pHOS or PNI level to be a lower risk than the HSRG would but, generally, if a program meets HSRG standards, NMFS will typically consider the risk levels to be acceptable.

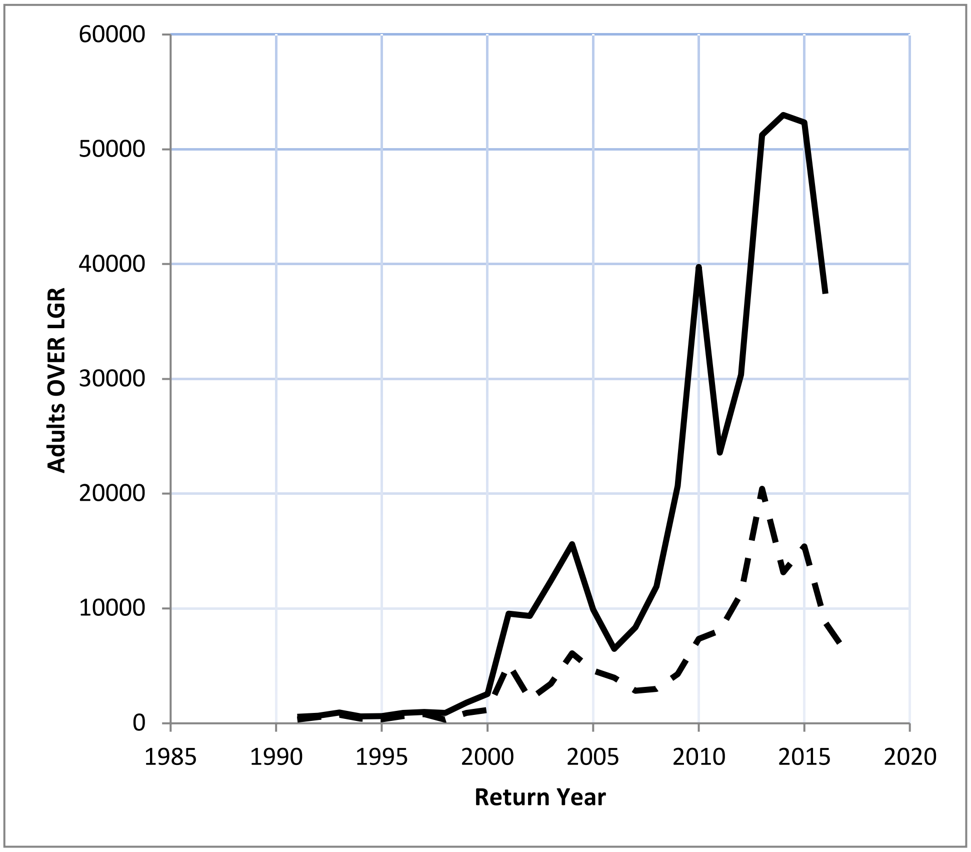


**Figure 7. Snake River adult fall Chinook escapement at Lower Granite Dam. Solid line is total escapement, and dashed line is natural-origin escapement.**

While recognizing these risks, in 2012 we also considered that although in theory the presence of so many hatchery-origin fish on the spawning grounds should in theory cause fitness to decline, natural production in the population was increasing. Given that the hatchery program was also increasing in size, it was possible that the increase in natural production was caused by spawning of an increasing number of hatchery-origin fish, but it could not be ruled out that this was a supplementation response. Based on this, and the relatively short number of generations the population had been subjected to hatchery influence, NMFS concluded that issuing an ESA section 10 permit to continue operation of the programs through broodstock collection in 2017, without attempting to reduce hatchery influence, posed no risk to the survival or recovery of the population and thus the Snake River fall Chinook ESU.

In 2012, it was also clear that there were important information gaps that made it difficult to recommend actions to reduce genetic risk. A key part of the 2012 Proposed Action was a supplemental RM&E package to allow more precise estimates hatchery-natural composition, homing fidelity of hatchery fish, and area of origin of naturally produced fish. Results of these RM&E efforts were presented at the *Snake River Fall Chinook Symposium* that took place on May 16th-17th, 2017 (USFWS 2017).

In terms of overall demographic impact of the hatchery program on the Snake River fall Chinook salmon, the uncertainty regarding the effects of the programs have not changed much since 2012. Although in recent years there has been a decrease in returns, likely due to ocean conditions, escapement has continued to grow since 2012, with natural-origin escapement correlating well in general with total escapement Figure 7. Especially interesting is the major departure from parallel total and natural-origin escapement trends seen in 2011. However, data presented at the symposium suggest that density-dependence may be limiting natural productivity (Perry et al. 2017). If the effect is further substantiated, changes in the hatchery programs may be indicated.

The most notable change in the hatchery risk situation since 2012 is an increase in PNI from approximately 7% to an average of over 25% (Table 19). While still far below the 67% recommendation, this is an impressive improvement. pHOS levels have not changed noticeably since 2012; the increase in PNI is due to higher pNOB values (Table 20) (Milks 2018a; NPT 2018a) that have been made possible by improved identification of natural-origin fish, selective use of older unmarked/untagged fish for broodstock, and limited reuse of known hatchery-origin males. The impacts of the latter two measures, which were developed during the 2012 consultation, on within-population diversity is discussed in the diversity section below.

**Table 19. pHOS and PNI for the Snake River Fall Chinook population including the four hatchery program contributions. The pNOB values from Table 20 were used to calculate two-population modeled PNI using the equation: $PNI = \frac{pNOB}{pNOB+pHOS}$ $PNI = \frac{pNOB}{pNOB+pHOS}$ (Milks 2018a; NPT 2018a)**

| | pHOS return to LGR | | pHOS escapement above LGR[1] | | PNI using all fish returning to LGR | PNI using all fish above LGR[1] |
|---|---|---|---|---|---|---|
| **Year** | **Adults only** | **Adults and jacks** | **Adults only** | **Adults and jacks** | | |
| 2012 | 0.65 | 0.70 | 0.61 | 0.66 | 0.30 | 0.31 |
| 2013 | 0.63 | 0.64 | 0.58 | 0.59 | 0.28 | 0.30 |
| 2014 | 0.78 | 0.77 | 0.74 | 0.73 | 0.24 | 0.25 |
| 2015 | 0.73 | 0.73 | 0.70 | 0.70 | 0.18 | 0.23 |
| 2016 | 0.80 | 0.76 | 0.72 | 0.74 | 0.27/0.32[2] | 0.27/0.32[2] |
| 2017 | 0.72 | 0.74 | N/A[3] | N/A[3] | 0.26 | N/A[3] |
| **Mean** | **0.72** | **0.72** | **0.67** | **0.68** | **0.26[4]** | **0.27/0.28** |

[1]pHOS above LGR was calculated by estimating escapement above LGR through subtracting broodstock removals, fallback below Granite, sport and Tribal harvest and NPTH volunteers from the return to Granite estimate
[2]The two modeled scenarios used run-reconstruction as well as PBT estimates from 2016, and are reported in that order
[3]pHOS values for 2017 are not available above LGR at this time
[4]Overal means were found with both 2016 pNOB estimates; however, this did not change overall mean

**Table 20. Brood years and pNOB values for the WDFW and NPT hatchery components as well as total combined pNOB. LGRThese values were calculated based on run-reconstruction methodology at LGR, where males used multiple times were counted multiple times in the estimates (Milks 2018a; NPT 2018a)**

| Brood Year | Total pNOB | WDFW pNOB | NPT pNOB |
|---|---|---|---|
| 2010 | 0.14 | 0.14 | 0.15 |
| 2011 | 0.24 | 0.22 | 0.31 |

| | | | |
|---|---|---|---|
| 2012 | 0.30 | 0.25 | 0.42 |
| 2013 | 0.25 | 0.21 | 0.35 |
| 2014 | 0.24 | 0.22 | 0.29 |
| 2015 | 0.16 | 0.15 | 0.18 |
| 2016 | 0.28[1] | 0.28 | 0.28 |
| 2017 | 0.26 | 0.26 | 0.28 |
| Mean between eight years | **0.23[2]** | **0.22** | **0.28** |

[1]PBT samples were analyzed for this year and used to compared to the current run-reconstruction methods to estimating pNOB. In comparison to the run-reconstruction method, the PBT method resulted in a pNOB value of 0.35. 2017 PBT samples are still being analyzed, but may be helpful for determining true pNOB values in the future.
[2]We expect that the annual proportion of natural-origin broodstock will be greater than 0.15 or 15% in the future.

An important development since the 2012 consultation was completion of a Snake River fall Chinook salmon recovery plan (NMFS 2017d). One recovery scenario dealt with genetic risk in an innovative way. Elaborating on the possibility that the population could support a subpopulation structure, recovery planners considered whether it would be possible to establish one or more "subpopulations" of greatly reduced hatchery influence relative to other spawning areas by reconfiguring the hatchery releases but not reducing program sizes. These areas are termed NPEAs, and were described earlier in the document. Previous homing fidelity research (Garcia et al. 2004) suggested it may be possible to develop an area of lower hatchery influence in the Upper Salmon River[11]. An extension of the Ford (2002) genetic model to multiple populations was then developed (Busack 2015)[12] and linked to the dispersal information to determine if an adequate PNI level could be achieved in the NPEA. Dispersal data produced by new radio-tagging study (Cleary et al. 2017) were used to update the modelling (Cooney and Busack 2017). Tentative targets set by NMFS for the NPEA were a PNI of 67% or more, and contributing 40% or more of the population's total natural production. Early expectations were that the targets could be met by moving both the Hells Canyon and Pittsburgh Landing releases to the Salmon River, which amounted to 27% of the total release of juvenile Snake River fall Chinook salmon. However, it appeared through additional model runs that achievement of the NPEA targets could require the movement of additional groups. Considerations of the uncertainties regarding survival rates, dispersal data, lack of homing information for the proposed Salmon River releases, and response of natural production to a large scale change from the present configuration of releases lead to the operators to use a phased approach to the NPEA concept. The result is that the current Proposed Action as well as the present *U.S. v. Oregon* Management Agreement and accompanying Biological Opinion (NMFS et al. 2018) includes only one change in release locations: moving the release of 1,000,000 subyearling fall Chinook salmon from Hells Canyon to a site (of equivalent distance to LGR) on the lower Salmon River[13].

The scenarios for evaluating the impact of moving fish releases were developed and analyzed in a Microsoft Excel® workbook model (Cooney and Busack 2017). Figure 8. displays the "control panel" page of the model. The figure gives some sense of the complexity of the model; the only major aspect of the model not portrayed on this page is the 3-population version of the

[11] The reach between the Salmon-Snake confluence and Hells Canyon Dam
[12] Expansion of the model was a collaboration between Cooney, Busack, and Ford. Now known as the multi-population PNI model, it has become a common analytical tool in hatchery consultations.
[13] Hammer Cr. boat launch, Salmon R. RM 52.5.

Ford model, the basics of which are detailed in Busack (2015). The three populations modeled are the hatchery programs (collectively), the NPEA (the Snake upstream of its confluence with the salmon), and the rest of the natural area occupied by the population (collectively). The model assumes a user-selected number of hatchery-origin and natural-origin returnees, survival, and dispersion rates of the returnees according to Cleary et al. (2017) and Rosenberger et al. (2017). Gene flow among the three areas are based on hatchery-origin fish from the different areas being taken for broodstock in the proportion and the dispersion rates of Cleary et al. (2017). The model further assumes that the upper Snake area currently accounts for 30-40% (depending on the method, and years of data used) of the natural production (Cooney, NMFS, pers. comm.).

Table 21 presents expected results from the model in terms of PNI and pHOS in the upper Snake River for two programming options: current (Proposed Action not implemented) and Proposed Action implemented (Hells Canyon release moved to Salmon R.). The results were sensitive to a number of assumptions, which will be discussed shortly, but one of the most important was the selection strength used in the genetic programming of the model. Therefore, for bothprogramming scenarios, the table presents the results of two different levels of selection strength: stronger (1 standard deviation), and weaker (3 standard deviations)[14]. The stronger level was outside the range of selection strengths used by Ford (2002), so its inclusion was somewhat speculative[15]. However, we felt it important to include it because of its large effect and also to highlight the reliance of the analysis on this theoretical evolutionary model. The results presented assume a return of 23,000 hatchery-origin fish and 13,400 natural-origin fish.

The table presents information for a variety of combinations of pNOB and proportionate contributions of the potential NPEA. The achievable PNI level, quite logically, depends greatly on pNOB. The stated pNOB target remains 30%[16], so this is a reasonable reference point, especially in view of recent levels (Table 20). The nominal target contribution of 40% is highlighted. Assuming this level can be reached, under the existing program the potential NPEA PNI would be 43-55%. Under the Proposed Action this increases to 46-62%. Although this may seem only a modest increase, this change could result in a large change a hatchery fish density that could have large demographic consequences that may in turn influence PNI. One possibility is that natural-origin production will increase, which would increase PNI over what is expected based on the modelling. On the other hand, if the natural production is heavily “subsidized” by hatchery-origin spawners, the potential NPEA PNI could be lower. Either outcome would be very important to better understanding the population.
It is important to realize that this action involves a number of uncertainties. To this point, this discussion has focused on only one: which selection strength should be used in modelling. The genetic modelling itself is subject to additional uncertainties. It assumes a particular mode of

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[14]Ford’s model considered a single trait underbalancing selection. Use of this model assumed this single trait modeled is a surrogate for the complex of traits that constitute a response to domesticating selection. Selection strength describes the shape of the fitness curve relative to the fitness optimum, the larger the number, the more gradual the drop-off. Ford used selection strengths of 3 and 10 standard deviations.)

[15] We used selection strengths of 1 and 3 standard deviations, as this better represented the selection strengths for various traits that have been empirically studied, but because the Ford model uses a statistical distribution that simulates weak selection, we were concerned that a strength of 1 standard deviation may cause model results to be distorted.

[16] For perspective on the relative importance of pNOB, Table 21 includes results for pNOB levels as high as 45%, far above the target level of 30%, and currently well outside the range of feasibility.

selection at a particular life stage, and uses mathematical functions to simulate genetic mechanisms. Under present circumstances, this model is preferable and is reasonable for providing guidance regarding levels of hatchery influence (RIST 2009). As in any other model of complex phenomena, uncertainty increases the more precisely you attempt to apply it. But there are three other notable areas of uncertainty in the modelling:

- Dispersion. The model assumes the dispersion results from the recent radio-tracking work (Cleary et al. 2017), which were based on the existing program reflects patterns that will be experienced in the future. Aside from being subject to error due to unavoidably small sample sizes, the extent to which patterns may change from year to year is unknown. Most notably, because there have been no Salmon River releases in the past, there is no information on how returning fish may disperse. The modelling assumed a dispersal pattern for Salmon River release that was basically the same as the dispersal psttern for fish released into the Clearwater Basin. This may be an underestimate of the degree and extent of dispersal.
- Ratio of natural-origin to hatchery-origin returnees. As previously mentioned, the modelling assumed 23,000 hatchery-origin returnees and 13,400 natural-origin returnees). This is a reasonable proportion, but it could vary considerably over time. If natural-origin fish constitute a larger mixof the run than the modeled value, higher levels of PNI will be achieved, and the converse is true if hatchery-origin fish constitute a larger portion of the run.
- Response of the spawning population in the upper Snake to the lower density of hatchery-origin spawners in the area. If the high density was suppressing natural-origin productivity through density dependence, PNI could be boosted, as well as the relative contribution of the upper Snake to overall production of natural-origin Snake River fall Chinook salmon. On the other hand, if natural-origin production in that reach of the river is heavily dependent on hatchery-origin spawners, natural-origin production could drop in that area, which could have the opposite effects genetically and demographically. Considering all these uncertainties, the level of reprogramming reflected in the Proposed Action seems appropriately cautious.

Evaluating the demographic and genetic consequences of the reprogramming of releases from the upper Snake River to the Salmon River is very important. The demographic consequences are the simpler issue, as the proportion of overall production and changes therein can be estimated from ongoing redd surveys. Understanding the PNI of the potential NPEA is a more complicated issue. A specific PNI level is a target, not a state of the population that can be measured directly. In the typical application of this kind of modeling, the familiar equation $PNI \approx pNOB/(pNOB + pHOS) PNI \approx pNOB/(pNOB + pHOS)$ can be used to verify the population is on a trajectory to achieve the specified PNI value, where pHOS is measured over the entire population. In this application of the 3-population version of the Ford model, two pHOS values are important: the overall population pHOS, and that in the potential NPEA (upper Snake River).

While overall pHOS is easily obtainable from sampling at LGR, measuring NPEA-specific pHOS is more complicated. At this point, two options seem available. One is an indirect measure based on return rates and assumed dispersal rates. One approach would be to estimate contributions of the various release groups to the upper Snake spawning area, and then subtract that from observed redd counts in the area to estimate what proportion of the spawners are of natural origin. This approach is subject to many sources of error. The other approach, sampling carcasses, is more direct but feasibility is problematic—recovering carcasses in the mainstem Snake River is notoriously difficult. The Proposed Action includes a commitment to exploring feasibility of expanded carcass recoveries, but sample size may limit precision of pHOS estimates.

An important consideration in RM&E of the reprogramming is the time frame over which changes can be detected. The first Salmon River release occurred in 2018, so the first full generation of 4-year-old returns will be 2021-2025. The first full generation of natural production (again, based on a 4-year generation time) under the reduced hatchery influence will occur in 2026-2030, and the productivity of fish in this area, and consequent proportionate production resulting from it, will not be seen until 2031-2034.

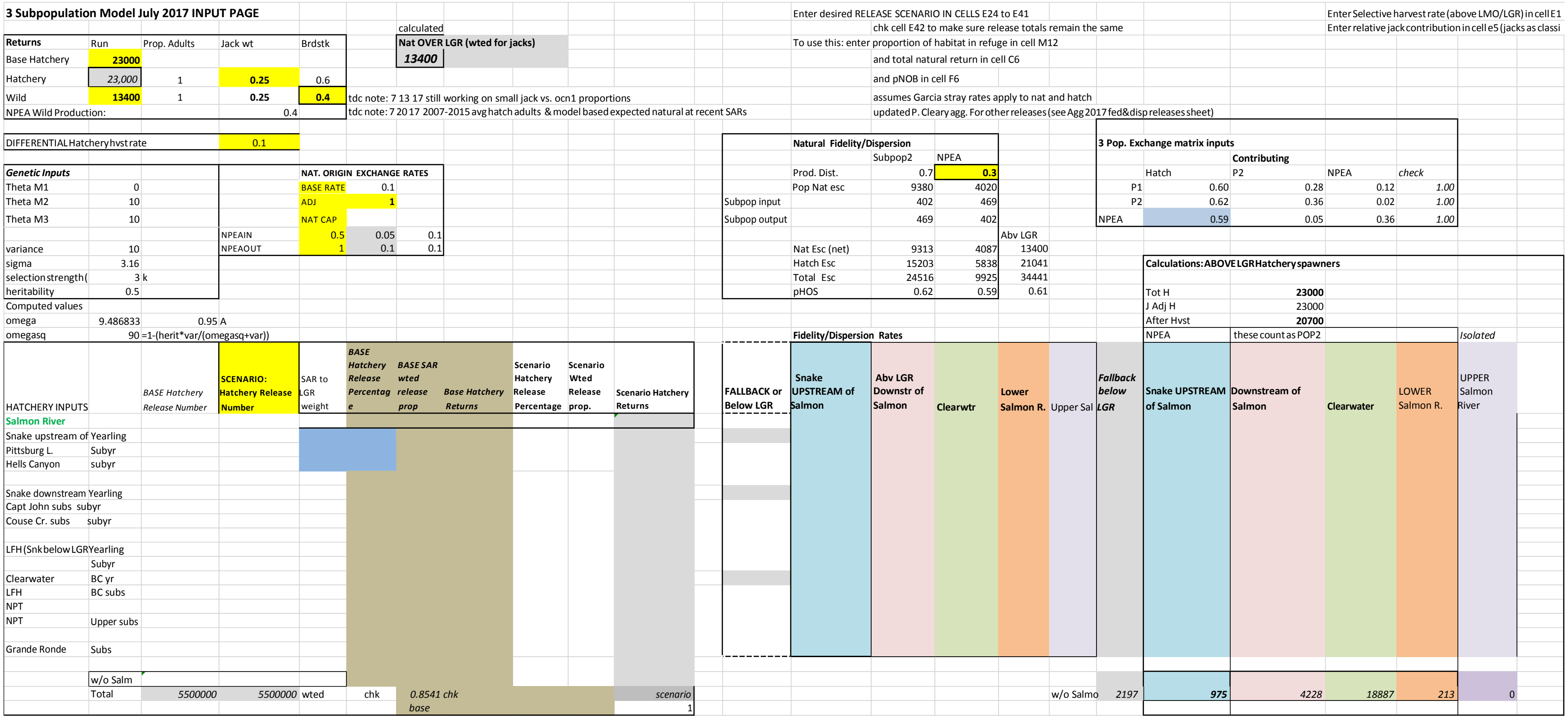


**Figure 8. Basic page of Excel® workbook model developed to evaluate the impact of moving fish releases in the Snake River fall Chinook salmon hatchery programs (Cooney and Busack 2017).**

**Table 21. PNI and pHOS for current and proposed hatchery programming scenarios, under varying assumptions of the potential NPEA contribution to natural production, pNOB, and selection strength.**

| Scenario | NPEA proportion of natural production | PNI in NPEA | | | | | | pHOS in NPEA | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | pNOB | | | | | | pNOB | | | | | |
| | | 0.2 | 0.25 | 0.3 | 0.35 | 0.4 | 0.45 | 0.2 | 0.25 | 0.3 | 0.35 | 0.4 | 0.45 |
| **Baseline (Proposed Action not implemented), under stronger selection** | 0.3 | 0.50 | 0.51 | 0.52 | 0.53 | 0.54 | 0.55 | 0.66 | 0.62 | 0.59 | 0.56 | 0.53 | 0.50 |
| | 0.35 | 0.52 | 0.52 | 0.53 | 0.54 | 0.55 | 0.56 | 0.66 | 0.62 | 0.59 | 0.56 | 0.53 | 0.50 |
| | 0.4 | 0.53 | 0.54 | 0.55 | 0.56 | 0.57 | 0.58 | 0.66 | 0.62 | 0.59 | 0.56 | 0.53 | 0.50 |
| | 0.45 | 0.55 | 0.56 | 0.57 | 0.58 | 0.59 | 0.60 | 0.66 | 0.62 | 0.59 | 0.56 | 0.53 | 0.50 |
| | 0.5 | 0.57 | 0.57 | 0.58 | 0.59 | 0.60 | 0.61 | 0.66 | 0.62 | 0.59 | 0.56 | 0.53 | 0.50 |
| **Baseline (Proposed Action not implemented), under weaker selection** | 0.3 | 0.36 | 0.37 | 0.37 | 0.37 | 0.38 | 0.38 | | | | | | |
| | 0.35 | 0.40 | 0.40 | 0.40 | 0.40 | 0.41 | 0.42 | | | | | | |
| | 0.4 | 0.42 | 0.42 | 0.43 | 0.43 | 0.44 | 0.44 | | | | | | |
| | 0.45 | 0.45 | 0.45 | 0.45 | 0.46 | 0.46 | 0.47 | | | | | | |
| | 0.5 | 0.47 | 0.47 | 0.48 | 0.48 | 0.49 | 0.49 | | | | | | |
| **Proposed Action (1,000,000 Hells Canyon fish moved to Salmon) , under stronger selection** | 0.3 | 0.55 | 0.57 | 0.59 | 0.60 | 0.62 | 0.63 | 0.48 | 0.44 | 0.40 | 0.37 | 0.35 | 0.32 |
| | 0.35 | 0.57 | 0.59 | 0.60 | 0.62 | 0.63 | 0.65 | 0.48 | 0.44 | 0.40 | 0.37 | 0.35 | 0.32 |
| | 0.4 | 0.59 | 0.60 | 0.62 | 0.63 | 0.65 | 0.66 | 0.48 | 0.44 | 0.40 | 0.37 | 0.35 | 0.32 |
| | 0.45 | 0.60 | 0.62 | 0.63 | 0.65 | 0.66 | 0.68 | 0.48 | 0.44 | 0.40 | 0.37 | 0.35 | 0.32 |
| | 0.5 | 0.62 | 0.63 | 0.65 | 0.66 | 0.67 | 0.69 | 0.48 | 0.44 | 0.40 | 0.37 | 0.35 | 0.32 |
| **Proposed Action (1,000,000 Hells Canyon fish moved to Salmon) , under weaker selection** | 0.3 | 0.39 | 0.40 | 0.41 | 0.42 | 0.44 | 0.45 | | | | | | |
| | 0.35 | 0.42 | 0.43 | 0.44 | 0.45 | 0.47 | 0.48 | | | | | | |
| | 0.4 | 0.45 | 0.46 | 0.47 | 0.48 | 0.50 | 0.51 | | | | | | |
| | 0.45 | 0.48 | 0.48 | 0.50 | 0.51 | 0.52 | 0.54 | | | | | | |
| | 0.5 | 0.50 | 0.51 | 0.52 | 0.53 | 0.54 | 0.56 | | | | | | |

Although implementation of this aspect of the Proposed Action involves considerable uncertainty in possible outcomes and in terms of how large a step it may be toward recovery, the creation of the area of reduced hatchery influence is a large step in risk reduction. Overall pHOS is unlikely to go up and pHOS in the upper Snake may go down considerably. There are benefits of moving the Hells Canyon release far beyond genetic risk reduction, however. The reduction of releases of hatchery fish in the upper Snake by 2/3 should also lead to a greater understanding of natural productivity and density dependence in this population. Such a massive reduction in the number of hatchery fish released in the upper Snake may also provide useful information on the response of predators, particularly smallmouth bass (*Micropterus dolomieu*), which are known to be present in large numbers in the Snake River (Tiffan and Erhardt 2017). Finally, this is the largest size-neutral reprogramming of hatchery programs so far attempted to establish a level of lower hatchery influence in a population. It is essentially a test-run of the NPEA concept.

The genetic and demographic results of this action will no doubt inform future risk reduction and recovery actions.

**Within-population diversity**

In this section, we discuss two aspects of program operation items that have a bearing on genetic diversity in the Snake River fall Chinook salmon population: reduction of yearling releases and broodstock mating strategies.

*Reduction of yearling releases*

The Snake River fall Chinook salmon population predominantly exhibits a subyearling life history, but the hatchery programs have been releasing about 15% of the production as yearlings. This practice was adopted to achieve higher survivals of hatchery fish; survival rates to adulthood of yearling releases are routinely twice as high as those of subyearlings (WDFW et al. 2011). The balance between achieving the higher survival rates yielded by yearling releases and possible selective effects on juvenile life history is an ongoing discussion by the operators (WDFW et al. 2011), and the yearling releases were questioned in the review by the Columbia Basin Hatchery Review Team (USFWS 2011).

Although most fall Chinook salmon juveniles from the Snake River migrate to sea as subyearlings, a substantial number of outmigrants from the Clearwater River overwinter in reservoirs of the hydropower system and enter the ocean as yearlings (Connor et al. 2002; Connor et al. 2005), possibly representing an evolutionary response to a decrease in stream temperature caused by Dworshak Dam (Williams et al. 2008).

The subyearlings from the hatchery programs appear to mimic the natural life history pattern of Snake River fall Chinook salmon but may still be subject to considerably different selection pressures than the natural-origin yearlings. For example, hatchery-origin yearlings experience little or no overwinter mortality compared to natural-origin yearlings. The survival rates to adulthood of yearling releases are much higher than the subyearling releases, accounting for about 50% of the returning adults although they comprise only 15% of the releases.
Thus, it seems possible that the yearling releases may be a source of genetic change in the population. But it is unclear in what way that would change the population.

At the time of the last consultation, research was underway into the genetic determination of juvenile life history in Snake River fall Chinook salmon. This research has now been completed. Results indicate substantial heritability for growth rate and association between juvenile life history of parents and growth rate of progeny, suggesting that the observed increase in the proportion of natural yearling outmigrants could have been an evolutionary response to a changing environment. In addition, the research demonstrated that forced yearling outmigrants tend to produce faster-growing progeny, which would then be expected to mature earlier. The mechanism underlying this phenomenon is unclear, but if it reflects epigenetic change, it could have consequences lasting multiple generations (Waples et al. 2017).

Rosenberger et al. (2017) report that yearling releases no longer exhibit the previously observed survival advantage over subyearling releases for adult returns. As a result, the new Proposed

Action reduces yearling releases by 50%; the only yearling fish release will be from Lyons Ferry Hatchery. The yearling release from LFH is being retained as a safety net release to buffer against a possible downturn in subyearling survival during poor ocean conditions and to retain returns to LFH for trapping if LGR trapping is interrupted and broodstock needs are not met (D. Milks, WDFW, pers. comm.). Given the possible genetic consequences of producing yearlings, the large reduction in yearling releases, coupled with the retention of the LFH yearling release as a safety net is an appropriate step in risk reduction. LFH is advantageous as a site for the safety-net release because yearling releases produce proportionately more jacks than subyearling releases, and release from LFH can be expected to cause more of the jacks to return to LFH, many miles below the bulk of natural spawning areas above LGR (D. Milks, WDFW, pers. comm.).

Until the 2012 consultation the mating protocols at both hatcheries were largely random mating but with limits on the incorporation of 0- and 1-ocean age fish (mainly males), with age based on size. In recent years, however, the younger fish have returned at larger sizes, resulting in them being used in a large proportion of matings, on average 58% between 2000 and 2010, with a high of 83% (NMFS 2012a).

This large contribution of young fish raised concerns about the long-term effect on population age structure because age at maturity is heritable (e.g., Hankin et al. 1993; Heath et al. 1994). Beginning in 2009, older fish have been used preferentially for broodstock in the Snake River fall Chinook salmon hatchery programs. This protocol was motivated not only by the past overrepresentation of young fish, but also by the observation that older fish are harvested at higher rates in lower river fisheries (and may thus be under represented) (WDFW 2011), and by research within the Columbia Basin (Schroder et al. 2012) demonstrating that large adult males contribute disproportionately to spawning, presumably due to competitive dominance, and by modeling (Hankin et al. 2009) showing that random mating with respect to size and age results in a population of younger, smaller fish.

*Broodstock mating strategies*

The 2011 HGMPs (NPT 2011; WDFW et al. 2011) proposed a non-random mating strategy, emphasizing the use of bigger/older fish as broodstock. Table 22 contrasts the percent age structure of fish in the run at LGR with those used as broodstock. Selection against 2-yr and 3 yr-old fish old in favor of 4-yr and 5-yr old fish is preferred, especially for males. Given the well-known tendency of hatcheries to produce younger fish, it is unclear to what extent this practice may be diversifying the hatchery effect as opposed to selecting for older age. However, given the existing available literature, especially Hankin et al. (2009), that shows that random mating could essentially be artificial selection for a younger age structure, the extent of selection being practiced in these programs does not pose significant risk, and in fact may be a substantial risk reduction.

**Table 22. Salt age and total age composition percentages of Snake River fall Chinook salmon at Lower Granite Dam and in the NPTH and LFH broodstocks (2015-2017) (D. Milks, WDFW, pers. comm.)**

| | 2015 | 2016 | 2017 | Mean |
|---|---|---|---|---|

| Salt Age | Females Brdstk | Females Run | Males Brdstk | Males Run | Females Brdstk | Females Run | Males Brdstk | Males Run | Females Brdstk | Females Run | Males Brdstk | Males Run | Females Brdstk | Females Run | Males Brdstk | Males Run |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 6 |
| 1 | 0 | 1 | 0 | 18 | 0 | 2 | 0 | 28 | 1 | 2 | 1 | 29 | 0 | 2 | 1 | 25 |
| 2 | 25 | 30 | 30 | 51 | 16 | 25 | 28 | 37 | 34 | 39 | 44 | 44 | 25 | 31 | 34 | 44 |
| 3 | 58 | 53 | 63 | 23 | 66 | 59 | 60 | 22 | 47 | 44 | 44 | 21 | 57 | 52 | 56 | 22 |
| 4 | 17 | 15 | 7 | 3 | 17 | 13 | 12 | 3 | 18 | 15 | 11 | 4 | 18 | 14 | 10 | 3 |
| Total Age | | | | | | | | | | | | | | | | |
| 2 | 0 | 1 | 0 | 16 | 0 | 0 | 0 | 29 | 0 | 0 | 0 | 20 | 0 | 1 | 0 | 22 |
| 3 | 7 | 17 | 18 | 49 | 8 | 16 | 19 | 41 | 21 | 28 | 34 | 49 | 12 | 20 | 24 | 46 |
| 4 | 64 | 60 | 65 | 31 | 64 | 62 | 61 | 25 | 57 | 54 | 52 | 26 | 61 | 59 | 60 | 27 |
| 5 | 22 | 22 | 9 | 4 | 26 | 21 | 16 | 5 | 22 | 17 | 14 | 5 | 23 | 20 | 13 | 5 |
| 6 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

## Outbreeding effects

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

This straying analysis includes populations where natural-origin fish may interact with hatchery-origin fish from the proposed hatchery programs. At a minimum, this includes the population where fall Chinook salmon from other hatchery programs are detected at Snake River fall Chinook hatchery traps. In addition, the analysis may include additional locations where strays from the proposed hatchery programs have been detected. This stray information has then been expanded to a population level. These population level analyses all include river reaches where natural-origin fish may geographically overlap with fish from the proposed hatchery programs.

Here and elsewhere in Idaho, Washington, and Oregon, strays are detected by PIT tag detections, CWT recoveries, or by use of PBT (parentage-based tagging). PIT tag readers are dispersed throughout the Salmon River Basin, and PIT-tagged fish are identified as they pass through these readers. CWT recoveries are typically made during fisheries, on spawning grounds, and at hatchery traps. PBT is an alternative method to PIT tagging and CWT that uses genotyping of hatchery broodstock. Tissue samples are collected, typically from hatchery broodstock and during spawning surveys. With this information, parentage assignments are used to identify the origin and brood year of their progeny. Program strays can be identified with this method after genetic samples have been analyzed. In our straying analyses, CWT and PBT were used to detect fish and calculate population level pHOS and pHOB values. PBT is used widely among hatchery programs in the Snake River Basin, and all proposed Snake River fall Chinook hatchery programs utilize 100% PBT. All returning adult program fish used in hatchery broodstock within the Snake River Basin are sampled via fin clip for PBT analysis.

Data for our analyses was detected from CWT recoveries and PBT analysis by WDFW, NPT, IDFG, ODFW, and CTUIRat hatchery traps, dams, or on spawning grounds from 2012 to 2016, unless otherwise specified. We analyze strays from each of the hatchery programs in the

Proposed Action into other populations. This pHOS analysis was largely completed in the *U.S. v. Oregon* Biological Opinion (NMFS et al. 2018), but we also list all of the strays from the Snake River fall Chinook hatchery programs below. Furthermore, these strays were largely not included in this analysis because that area does not fall within the geographic boundaries of the Snake River Fall-run Chinook Salmon ESU. We also account for hatchery-origin strays from other programs into the populations within our Action Area.

*Straying from Snake River fall Chinook Hatchery Programs*

At present, the HSRG standards and the 5% (or 0.05) stray standard from Grant (1997) are the only acknowledged quantitative standards available for outbreeding effects. Table 23 (Milks 2018b; Young 2018) summarizes detections of Snake River fall Chinook salmon from the proposed programs at hatcheries or on spawning grounds where they would be considered strays. For the most part, fish from the Proposed Action programs return to areas within the Snake River Fall-run Chinook Salmon ESU. However, some strays from hatchery programs have been recorded in the Columbia River in Oregon and Washington outside of the geographic boundaries of the ESU. This analysis was included in the *U.S. v. Oregon* Biological Opinion (NMFS et al. 2018). Overall, these gene flow effects from straying do not constitute a major risk to diversity, since they are below 0.05 (Grant 1997).

**Table 23. Fall Chinook salmon from all of the proposed Snake River Fall Chinook hatchery programs detected in areas (*hatchery traps, dams, or during spawning ground surveys*) outside of their facilities (Milks 2018b; Young 2018)**

| Years | Fish detected by CWT and/or PBT[1, 2] | Recovery location<br><br>(*H = Hatchery, R = River, C = Creek, and NFH = National Fish Hatchery*)<br>Blue = state or tribal trap/survey in Washington, Green = state or tribal trap/survey in Oregon |
|---|---|---|
| 2012 | 219 | Three Mile Dam, Priest Rapids H, Ringold Springs H, Wells H, Bonneville H, Round Butte H, Drano Lake, Hanford Reach, Moran Slough, and Lower Yakima R |
| 2013 | 852 | Three Mile Dam, Priest Rapids H, Ringold Springs H, Wells H, Spring C NFH, Chief Joseph Fish H, Bonneville H, Chelan R, Columbia R (general), Drano Lake, Hanford Reach, Little White Salmon R, Wenatchee R, White Salmon R, Wind R, and Lower Yakima R |
| 2014 | 328 | Three Mile Dam, Kalama Falls H, Little White Salmon NFH, Priest Rapids H, Ringold Springs H, Spring C NFH, Chief Joseph Fish H, Wells Dam, Big C, Bonneville H, Columbia R (at Ives), Hanford Reach, Lacamas R, Lewis R, Little White Salmon R, Spring C, White Salmon R, Wind R, Lower Yakima R, and Voights C |
| 2015 | 247 | Three Mile Dam, Little White Salmon NFH, Priest Rapids H, Ringold Springs H, Chief Joseph Fish H, Bonneville H, Hanford Reach, Little White Salmon R, Similkameen R, White Salmon R, Wind R, Elk R H, Noble C, and Voights CH |
| 2016 | 396 | Three Mile Dam, Priest Rapids H, Ringold Springs H, Wells H, Chief Joseph Fish H, Bonneville H, Chelan R, Columbia R (at Ives and Priest-Wanapum), Hamilton C, Hanford Reach, Lewis R, Little White Salmon R, and Salmon RH |
| **Annual mean[3]** | **408.4** (*from all recovery locations*) | |

[1]Expanded value for tagging rate.
[2]PBT stands for parentage based tagging and has been sampled and analyzed since 2014 (brood year 2010). All fish used for broodstock and released upstream of the weir are PBT sampled.
[3]Means calculated using expanded values, if applicable, per recovery and release location.

Table 24 (Milks 2018b; Young 2018) summarizes detections of fall Chinook salmon at LGR from programs other than those in the proposed action from 2012 onward. Of a total of over 26,000 fish evaluated, only 963 were considered strays, about 3.7%. So in the worst-case situation, less than 5% naturally spawning fish in the Snake River fall Chinook salmon ESU are stray hatchery fish. This level posts only a negligible threat to the population. Inclusion of stray fish in the broodstock is at an even lower level. Given that most of the fish on the spawning grounds are hatchery-origin, gene flow into the Snake River fall Chinook salmon ESU from other hatchery programs is negligibly low.

**Table 24. Fall Chinook salmon from other hatchery programs estimated at the Lower Granite Trap and incorporated into the hatchery broodstocks (Milks 2018b; Young 2018)**

| Years | Strays at Lower Granite Dam | | Strays in Snake Basin Hatchery Broodstock | | | Release location of strays[4] |
|---|---|---|---|---|---|---|
| | Fish detected by CWT and/or PBT[1, 2] | Percent of the total run at LGR | Total fish in matings (M+F) | Total numbers of strays (M+F) | Strays as % of production (pHOB)[3] | |
| 2012 | 138 | 0.25 | 3304 | 1 | 0.03 | Umatilla |
| 2013 | 1,754 | 2.31 | 3330 | 71 | 2.13 | Umatilla, Klickitat, Priest Rapids |
| 2014 | 1,231 | 1.67 | 3154 | 8 | 0.25 | Umatilla, Klickitat, Priest Rapids, Santiam, San Pablo Bay |
| 2015 | 1,371 | 2.09 | 3180 | 27 | 0.85 | Umatilla, Klickitat |
| 2016 | 321 | 0.76 | 3300 | 18 | 0.55 | Umatilla, Prosser (Yakima), Little White Salmon |
| 2017 | N/A | NA | 3418 | 7 | 0.21 | N/A |
| **Annual mean[5]** | ***963*** | ***1.54%*** | ***3,281*** | ***22*** | ***0.67*** | Umatilla, Klickitat, Priest Rapids, Santiam, San Pablo Bay, Prosser (Yakima), Little White Salmon |

[1]Expanded by tagging rate and sampling rate at Lower Granite Dam.
[2]PBT data not available before 2016; PBT broodstock sampling initiated in brood year 2011; stray proportion determined by PBT analysis of fall Chinook salmon trapped at Lower Granite Dam
[3]Percentage was likely overestimated in the previous 2010 Biological Opinion (NMFS 2012a), due to using scale analysis to determine in-basin and out-of-basin origin. Please see (Milks 2018b) for additional information regarding these new calculations.
[4] Release location of strays determined from CWT sampling and run reconstruction at Lower Granite Dam; composition of strays in broodstock are a subset of these locations.
[5]Averages calculated using expanded values, if applicable.

In summation, the overall genetic effects- hatchery-influenced selection, within-population diversity, and outbreeding effects resulting from the hatchery programs in the Proposed Action do not constitute a serious threat to the Snake River Fall-run Chinook Salmon ESU.

#### 2.6.2.2.2. 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 added fish to the ecosystem, there can be positive effects. For example, when anadromous salmonids return to spawn, hatchery-origin and natural-origin alike, they transport marine-derived nutrients stored in their bodies to freshwater and terrestrial ecosystems. Their carcasses provide a direct food source for juvenile salmonids and other fish, aquatic invertebrates, and terrestrial animals, and their decomposition supplies nutrients that may increase primary and secondary production (Gresh et al. 2000; Kline et al. 1990; Larkin and Slaney 1996; Murota 2003; Piorkowski 1995; Quamme and Slaney 2003; Wipfli et al. 2003). As a result, the growth and survival of juvenile salmonids may increase (Bell 2001; Bilton et al. 1982; Bradford et al. 2000; Brakensiek 2002; Hager and Noble 1976; Hartman and Scrivener 1990; Holtby 1988; Johnston et al. 1990; Larkin and Slaney 1996; Quinn and Peterson 1996; Ward and Slaney 1988). For a more detailed description of ecological interactions, refer to the Mitchell Act Biological Opinion (NMFS 2017b).

Salmon and steelhead are important transporters of marine-derived nutrients into the freshwater and terrestrial systems through the decomposition of fish carcasses (Cederholm et al. 2000). One typical added nutrient as result of increased hatchery fish production is phosphorus. Increased phosphorus can benefit salmonids because phosphorus is typically a limiting nutrient for prey sources. 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 by increasing phosphorus in the system, this could potentially provide a larger prey mass for salmonids.

The propagation and release of hatchery-origin fish and eggs from the four proposed programs potentially adds 1062.7 kg (Table 25) of phosphorus annually into the environment in addition to what is typically added to the system by natural-origin fish. Compared to the *U.S. v. Oregon* Biological Opinion (NMFS et al. 2018) and previous 2012 Biological Opinion (NMFS 2012a), this only results in 28.2 kg (represented by 150,000 additional subyearling smolts released) more than what was previously analyzed. Moreover, this is likely an overestimation of nutrients added to the system, because hatchery-origin returns are subjected to removal from harvest, broodstock collection, and gene flow management. Regardless, these added hatchery-origin fish may add additional beneficial nutrients into the system.

**Table 25. Total phosphorous imported by adult returns from the proposed hatchery programs per year based on the equation:** $I_t = A_t \times m_A \times P_A$ $\boldsymbol{I_t = A_t \times m_A \times P_A}$ **, 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 2005).**

| All program releases by lifestage | #smoltrelease × smolttoadultsurvival = $A_t$# $\boldsymbol{smolt\ release \times smolt\ to\ adult\ survival = A_t}$[1] | Number of adults, $A_t$ | Adult Mass (kg), $m_A$[2] | Concentration of phosphorous (kg/adult), $P_A$[3] | Phosphorus imported (kg/year), $I_t$ |
|---|---|---|---|---|---|
| 5.2 million subyearlings | 5.2 million × ~0.009 | 46,800 | 5.5 | 0.0038 | 978.1 |

| | | | | | |
|---|---|---|---|---|---|
| 450,000 yearlings | 450,000 $\times$ ~0.009 | 4,050 | | | 84.6 |
| **Total phosphorus production from all releases:** | | | | | **1062.7** |
| *Increase of 150,000 subyearlings from 2012 Biological Opinion* and *U.S. v. Oregon Biological Opinion* | 150,000 $\times$ ~0.009 | 1,350 | 5.5 | 0.0038 | 28.2 |
| **Total change in phosphorus production from previous releases:** | | | | | **28.2** |

[1]Average smolt to adult survival to LGR for the most recent years for all release sites combined, separated by lifestage (USFWS 2017). Adult and jack returns were used to estimate the maximum phosphorus contribution.
[2]5.5 kg was used as the mean mass of adult Chinook salmon from the Snake River basin (Peery et al. 2003)
[3]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 hatchery-origin and natural-origin Snake River fall Chinook is very similar. Therefore, hatchery-origin fish that make it onto spawning grounds may compete with natural-origin fall Chinook salmon for spawning sites and redd superimposition may also occur. These integrated hatchery programs produce hatchery-origin fish that are intended to spawn with natural-origin fish to supplement the natural-origin population. As described in Factor 1, Section 2.6.2.1 the natural Snake River Fall Chinook salmon population remains over the abundance threshold for a “Large” population. Because of this, there is likely room for both natural-origin and hatchery-origin returns to spawn without competing for spawning sites or superimposing redds.

Regardless, the Proposed Action of relocating hatchery releases from the upper Snake River into the Salmon River creates an area where natural fish may not be subject to the extent of site competition and redd superimposition that they previously were. This change is expected to reduce hatchery-origin spawners on natural-origin spawning grounds in the upper Snake River, and pHOS calculations are expected to decrease.

There is unlikely to be spawning site competition or redd superimposition with hatchery-origin fall Chinook salmon and the other three listed species (Table 26). 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 hatchery-origin fall Chinook salmon could compete with natural-origin spring/summer Chinook salmon because there is a slight overlap in spawn timings in October. However, the single-population Snake River Fall-run Chinook Salmon ESU only geographically overlaps with a portion of the Snake River Spring/summer Chinook Salmon ESU. This overlap primarily occurs in the South Fork of the Salmon River MPG Little Salmon River population, but there is also a small portion of overlap with the South Fork of the Salmon River population. However, Snake River fall Chinook spawn in the mainstem rivers while Snake River spring/summer Chinook salmon spawn in tributarties. Becaue of these spatial, temporal, and life history differences, we expect the effects from spawning site competition and redd superimposition between hatchery-origin fall Chinook salmon and Snake River spring/summer Chinook salmon to be minimal. Hatchery operators are familiar with identifying morphological differences between fall and spring/summer Chinook, therefore it is unlikely that they use incorrect species for broodstock purposes. The ongoing PBT genetic analyses will indicate any spawning overlap between fall and spring/summer Chinook, which would determine levels of spawning site competition and redd superimposition between these species.

**Table 26. Run and spawn timing of Snake River fall Chinook salmon, steelhead, spring/ summer Chinook salmon, and sockeye salmon**

<table>
<tr><th colspan="2">Species</th><th>Run timing</th><th>Spawning</th></tr>
<tr><td colspan="2">fall Chinook salmon</td><td>late-August to November</td><td>mid-October to mid-December</td></tr>
<tr><td colspan="2">steelhead</td><td>September to November</td><td>March to June</td></tr>
<tr><td colspan="2">spring/summer Chinook salmon</td><td>March to mid-August</td><td>late July to October</td></tr>
<tr><td rowspan="3">sockeye salmon</td><td>resident life form I</td><td>NA</td><td>late-fall</td></tr>
<tr><td>resident life form II: kokanee</td><td>NA</td><td>late-summer to early-fall</td></tr>
<tr><td>anadromous</td><td>mid-summer</td><td>late-fall</td></tr>
</table>

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

The overall ecological effects from adult hatchery-origin 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.

#### *2.6.2.2.3. 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 Chinook salmon not intended for broodstock, steelhead, spring/summer Chinook salmon, and sockeye salmon. This threat can be minimized by collecting, processing, and passing fish within 24 hours of initial trapping.

**Snake River Fall Chinook salmon**

Adult collection facilities may affect fall Chinook 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.

This analysis was first completed in the 2012 Biological Opinion (NMFS 2012a) 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 in the 2012 Biological Opinion. This is because broodstock handling and collection methods at adult collection facilities are the same as what was proposed in the 2012 Biological Opinion. Take tables associated with adult collection facilitates from the from the 2012 Biological Opinion (NMFS 2012a) and accompanying Section 10(a)(1)(A) permits were compared to co-manager submitted Annual Reports (Milks et al. 2013; Milks and Oakerman 2014; WDFW 2015; WDFW 2016), and take was not exceeded during the five-year term of the Biological Opinion and permits. While benefits also existed, the overall effects of the hatchery operations as analyzed in the 2012 Biological Opinion and accompanying permits on ESA-listed salmon and steelhead were negative.

#### 2.6.2.3. 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 2.6) of the natural population. The effect of this factor ranges from negligible to negative. See the Appendix A for a description of the full range of effects due to competition and predation.

This analysis was first completed in the 2012 Biological Opinion (NMFS 2012a) under the *Fish Removal* section (Section 2.4.3.) as well as the *U.S. v. Oregon* Biological Opinion (NMFS et al. 2018). The movement of the 1 million IPC releases at Hells Canyon into the Salmon River were analyzed in the *U.S. v. Oregon* Biological Opinion (NMFS et al. 2018); thus, the only changes in the current Proposed Action that would affect this factor is the additional release of 150,000 subyearlings from the LFH program. While additional changes were made to release sites under the current Proposed Action, the new release sites were either at a comparable distance or were lower down in the River. Therefore, these effects were likely maximized in past operations, the ecological analyses of which can be found in the 2012 Biological Opinion (NMFS 2012a) and the *U.S. v. Oregon* Biological Opinion (NMFS et al. 2018). Both of 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. The only juvenile ecological interactions not previously described in the 2012 Biological Opinion (NMFS 2012a) or the *U.S. v. Oregon* Biological Opinion (NMFS et al. 2018) were the additional 150,000 subyearlings included in the proposed action. Therefore, these additional 150,000 subyearlings are what we have analyzed in here in detail. Overall, the effects of Factor 3 on all listed species analyzed in this Biological Opinion are considered negative.

##### 2.6.2.3.1. 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 and steelhead juveniles from the additional 150,000 subyearlings released at LFH. To clarify, the LFH is releasing 500,000 more subyearlings from this location compared to the previous 2012 Biological Opinion (NMFS 2012a). However, the 350,000 subyearlings not analyzed in this section are released lower in the Snake River than they were previously. Thus, the overall ecological interactions with natural-origin fish would be expected to be lower than they have been in the past. As discussed in more detail in the Appendix A, outputs from the PCD Risk model should not be considered estimates of the actual predation and competition impact on natural-origin salmon and steelhead from hatchery-origin juveniles because the PCD Risk model is not a total simulation of ecological interactions between hatchery and wild fish. Nonetheless, the simulations are useful 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 27, Table 28, and Table 29.

For our model runs, we assumed a 100 percent population overlap between hatchery-origin fall Chinook salmon juveniles and all natural-origin species (juveniles) present. The release of the additional 150,000 subyearlings could potentially overlap with natural-origin Chinook and sockeye salmon, and steelhead in the Snake River Basin. However, we acknowledge that a 100 percent population overlap in microhabitats is likely a large 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 27. 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 | 11.4°C[2] |

[1] (Daly et al. 2009)
[2] USGS (gauge #13352600) website accessed in May 2018

**Table 28. Age and average size of listed natural-origin salmon and steelhead encountered by juvenile hatchery fish after release.**

| Species | Age Class | Size in mm (SD) |
|---|---|---|
| Chinook salmon | 0 | 55 (10) |
| | 1 | 91 (11) |
| Steelhead | 1 | 71 (10) |
| | 2 | 128 (30) |
| Sockeye Salmon[1] | 1 | 86 (7) |
| | 2 | 128 (8) |

[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 29. Hatchery fish parameter values for the PCDRisk model. Model runs for release at Lyons Ferry Hatchery (LFH) to Ice Harbor Dam (ICH). Travel rate (12.59 RM/day) and mortality/day (0.0345) were used to calculate travel time and survival per reach. (Bumgarner 2017)**

| Program | Release site | Proposed Release # | Size in mm (SD) | Survival rate | | Travel (Residence) Time in median days | |
|---|---|---|---|---|---|---|---|
| | | | | LFH to LOMO[1] | LOMO to ICH[1] | LFH to LOMO[1] | LOMO to ICE[1] |
| LFH | On station | 150,000 | 103 (20) | 0.95 | 0.91 | 1.4 | 2.5 |

[1] LOMO stands for Lower Monumental Dam; ICH stands for Ice Harbor Dam.

Based on the data above, our model results show that the largest effect hatchery-origin Chinook salmon are likely to have is on natural-origin Chinook (all runs), followed by their effect on natural-origin steelhead. The maximum numbers of fish lost are also shown in Table 30 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 is for sockeye salmon because we have data for natural-origin abundance for the one population that the ESU comprises that 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 Chinook outmigrants to reach Ice Harbor Dam after release (Table 29) beginning in year 2018. Once this is accomplished, you can then compare the five year running medians across a given five year time frame (e.g., 2018 to 2022). 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: 30,607 for natural-origin Chinook salmon (Table 16 and Table 15 both fall and spring/summer runs combined; in Harvest baseline section), 25,991 for steelhead (Table 17 in Harvest baseline section), and 1,115 for both hatchery and natural sockeye salmon (DART, 10-year average from 2007-2016 accessed August 2, 2017). These would equate to a potential loss of <1 percent of the potential adult return from competition and predation during the juvenile life stage. In addition, these negative effects are spread out over the various populations that comprise the Snake River ESUs/DPSs, and also include the unlisted spring/summer Chinook salmon originating from the Clearwater Subbasin. 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, it appears that ecological impacts from the release of the 150,000 hatchery-origin subyearlings included in this Proposed Action is negligible.

**Table 30. Maximum numbers and percent of natural-origin salmon and steelhead lost to competition and predation with hatchery-origin fall Chinook salmon released from the Proposed Action**

| **Program** | **Chinook** | **Steelhead[2]** | **Sockeye** |
|---|---|---|---|
| | **Competition[1]** | **Competition[1]** | **Competition[1]** |
| ***LFH to Ice Harbor Dam*** | | | |
| LFH to LOMO | 152 | 42 | 13 |
| Lomo to ICH | 452 | 115 | 42 |
| **Total Juveniles Lost** | **604** | **157** | **55** |
| SAR[3] | 0.6 | 0.7 | 0.5 |
| **Adult Equivalents** | **4** | **1** | **0** |

[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: Chinook Salmon (IDFG 2011; IDFG 2016b; IDFG 2017b; NPT 2017; SBT 2017; SBT and IDFG 2010), Steelhead (NMFS 2017), and sockeye salmon (IDFG 2012).

Similar to the use of models for biological systems elsewhere, this model cannot possibly account for all the variables that could influence competition and predation of hatchery juveniles on natural juveniles. For example, the model assumes that, if a hatchery fish is piscivorous and stomach capacity allows the fish to consume prey, it will be natural-origin prey. The reality is 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, to the best of our ability, a worst-case estimate for the effects on natural-origin juveniles.

Residual hatchery fall Chinook salmon are not explicitly accounted for in our model at this time. However, the applicants have proposed actions that are expected to minimize their ecological and genetic impacts. Recent data exists that residualism may occur as result of hatchery rearing and has been measured in some Upper Columbia River hatchery programs (NMFS 2017c). Therefore, co-managers will measure and NMFS will interpret the residualism effects resulting from this action. We will measure this through visual observation at pre-release sampling, and the percentage of fall 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 to date has only occurred for the LFH portions of these programs. Table Table 31 shows the extent of precocious maturation observed at LFH over the most recent five years where data was available. However, the NPT has not utilized visual observation to date. Moving forward, they will be 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). We do not expect precocial maturation rates to be this high in the fall Chinook salmon programs because these results largely reflect environmental conditions that are not observed in the Snake River Basin. This is because recent data from LFH (Table 31) suggests that no fall Chinook salmon have expressed precocial maturation during pre-release sampling.

Based on informal communications with co-managers, review of LFH data (Table 31) and 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 into 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 31), this may be implemented into the future after we have assessed results.

**Table 31. Numbers of precocious maturation observed during pre-release sampling at Lyons Ferry Hatchery**

| Brood Year | # Precocious | Total sampled | Total released | % Precocious |
|---|---|---|---|---|
| ***Yearings*** | | | | |
| 2012 | 0 | 468 | 503273 | 0 |
| 2013 | 0 | 448 | 452373 | 0 |

| | | | | |
|---|---|---|---|---|
| 2014 | 0 | 415 | 487177 | 0 |
| 2015 | 0 | 405 | 458558 | 0 |
| 2016 | 0 | 426 | 472511 | 0 |
| ***Subyearlings*** | | | | |
| 2013 | 0 | 254 | 209972 | 0 |
| 2014 | 0 | 226 | 219359 | 0 |
| 2015 | 0 | 237 | 202460 | 0 |
| 2016 | 0 | 235 | 204579 | 0 |
| 2017 | 0 | 200 | 199788 | 0 |

##### 2.6.2.3.2. 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), but the progeny of such hatchery-origin spawners are still likely to make up a sizable portion of the juvenile fish population. This is actually a desired result of the integrated recovery programs. There is no reason to expect offspring of naturally spawning hatchery-origin adults to behave differently from the offspring 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 into the future. There is overall a slight negative effect from these actions.

NMFS expects that the monitoring efforts would detect negative impacts before they reach problematic levels, and we include language in the Incidental Take Statement (ITS; Section 2.10) to ensure that appropriate monitoring takes place.

##### 2.6.2.3.3. Disease

The risk of pathogen transmission to natural-origin salmon and steelhead is negligible for these Chinook salmon programs. Please refer to Table 32 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 determined 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 32. Pathogen information over the most recent six years of data at facilities where Snake River fall Chinook salmon are reared, acclimated, or spawned (NPT 2018b; WDFW 2018)**

| Program | Years | Life Stage | Pathogen detected | Treatment or control regime | Epidemic? | Exotic pathogen detection |
|---|---|---|---|---|---|---|
| Nez Perce Tribal Hatchery Complex[1] | 2012 | Juvenile | *Renibacterium salmoninarum* | No treatment | No | No |
| | | Adult | *Infectious Hemopoietic Necrosis Virus; Renibacterium salmoninarum* | | | |
| | 2013 | Juvenile | *Renibacterium salmoninarum* | No treatment | No | No |
| | | Adult | *Infectious Hemopoietic Necrosis Virus; Renibacterium salmoninarum; Flavobacterium psychrophilum* | | | |
| | 2014 | Juvenile | *None* | No treatment | No | No |
| | | Adult | *Aeromonas salmonicida; Infectious Hemopoietic Necrosis Virus; Renibacterium salmoninarum* | | | |
| | 2015 | Juvenile | *Renibacterium salmoninarum* | No treatment | No | No |
| | | Adult | *Aeromonas salmonicida; Infectious Hemopoietic Necrosis Virus; Renibacterium salmoninarum; Flavobacterium psychrophilum* | | | |
| | 2016 | Juvenile | *None* | No treatment | No | No |
| | | Adult | *Infectious Hemopoietic Necrosis Virus; Renibacterium salmoninarum; Flavobacterium psychrophilum* | | | |
| | 2017 | Juvenile | *Renibacterium salmoninarum* | No treatment | No | No |
| | | Adult | *Aeromonas salmonicida; Renibacterium salmoninarum* | | | |
| Lyons Ferry Hatchery | 2012 | Juvenile | *None* | No treatment | No | No |
| | | Adult | *Renibacterium salmoninarum* | | | |
| | 2013 | Juvenile | *None* | No treatment | No | No |
| | | Adult | *Renibacterium salmoninarum* | | | |
| | 2014 | Juvenile | *None* | No treatment | No | No |
| | | Adult | *Renibacterium salmoninarum* | | | |
| | 2015 | Juvenile | *None* | No treatment | No | No |
| | | Adult | *Renibacterium salmoninarum* | | | |
| | 2016 | Juvenile | *None* | No treatment | No | No |
| | | Adult | *Renibacterium salmoninarum* | | | |
| | 2017 | Juvenile | *None* | No treatment | No | No |
| | | Adult | *Renibacterium salmoninarum* | | | |
| Irrigon Fish Hatchery[2] | 2012 | Juvenile | *Flavobacterium psychrophilum* | No treatment | No | No |
| | | Adult | *Renibacterium salmoninarum* | | | |
| | 2013 | Juvenile | *Flavobacterium psychrophilum (Hells Canyon)* | | No | No |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | Adult | *None* | No treatment | | |
| | 2014 | Juvenile | *Flavobacterium psychrophilum (Grande Ronde)* | No treatment | No | No |
| | | Adult | *Renibacterium salmoninarum* | | | |
| | 2015 | Juvenile | *None* | No treatment | No | No |
| | | Adult | *None* | | | |
| | 2016 | Juvenile | *Renibacterium salmoninarum; Flavobacterium psychrophilum* | No treatment | No | No |
| | | Adult | *None* | | | |
| | 2017 | Juvenile | *Renibacterium salmoninarum; Flavobacterium psychrophilum* | No treatment | No | No |
| | | Adult | *None* | | | |

[1]Includes fish reared at the North Lapwei Valley, Cedar Flats, and Lukes Gulch Acclimation Facilities
[2]Includes fish reared for releases at Grande Ronde and those previously released at Hells Canyon

#### 2.6.2.4. 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 productivity VSP parameter (Section 2.6) of the natural population.

This analysis was first completed in the 2012 Biological Opinion (NMFS 2012a) under the *Monitoring and Evaluation* section (Section 2.4.6.) as well as the *U.S. v. Oregon* Biological Opinion (NMFS et al. 2018). As described in the Proposed Action (Section 1.3) the previous Biological Opinion (NMFS 2012a) included significant RM&E effort from the co-managers to inform some of our gaps in knowledge regarding this single-population ESU. The co-manager organized *Snake River Fall Chinook Symposium* (USFWS 2017) served to review all of these findings. This effort 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 will continue for all groups. These measures were all analyzed in the 2012 Biological Opinion (NMFS 2012a), and there are no additional effects from these activities. In addition to these ongoing efforts, the cooperators are exploring monitoring that will assess the effects of the change in release strategies on distribution of hatchery spawners into the Snake River. These additional monitoring activities are in the form of carcass sampling surveys and PBT sampling that occur primarily during redd surveys. Because these sampling efforts target deceased fish through remote aerial surveys and targeted collection methods, there are no additional incidental effects on listed species.

M&E take tables from the 2012 Biological Opinion (NMFS 2012a) and accompanying Section 10(a)(1)(A) permits (NMFS 2012b) were compared to co-manager submitted Annual Reports (Milks et al. 2013; Milks and Oakerman 2014; WDFW 2015; WDFW 2016), and take was not exceeded during the five-year term of the Biological Opinion and permits. Therefore, while the data requirements for the actions have changed in focus due to updates to the Proposed Action, there are no additional actions that have incidentally impacted listed species. Please see the below table for additional information.

The monitoring and evaluation activities directly related to the proposed hatchery programs are part of a larger effort to determine the overall status of the Snake River Fall Chinook Salmon ESU. Because the intent is to improve our understanding of listed population status, the information gained through these studies outweigh the associated risks to the populations. 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 Snake River fall Chinook salmon. The effects on Snake River spring/summer Chinook, sockeye, and steelhead are also negligible.

#### 2.6.2.5. 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. Here, NMFS analyzes changes to riparian habitat, channel morphology and habitat complexity, in-stream substrates, and water quantity and water quality attributable to operation, maintenance, and construction activities and confirms whether water diversions and fish passage facilities are constructed and operated consistent with NMFS criteria. This factor can potentially affect a population's abundance, productivity, and spatial structure VSP parameters (Section 2.6). The effect of this factor ranges from negligible to negative.

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 considered in the 2012 Biological Opinion (NMFS 2012a) and the *U.S. v. Oregon* Biological Opinion (NMFS et al. 2018), and are summarized below. Please refer to the previous Biological Opinions for additional details on facility effects on ESA-listed salmon and steelhead.

No new construction is included as part of the Proposed Action. 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 listed salmonids and their associated critical habitat. Furthermore, the hatchery facility activities described in the Proposed Action (Table 7) do not include any facility construction actions. Therefore, the Lyons Ferry Hatchery, Nez Perce Tribal Hatchery, Irrigon Hatchery, Pittsburg Landing Acclimation Facility, Big Canyon Acclimation Facility, Captain John Rapids Acclimation Facility, Lukes Gulch Acclimation Facility, Sweetwater Springs Satellite Facility, Cedar Flats Acclimation Facility, and the North Lapwai Valley Acclimation Facility will have a small negative effect on listed salmon and steelhead as described in the 2012 Biological Opinion (NMFS 2012a) and the *U.S. v. Oregon* Biological Opinion (NMFS et al. 2018).

The Proposed Action does not propose any changes in water withdrawals from current operations; therefore, current effects are as they were described in the 2012 Biological Opinion (NMFS 2012a) and the *U.S. v. Oregon* Biological Opinion (NMFS et al. 2018). The current surface water withdrawals measured in maximum percent of flow diversions (in cubic feet per second; cfs) from hatchery facility operations are shown in Table 33. The maximum percent of flow divergence is highest in the Sweetwater Springs Satellite Facility at between 25 and 100%; however; no fish are present at the point of diversion. In addition, all of the water diverted from the spring (minus evaporation) would be returned to the West Fork Sweetwater Creek in less than 300 feet after circulating through the facility. So the only potentially impacted segment of the creek would be the short distance between the water intake and discharge structures, where no fish are present in this reach between them. In addition, the North Lapwai Valley Acclimation Facility diverts up to 4.2% of the total streamflow in the Lapwai River. At its maximum effect, his would leave 114 cfs remaining in the River. We do not expect this to have a measurable effect on ESA-listed salmon or steelhead in the River. Therefore, the withdrawal would not result in a hydrologic change where fish are present and habitat available to ESA-listed salmonids would not change perceptibly.

Dewatering of redds or prevention of natural-origin fish movement had not been observed at any facility when water flow could be limited by hatchery operations during "low-flow" months. Moreover, the facility funders and operators are reviewing all facilities 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 of hatchery facilities, funders and 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 climate change trends indicate that juveniles may outmigrate 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. Range of daily minimum average streamflow (in cfs) measured all months of the year, maximum daily water use per facility, and calculated range of maximum percent flow divergence from facility operations (NMFS 2012a)**

| Program | Range of daily minimum average streamflow (in cfs) | Maximum daily surface water use (in cfs) | % flow divergence |
|---|---|---|---|
| LFH and Irrigon Hatchery[1] | N/A | | |
| Pittsburg Landing, Big Canyon, and Captain John Rapids Acclimation Facilities | 10,000 (USGS website Snake and Clearwater Rivers accessed 5/11/2012) | 4.4 to 5.6 | <0.1% |
| Sweetwater Springs Satellite Facility | 0.45 and 8.9[2] (USGS website West Fork Sweetwater Creek accessed 5/11/2012) | 2.2[2] | 25-100%[2] |
| Cedar Flats Acclimation Facility | 3,813 (USGS website Selway River accessed 5/11/2012) | 2.2 | <0.1% |
| NPTH | 1,260 (USGS website Clearwater River accessed 5/11/2012) | 10 | <1% |
| Lukes Gulch Acclimation Facility | 585 | 2.8 | <0.4% |

| | | | |
|---|---|---|---|
| | (USGS website Snake River at Hells Canyon Dam accessed 5/11/2012) | | |
| North Lapwai Valley Acclimation Facility | 119<br>(USGS website Lapwai Creek accessed 5/11/2012) | 1.4 to 5 | <4.2% |

[1]Not applicable because it is a well water supplied facility where no surface water is used
[2]No fish are present at the point of diversion

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 2004a), 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), but 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 a 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 for the purposes of rearing 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 does not have an effect on 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.

### 2.6.2.6. Factor 6. Fisheries that exist because of the hatchery program

There are two aspects of fisheries that are potentially relevant to NMFS' analysis of 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 have negative effects on the *abundance* VSP parameter of the affected populations (Section 2.6). The other is when fisheries are used as a tool to prevent the hatchery fish associated with the Proposed Action, including hatchery-origin fish included in an ESA-listed salmon ESU or steelhead DPS, from spawning naturally. The effects of these fisheries can range from positive to negative.

Many hatchery programs are capable of producing more fish than are immediately useful in the conservation and recovery of an ESU and can play an important role in fulfilling trust and treaty obligations, and non-treaty sustainable fisheries objectives with regard to the harvest of some Pacific salmon and steelhead populations. For ESUs listed as threatened, NMFS will, where appropriate, exercise its authority under Section 4(d) of the ESA to allow the harvest of listed hatchery fish that are surplus to the conservation and recovery needs of the ESU, in accordance with approved harvest plans" (NMFS 2005d). In any event, fisheries must be strictly regulated based on the take, including catch and release effects, of ESA-listed species.

For a detailed description of listed encounters during and the effects of fisheries that exist because of hatchery programs, refer to Section 2.5.6 and see Table 34 below. Based on these detailed descriptions, the effects from fisheries on natural-origin fall Chinook salmon, spring/summer Chinook salmon, steelhead, and sockeye salmon are negative.

**Table 34. 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 Chinook** | | 31.29 | 11.6 – 23.04 | 5.9 – 8.25 |
| **Snake River spring/summer Chinook** | | 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** | | 6.0 – 8.08 | 2.8 – 7.0 | 0.0 – 1.0 |

### 2.6.2.7. Effects of the Action on Critical Habitat

This consultation analyzed the Proposed Action for its effects on designated critical habitat and has determined that 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 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 and Section 2.6.2.5). 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. Semi-routine maintenance (e.g., construction of facilities or reconstruction of in-river hatchery structures) is not considered in this opinion and would require separate consultation.

## 2.7. 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). For the purpose of this analysis, the Action Area is that part of the Snake River Basin described in the Section 2.4. 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 effects 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 Fall Chinook Salmon (NMFS 2017d) is such a plan and it describes, in detail, the on-going 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, and 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 FCRPS Biological Opinion and its (NMFS 2008b), the Mitchell Act Biological Opinion (NMFS 2017a), and the *U.S. v. Oregon* Biological Opinion (NMFS et al. 2018). The effects from these Opinions are relevant to this Action Area.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult, if not impossible, to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the Environmental Baseline section.

More detailed discussion of Cumulative effects for the Columbia River basin can be found in our biological opinion on the funding of Mitchell Act hatchery programs (NMFS 2017). 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, it is likely that the type and extent of salmon and steelhead hatchery programs and the numbers of fish released in the analysis area and throughout the Columbia 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 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.

The cumulative effects of climate change on ESA-listed salmon and steelhead are difficult to predict, but are assumed in the status of the ESA-listed species affected by the Proposed Action and are expected to continue indefinitely into the future. We expect that climate change may have long-term effects that include, but are not limited to, depletion of important cold water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, premature emergence of fry, and increased competition among species. These resulting conditions may affect ESA-listed salmon and steelhead into the future. The Proposed Action responds to climate change effects by aligning future hatchery operations with recovery, primarily by ensuring that natural populations are capable of improving in productivity, abundance, and diversity, which will allow them to adapt to changing environments. Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life history types that will be successful in the future are neither static nor predictable, therefore maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations.

In addition, NMFS anticipates that human development activities will continue to have adverse effects on listed species in the Action Area. On the other hand, NMFS is also certain that available scientific information will continue to grow at a fast pace and tribal, public, and private support for salmon recovery will remain high and this will fuel the upward trend in habitat restoration and protection actions as well as hatchery, harvest, and hydropower reforms that are likely to result in improvements in fish survival.

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 those in the recent past, and much lower than those in the more distant past. NMFS anticipates that available scientific information will continue to grow and tribal, public, and private support for salmon recovery will remain high. This will continue to fuel state and local habitat restoration and protection actions as well as hatchery, harvest, and other reforms that are likely to result in improvements in fish survival.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult, if not impossible, to distinguish between the Action Area's future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the Environmental Baseline (Section 2.5).

### 2.8. Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the benefits and risks posed to ESA-listed species and critical habitat as a result of implementing the Proposed Action. In this section, NMFS add the effects of the Proposed Action (Section 2.6.2) to the environmental baseline (Section 2.5) and the cumulative effects (Section 2.7) to formulate the agency's opinion as to whether the Proposed Action is likely to: (1) result in appreciable reductions in the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat. This assessment is made in full consideration of the status of the species and critical habitat and the status and role of the affected populations in recovery (Sections 2.3.1 and 2.3.2).

In assessing the overall risk of the Proposed Action on each species, NMFS considers the benefits and risks of each factor discussed in Section 2.6.2, above, in combination, considering their potential additive effects with each other and with other actions in the area (environmental baseline and cumulative effects). This combination serves to translate the positive and negative effects posed by the Proposed Action into a determination as to whether the Proposed Action as a whole would appreciably reduce the likelihood of survival and recovery of the ESA-listed species and their designated critical habitat.

The accumulated impacts from these programs contribute to the total impacts from hatcheries in the entire Columbia River Basin, which is noted in the Mitchell Act Biological Opinion (NMFS 2017a). Between those programs that have already undergone consultation and those for which consultation is underway, it is likely (though uncertain for ongoing consultations) that the type and extent of salmon and steelhead hatchery programs and the numbers of fish released in the Columbia River Basin will change over time. Although adverse effects will continue, these program changes are likely to reduce the magnitude of adverse effects such as competition and predation on natural-origin salmon and steelhead compared to current levels, especially for those species that are listed under the ESA. This is because all salmon and steelhead hatchery programs funded and operated by non-federal agencies and tribes in the Columbia River Basin have to undergo review under the ESA to ensure that listed species are not jeopardized and that "take" under the ESA from salmon and steelhead hatchery programs is minimized or avoided. Although adverse effects on natural-origin salmon and steelhead will likely not be completely eliminated, the severity of such effects would be expected to decrease from current levels over time to the extent that hatchery programs are reviewed and approved by NMFS under the ESA. Where needed, future reductions in adverse effects on listed salmon and steelhead may occur through changes in:

- Hatchery monitoring information and use of best available science
- Times and locations of fish releases to reduce risks of competition and predation
- Management of diversity concerns through meeting recovery plan objectives (Section 2.3.1.1)
- Incorporation of new research results and improved best management practices for hatchery operations
- More-accurate estimates of natural-origin salmon abundance for abundance-based fishery management approaches

These findings apply to both the proposed action and the addition of a 10% buffer in years where that occurs, even assuming that applies in all ten years of the permit. The effects to listed salmonids do not meaningfully change in the case of an additional 10% smolts released.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the Action Area. However, it is difficult, if not impossible, to distinguish between the Action Area's future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the Action Area are described in the environmental baseline (Section 2.5). As described there, those changes consist of:

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

These potential changes to hatchery operations, combined with the ongoing operations of the hatchery programs described in the proposed action, result in a net beneficial change compared to the previous 2012 Biological Opinion (NMFS 2012a). However, the overall effect from the operation of these hatchery programs is negative on listed salmon and steelhead. While the hatchery programs around the basin, and those under review here as well, lead to negative impacts on listed salmonid species as described above, when the beneficial changes to hatchery practices are also combined with the potential negative impacts from these hatchery programs and the rest of the operations in the Columbia River basin, a net beneficial result is expected as hatchery practices continue to improve and to reduce their negative impacts.

### 2.8.1. Listed Species

#### 2.8.1.1. Snake River Fall Chinook Salmon ESU

Best available information indicates that the risk rating for the Lower Mainstem Snake River fall Chinook salmon population in the Snake River Fall Chinook Salmon ESU is "viable"; however, it remains designated as threatened (NWFSC 2015). The overall risk rating is based on a low risk rating for abundance and productivity viability parameters and a moderate risk rating for spatial structure and diversity viability parameters. The primary threat to this population are risks to diversity from the relatively high proportion of within-population hatchery-origin spawners in all major spawning areas (NWFSC 2015). Moreover, the current single population delisting options in the Snake River fall Chinook salmon recovery plan (NMFS 2017d) requires the population to meet or exceed minimum requirements for a "highly viable" population. Given the current Proposed Action, which includes the reprogramming of the IPC Hells Canyon releases to the Salmon River. The Proposed Action makes testing the preliminary feasibility of the NPEA, Scenario C of the Snake River Fall Chinook Recovery Plan (NMFS 2017d), possible.

Still, after taking into account the current viability status of this 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 ESU in the wild, as discussed below.

Our environmental baseline analysis considers the effects of hydropower, changes in habitat (both beneficial and adverse), fisheries, and hatcheries on this ESU. Although all may have contributed to the listing of this ESU, all factors have also seen improvements in the way they are managed/operated. As we continue to deal with a changing climate, management of these factors may also alleviate some of the potential adverse effects on VSP parameters (abundance, productivity, diversity, and spatial structure) covered in the Appendix A (e.g., through hatcheries serving as a genetic reserve for natural populations).

The majority of the effects of the Proposed Action on this ESU are genetic and ecological in nature. This is a factor in the abundance (ecological), productivity (ecological), and diversity (genetic) parameters. Effects of facility operation and broodstock collection are small and localized. While RM&E requires handling of a substantial portion of the juvenile population, the information gained from conducting the work is essential for understanding the effects of the hatchery program on natural-origin fall Chinook salmon population. NMFS will monitor 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 (Appendix A).

The ecological and genetic effects on the adult life stage are limited by minimizing the proportion of hatchery-origin fish spawning naturally as well as the proportion of natural-origin fish used in broodstock. For these programs, this is managed through the removal of hatchery-origin fish via fisheries downriver of the Snake River and through capturing natural-origin adults at adult trapping locations (LGR, NPTH, and LFH). Moreover, these hatchery releases are subject to very high direct harvest rates from tribal and non-tribal fisheries downriver of the Snake River.

With the relocation of the IPC subyearling releases to the Salmon River, we expect the negative genetic (diversity) effects previously described 2012 Biological Opinion (NMFS 2012a) to decrease in the upper Snake River in the Hells Canyon reach. We expect the proportion of hatchery-origin spawners in the Hells Canyon reach to decrease, and therefore the proportion of natural-origin spawners in this reach to increase, because we do not expect hatchery fish released in the Salmon River to return to the upper Snake River. We also expect that the proportion of natural-origin spawners used in broodstock for all of the programs will remain at the same level if not greater than it has been in recent years (Table 20). All of these elements are expected to decrease the overall negative genetic (diversity) effects from the hatchery programs on the natural population, relative to the 2012 Biological Opinion (NMFS 2012a). Moreover, these actions should contribute to an increase in abundance and productivity for this population in the long-term. Overall, the combined genetic effects from the proposed hatchery programs will not result in a substantial negative effect on the diversity of Snake River Fall-run Chinook Salmon ESU. These genetic effects are considered to be a significant improvement to the diversity of the ESU from the past hatchery practices analyzed in 2012 Biological Opinion (NMFS 2012a). Despite these improvements, this is still a detriment to diversity and productivity.

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 2.6.2.3). This includes the effects on both the Snake River Spring/summer and Fall-run Chinook Salmon ESUs, because the analyses combined all Chinook effects in the model. It is likely that this percentage is even smaller because the analysis did not account for potential predation of hatchery program fish on other hatchery program fish in the Snake River Basin (Section 2.6.2.3). Overall, this relatively small loss is unlikely to have an effect on the abundance and productivity of either the spring/summer or fall 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 2017d) describes the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed Fall Chinook salmon. Such actions are improving habitat conditions and hatchery and harvest practices to protect ESA-listed fall Chinook 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.

In summary, we considered the baseline effects (including the exacerbating effects of climate change) and species status, where we found that abundance, productivity, and diversity were the critical problems in most populations, consistent with the 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 impact could provide 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, problems that will be positively addressed by expected reforms though compounded to a degree by climate change (Section 2.7). Taken together, these activities are not likely to appreciably reduce the survival and recovery of ESA-listed Snake River fall Chinook salmon.

#### 2.8.1.2. Snake River Steelhead, Spring/Summer Chinook, and Sockeye Salmon DPS and ESU's

Best available information indicates that the Snake River Steelhead DPS and the Spring/Summer Chinook Salmon ESU are at high risk and remain at threatened status (NWFSC 2015). The Snake River Sockeye Salmon ESU is at high risk and remains endangered (NWFSC 2015). After taking into account the current viability status of these species, the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the effects of the Proposed Action will not appreciably reduce the likelihood of survival and recovery of these ESA-listed ESUs in the wild, as discussed here.

Our environmental baseline analysis considers the effects of hydropower, changes in habitat (both beneficial and adverse), fisheries, and hatcheries on these ESUs. Although all may have contributed to the listing of these ESUs, all factors have also seen improvements in the way they are managed/operated. As we continue to deal with a changing climate, management of these factors may also alleviate some of the potential adverse effects on VSP parameters (abundance, productivity, diversity, and spatial structure) covered in the Appendix A (e.g., hatcheries serving as a genetic reserve for natural populations).

The effects of our Proposed Action on these DPS and ESUs is limited to ecological effects, broodstock collection, and RM&E. These effects may result in changes to the abundance and productivity of natural-origin fish. Adverse ecological effects on adults are small because of the differences in spatial and temporal overlap of these three species with fall Chinook salmon. However, juveniles may potentially undergo larger effects because of the overlap in outmigration timing. Our analysis showed that the impacts of these programs on spring/summer Chinook and steelhead were less than one percent on the Snake River ESU and DPS; however, these values are likely to be overestimates based on many of the assumptions in the model analyses. The small percentage loss within the ESU and DPS is unlikely to affect the productivity of these natural-origin fish in the Snake River Basin.

These would equate to a potential loss of less than one percent of the potential adult return from competition and predation during the juvenile life stage. The co-managers will monitor 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 impacts on these VSP parameters in these ESUs (Appendix A).

Effects of RM&E and broodstock collection targeting fall Chinook salmon are also small because M&E and collection targeting the other species generally occurs using the same traps in the same locations, and is therefore a direct effect associated with a different hatchery program. Thus, there is very little incidental effect on other Snake River ESA-listed species. Therefore, it is unlikely that these activities would lead to a decrease in the abundance, productivity, diversity, or spatial structure of the Snake River steelhead, Spring/Summer Chinook salmon, or sockeye salmon ESUs.

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 describe the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed salmon. Such actions are improving habitat conditions, and hatchery and harvest practices to protect listed salmon ESUs, and NMFS expects this trend to continue.

We considered the baseline effects (including the exacerbating effects of climate change) and species status, where we found that abundance, productivity, and diversity were the critical problems in most populations, consistent with the 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 impact could provide 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. These problems will be positively addressed by expected reforms, though compounded to a degree by climate change (Section 2.7). Taken together, these activities are not likely to appreciably reduce the survival and recovery of listed Snake River Steelhead, Spring/Summer Chinook Salmon, or Sockeye Salmon.

### 2.8.2. Critical Habitat

The hatchery water diversion and the discharge pose a negligible effect on designated critical habitat in the Action Area (Section 2.6.2.7). 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 small and the delay would be for only a short period. Rejection of weirs and other facilities is also expected to be small, since weirs are operated to reduce harmful effects during handling and to minimize passage delay. Thus, the impact on the spawning, rearing, and migration PBFs will be small in scale, and will not appreciably diminish the capability of the critical habitat to satisfy the essential requirements of the species.

Climate change may have some effects on critical habitat as discussed in Section 2.5.4. 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.

## 2.9. Conclusion

After reviewing the current status of the listed species, the environmental baseline within the Action Area, the effects of the Proposed Action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' Biological Opinion that the Proposed Action is not likely to jeopardize the continued existence or recovery of any of the ESA-listed ESUs and DPSs listed in the Columbia River Basin (Table 8), or destroy or adversely modify designated critical habitat.

## 2.10. Incidental Take Statement

Section 9 of the ESA and Federal regulation pursuant to section 10 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 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 prohibited under the ESA if that action is performed in compliance with the terms and conditions of the ITS.

### 2.10.1. Amount of Extent of Take

The primary form of take of ESA-listed fall Chinook salmon is direct take, under the Section 10 Authorizations for the hatchery programs. 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.

**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 fish on the genetics of natural-origin fish can occur through a reduction in genetic diversity, outbreeding depression, and hatchery-influenced selection. There is further take caused by ecological interactions between hatchery- and 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 or interbreeding between hatchery and natural fish in a reliable way.

NMFS is applying surrogate take indicators to measure these genetic and ecological interactions between hatchery and natural-origin adults. For each form of take described above, NMFS will rely on a single surrogate take indicator, the proportion of natural-origin spawners used in hatchery broodstock. This metric is rationally connected to incidental take in the form of genetic effects, because the proportion of natural-origin fish used in broodstock has a direct link to the overall incidental genetic impacts resulting from the operation of the hatchery program. In other words, maximizing the proportion of natural-origin broodstock reduces take by genetic effects. While this metric does not directly address ecological interactions (e.g. redd superimposition and spawning site competition), a higher proportion of natural-origin spawners used in broodstock is expected to decrease the level of hatchery influence (and so any ecological interactions) on natural spawners. Moreover, the movement of the IPC releases to the Salmon River is expected to decrease negative ecological interactions from levels analyzed in the 2012 Biological Opinion (NMFS 2012a). Carcass sampling and analysis of PBT samples as described in the Proposed Action (Section 1.3) will serve to inform us of these results over time. The take associated with adult genetic and ecological effects will be considered to have been exceeded if a consecutive running five-year mean of the proportion of natural-origin broodstock is less than 0.15 or 15% (Section 2.6.2.2). Given management limitations in poor return years, the annual proportion of natural-origin broodstock may be less than 15% in more than two out of the five years in the running five-year mean.

Through general hatchery program management, PBT measurements, and broodstock collection, measuring, and monitoring at LGR, the take surrogate can be reliably measured and monitored.

Listed salmon and steelhead, including Snake River spring/summer Chinook, fall Chinook, 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 incidental take information from Factor 2.

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

| Species | Take Activity | Location[2] | Number handled annually | Number killed annually | Notes |
|---|---|---|---|---|---|
| Spring/summer Chinook salmon - Adipose fin intact | Capture, handle, release | LGR | 300 adults | 12 Adults | |

| | | | | | |
|---|---|---|---|---|---|
| Spring/summer Chinook salmon – adipose fin clipped[1] | Capture, handle, transport, kill | From LGR | N/A | 10 Adults[1] | Inadvertently taken as broodstock |
| Steelhead – adipose fin intact [1] | Capture, handle, release | LGR | 30 % of the entire annual return, based on post-season estimates | 0.5 % of those captured | |
| Steelhead – adipose fin intact [1] | Capture, handle, release | SF Clearwater weir | 2 % of the SF Clearwater River run up, based on post-season estimates, to 400 adults | 2 Adults | |
| Steelhead – adipose fin intact [1] | Capture, handle, 21-day hold, and release | LFH | 10 Adults | 2 Adults | Inadvertently held and anesthetized with broodstock |
| Steelhead – adipose fin in-tact and adipose fin clipped[1] | Capture, handle, release | NPTH | 10 Adults | 0 | |
| Sockeye | Capture, handle, release | LGR | 2% of the entire annual return return, based on post-season estimates | 0.5 % of those captured | |

[1]NMFS updated the 4(d) rule for Snake River spring/summer Chinook salmon and Snake River steelhead (70 FR 37160, June 28, 2005), specifying that ESA take prohibitions would not apply to hatchery-origin adipose fin-clipped fish. Therefore, the number of hatchery-origin adipose fin-clipped adults that may be handled at Lower Granite Dam is not limited; however numbers are provided here for reference.

[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.

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

Predation and competition, collectively referred to as ecological interactions between natural-origin juvenile Chinook and sockeye salmon and steelhead and hatchery steelhead smolts, could result in take of natural-origin Chinook and sockeye salmon and steelhead. This take occurs as a result of, and in proportion to, the co-occurrence of hatchery- and natural-origin juvenile fish in the juvenile rearing areas and in relationship to the opportunity they would have to compete for resources or to prey on each other. It is difficult to quantify take from predation and competition because, while these interactions are linked to release numbers, the ecological interactions cannot be directly or reliably measured and/or observed. Thus, NMFS will rely on two surrogate take variables, one for outmigrants and one for potential non-migrants.

For the outmigrant effects NMFS applies a surrogate take variable that relates to the median travel time for hatchery-origin fall Chinook salmon to travel from the release site to reach Ice Harbor Dam after release. Specifically, the extent of take from interactions between hatchery and natural-origin juvenile salmonids released between release site and Ice Harbor will be represented by the travel time[17] for emigrating juvenile hatchery-origin fall Chinook salmon (separated by subyearling and yearlings) taking more than three days longer than the median travel time value (which equates to 50% of the fish) following hatchery release (Table 29) for each program. Take will be considered to have been exceeded if travel times exceed the five-year median by three or more days in at least three of the five years used to establish the median. NMFS will begin calculating each five-year running medians beginning in 2018 with data from 2018 to 2022. This is a reasonable, reliable, and measurable surrogate for incidental take because if travel rate is three days more than previous estimates, it is a sign that fish are not migrating as quickly as expected, and therefore the expected take from interactions has likely been exceeded as a result of greater overlap between hatchery and natural-origin fish. This threshold will be monitored using emigration estimates from PIT tags, screw traps, or other juvenile monitoring techniques developed by the operators and approved by NMFS.

To account for take occurring as a result of competition and predation associated with residualism, NMFS applies the take variable described below for hatchery-origin fall Chinook salmon.

- The surrogate measure of take resulting from the presence of residuals for these programs is the percentage of fall Chinook salmon juveniles of those programs that are observed to be precociously mature prior to release. This surrogate has a rational connection to the amount of take expected from residualism because precocious fall Chinook salmon may residualize at higher rates than normal, and these observations would be sufficient to detect a trend of increasing residualization potential. NMFS considers, for the purpose of this take surrogate, that no more than five percent of program fish should be observed to be precociously mature (based on visual observation at pre-release sampling), using a running five-year average beginning with the 2018 release[7]. The take surrogate can be reliably measured and monitored through assessment of precocious maturation rates prior to release. This assessment relies on visual observation at pre-release sampling with a reasonable sample size determined by hatchery evaluation staff.

Take from ecological interactions is indirectly related to the number of juveniles released through these hatchery programs. Since 2012, juvenile releases have been consistent with the take authorized in the permits. Though release numbers have been higher than targets in every year, releases have not exceeded the allowed 110% of target releases. These values have been analyzed in our Effects of the Action (Section 2.6).

[17] NMFS recognizes that this metric can be influenced by factors other than hatchery operation. Therefore, we rely on a surrogate measurement of take whereby the travel time should be within the limit in three of every five years.

**Factor 4: Research, monitoring, and evaluation that exists because of the hatchery program**

Listed salmonids will also be taken as a result RM&E activities. Research and monitoring activities authorized in the permits has also been largely compliant with take limits. The Tucannon screw trap exceeded take the initial year of operation because initial estimates were based on low run sizes and redd locations distributed farther away from the trap. Because run sizes have increased some, the take allowance was increased to approximately maintain a similar level of monitoring. Mortality rate is expected to be no more than 3% of total percent of fish handled. Please see Table 36 below for incidental take information from Factor 4.

**Table 36. Incidental take of Snake River fall Chinook salmon, spring/summer Chinook salmon, steelhead, and sockeye salmon for monitoring activities not directly related to fish culture.**

| Species and Lifestage | Take Activity | Capture Method and Location | Total Number Handled annually | Number marked/tagged annually | Total Number Killed annually |
|---|---|---|---|---|---|
| Juvenile SR fall Chinook salmon - Adipose fin in-tact | Capture/Mark, Tag, Sample, Tissue/Release Live Animal | Seines, fyke nets, trawls, and purse seines in Lower Snake, Lower Salmon, Grande Ronde, and Imnaha | 7,500 (30 mortalities) | 4,000 (40 mortalities) | 70 |
| Juvenile SR spring/summer Chinook salmon - Adipose fin in-tact | Capture/Mark, Tag, Sample, Tissue/Release Live Animal | Seines, fyke nets, trawls, and purse seines in Lower Snake, Lower Salmon, Grande Ronde, and Imnaha | 1,500 (6 mortalities) | 100 (misidentified) (1 mortality) | 7 |
| 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 fall Chinook salmon - Adipose fin in-tact | Capture/Mark, Tag, Sample, Tissue/Release Live Animal | Screw Trap Clearwater River | 3,500 (14 mortalities) | 1,000 (10 mortalities) | 24 |
| 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 |
| Adult SR fall Chinook salmon - Adipose fin in-tact | Adult fall-back | Screw Trap Clearwater River | 70 (10 mortalities) | 0 | 10 |

### 2.10.2. Effect of the Take

In the biological opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the Proposed Action, is not likely to jeopardize the continued existence of the Snake River Fall-run Chinook Salmon ESU, Snake River Spring/Summer Chinook Salmon ESU, Snake River Sockeye Salmon ESU, and Snake River Basin Steelhead DPS or result in the destruction or adverse modification of their designated critical habitat.

### 2.10.3. Reasonable and Prudent Measures

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

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

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 Chinook salmon Nez Perce Tribal Hatchery (permit #16615) and the FCAP/WDFW Lyons Ferry/ODFW/Idaho Power Company Hatchery (permit #16607) 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. The applicants provide reports to NMFS' Sustainable Fisheries Division annually for all hatchery programs, and associated RM&E.

### 2.10.4. Terms and Conditions

The terms and conditions described below are non-discretionary, and the Action Agencies must comply with them in order to implement the reasonable and prudent measures (50 CFR 402.14), where applicable to each entity as specifically directed. The Action Agencies, to the extent directed below, have a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this incidental take statement (50 CFR 402.14). If the following terms and conditions outlined below are not complied with, the protective coverage of section 7(o)(2) will 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.

   b. All reports, along with other required notifications, are submitted by applicants electronically to NMFS, West Coast Region, Sustainable Fisheries Division, APIF Program. The current point of contact for document submission is Natasha Preston (natasha.preston@noaa.gov, 503-231-2178) to ensure consistency with the Proposed Action.

2. BPA, USFWS, and NMFS shall take the following measures to ensure that an annual monitoring and evaluation report is submitted by applicants that describe the activities identified in the Proposed Action relative to each agency's respective role no later than May 15, two years following the monitoring and evaluation activities (i.e., surveys conducted in 2018, report due May 2020) 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 should include:

    *i. A calculation of quantifiable encounter and mortality take for each species across all HGMP activities*

    *ii. Hatchery Environment Monitoring and Reporting (for all programs and operations covered in this Biological Opinion unless specified)*

    • Number, hatchery/natural composition, age structure (total and saltwater), and dates of collection of broodstock
    • Numbers, fpp, dates, locations, and tag/mark information of released fish
    • Mean length and coefficient of variation immediately prior to release
    • Survival rates of hatchery-origin fish life stages (green egg to smolt)
    • Disease occurrence at facilities and the acclimation sites
    • Any problems that may have arisen during hatchery activities
    • Any unforeseen effects on listed fish
    • The number and species of listed fish encountered at each adult collection location, and the number that die
    • Distribution of hatchery- and listed natural-origin spawners in all major natural spawning areas (based on PBT sampling and carcass surveys if technically feasible)
    • pHOS, pNOB, and resulting PNI (based on run reconstruction at LGR, PBT sampling, and carcass surveys) in the upper Snake River in the Hells Canyon reach

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

    • The number of returning hatchery and natural-origin adults and age structure (total and saltwater)
    • Smolt-to-adult survival rate
    • The contribution of fish from these programs into other populations
    • Post release out-of-basin migration timing (median travel time and residual rates) of juvenile hatchery-origin fish to Ice Harbor Dam
    • Mean length, coefficient of variation, number, and age at outmigration of natural-origin juveniles

    iv.
    *Funding decisions for some SRFC monitoring and evaluation activities have not been finalized. Therefore, a funding plan outlining these responsibilities between*

*BPA, LSRCP, and IPC needs to be completed and submitted to NMFS two years from the issuance of the permit. These activities include, but are not limited to:*

- Running PBT samples
- Carcass survey efforts
- M&E and tagging components of the FCAP program

### 2.11. 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 one conservation recommendation appropriate to the Proposed Action:

1. *Continue to prioritize Snake River Fall Chinook natural population monitoring.*

   This information is essential to understanding the status of the Snake River Fall Chinook Salmon ESU. The Recovery Plan (NMFS 2017d) 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. *Consider the movement of additional Snake River fall Chinook salmon releases in the future*

   According to the current *U.S. v. Oregon* Management Agreement,

   "*The adult return information from these releases [in this Proposed Action] will inform the Parties as they consider whether to move additional release locations during the course of the Management Agreement*."

   Depending on the results and success of the current Proposed Action, NMFS may recommend moving the Pittsburg Landing releases into the Salmon River in the future. Based on preliminary modeling (Cooney and Busack 2017), this action could align with *Scenario C* of the Snake River fall Chinook Recovery Plan (NMFS 2017d). It is important to note that, as discussed in Section 2.6.2.2.1, the modeling scenarios involve a number of uncertainties and assumptions.

### 2.12. Reinitiation of Consultation

This concludes formal consultation for a section 7 Biological Opinion and section 10 permits on the Snake River fall Chinook hatchery programs.

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

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

If the amount or extent of take considered in this opinion is exceeded, NMFS may reinitiate consultation. SFD will consult with the operators to determine specific actions and measures that can be implemented to address the take or implement further analysis of the impacts on listed species.

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

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

This analysis is based, in part, on descriptions of EFH for Pacific Coast salmon (PFMC 2003a; PFMC 2014) contained in the fishery management plans developed by the Pacific Fishery Management Council (PFMC) and approved by the Secretary of Commerce.

### 3.1. Essential Fish Habitat Affected by the Project

The Proposed Action is the issuance of permits and associated Federal funding as implemented by operators of the Snake River fall Chinook salmon hatchery programs, as described in Section 1.3. The Action Area (Section 2.4) includes habitat described as EFH for Chinook and coho salmon (PFMC 2003a) within the Snake River Basin. Because EFH has not been described for steelhead, the analysis is restricted to the effects of the Proposed Action on EFH for Chinook and coho salmon.

As described by PFMC (2003a), the freshwater EFH for Chinook and coho salmon has five habitat areas of particular concern (HAPCs): (1) complex channels and floodplain habitat; (2) thermal refugia; (3) spawning habitat; (4) estuaries; and (5) marine and estuarine submerged aquatic vegetation. 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. As described in Section 2.6.2.5, 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 2003b) 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 2.6.2.2; Appendix A). 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 2.6.2.2 and 2.6.2.3. Hatchery fish returning to the Snake River Basin are expected to largely spawn and rear near the hatchery and not compete for space with steelhead or sockeye salmon. Some fall 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 Chinook salmon on juvenile natural-origin Chinook and sockeye salmon as well as steelhead has been analyzed in Section 2.6.2.3. Predation and competition by juvenile hatchery fall Chinook salmon on juvenile natural-origin Chinook or sockeye salmon or steelhead is small (Section 2.6.2.3) because these fish outmigrate relatively quickly and at sizes that limit these types of interactions.

NMFS has determined that the proposed action would adversely affect EFH for Pacific salmon.

### 3.3. Essential Fish Habitat Conservation Recommendations

For each of the potential adverse effects by the Proposed Action on EFH for Chinook and coho salmon, NMFS believes that the Proposed Action, as described in the HGMPs (NPT 2011; Washington Department of Fish and Wildlife et al. 2011) and the ITS (Section 2.10) includes the best approaches to avoid or minimize those adverse effects. Thus, NMFS' conservation recommendation for Chinook and coho salmon EFH is to implement the Terms and Conditions (Section 2.10.4).

### 3.4. Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, an action 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 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

Section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-554) ("Data Quality Act"; DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

### 4.1. Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users are NMFS, BPA, LSRCP, and the program operators and their co-operators. The scientific community, resource managers, and stakeholders benefit from the consultation through the anticipated increase in returns of salmonids, and through the collection of data indicating the potential effects of the operation on the viability of natural populations of ESA-listed salmon and steelhead in the Snake River Basin. This information will improve scientific understanding of hatchery salmon and steelhead effects that can be applied broadly within the Pacific Northwest area for managing benefits and risks associated with hatchery operations.

### 4.2. Integrity

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

### 4.3. Objectivity

***Information Product Category:*** Natural Resource Plan

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

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

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

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

## 5. Appendix A: Factors Considered When Analyzing Hatchery Effects

NMFS' analysis of the Proposed Action is in terms of effects the Proposed Action would be expected to have on ESA-listed species and on designated critical habitat, based on the best scientific information available. The effects, positive and negative, for the two categories of hatchery programs are summarized in Table 1. Generally speaking, effects range from beneficial to negative when programs use local fish for hatchery broodstock, and from negligible to negative when programs do not use local fish for broodstock. Hatchery programs can benefit population viability, but only if they use genetic resources that represent the ecological and genetic diversity of the target or affected natural population(s). When hatchery programs use genetic resources that do not represent the ecological and genetic diversity of the target or affected natural population(s), NMFS is particularly interested in how effective the program will be at isolating hatchery fish and at avoiding co-occurrence and effects that potentially disadvantage fish from natural populations. 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. Analysis of a Proposed Action for its effects on ESA-listed species and on 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, the migration corridor, estuary, and ocean,
(4) RM&E that exists because of the hatchery program,
(5) operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program, and
(6) fisheries that exist because of the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds.

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

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

The effects of hatchery fish on ESU/DPS status will depend on which of the four VSP criteria are currently limiting the ESU/DPS and how the hatchery program affects each of the criteria (NMFS 2005c). The category of effect assigned to a factor is based on an analysis of each factor weighed against each affected population's current risk level for abundance, productivity, spatial structure, and diversity, the role or importance of the affected natural population(s) in ESU or steelhead DPS recovery, the target viability for the affected natural population(s), and the environmental baseline including the factors currently limiting population viability.

**Table 34. An overview of the range of effects on natural population viability parameters from the two categories of hatchery programs.**

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

| | | |
|---|---|---|
| **Spatial Structure** | **Positive to negative effect** Hatcheries can accelerate re-colonization and increase population spatial structure, but only in conjunction with remediation of the factor(s) that limited spatial structure in the first place. "Any benefits to spatial structure over the long term depend on the degree to which the hatchery stock(s) add to (rather than replace) natural populations" (70 FR 37204, June 28, 2005 at 37213). | **Negligible to negative effect** Spatial structure is dependent on facility operation, maintenance, and construction effects and the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the closer to a negligible effect). |

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

This factor considers the risk to a natural population from the removal of natural-origin fish for hatchery broodstock. The level of effect for this factor ranges from neutral or negligible to negative.

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

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

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

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

However, NMFS recognizes that beneficial effects exist as well, and that the risks just mentioned may be outweighed under circumstances where demographic or short-term extinction risk to the population is greater than risks to population diversity and productivity. Conservation hatchery programs may accelerate recovery of a target population by increasing abundance faster than may occur naturally (Waples 1999). Hatchery programs can also be used to create genetic reserves for a population to prevent the loss of its unique traits due to catastrophes.

NMFS also recognizes there is considerable debate regarding genetic risk. The extent and duration of genetic change and fitness loss and the short- and long-term implications and consequences for different species (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, NMFS believes that hatchery intervention is a legitimate and useful tool to alleviate short-term extinction risk, but otherwise managers should seek to limit interactions between hatchery and natural-origin fish and implement hatchery practices that harmonize conservation with the implementation of treaty Indian fishing rights and other applicable laws and policies (NMFS 2011b).

### 5.2.1. Genetic effects

Hatchery fish can have a variety of genetic effects on natural population productivity and diversity when they interbreed with natural-origin fish. Although there is biological interdependence between them, NMFS considers three major areas of genetic effects of hatchery programs: within-population diversity, outbreeding effects, and hatchery-induced selection. As we have stated above, in most cases, the effects are viewed as risks, but in small populations these effects can sometimes be beneficial, reducing extinction risks.
First, within-population genetic diversity is a general term for the quantity, variety, and combinations of genetic material in a population (Busack and Currens 1995). Within-population diversity is gained through mutations or gene flow from other populations (described below under outbreeding effects) and is lost primarily due to genetic drift, a random loss of diversity due to population size. The rate of loss is determined by the population's effective population size ($N_e$), which can be considerably smaller than its census size. For a population to maintain genetic diversity reasonably well, the effective size should be in the hundreds (Lande 1987), and diversity loss can be severe if $N_e$ drops to a few dozen.

Hatchery programs, simply by virtue of creating more fish, can increase $N_e$. In very small populations, this increase can be a benefit, making selection more effective and reducing other small-population risks (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 $N_e$ by two principal methods. One is by the simple removal of fish from the population so that they can be used in the hatchery 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). Two is when $N_e$ 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 semen is especially problematic because when semen of several males is mixed and applied to eggs, a large portion of the eggs may be fertilized by a single male (Gharrett and Shirley 1985; Withler 1988). An extreme form of $N_e$ reduction is the Ryman-Laikre effect (Ryman et al. 1995; Ryman and Laikre 1991), when $N_e$ is reduced through the return to the spawning grounds of large numbers of hatchery fish from very few parents. On the other hand, factorial mating schemes, in which fish are systematically mated multiple times, can be used to increase $N_e$ (Busack and Knudsen 2007; Fiumera et al. 2004).

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

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

Gene flow from other populations can have two effects. It can increase genetic diversity (Ayllon et al. 2006), which can be a benefit in small populations, but it can also alter established allele frequencies (and co-adapted gene complexes) and reduce the population's level of adaptation, a phenomenon called outbreeding depression (Edmands 2007; McClelland and Naish 2007). In general, the greater the geographic separation between the source or origin of hatchery fish and the recipient natural population, the greater the genetic difference between the two populations

(ICTRT 2007), and the greater potential for outbreeding depression. For this reason, NMFS advises hatchery action agencies to develop locally derived hatchery broodstock. Additionally, unusual rates of straying into other populations within or beyond the population’s MPG, salmon ESU, or a steelhead DPS can have an homogenizing effect, decreasing intra-population genetic variability (Vasemagi et al. 2005), and increasing risk to population diversity, one of the four attributes measured to determine population viability. Reduction of within-population and among-population diversity can reduce adaptive potential.

The proportion of hatchery fish (pHOS) among natural spawners is often used as a surrogate measure of gene flow. Appropriate cautions and qualifications should be considered when using this proportion to analyze 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). Caution must also be taken in assuming that strays contribute genetically in proportion to their abundance. Several studies demonstrate little genetic impact from straying despite a considerable presence of strays in the spawning population (Blankenship et al. 2007; Saisa et al. 2003). The causative factors for poorer breeding success of strays are likely similar to those identified as responsible for reduced productivity of hatchery-origin fish in general, e.g., differences in run and spawn timing, spawning in less productive habitats, and reduced survival of their progeny (Leider et al. 1990; Reisenbichler and McIntyre 1977; Williamson et al. 2010).

Hatchery-influenced selection (often called domestication), the third major area of genetic effects of hatchery programs, occurs when selection pressures imposed by hatchery spawning and rearing differ greatly from those imposed by the natural environment and causes genetic change that is passed on to natural populations through interbreeding with hatchery-origin fish. 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).

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

Most of the empirical evidence of fitness depression due to hatchery-influenced selection comes from studies of species that are reared in the hatchery environment for an extended period – one to two years – prior to release (Berejikian and Ford 2004). Exposure time in the hatchery for fall and summer Chinook salmon and Chum salmon is much shorter, just a few months. One especially well-publicized steelhead study (Araki et al. 2007), showed dramatic fitness declines in the progeny of naturally spawning Hood River hatchery steelhead. Researchers and managers alike have wondered if these results could be considered a potential outcome applicable to all salmonid species, life-history types, and hatchery rearing strategies, but researchers have not reached a definitive conclusion.

Besides the Hood River steelhead work, a number of studies are available on the relative reproductive success (RRS) of hatchery- and natural-origin fish (Berntson et al. 2011; Ford et al. 2012; Hess et al. 2012; Theriault et al. 2011). All have shown that, generally, hatchery-origin fish have lower reproductive success; however, the differences have not always been statistically significant and, in some years in some studies, the opposite was true. Lowered reproductive success of hatchery-origin fish in these studies is typically considered evidence of hatchery-influenced selection. Although RRS may be a result of hatchery-influenced selection, studies must be carried out for multiple generations to unambiguously detect a genetic effect. To date, only the Hood River steelhead (Araki et al. 2007; Berntson et al. 2011; Christie et al. 2011) and Wenatchee spring Chinook salmon (Ford et al. 2012) RRS studies have reported multiple-generation effects.

Critical information for analysis of hatchery-induced selection includes the number, location, and timing of naturally spawning hatchery fish, the estimated level of gene flow between hatchery-origin and natural-origin fish, the origin of the hatchery stock (the more distant the origin compared to the affected natural population, the greater the threat), the level and intensity of hatchery selection and the number of years the operation has been run in this way. Efforts to control and evaluate the risk of hatchery-influenced selection are currently largely focused on gene flow between natural-origin and hatchery-origin fish. The Interior Columbia Technical Recovery Team (ICTRT) developed guidelines based on the proportion of spawners in the wild consisting of hatchery-origin fish (pHOS).

More recently, the Hatchery Scientific Review Group (HSRG) developed gene-flow guidelines based on mathematical models developed by (Ford 2002) and by (Lynch and O'Hely 2001). Guidelines for isolated programs are based on pHOS, but guidelines for integrated programs are based also on a metric called proportionate natural influence (PNI), which is a function of pHOS and the proportion of natural-origin fish in the broodstock (pNOB). PNI is, in theory, a reflection of the relative strength of selection in the hatchery and natural environments; a PNI value greater than 0.5 indicates dominance of natural selective forces. The HSRG guidelines vary according to type of program and conservation importance of the population. When the underlying natural population is of high conservation importance, the guidelines are a pHOS of no greater than 5 percent for isolated programs. For integrated programs, the guidelines are a pHOS no greater than 30 percent and PNI of at least 67 percent for integrated programs (HSRG 2009b). Higher levels of hatchery influence are acceptable, however, when a population is at high risk or very high risk of extinction due to low abundance and the hatchery program is being used to conserve the population and reduce extinction risk in the short-term. HSRG 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. The HSRG recently produced an update report (HSRG 2014) that stated that the guidelines for isolated programs may not provide as much protection from fitness loss as the corresponding guidelines for integrated programs.

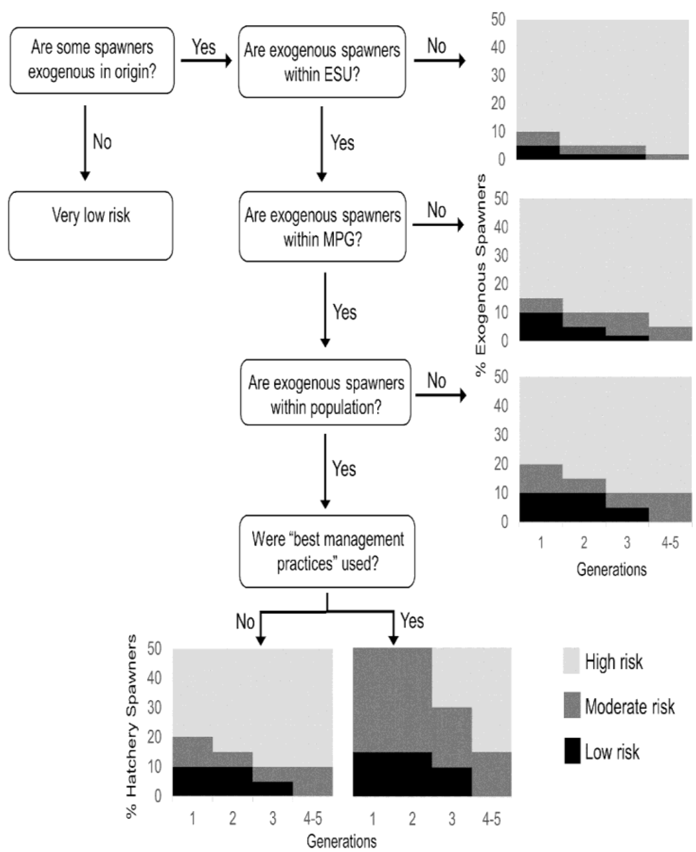


**Figure 5. ICTRT (2007b) risk criteria associated with spawner composition for viability assessment of exogenous spawners on maintaining natural patterns of gene flow. Exogenous fish are considered to be all fish hatchery origin, and non-normative strays of natural origin.**

Another HSRG team recently reviewed California hatchery programs and developed guidelines that differed considerably from those developed by the earlier group (California HSRG 2012). The California HSRG felt that truly isolated programs in which no hatchery-origin returnees interact genetically with natural populations were impossible in California, and was “generally unsupportive” of the concept. However, if programs were to be managed as isolated, they recommend a pHOS of less than 5 percent. They rejected development of overall pHOS guidelines for integrated programs because the optimal pHOS will depend upon multiple factors, such as “the amount of spawning by natural-origin fish in areas integrated with the hatchery, the value of pNOB, the importance of the integrated population to the larger stock, the fitness differences between hatchery- and natural-origin fish, and societal values, such as angling opportunity.” They recommended that program-specific plans be developed with corresponding population-specific targets and thresholds for pHOS, pNOB, and PNI that reflect these factors. However, they did state that PNI should exceed 50 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. They also 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.

Discussions involving pHOS can be problematic due to variation in its definition. Most commonly, the term pHOS refers to the proportion of the total natural spawning population consisting of hatchery fish, and the term has been used in this way in all NMFS documents. However, the HSRG has defined pHOS inconsistently in its Columbia Basin system report, equating it with “the proportion of the natural spawning population that is made up of hatchery fish” in the Conclusion, Principles and Recommendations section (HSRG 2009b), but with “the proportion of *effective* hatchery origin spawners” in their gene-flow criteria. In addition, in their Analytical Methods and Information Sources section (HSRG 2009a) they introduce a new term, *effective pHOS* ($pHOS_{eff)}$ defined as the effective proportion of hatchery fish in the naturally spawning population. This confusion was cleared up in the 2014 update document, where it is clearly stated that the metric of interest is effective pHOS .

The HSRG recognized that hatchery fish spawning naturally may on average produce fewer adult progeny than natural-origin spawners, as described above. To account for this difference the HSRG defined *effective* pHOS as:

$$pHOS_{eff} = RRS * pHOS_{census}$$

where $pHOS_{census}$ is the proportion of the naturally spawning population that is composed of hatchery-origin adults (HSRG 2014). In the 2014 report, the HSRG explicitly addressed the differences between *census* pHOS and *effective* pHOS, by defining PNI as:

$$PNI = \frac{pNOB}{(pNOB + pHOS_{eff})}$$

NMFS feels that adjustment of census pHOS by RRS should be done very cautiously, 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, however, 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 natural-origin and hatchery-origin spawners differs, and the hatchery-origin 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 natural-origin 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 also 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 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, NMFS feels that census pHOS, rather than effective pHOS, is the appropriate metric to use for genetic risk evaluation.

Additional perspective on pHOS that is independent of HSRG modelling is provided by a simple analysis of the expected proportions of mating types. Figure 14 shows the expected proportion of mating types in a mixed population of natural-origin (N) and hatchery-origin (H) fish as a function of the census pHOS, assuming that N and H adults mate randomly. For example, at a census pHOS level of 10 percent, 81 percent of the matings will be NxN, 18 percent will be NxH, and 1 percent will be HxH. This diagram can also be interpreted as probability of parentage of naturally produced progeny, assuming random mating and equal reproductive success of all mating types. Under this interpretation, progeny produced by a parental group with a pHOS level of 10 percent will have an 81 percent chance of having two natural-origin parents, etc.

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

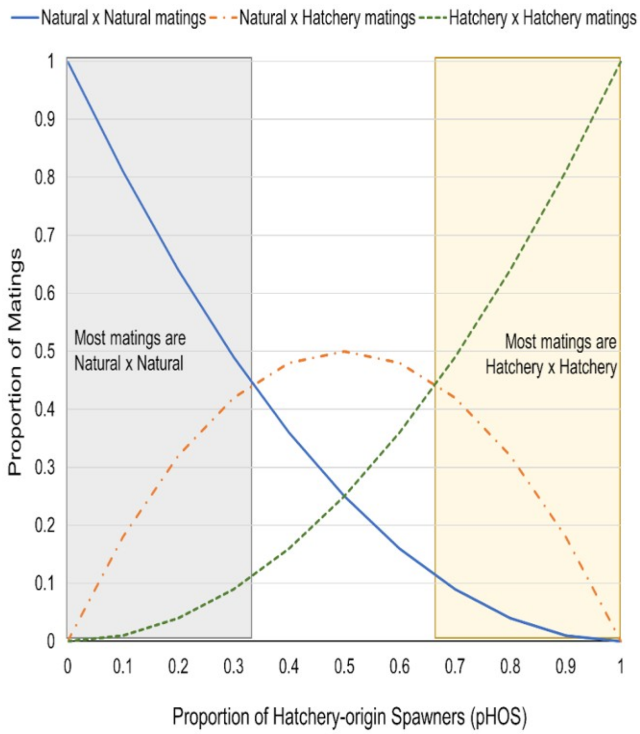


**Figure 6. Relative proportions of types of matings as a function of proportion of hatchery-origin fish on the spawning grounds (pHOS).**

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

Additionally, studies have demonstrated that perturbation of spawning gravels by spawning salmonids loosens cemented (compacted) gravel areas used by spawning salmon (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 at times. In particular, the potential exists for hatchery-derived fish to superimpose or destroy the eggs and embryos of ESA-listed species when there is spatial overlap between hatchery and natural spawners. Redd superimposition has been shown to be a cause of egg loss in pink salmon and other species (Fukushima et al. 1998).

### 5.3. 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. Generally speaking, the more a hatchery program accesses the run at large for hatchery broodstock – that is, the more fish that are handled or delayed during migration – the greater the negative effect on natural-origin and hatchery-origin fish that are intended to spawn naturally and 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.

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

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

### 5.4.1. Competition

Generally speaking, 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 naturally produced 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 would thus depend on the degree of dietary overlap, food availability, size-related differences in prey selection, foraging tactics, and differences in microhabitat use (Steward and Bjornn 1990).

Specific hazards associated with competitive impacts of hatchery salmonids on listed natural-origin salmonids may include competition for food and rearing sites. In an assessment of the potential ecological impacts of hatchery fish production on naturally produced salmonids, the Species Interaction Work Group (Rensel et al. 1984) concluded that naturally produced coho and Chinook salmon and steelhead are all potentially at “high risk” due to competition (both interspecific and intraspecific) from hatchery fish of any of these three species. In contrast, the risk to naturally produced pink, chum, and sockeye salmon due to competition from hatchery salmon and steelhead was judged to be low.

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

*En masse* hatchery salmon smolt releases may cause displacement of rearing natural-origin juvenile salmonids from occupied stream areas, leading to abandonment of advantageous feeding stations, or premature out-migration by natural-origin juvenile salmonids. Pearsons et al.

reported small-scale displacement of juvenile naturally produced 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.

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

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

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

Critical to analyzing competition risk is information on the quality and quantity of spawning and rearing habitat in the Action Area, 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.

### 5.4.2. Predation

Another potential ecological effect of hatchery releases is predation. Salmon and steelhead are piscivorous and can prey on other salmon and steelhead. Predation, either direct (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. Considered here is predation by hatchery-origin fish, the progeny of naturally spawning hatchery fish, and avian and other predators attracted to the area by an abundance of hatchery fish. Hatchery fish originating from egg boxes and fish planted as non-migrant fry or fingerlings can prey upon fish from the local natural population during juvenile rearing. Hatchery fish released at a later stage, so they are more likely to emigrate quickly to the ocean, can prey on fry and fingerlings that are encountered during the downstream migration. Some of these hatchery fish do not emigrate and instead take up residence in the stream (residuals) where they can prey on stream-rearing juveniles over a more prolonged period, as discussed above. The progeny of naturally spawning hatchery fish also can prey on fish from a natural population and pose a threat. In general, the threat from predation is greatest when natural populations of salmon and steelhead are at low abundance, when spatial structure is already reduced, when habitat, particularly refuge habitat, is limited, and when environmental conditions favor high visibility.

Rensel et al. (1984) rated most risks associated with predation as unknown because there was relatively little documentation in the literature of predation interactions in either freshwater or marine areas at the time. More studies are now available, but they are still too sparse to allow many generalizations to be made about risk. Newly released hatchery-origin yearling salmon and steelhead may prey on juvenile fall Chinook and steelhead and other juvenile salmon in the freshwater and marine environments (Hargreaves and LeBrasseur 1986; Hawkins and Tipping 1999; Pearsons and Hopley 1999). Low predation rates have been reported for released steelhead juveniles (Hawkins and Tipping 1999; Naman and Sharpe 2012). Hatchery steelhead release timing and protocols used widely in the Pacific Northwest were shown to be associated with negligible predation by migrating hatchery steelhead on fall Chinook fry, which had already emigrated or had grown large enough to reduce or eliminate their susceptibility to predation when hatchery steelhead entered the rivers (Sharpe et al. 2008). Hawkins (1998) documented hatchery spring Chinook salmon yearling predation on naturally produced fall Chinook salmon juveniles in the Lewis River. Predation on smaller Chinook salmon was found to be much higher in naturally produced smolts (coho salmon and cutthroat, predominately) than their hatchery counterparts.

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

Some reports suggest that hatchery fish can prey on fish that are up to 1/2 their length (HSRG 2004; Pearsons and Fritts 1999), but other studies have concluded that salmonid predators prey on fish 1/3 or less their length (Beauchamp 1990; Cannamela 1992; CBFWA 1996; Hillman and Mullan 1989; Horner 1978).

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

- Releasing all hatchery fish as actively migrating smolts through volitional release practices so that the fish migrate quickly seaward, limiting the duration of interaction with any co-occurring natural-origin fish downstream of the release site.
- Ensuring that a high proportion of the population have physiologically achieved full smolt status. Juvenile salmon tend to migrate seaward rapidly when fully smolted, limiting the duration of interaction between hatchery fish and naturally produced fish present within, and downstream of, release areas.
- Releasing hatchery smolts in lower river areas near river mouths and below upstream areas used for stream-rearing young-of-the-year naturally produced salmon fry, thereby reducing the likelihood for interaction between the hatchery and naturally produced fish.
- Operating hatchery programs and releases to minimize the potential for residualism.

### 5.4.3. Disease

The release of hatchery fish and hatchery effluent into juvenile rearing areas can lead to transmission of pathogens, contact with chemicals or altering of environmental parameters (e.g., dissolved oxygen) that can result in disease outbreaks. Fish diseases can be subdivided into two main categories: infectious and non-infectious. 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 genetic or environmental factors (e.g., low dissolved oxygen). Pathogens can also be categorized as exotic or endemic. For our purposes, exotic pathogens are those that have no history of occurrence within state boundaries. For example, *Oncorhynchus masou virus* (OMV) would be considered an exotic pathogen if identified anywhere in Washington state. 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. 2008), including:

- 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 transmission of pathogens 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 (Naish et al. 2008; Steward and Bjornn 1990). 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).

Adherence to a number of state, federal, and tribal fish health policies limits the disease risks associated with hatchery programs (IHOT 1995; NWIFC and WDFW 2006; ODFW 2003; USFWS 2004). Specifically, the policies govern the transfer of fish, eggs, carcasses, and water to prevent the spread of exotic and endemic reportable pathogens. For all pathogens, both reportable and non-reportable, pathogen spread and amplification are minimized through regular monitoring (typically monthly) removing mortalities, and disinfecting all eggs. Vaccines may provide additional protection from certain pathogens when available (e.g., *Vibrio anguillarum*). If a pathogen is determined to be the cause of fish mortality, treatments (e.g., antibiotics) will be used to limit further pathogen transmission and amplification. Some pathogens, such as *infectious hematopoietic necrosis virus* (IHNV), have no known treatment. Thus, if an epizootic occurs for those pathogens, the only way to control pathogen amplification is to cull infected individuals or terminate all susceptible fish. In addition, current hatchery operations often rear hatchery fish on a timeline that mimics their natural life history, which limits the presence of fish susceptible to pathogen infection and prevents hatchery fish from becoming a pathogen reservoir when no natural fish hosts are present.

In addition to the state, federal and tribal fish health policies, disease risks can be further minimized by preventing pathogens from entering the hatchery facility through the treatment of incoming water (e.g., by using ozone) or by leaving the hatchery through hatchery effluent (Naish et al. 2008). Although preventing the exposure of fish to any pathogens prior to 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. 2008). Treating the hatchery effluent would also minimize amplification, but would not reduce disease outbreaks within the hatchery itself 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 those that cannot be transmitted between fish and are typically caused by genetic or 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 monitoring of settleable and unsettleable solids, temperature, and dissolved oxygen in the hatchery effluent on a regular basis 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 period of time. One group of non-infectious diseases that are expected to occur rarely in current hatchery operations are those caused by nutritional deficiencies because of the vast literature available on successful rearing of salmon and trout in aquaculture.

### 5.4.4. Acclimation

One factor the 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 juvenile before release increases the probability that hatchery adults will home back to the release location, reducing their potential to stray into natural spawning areas. Acclimating fish for a period of 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 2013). 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; 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 (Beckman et al. 2000; Hoar 1976). 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 (Bentzen et al.

2001; Fulton and Pearson 1981; Hard and Heard 1999; Kostow 2009; Quinn 1997; 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 (Clarke et al. 2011; Kenaston et al. 2001).

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

- The timing of the acclimation, such that a majority of the hatchery juveniles are going through the parr-smolt transformation during acclimation
- A water source unique enough to attract returning adults
- Whether or not the hatchery fish can access the stream reach where they were released
- Whether or not the water quantity and quality is such that returning hatchery fish will hold in that area before removal and/or their harvest in fisheries.

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

NMFS also analyzes proposed RM&E for its effects on listed species and on designated critical habitat. The level of effect for this factor ranges from positive to negative.

Generally speaking, negative effects on the fish from RM&E are weighed against the value or benefit of new information, particularly information that tests key assumptions and that reduces uncertainty. RM&E actions can cause harmful changes in behavior and reduced survival; such actions include, but are not limited to:

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

### 5.5.1. Observing/Harassing

For some parts of the proposed studies, listed fish would be 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 their relative numbers. Its effects are also generally the shortest-lived and least harmful of the research activities discussed in this section because a cautious observer can effectively obtain data while only slightly disrupting fishes' behavior. Fry and juveniles frightened by the turbulence and sound created by observers are likely to seek temporary refuge in deeper water, or behind/under rocks or vegetation. In extreme cases, some individuals may leave a particular pool or habitat type and then return when observers leave the area. At times, the research involves observing adult fish, which are more sensitive to disturbance. These avoidance behaviors are expected to be in the range of normal predator and disturbance behaviors. Redds may be visually inspected, but would not be walked on.

### 5.5.2. 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 because stress can be immediately debilitating, and may also increase the potential for vulnerability to subsequent challenges (Sharpe et al. 1998). Debris buildup at traps can also kill or injure fish if the traps are not monitored and cleared regularly.

### 5.5.3. Fin clipping and tagging

Many studies have examined the effects of fin clips on fish growth, survival, and behavior. The results of these studies are somewhat varied, but fin clips do not generally 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 (Buckland-Nicks et al. 2011; Reimchen and Temple 2003).

In addition to fin clipping, PIT tags and CWTs are included in the Proposed Action. 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, so it is critical that researchers ensure that the operations take place in the safest possible manner. 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 holding 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 et al. 1987; Prentice and Park 1984; Rondorf and Miller 1994). In a study between the tailraces of Lower Granite and McNary Dams (225 km), (Hockersmith et al. 2000) concluded that the performance of yearling Chinook salmon was not adversely affected by orally or surgically implanted sham radio tags or PIT tags. However, (Knudsen et al. 2009) found that, over several brood years, PIT tag induced smolt-adult mortality in Yakima River spring Chinook salmon averaged 10.3 percent and was at times as high as 33.3 percent.

Coded-wire tags 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.

NMFS has developed general guidelines to reduce impacts when collecting listed adult and juvenile salmonids (NFMS 2008; NMFS 2000) 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 the (Galbreath et al. 2008).

The effects of these actions should not be confused with handling effects analyzed under broodstock collection. In addition, NMFS also considers the overall effectiveness of the RM&E program. There are five factors that NMFS takes into account when it assesses the beneficial and negative effects of hatchery RM&E: (1) the status of the affected species and effects of the proposed RM&E on the species and on designated critical habitat, (2) critical uncertainties concerning effects on the species, (3) performance monitoring and determining the effectiveness of the hatchery program at achieving its goals and objectives, (4) identifying and quantifying collateral effects, and (5) tracking compliance of the hatchery program with the terms and conditions for implementing the program. After assessing the proposed hatchery RM&E and before it makes any recommendations to the action 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.

Hatchery actions also must be assessed for masking effects. For these purposes, masking is when hatchery fish included in the Proposed Action mix with and are not identifiable from other fish. The effect of masking is that it undermines and confuses RM&E and status and trends monitoring. Both adult and juvenile hatchery fish can have masking effects. When presented with a proposed hatchery action, NMFS analyzes the nature and level of uncertainties caused by masking and whether and to what extent listed salmon and steelhead are at increased risk. The analysis also takes into account the role of the affected salmon and steelhead population(s) in recovery and whether unidentifiable hatchery fish compromise important RM&E.

### 5.6. 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. The level of effect for this factor ranges from neutral or negligible to negative.

### 5.7. Factor 6. Fisheries that exist because of the hatchery program

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

"Many hatchery programs are capable of producing more fish than are immediately useful in the conservation and recovery of an ESU and can play an important role in fulfilling trust and treaty obligations with regard to harvest of some Pacific salmon and steelhead populations. For ESUs listed as threatened, NMFS will, where appropriate, exercise its authority under section 4(d) of the ESA to allow the harvest of listed hatchery fish that are surplus to the conservation and recovery needs of the ESU, in accordance with approved harvest plans" (NMFS 2005b). In any event, fisheries must be strictly regulated based on the take, including catch and release effects, of ESA-listed species.

## 6. References


Araki, H., W. R. Ardren, E. Olsen, B. Cooper, and M. S. Blouin. 2007. Reproductive success of captive-bred steelhead trout in the wild: Evaluation of three hatchery programs in the Hood River. Conservation Biology 21(1):181-190.

Ayllon, F., J. L. Martinez, and E. Garcia-Vazquez. 2006. Loss of regional population structure in Atlantic salmon, *Salmo salar* L., following stocking. ICES Journal of Marine Science 63:1269-1273.

Beauchamp, D. A. 1990. Seasonal and diet food habit of rainbow trout stocked as juveniles in Lake Washington. Transactions of the American Fisheries Society 119:475-485.

Beckman, B. R., and coauthors. 2000. Physiological status of naturally reared juvenile spring Chinook salmon in the Yakima River: Seasonal dynamics and changes associated with smolting. Transactions of the American Fisheries Society 129:727-753.

Bell, E. 2001. Survival, Growth and Movement of Juvenile Coho Salmon (*Oncorhynchus kisutch*) Over-wintering in Alcoves, Backwaters, and Main Channel Pools in Prairie Creek, California. September, 2001. A Thesis presented to the faculty of Humboldt State University. 85p.

Bentzen, P., J. B. Olsen, J. E. McLean, T. R. Seamons, and T. P. Quinn. 2001. Kinship analysis of Pacific salmon: Insights into mating, homing, and timing of reproduction. Journal of Heredity 92:127-136.

Berejikian, B. A., and M. J. Ford. 2004. Review of Relative Fitness of Hatchery and Natural Salmon. U.S. Dept. Commer., NOAA Tech. Memo., NMFS-NWFSC-61. 43p.

Bergman, P. K., K. B. Jefferts, H. F. Fiscus, and R. C. Hager. 1968. A preliminary evaluation of an implanted, coded wire fish tag. Fisheries Research Papers, Washington Department of Fisheries 3(1):63-84.

Berntson, E. A., R. W. Carmichael, M. W. Flesher, E. J. Ward, and P. Moran. 2011. Diminished reproductive success of steelhead from a hatchery supplementation program (Little Sheep Creek, Imnaha Basin, Oregon). Transactions of the American Fisheries Society 140:685-698.

Bilton, T., D. F. Alderdice, and J. T. Schnute. 1982. Influence of time and size at release of juvenile coho salmon (*Oncorhynchus kisutch*) on returns at maturity. Canadian Journal of Fisheries and Aquatic Sciences 39(3):426-447.

Blankenship, S. M., M. P. Small, J. Bumgarner, M. Schuck, and G. Mendel. 2007. Genetic relationships among Tucannon, Touchet, and Walla Walla river summer steelhead (*Oncorhynchus mykiss*) receiving mitigation hatchery fish from Lyons Ferry Hatchery. WDFW, Olympia, Washington. 39p.

Bordner, C. E., and coauthors. 1990. Evaluation of marking techniques for juvenile and adult white sturgeons reared in captivity. American Fisheries Society Symposium 7:293-303.

Bradford, M. J., B. J. Pyper, and K. S. Shortreed. 2000. Biological responses of sockeye salmon to the fertilization of Chilko Lake, a large lake in the interior of British Columbia. North American Journal of Fisheries Management 20:661-671.

Brakensiek, K. E. 2002. Abundance and Survival Rates of Juvenile Coho Salmon (*Oncorhynchus kisutch*) in Prairie Creek, Redwood National Park. January 7, 2002. MS Thesis. Humboldt State University, Arcata, California. 119p.

Brynildson, O. M., and C. L. Brynildson. 1967. The effect of pectoral and ventral fin removal on survival and growth of wild brown trout in a Wisconsin stream. Transactions of the American Fisheries Society 96(3):353-355.

Buckland-Nicks, J. A., M. Gillis, and T. E. Reimchen. 2011. Neural network detected in a presumed vestigial trait: ultrastructure of the salmonid adipose fin. Proceedings of the Royal Society B: Biological Sciences 297:553-563.

Bumgarner, J. D. 2017. FAll Chinook to LGR excel report. August 17, 2017.

Busack, C. 2007. The impact of repeat spawning of males on effective number of breeders in hatchery operations. Aquaculture 270:523-528.

Busack, C. 2015. Extending the Ford model to three or more populations. August 31, 2015. Sustainable Fisheries Division, West Coast Region, National Marine Fisheries Service. 5p.

Busack, C., and K. P. Currens. 1995. Genetic risks and hazards in hatchery operations: Fundamental concepts and issues. AFS Symposium 15:71-80.

Busack, C., and C. M. Knudsen. 2007. Using factorial mating designs to increase the effective number of breeders in fish hatcheries. Aquaculture 273:24-32.

Busby, P. J., and coauthors. 1996. Status Review of West Coast steelhead from Washington, Idaho, Oregon, and California. August 1996. U.S. Dept. Commer. NOAA Tech. Memo., NMFS-NWFSC-27. NMFS, Seattle, Washington. 275p.

California HSRG. 2012. California Hatchery Review Report. Prepared for the U.S. Fish and Wildlife Service and Pacific States Marine Fisheries Commission. June 2012. 110p.

Cannamela, D. A. 1992. Potential Impacts of Releases of Hatchery Steelhead Trout "Smolts" on Wild and Natural Juvenile Chinook and Sockeye Salmon, Appendix A. A White Paper. March 1992. Idaho Department of Fish and Game, Boise, Idaho. 26p.

CBFWA. 1996. Draft Programmatic Environmental Impact Statement. Impacts of Artificial Salmon and Steelhead Production Strategies in the Columbia River Basin. December 10, 1996. Prepared by the Columbia Basin Fish and Wildlife Authority, Portland, Oregon. 475p.

Cederholm, C. J., M. D. Kunze, T. Murota, and A. Sibatani. 1999. Pacific salmon carcasses: Essential contributions of nutrients and energy for aquatic and terrestrial ecosystems. Fisheries 24(10):6-15.

Christie, M. R., M. J. Ford, and M. S. Blouin. 2014. On the reproductive successs of early-generation hatchery fish in the wild. Evolutionary Applications 7:883-896.

Christie, M. R., M. L. Marine, R. A. French, and M. S. Blouin. 2011. Genetic adaptation to captivity can occur in a single generation. Proceedings of the National Academy of Sciences 109(1):238–242.

Clarke, L. R., M. W. Flesher, S. M. Warren, and R. W. Carmichael. 2011. Survival and straying of hatchery steelhead following forced or volitional release. North American Journal of Fisheries Management 31:116-123.

Cleary, P., D. Milks, A. Oakerman, W. P. Connor, and K. Tiffan. 2017. Fidelity, dispersal, and fallback of Snake River fall Chinook salmon yearling and subyearling adult returns. Snake River Fall Chinook Symposium, May 16-17, 2017, Clarkston, Washington. 15p.

Climate Impacts Group. 2004. Overview of Climate Change Impacts in the U.S. Pacific Northwest. July 29, 2004. Climate Impacts Group, University of Washington, Seattle, Washington. 13p.

Connor, W. P., H. L. Burge, R. Waitt, and T. C. Bjornnn. 2002. Juvenile life history of wild fall Chinook salmon in the Snake and Clearwater rivers. North American Journal of Fisheries Management 22:703–712.

Connor, W. P., J. G. Sneva, K. F. Tiffan, R. K. Steinhorst, and D. Ross. 2005. Two alternative juvenile life history types for fall Chinook salmon in the Snake River basin. Transactions of the American Fisheries Society 134(2):291-304.

Cooney, T. D., and C. Busack. 2017. SRFC Gene Flow July 21 2017 tdc IN PROG V 3.d.xlsx.

Crozier, L. G., and coauthors. 2008a. Potential responses to climate change in organisms with complex life histories: Evolution and plasticity in Pacific salmon.

Crozier, L. G., R. W. Zabel, and A. F. Hamlet. 2008b. Predicting differential effects of climate change at the population level with life-cycle models of spring Chinook salmon. Global Change Biology 14(2):236–249.

Daly, E. A., R. D. Brodeur, and L. A. Weitkamp. 2009. Ontogenetic shifts in diets of juvenile and subadult coho and Chinook salmon in coastal marine waters: Important for marine survival? Transactions of the American Fisheries Society 138(6):1420-1438.

Dauble, D. D., T. P. Hanrahan, D. R. Geist, and M. J. Parsley. 2003 Impacts of the Columbia River hydroelectric system on main-stem habitats of fall Chinook salmon. North American Journal of Fisheries Management 23:641-659.

Dittman, A. H., and coauthors. 2010. Homing and spawning site selection by supplemented hatchery- and natural-origin Yakima River spring Chinook salmon. Transactions of the American Fisheries Society 139(4):1014-1028.

Dittman, A. H., and T. P. Quinn. 2008. Assessment of the Effects of the Yakima Basin Storage Study on Columbia River Fish Proximate to the Proposed Intake Locations. A component of Yakima River Basin Water Storage Feasibility Study, Washington. Technical Series No. TS-YSS-13. U.S. Department of the Interior, Denver, Colorado. 179p.

Edmands, S. 2007. Between a rock and a hard place: Evaluating the relative risks of inbreeding and outbreeding for conservation and management. Molecular Ecology 16:463-475.

EPA. 2015. Federal Aquaculture Facilities and Aquaculture Facilities Located in Indian Country within the Boundaries of Washington State. Biological Evaluation for Endangered Species Act Section 7 Consultation with the National Marine Fisheries Service and the U.S. Fish and Wildlife Service. NPDES General Permit WAG130000. December 23, 2015. 191p.

Fiumera, A. C., B. A. Porter, G. Looney, M. A. Asmussen, and J. C. Avise. 2004. Maximizing offspring production while maintaining genetic diversity in supplemental breeding programs of highly fecund managed species. Conservation Biology 18(1):94-101.

Flagg, T. A., C. V. W. Mahnken, and R. N. Iwamoto. 2004. Conservation hatchery protocols for Pacific salmon. AFS Symposium 44:603-619.

Fletcher, D. H., F. Haw, and P. K. Bergman. 1987. Retention of coded-wire tags implanted into cheek musculature of largemouth bass. North American Journal of Fisheries Management 7:436-439.

Ford, M., A. Murdoch, and S. Howard. 2012. Early male maturity explains a negative correlation in reproductive success between hatchery-spawned salmon and their naturally spawning progeny. Conservation Letters 5:450-458.

Ford, M. J. 2002. Selection in captivity during supportive breeding may reduce fitness in the wild. Conservation Biology 16(3):815-825.

Ford, M. J., and coauthors. 2011. Status Review Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Pacific Northwest. November 2011. U.S. Dept. Commer., NOAA Tech. Memo., NMFS-NWFSC-113. 307p.

Foster, R. W. 2004. Letter to Interested Parties from Robert Foster (NMFS). February 3, 2004. Developing the Hatchery and Genetic Management Plans (HGMPs) for Columbia River Basin Anadromous Fish Propagation Programs. NMFS, Portland, Oregon. 3p.

Fukushima, M., T. J. Quinn, and W. W. Smoker. 1998. Estimation of eggs lost from superimposed pink salmon (*Oncorhynchus gorbuscha*) redds. Canadian Journal of Fisheries and Aquatic Sciences 55:618-625.

Fulton, L. A., and R. E. Pearson. 1981. Transplantation and Homing Experiments on salmon, *Oncorhynchus* spp., and steelhead trout, *Salmo gairdneri*, in the Columbia River System: Fish of the 1939-44 broods. July 1981. NOAA Technical Memorandum NMFS F/NWC-12. 109p.

Galbreath, P. F., and coauthors. 2008. Recommendations for Broad Scale Monitoring to Evaluate the Effects of Hatchery Supplementation on the Fitness of Natural Salmon and Steelhead Populations. April 4, 2008. Final draft report of the Ad Hoc Supplementation Monitoring and Evaluation Workgroup. 69p.

Garcia, A. P., W. P. Connor, D. J. Milks, S. J. Rocklage, and R. K. Steinhorst. 2004. Movement and spawner distribution of hatchery fall Chinook salmon adults acclimated and released as yealrings at three locations in the Snake basin. North American Journal of Fisheries Management 24:1134-1144.

Gharrett, A. J., and S. M. Shirley. 1985. A genetic examination of spawning methodology in a salmon hatchery. Aquaculture 47:245-256.

Gilmore, T. 2018. Snake River Fall Chinook hatchery map. June 4, 2018. 1p.

Gjerde, B., and T. Refstie. 1988. The effect of fin-clipping on growth rate, survival and sexual maturity of rainbow trout. Aquaculture 73(1-4):383-389.

Good, T. P., R. S. Waples, and P. Adams. 2005. Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead. June 2005. U.S. Dept. of Commer., NOAA Tech. Memo., NMFS-NWFSC-66. 637p.

Goodman, D. 2005. Selection equilibrium for hatchery and wild spawning fitness in integrated breeding programs. Canadian Journal of Fisheries and Aquatic Sciences 62(2):374-389.

Grant, W. S. 1997. Genetic Effects of Straying of Non-Native Hatchery Fish into Natural Populations. Proceedings of the workshop, June 1-2, 1995, Seattle, Washington. U.S. Department of Commerce, NOAA Tech. Memo., NMFS-NWFSC-30. 157p.

Gresh, T., J. Lichatowich, and P. Schoonmaker. 2000. An estimation of historic and current levels of salmon production in the Northeast Pacific Ecosystem: Evidence of a nutrient deficit in the freshwater systems of the Pacific Northwest Fisheries Habitat. Fisheries 25(1):15-21.

Hager, R. C., and R. E. Noble. 1976. Relation of size at release of hatchery-reared coho salmon to age, size, and sex composition of returning adults. The Progressive Fish-Culturist 38(3):144-147.

Hankin, D. G., J. Fitzgibbons, and Y. Chen. 2009. Unnatural random mating policies select for younger age at maturity in hatchery Chinook salmon (*Oncorhynchus tshawytscha*) populations. Canadian Journal of Fisheries and Aquatic Sciences 66:1505-1521.

Hard, J. J., and W. R. Heard. 1999. Analysis of straying variation in Alaskan hatchery Chinook salmon (*Oncorhynchus tshawytscha*) following transplantation. Canadian Journal of Fisheries and Aquatic Sciences 56:578- 589.

Hard, J. J., R.P. Jones Jr., M. R. Delarm, and R. S. Waples. 1992. Pacific Salmon and Artificial Propagation under the Endangered Species Act. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-2. 64p.

Hargreaves, N. B., and R. J. LeBrasseur. 1986. Size selectivity of coho (*Oncorhynchus kisutch*) preying on juvenile chum salmon (*O. keta*). Canadian Journal of Fisheries and Aquatic Science 43:581-586.

Hartman, G. F., and J. C. Scrivener. 1990. Impacts of forestry practices on a coastal stream ecosystem, Carnation Creek, British Columbia. Canadian Bulletin of Fisheries and Aquatic Sciences 223. 80p.

Hawkins, S. 1998. Residual Hatchery Smolt Impact Study: Wild Fall Chinook Mortality 1995-97. Columbia River Progress Report #98-8. WDFW, Vancouver, Washington. 24p.

Hawkins, S. W., and J. M. Tipping. 1999. Predation by juvenile hatchery salmonids on wild fall Chinook salmon fry in the Lewis River, Washington. California Fish and Game 85(3):124-129.

Hess, M. A., and coauthors. 2012. Supportive breeding boosts natural population abundance with minimal negative impacts on fitness of a wild population of Chinook salmon. Molecular Ecology 21:5236-5250.

HETT. 2014. NTTOC.accdb. (database for NTTOC simulations). Douglas County Public Utility District ftp site.

Hillman, T. W., and J. W. Mullan. 1989. Effect of Hatchery Releases on the Abundance of Wild Juvenile Salmonids. Chapter 8 *in* Summer and Winter Ecology of Juvenile Chinook salmon and steelhead trout in the Wenatchee River, Washington. Report to Chelan County PUD by D.W. Chapman Consultants, Inc. Boise, Idaho. 22p.

Hoar, W. S. 1976. Smolt transformation: Evolution, behavior and physiology. Journal of the Fisheries Research Board of Canada 33:1233-1252.

Hockersmith, E. E., W. D. Muir, S. G. Smith, and B. P. Sandford. 2000. Comparative performance of sham radio-tagged and PIT-tagged juvenile salmon. Report to U.S. Army Corps of Engineers, Contract W66Qkz91521282. 25p.

Holtby, L. B. 1988. Effects of logging on stream temperatures in Carnation Creek, British Columbia, and associated impacts on the coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences 45:502-515.

Horner, N. J. 1978. Survival, Densities and Behavior of Salmonid Fry in Stream in Relation to Fish Predation. July 1978. A Master's Thesis, University of Idaho, Moscow, Idaho. 132p.

Howe, N. R., and P. R. Hoyt. 1982. Mortality of juvenile brown shrimp Penaeus aztecus associated with streamer tags. Transactions of the American Fisheries Society 111(3):317-325.

HSRG. 2004. Hatchery reform: Principles and Recommendations of the Hatchery Scientific Review Group. April 2004. Available at Long Live the Kings. 329p.

HSRG. 2009a. Columbia River Hatchery Reform Project. Final Systemwide Report. Appendix C. Analytical Methods and Information Sources. 20p.

HSRG. 2009b. Columbia River Hatchery Reform System-Wide Report. February 2009. Prepared by Hatchery Scientific Review Group. 278p.

HSRG. 2014. On the Science of Hatcheries: An updated perspective on the role of hatcheries in salmon and steelhead management in the Pacific Northwest. June 2014, (updated October 2014). 160p.

Hurst, C. 2017. Email to Kurt Tardy (SBT) from Charlene Hurst (NMFS). May 8, 2017. Fisheries take for informing the baseline for the hatchery consultations. 1p.

ICTRT. 2007. Scenarios for MPG and ESU viability consistent with TRT viability criteria.

IDFG. 2011. Hells Canyon Snake River Summer Steelhead HGMP. September 13, 2011. IDFG, Boise, Idaho. 80p.

IDFG. 2012. Snake River Sockeye Salmon Captive Broodstock, Research and Production HGMP.

IDFG. 2014. 2014 Annual Report to NOAA Fisheries Fishery Management and Evaluation Plans 4(d) Rule Limit 4. June 2014. The Incidental Take of ESA Listed Salmon and Steelhead During Conduct of Recreational Fisheries in Idaho. IDFG, Boise, Idaho. 20p.

IDFG. 2015. Chinook and Steelhead Genotyping for Genetic Stock Identification at Lower Granite Dam. IDFG Report Number 15-02. January 2015. Annual Progress Report - January 1, 2014 - December 31, 2014. IDFG, Boise, Idaho. 69p.

IDFG. 2016a. 2015 Annual Report to NOAA Fisheries Fishery Management and Evaluation Plans 4(d) Rule Limit 4. May 2016. The Incidental Take of ESA Listed Salmon and Steelhead During Conduct of Recreational Fisheries in Idaho. IDFG, Boise, Idaho. 20p.

IDFG. 2016b. Little Salmon River Basin, Spring Chinook Salmon Rapid River Fish Hatchery HGMP. October 28, 2016. IDFG, Boise, Idaho. 87p.

IDFG. 2017a. 2016 Annual Report to NOAA Fisheries Fishery Management and Evaluation Plans 4(d) Rule Limit 4. June 2017. The Incidental Take of ESA Listed Salmon and Steelhead During Conduct of Recreational Fisheries in Idaho. IDFG, Boise, Idaho. 19p.

IDFG. 2017b. South Fork Salmon River Summer Chinook HGMP. March 2017. IDFG, Boise, Idaho. 92p.

IHOT. 1995. Policies and procedures for Columbia basin anadromous salmonid hatcheries. Annual report 1994 to Bonneville Power Administration, project No. 199204300, (BPA Report DOE/BP-60629). Bonneville Power Administration.

ISAB. 2007. Climate Change Impacts on Columbia River Basin Fish and Wildlife. May 11, 2007. Report ISAB 2007-2. Northwest Power and Conservation Council, Portland, Oregon. 146p

Johnston, N. T., C. J. Perrin, P. A. Slaney, and B. R. Ward. 1990. Increased juvenile salmonid growth by whole-river fertilization. Canadian Journal of Fisheries and Aquatic Sciences 47:862-872.

Jones Jr., R. P. 2002. Letter to Interested Parties from Rob Jones (NMFS). Update of Columbia Basin APRE and HGMP Processes. May 31, 2002. NMFS, Portland, Oregon. 4p.

Jones Jr., R. P. 2008. Letter to Jeff Koenings (WDFW) from Rob Jones (NMFS). Review of hatchery programs in the Upper Columbia River. November 13, 2008. NMFS, Portland, Oregon. 11p.

Jones Jr., R. P. 2009. Letter to Interested Parties from Rob Jones (NMFS). Offer of guidance and assistance to ensure hatchery programs in the Upper Columbia River are in compliance with the ESA. February 6, 2009. NMFS, Portland, Oregon. 3p.

Jones Jr., R. P. 2015. Memorandum to Chris Yates from Rob Jones 2015 5-Year Review - Listing Status under the Endangered Species Act for Hatchery Programs Associated with 28 Salmon Evolutionarily Significant Units and Steelhead Distinct Population Segments. September 28, 2015. NMFS West Coast Region, Sustainable Fisheries Division, Portland, Oregon. 54p.

Jones, R. P. 2006. Files. Artificial Propagation. January 19, 2006. Updates to May 28, 2004 Salmonid Hatchery Inventory and Effects Evaluation Report. 84p.

Jonsson, N., B. Johsson, and L. P. Hansen. 2003. The marine survival and growth of wild and hatcheryreared Atlantic salmon. Journal of Applied Ecology of Freshwater Fish 40:900–911.

Keefer, M. L., and C. C. Caudill. 2013. Homing and straying by anadromous salmonids: a review of mechanisms and rates. Reviews in Fish Biology and Fisheries 24:333-368.

Keefer, M. L., C. C. Caudill, C. A. Peery, and C. T. Boggs. 2008. Non-direct homing behaviours by adult Chinook salmon in a large, multi-stock river system. Journal of Fish Biology 72:27-44.

Kenaston, K. R., R. B. Lindsay, and R. K. Schroeder. 2001. Effect of acclimation on the homing and survival of hatchery winter steelhead. North American Journal of Fisheries Management 21:765-773.

Kline, T. C., Jr., J. J. Goering, O. A. Mathisen, P. H. Poe, and P. L. Parker. 1990. Recycling of elements transported upstream by runs of Pacific salmon: I, δ15N and δ13C evidence in Sashin Creek, Southeastern Alaska. Canadian Journal of Fisheries and Aquatic Sciences 47(1):136-144.

Knudsen, C. M., and coauthors. 2009. Effects of passive integrated transponder tags on smolt-to-adult recruit survival, growth, and behavior of hatchery spring Chinook salmon. North American Journal of Fisheries Management 29:658-669.

Kostow, K. 2009. Factors that contribute to the ecological risks of salmon and steelhead hatchery programs and some mitigating strategies. Reviews in Fish Biology and Fisheries 19:9-31.

Kozfkay, C. 2017. Outmigration total for natural-origin sockeye salmon_IDFG excel report. August 3, 2017.

Lacy, R. C. 1987. Loss of genetic variation from managed populations: Interacting effects of drift, mutation, immigration, selection, and population subdivision. Conservation Biology 1:143-158.

Lande, R. 1987. Extinction thresholds in demographic models of territorial populations. The American Naturalist 130(4):624-635.

LaPatra, S. E. 2003. The lack of scientific evidence to support the development of effluent limitations guidelines for aquatic animal pathogens Aquaculture 226:191–199.

Larkin, G. A., and P. A. Slaney. 1996. Trends in Marine-Derived Nutrient Sources to South Coastal British Columbia Streams: Impending Implications to Salmonid Production. Report No. 3. Watershed Restoration Program, Ministry of Environment, Lands and Parks and Ministry of Forests. 59p.

Leider, S. A., P. L. Hulett, J. J. Loch, and M. W. Chilcote. 1990. Electrophoretic comparison of the reproductive success of naturally spawning transplanted and wild steelhead trout through the returning adult stage. Aquaculture 88(3-4):239-252.

Leth, B. 2017. Juvenile Survival and Travel Time - Release to Lower Granite. May 15, 2017 excel report.

Lynch, M., and M. O'Hely. 2001. Captive breeding and the genetic fitness of natural populations. Conservation Genetics 2:363-378.

Martins, E. G., S. G. Hinch, S. J. Cooke, and D. A. Patterson. 2012. Climate effects on growth, phenology, and survival of sockeye salmon (*Oncorhynchus nerka*): a synthesis of the current state of knowledge and future research directions. Reviews in Fish Biology and Fisheries 22(4):887-914.

Martins, E. G., and coauthors. 2011. Effects of river temperature and climate warming on stock-specific survival of adult migrating Fraser River sockeye salmon (*Oncorhynchus nerka*). Global Change Biology 17(1):99-114.

Matthews, G. M., and R. S. Waples. 1991. Status Review for Snake River spring and summer Chinook salmon. NOAA Tech. Memo. NMFS F/NWC-200. National Marine Fisheries Service, Seattle, Washington. 82p.

Matthews, K. R., and R. H. Reavis. 1990. Underwater tagging and visual recapture as a technique for studying movement patterns of rockfish. American Fisheries Society Symposium 7:168-172.

McClelland, E. K., and K. A. Naish. 2007. What is the fitness outcome of crossing unrelated fish populations? A meta-analysis and an evaluation of future research directions. Conservation Genetics 8:397-416.

McClure, M., T. Cooney, and ICTRT. 2005. Memorandum to NMFS NW Regional Office, Co-managers and other interested parties. May 11, 2005. Updated population delineation in the interior Columbia Basin. 14p.

McElhany, P., M. H. Rucklelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-42. 174p.

McNeil, F. I., and E. J. Crossman. 1979. Fin clips in the evaluation of stocking programs for muskellunge *(Esox masquinongy)*. Transactions of the American Fisheries Society 108:335-343.

Milks, D. 2012. Historical strays processed vs broodstock for Craig Busack.xls. Spreadsheet provided to Craig Busack (NMFS) March 2, 2012. WDFW Snake River Lab, Dayton, Washington.

Milks, D. 2018a. Email to Natasha Preston (NMFS) from Deborah Milks (DFW). SRFC pNOB data. March 12, 2018. 2p.

Milks, D. 2018b. SRFC stray data May 10, 2018 excel report.

Milks, D., A. Grider, and M. Schuck. 2013. Lyons Ferry Hatchery Evaluation Fall Chinook Salmon. 2011 Annual report. WDFW, Olympia, Washington. 139p.

Milks, D., and A. Oakerman. 2014. Lyons Ferry Hatchery Evaluation Fall Chinook Salmon: 2012 Annual report. WDFW, Olympia, Washington. 134p.

Montgomery, D. R., J. M. Buffington, N. P. Peterson, D. Schuett-Hames, and T. P. Quinn. 1996. Stream-bed scour, egg burial depths, and the influecne of salmonid spawning on bed surface mobility and embryo survival. Canadian Journal of Fisheries and Aquatic Sciences 53:1061-1070.

Moring, J. R. 1990. Marking and tagging intertidal fishes: Review of techniques. American Fisheries Society Symposium 7:109-116.

Morrison, J., and D. Zajac. 1987. Histologic effect of coded wire tagging in chum salmon. North American Journal of Fisheries Management 7:439-441.

Morrison, W. E., M. W. Nelson, R. B. Griffis, and J. A. Hare. 2016. Methodology for assessing the vulnerability of marine and anadromous fish stocks in a changing climate. Fisheries 41(7):407-409.

Mote, P. W., and coauthors. 2003. Preparing for climatic change: the water, salmon, and forests of the Pacific Northwest. Climatic change 61(1-2):45-88.

Murota, T. 2003. The marine nutrient shadow: A global comparison of anadromous fishery and guano occurrence. Pages 17-31 *in* J.G. Stockner, ed. Nutrients in salmonid ecosystems.

American Fisheries Society Symposium 34, Bethesda, Maryland. AFS Symposium 34:17-31.
Myers, J. M., and coauthors. 1998. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. February 1998. U.S. Dept. Commer., NOAA Tech Memo., NMFS-NWFSC-35. 476p.
Myers, R. A., and coauthors. 2004. Hatcheries and endangered salmon. Science 303:1980.
Naish, K. A., and coauthors. 2008. An Evaluation of the Effects of Conservation and Fishery Enhancement Hatcheries on Wild Populations of Salmon Advances in Marine Biology in Advances in Marine Biology, Volume 53. David W. Sims, Series Editor. 318p.
Naman, S. W., and C. S. Sharpe. 2012. Predation by hatchery yearling salmonids on wild subyearling salmonids in the freshwater environment: A review of studies, two case histories, and implications for management. Environmental Biology of Fisheries 94(1):21-28.
NFMS. 2008. Artificial Propagation for Pacific Salmon: Assessing Benefits and Risks and Recommendations for Planning and Operating Hatchery Programs. October 2008. Pre-Decisional Draft. NMFS, Portland, Oregon. 49p.
Nicola, S. J., and A. J. Cordone. 1973. Effects of fin removal on survival and growth of rainbow trout *(Salmo gairdneri)* in a natural environment. Transactions of the American Fisheries Society 102:753-759.
NMFS. 1994. Biological Opinion for Hatchery Operations in the Columbia River Basin. April 7, 1994. National Marine Fisheries Service, Seattle, Washington. 79p.
NMFS. 1995. Proposed Recovery Plan for Snake River Salmon. March 1995. NMFS, Portland, Oregon. 550p.
NMFS. 1999. Endangered Species Act Section 7 Consultation Biological Opinion on Artificial Propagation in the Columbia River Basin. Incidental Take of Listed Salmon and Steelhead from Federal and non-Federal Hatchery Programs that Collect, Rear and Release Unlisted Fish Species. March 29, 1999. NMFS Consultation No.: NWR-1999-01903. 231p.
NMFS. 2000. Guidelines for electrofishing waters containing salmonids listed under the Endangered Species Act. NMFS, Northwest Region, Portland, Oregon.
NMFS. 2004a. Anadromous Salmonid Passage Facility Guidelines and Criteria. January 31, 2004 external review draft. 88p. Northwest Region, Hydro Division, Portland, Oregon.
NMFS. 2004b. NOAA Fisheries' Approach to Making Determinations Pursuant to the Endangered Species Act about the Effects of Harvest Actions on Listed Pacific Salmon and Steelhead. November 16, 2004. Prepared by the Northwest Region Sustainable Fisheries Division. 85p.
NMFS. 2005a. Appendix A CHART assessment for the Puget Sound salmon evolutionary significant unit from final assessment of NOAA Fisheries' Critical Habitat Analytical Review Teams for 12 ESUs of West Coast salmon and steelhead. August 2005. 55p.
NMFS. 2005b. Biological Opinion on Impacts of Treaty Indian and Non-Indian Fisheries in the Columbia River Basin in years 2005-2007. May 4, 2005. NMFS Consultation No.: NWR-2005-00388. 145p.
NMFS. 2005c. Final assessment of NOAA Fisheries' Critical Habitat Analytical Review Teams for 12 Evolutionarily Significant Units of West Coast Salmon and Steelhead. NMFS NWR Protected Resources Division, Portland, Oregon. 587p.

NMFS. 2005d. Policy on the consideration of hatchery-origin fish in Endangered Species Act listing determinations for Pacific salmon and steelhead. Pages 37204-37216 *in* D. o. Commerce, editor. Federal Register, Volume 70 No. 123.

NMFS. 2007a. Endangered Species Act Section 7 Consultation Biological Opinion and Magnuson-Stevens Act Essential Fish Habitat Consultation. USFWS Artificial Propagation Programs in the Lower Columbia and Middle Columbia River. November 27, 2007. NMFS Consultation No.: NWR-2004-02625. 256p.

NMFS. 2007b. Guidance for Assessing Hatchery Effects and Hatchery Assessments for Columbia Basin Salmon and Steelhead Hatchery Programs. October 2007. NOAA Fisheries, Salmon Recovery Division, Portland, Oregon. 36p.

NMFS. 2008a. Assessing Benefits and Risks & Recommendations for Operating Hatchery Programs consistent with Conservation and Sustainable Fisheries Mandates. Appendix C of Supplementary Comprehensive Analysis of the Federal Columbia River Power System and Mainstem Effects of the Upper Snake and other Tributary Actions. May 5, 2008. NMFS, Portland, Oregon.

NMFS. 2008b. Endangered Species Act Section 7(a)(2) Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation: Consultation on Remand for Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(1)(A) Permit for Juvenile Fish Transportation Program (Revised and reissued pursuant to court order *NWF v. NMFS* Civ. No. CV 01-640-RE (D. Oregon)). May 5, 2008. NMFS, Portland, Oregon. NMFS Consultation No.: NWR-2005-05883. 929p.

NMFS. 2008c. NOAA Fisheries FCRPS Biological Opinion. Chapters 1-9, Effects Analysis for Salmonids. May 5, 2008. NMFS Consultation No.: NWR-2005-05883. NMFS, Portland, Oregon. 137p.

NMFS. 2008d. Supplemental Comprehensive Analysis of the Federal Columbia River Power System and Mainstem Effects of the Upper Snake and other Tributary Actions. May 5, 2008. NMFS, Portland, Oregon. 1230p.

NMFS. 2011a. 5-Year Review: Summary & Evaluation of Snake River Sockeye, Snake River Spring/Summer Chinook, Snake River Fall-run Chinook, Snake River Basin Steelhead. NMFS, Portland, Oregon. 65p.

NMFS. 2011b. Biennial Report to Congress on the Recovery Program for Threatened and Endangered Species October 1, 2008 - September 30, 2010. 200p.

NMFS. 2012a. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. Snake River Fall Chinook Salmon Hatchery Programs, ESA section 10(a)(l)(A) permits, numbers 16607 and 16615. October 9, 2012. NMFS, Portland, Oregon. NMFS Consultation No.: NWR-2011-03947 and NWR-2011-03948. 175p.

NMFS. 2012b. National Marine Fisheries Service ESA Section 10(a)(1)(A) Permit for Take of Endangered/Threatened Species. Snake River fall Chinook Permit 16615. Operation, Monitoring and Evaluation of the Nez Perce Tribal Hatchery (NPTH) fall Chinook Salmon Program. October 9, 2012. NMFS, Seattle, Washington. 18p.

NMFS. 2012c. Streamlining Restoration Project Consultation using Programmatic Biological Opinions. NMFS Northwest Region Habitat Conservation Division, Portland, Oregon.

NMFS. 2015. ESA Recovery Plan for Snake River Sockeye Salmon (*Oncorhynchus nerka*). June 8, 2015. NMFS, West Coast Region. 431p.
NMFS. 2016. Endangered Species Act Section 7(a)(2) Jeopardy and Destruction or Adverse Modification of Critical Habitat Biological Opinion and Section 7(a)(2) Not Likely to Adversely Affect Determination for the Implementation of the National Flood Insurance Program in the State of Oregon. April 14, 2016. NMFS, Seattle, Washington. Consultation No.: NWR-2011-3197. 410p.
NMFS. 2017a. Biological Assessment for NMFS' Implementation of the Final Mitchell Act EIS Preferred Alternative and Funding for Operation, Maintenance; and Monitoring, Evaluation and Reform of Columbia River Basin Hatchery Programs. NMFS, West Coast Region, January 2017.
NMFS. 2017b. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. NOAA's National Marine Fisheries Service's implementation of the Mitchell Act Final Environmental Impact Statement preferred alternative and administration of Mitchell Act hatchery funding. January 15, 2017. NMFS Consultation No.: WCR-2014-697. 535p.
NMFS. 2017c. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. Two Steelhead Hatchery Programs in the Methow River. October 10, 2017. NMFS Consultation No.: WCR-2017-6986. 117p.
NMFS. 2017d. ESA Recovery Plan for Snake River Fall Chinook Salmon (*Oncorhynchus tshawytscha*). November 2017. NMFS, West Coast Region, Portland, Oregon. 366p.
NMFS, USFWS, and BIA. 2018. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response. Consultation on effects of the 2018-2027 *U.S. v. Oregon* Management Agreement. February 23, 2018. NMFS Consultation No.: WCR-2017-7164. 597p.
NOAA, and WDFW. 2018. Southern Resident Killer Whale Priority Chinook Stocks Report. June 22, 2018. 8p.
Noakes, D. J., R. J. Beamish, and M. L. Kent. 2000. On the decline of Pacific salmon and speculative links to salmon farming in British Columbia. Aquaculture 183:363-386.
NPT. 2007. Application to renew ESA section 10(a)(1)(A) Permit 1134. Submitted by Bureau of Indian Affairs to NMFS on December 21, 2007. Nez Perce Tribe, Department of Fisheries Resources, Lapwai, Idaho.
NPT. 2011. Snake River Stock Fall Chinook Nez Perce Tribal Hatchery (NPTH), Fall Chinook salmon – Snake River Stock *Oncorhynchus tshawytscha* HGMP. May 11, 2011. 155p.
NPT. 2017. Johnson Creek Artificial Propagation Enhancement (JCAPE) Project Snake River Summer Chinook (*Oncorhynchus tshawytscha*). February 10, 2017. Nez Perce Tribe, Lapwai, Idaho. 113p.
NPT. 2018a. Email to Natasha Preston (NMFS) from Bill Young (NPT). SRFC pHOS data. March 13, 2018. 2p.
NPT. 2018b. SRFC pathogens 2012-2017 April 11, 2018 excel report.
NPT, and coauthors. 2018. Final Proposed Action for Snake River Fall Chinook Addendum. April 10, 2018. 9p.

NRC. 1996. Upstream: Salmon and Society in the Pacific Northwest. National Academy Press: Washington, D.C. 452p.

NWFSC. 2015. Status Review Update for Pacific Salmon and Steelhead listed under the Endangered Species Act: Pacific Northwest. December 21, 2015. NWFSC, Seattle, Washington. 356p.

NWIFC, and WDFW. 2006. The Salmonid Disease Control Policy of the Fisheries Co-Managers of Washington State. Revised July 2006. 38p.

Oatman, J. 2017a. NPT Steelhead-Fall Chinook estimates_NPT_7-25-17 excel report.

Oatman, J. 2017b. NPT_SRB SP-SU Chinook Estimates-7-7-17 excel report.

ODFW. 2003. Fish Health Management Policy, September 12, 2003. Oregon Department of Fish and Wildlife. 10p.

Pastor, S. M. 2004. An evaluation of fresh water recoveries of fish released from national fish hatcheries in the Columbia River basin, and observations of straying. AFS Symposium 44:87-98.

Pearsons, T. N., and C. A. Busack. 2012. PCD Risk 1: A tool for assessing and reducing ecological risks of hatchery operations in freshwater. Environmental Biology of Fishes 94:45-65.

Pearsons, T. N., and A. L. Fritts. 1999. Maximum size of Chinook salmon consumed by juvenile coho salmon. North American Journal of Fisheries Management 19(1):165-170.

Pearsons, T. N., and C. W. Hopley. 1999. A practical approach for assessing ecological risks associated with fish stocking programs. Fisheries 24(9):16-23.

Peltz, L., and J. Miller. 1990. Performance of half-length coded wire tags in a pink salmon hatchery marking program. American Fisheries Society Symposium 7:244-252.

Perry, R., and coauthors. 2017. The juvenile abundance component of the snake river basin fall Chinook salmon life cycle model. Snake River Fall Chinook Symposium, May 16-17, 2017, Clarkston, Washington. 10p.

Petrosky, C. E. 2012. 2011 Annual Report to NOAA Fisheries Fishery Management and Evaluation Plans 4(d) Rule Limit 4. April 2012. The Incidental Take of ESA Listed Salmon and Steelhead During Conduct of Recreational Fisheries in Idaho. IDFG, Boise, Idaho. 25p.

Petrosky, C. E. 2013. 2012 Annual Report to NOAA Fisheries Fishery Management and Evaluation Plans 4(d) Rule Limit 4. April 2013. The Incidental Take of ESA Listed Salmon and Steelhead During Conduct of Recreational Fisheries in Idaho. IDFG, Boise, Idaho. 25p.

Petrosky, C. E. 2014. 2013 Annual Report to NOAA Fisheries Fishery Management and Evaluation Plans 4(d) Rule Limit 4. April 2014. The Incidental Take of ESA Listed Salmon and Steelhead During Conduct of Recreational Fisheries in Idaho. IDFG, Boise, Idaho. 25p.

PFMC. 2003a. Pacific Coast Management Plan. Fishery Management Plan for Commercial and Recreational Salmon Fisheries off the coasts of Washington, Oregon and California as revised through Amendment 14. (Adopted March 1999). September 2003. PFMC, Portland, Oregon. 78p.

PFMC. 2003b. Review of 2002 Ocean Salmon Fisheries. Stock Assessment and Fishery Evaluation Document for the Pacific Coast Fishery Management Plan. February 27, 2003. PFMC, Portland, Oregon. 297p.

PFMC. 2014. Pacific Coast Salmon Fishery Management Plan for Commercial and Recreational Salmon Fisheries off the Coasts of Washington, Oregon, and California as amended through Amendment 18. PFMC, Portland, Oregon. 90p.

Piorkowski, R. J. 1995. Ecological effects of spawning salmon on several south central Alaskan streams. Ph.D. dissertation, University of Alaska, Fairbanks, Alaska. 191p.

Prentice, E. F., T. A. Flagg, and S. McCutcheon. 1987. A Study to Determine the Biological Feasibility of a New Fish Tagging System, 1986-1987. December 1987. Contract DE-AI79-84BP11982, Project 83-319. NMFS, Seattle, Washington. 120p.

Prentice, E. F., and D. L. Park. 1984. A Study to Determine the Biological Feasibility of a New Fish Tagging System, 1983-1984. May 1984. Contract DEA179-83BP11982, Project 83-19. BPA, Portland, Oregon. 44p.

Quamme, D. L., and P. A. Slaney. 2003. The relationship between nutrient concentration and stream insect abundance. American Fisheries Society Symposium 34:163-175.

Quinn, T. P. 1993. A review of homing and straying of wild and hatchery-produced salmon. Fisheries Research 18:29-44.

Quinn, T. P. 1997. Homing, Straying, and Colonization. Genetic Effects of Straying of Non-Native Fish Hatchery Fish into Natural Populations. NOAA Tech. Memo., NMFS-NWFSC-30. 13p.

Quinn, T. P., and N. P. Peterson. 1996. The influence of habitat complexity and fish size on over-winter survival and growth of individually marked juvenile coho salmon (*Oncorhynchus kisutch*) in Big Beef Creek, Washington. Canadian Journal of Fisheries and Aquatic Sciences 53:1555-1564.

Rabe, C. 2017. Supplementation Smolt Survival to LGD Rabe excel report.

Reimchen, T. E., and N. F. Temple. 2003. Hydrodynamic and phylogenetic aspects of the adipose fin in fishes. Canadian Journal of Zoology 82:910-916.

Reisenbichler, R. R., and J. D. McIntyre. 1977. Genetic differences in growth and survival of juvenile hatchery and wild steelhead trout, *Salmo gairdneri*. Journal of the Fisheries Research Board of Canada 34:123-128.

Rensel, J., and coauthors. 1984. Evaluation of Potential Interaction Effects in the Planning and Selection of Salmonid Enhancement Projects. J. Rensel, and K. Fresh editors. Report prepared by the Species Interaction Work Group for the Enhancement Planning Team for implementation of the Salmon and Steelhead Conservation and Enhancement Act of 1980. WDFW, Olympia, Washington. 90p.

RIST. 2009. Hatchery Reform Science. A review of some applications of science to hatchery reform issues. April 9, 2009. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. 93p.

Rondorf, D. W., and W. H. Miller. 1994. Identification of the Spawning, Rearing, and Migratory Requirements of Fall Chinook Salmon in the Columbia River Basin. Annual report 1994. Project 9l-029, (Report DOE/BP-21708-4). Bonneville Power Administration, Portland, Oregon.

Rosenberger, S., W. Young, D. Milks, B. Arnsberg, and D. Wickard. 2017. Snake River Hatchery Fall Chinook Salmon Age-at-Release Performance Evaluation White Paper. January 2017. 21p.

Ryman, N. 1991. Conservation genetics considerations in fishery management. Journal of Fish Biology 39 (Supplement A):211-224.

Ryman, N., P. E. Jorde, and L. Laikre. 1995. Supportive breeding and variance effective population size. Conservation Biology 9(6):1619-1628.

Ryman, N., and L. Laikre. 1991. Effects of supportive breeding on the genetically effective population size. Conservation Biology 5(3):325-329.

Saisa, M., M.-L. Koljonen, and J. Tahtinen. 2003. Genetic changes in Atlantic salmon stocks since historical times and the effective population size of a long-term captive breeding programme. Conservation Genetics 4:613–627.

SBT. 2017. Addendum for the Shoshone-Bannock South Fork Chinook Eggbox Program July 10, 2017. 2p.

SBT, and IDFG. 2010. Dollar Creek Eggbox Project Summer Chinook Salmon *Oncorhynchus mykiss* HGMP. June 3, 2010. SBT, Fort Hall, Idaho. 41p.

Scheuerell, M. D. 2005. Influence of juvenile size on the age at maturity of individually marked wild Chinook salmon. Transactions of the American Fisheries Society 134:999-1004.

Scheuerell, M. D., and J. G. Williams. 2005. Forecasting climate-induced changes in the survival of Snake River spring/summer Chinook salmon (*Oncorhynchus tshawytscha*). Fisheries Oceanography 14(6):448-457.

Sharpe, C. S., D. A. Thompson, H. L. Blankenship, and C. B. Schreck. 1998. Effects of routine handling and tagging procedures on physiological stress responses in juvenile Chinook salmon. The Progressive Fish-Culturist 60(2):81-87.

Sharpe, C. S., P. C. Topping, T. N. Pearsons, J. F. Dixon, and H. J. Fuss. 2008. Predation of Naturally-produced Subyearling Chinook by Hatchery Steelhead Juveniles in Western Washington Rivers. June 2008. FPT 07-09. WDFW Fish Program, Science Division. 68p.

Smith, S. 1999. Letter to Bob Austin (BPA) from Stephen Smith (NMFS). Endangered Species Act (ESA) Consultation on Artificial Propagation Programs in the Columbia River Basin. July 27, 1999. NMFS, Portland, Oregon. 4p.

Spangenberg, D. K., and coauthors. 2015. Stock differences in growth, smolting, and early male maturation in hatchery spring Chinook salmon: a common-garden experiment. North American Journal of Fisheries Management 35(6):1090-1100.

Steward, C. R., and T. C. Bjornn. 1990. Supplementation of Salmon and Steelhead Stocks with Hatchery Fish: A Synthesis of Published Literature. Technical Report 90-1. Idaho Cooperative Fish and Wildlife Research Unit, Moscow, Idaho. 132p.

Tatara, C. P., and B. A. Berejikian. 2012. Mechanisms influencing competition between hatchery and wild juvenile anadromous Pacific salmonids in fresh water and their relative competitive abilities. Environmental Biology of Fishes 94(1):7-19.

Theriault, V., G. R. Moyer, L. S. Jackson, M. S. Blouin, and M. A. Banks. 2011. Reduced reproductive success of hatchery coho salmon in the wild: Insights into most likely mechanisms. Molecular Ecology 20:1860-1869.

Tiffan, K., and J. Erhardt. 2017. Smallmouth bass predation on subyearling fall Chinook salmon . Snake River Fall Chinook Symposium, May 16-17, 2017, Clarkston, Washington. 5p.

Tolimieri, N., and P. Levin. 2004. Differences in responses of Chinook salmon to climate shifts: Implications for conservation. Environmental Biology of Fishes 70:155-167.

USFWS. 2004. U.S. Fish & Wildlife Service handbook of aquatic animal health procedures and protocols.

USFWS. 2011. USFWS Columbia Basin Hatchery Review Team- Washington LSRCP Hatcheries Assessments and Recommendations Report.

USFWS. 2017. U.S. Fish and Wildlife Service-Lower Snake River Compensation Plan Office, editor. 2017. Proceedings of the Snake River fall Chinook Symposium May 16th and 17th, 2017, Clarkston, Washington. https://www.fws.gov/lsnakecomplan/Meetings/2017FallChinookSymposium.html (Accessed 11/14/2017). 103p.

Vander Haegen, G. E., H. L. Blankenship, A. Hoffman, and O. A. Thompson. 2005. The effects of adipose fin clipping and coded wire tagging on the survival and growth of spring Chinook salmon. North American Journal of Fisheries Management 25:1160-1170.

Vasemagi, A., R. Gross, T. Paaver, M. L. Koljonen, and J. Nilsson. 2005. Extensive immigration from compensatory hatchery releases into wild Atlantic salmon population in the Baltic sea: Spatio-temporal analysis over 18 years. Heredity 95(1):76-83.

Vincent-Lang, D. 1993. Relative Survival of Unmarked and Fin-Clipped Coho Salmon from Bear Lake, Alaska. The Progressive Fish-Culturist 55(3):141-148.

Vogel, J. 2012. Phone discussion and email exchange with Brett Farman (NMFS) clarifying take associated with proposed monitoring of fall Chinook salmon related to HGMPs. August 24, 2012. Nez Perce Tribe, Lapwai, Idaho.

Wainwright, T. C., and L. A. Weitkamp. 2013. Effects of climate change on Oregon Coast coho salmon: habitat and life-cycle interactions. Northwest Science 87(3):219-242.

Walton, R. G. 2008. Letter to Interested Parties, from Rob Walton. NMFS' Intent to Conduct Consultations Under the ESA. September 12, 2008. NMFS, Portland, Oregon. 2p. with attachments.

Walton, R. G. 2010. Letter to Co-managers, Hatchery Operators, and Hatchery Funding Agencies. Development of Hatchery and Harvest Plans for Submittal under the ESA. April 28. 2010. 6p.

Waples, R. S. 1999. Dispelling some myths about hatcheries. Fisheries 24(2):12-21.

Waples, R. S., and C. Do. 1994. Genetic risk associated with supplementation of Pacific salmonids: Captive broodstock programs. Canadian Journal of Fisheries and Aquatic Sciences 51 (Supplement 1):310-329.

Waples, R. S., and coauthors. 2017. Human-mediated evolution in a threatened species? Juvenile life-history changes in Snake River salmon. Evolutionary Applications:1-15.

Ward, B. R., and P. A. Slaney. 1988. Life history and smolt-to-adult survival of Keogh River steelhead trout (*Salmo gairdneri*) and the relationship to smolt size. Canadian Journal of Fisheries and Aquatic Sciences 45:1110-1122.

Washington Department of Fish and Wildlife, Nez Perce Tribe, Idaho Department of Fish and Game, and Oregon Department of Fish and Wildlife. 2011. Snake River Stock Fall Chinook Lyons Ferry Hatchery, Fall Chinook Acclimation Program, and Idaho Power Company HGMP. May 9, 2011. 330p.

WDFW. 2015. 2014-2015 Annual Performance Report to Lower Snake River Fish and Wildlife Compensation Plan. December 2015. 17p.

WDFW. 2016. 2015-2016 Annual Performance Report to Lower Snake River Fish and Wildlife Compensation Plan. December 2016. 16p.

WDFW. 2018. SRFC pathogens 2012-2017 excel report. April 19, 2018.

WDFW, and NPT. 2011. Addendum to Snake River Fall Chinook HGMPs for Lyons Ferry Hatchery, Fall Chinook Acclimation Project, Idaho Power Company, and Nez Perce Tribal Hatchery.

WDFW, NPT, IDFG, and ODFW. 2011. Snake River Fall Chinook Lyons Ferry Hatchery, Fall Chinook Acclimation Program, and Idaho Power Company HGMP.

Westley, P. A. H., T. P. Quinn, and A. H. Dittman. 2013. Rates of straying by hatchery-produced Pacific salmon (*Oncorhynchus* spp.) and steelhead (*Oncorhynchus mykiss*) differ among species, life history types, and populations. Canadian Journal of Fisheries and Aquatic Sciences 70:735-746.

Whitlock, M. C. 2000. Fixation of new alleles and the extinction of small populations: Drift, load, beneficial alleles, and sexual selection. Evolution 54(6):1855-1861.

Willi, Y., J. V. Buskirk, and A. A. Hoffmann. 2006. Limits to the adaptive potential of small populations. Annual Review of Ecology, Evolution, and Systematics 37:433-458.

Williams, J. G., R. W. Zabel, R. S. Waples, J. A. Hutchings, and W. P. Connor. 2008. Potential for anthropogenic disturbance to influence evolutionary change in the life history of a threatened salmonid. Evolutionary Applications 1:271-285.

Williamson, K. S., A. R. Murdoch, T. N. Pearsons, E. J. Ward, and M. J. Ford. 2010. Factors influencing the relative fitness of hatchery and wild spring Chinook (*Oncorhynchus tshawytscha*) in the Wenatchee River, Washington. Canadian Journal of Fisheries and Aquatic Sciences 67:1840-1851.

Wipfli, M. S., J. P. Hudson, J. P. Caouette, and D. T. Chaloner. 2003. Marine subsidies in freshwater ecosystems: salmon carcasses increase growth rates of stream-resident salmonids. Transactions of the American Fisheries Society 132:371-381.

Withler, R. E. 1988. Genetic consequences of fertilizing chinook salmon (*Oncorhynchus tshawytscha*) eggs with pooled milt. Aquaculture 68:15-25.

YKFP. 2008. Klickitat River Anadromous Fisheries Master Plan. Yakima/Klickitat Fisheries Project 1988-115-35. 188p.

Young, B. 2018. SRFC stray analysis table data from run recon. May 3, 2018. 1p.

Zabel, R. W., M. D. Scheuerell, M. M. McClure, and J. G. Williams. 2006. The interplay between climate variability and density dependence in the population viability of Chinook salmon. Conservation Biology 20(1):190-200.