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 and 16615.

NMFS Consultation Numbers: *2011/03947* and *2011/03948*

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
Nez Perce Tribe
Oregon Department of Fish and Wildlife
Idaho Department of Fish and Game

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	Yes	Yes

Consultation Conducted By: National Marine Fisheries Service, Northwest Region

Issued By: Robert Turner for
William W. Stelle, Jr.
Regional Administrator

Date: 10/09/2012

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1. INTRODUCTION

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

1.1. Background

This biological opinion constitutes NMFS' review of two 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 programs, as described in the application documents, which consist of two hatchery and genetic management plans (HGMPs) and an addendum. The biological opinion (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. 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.

The NMFS also completed an Essential Fish Habitat (EFH) consultation. It was prepared 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.

The opinion and EFH conservation recommendations are both in compliance with section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-5444) ("Data Quality Act") and underwent pre-dissemination review. The administrative records for both consultations are on file at the Salmon Management Division (SMD) in Portland, Oregon.

Table 1. Snake River fall Chinook salmon HGMPs, hatchery programs and program operators

Hatchery and Genetics Management Plan	Program Operator(s)
Snake River Stock Fall Chinook salmon LFH, Fall Chinook salmon Acclimation Program, and Idaho Power Company	Washington Department of Fish and Wildlife, Nez Perce Tribe, Idaho Department of Fish and Game, Oregon Department of Fish and Wildlife
Snake River Stock Fall Chinook salmon Nez Perce Tribal Hatchery	Nez Perce Tribe

1.2. Consultation History

The current proposed action is the latest in a long series of hatchery consultations intended to improve the operation of hatchery programs with respect to conservation needs of ESA-listed salmonids. Hatchery consultations in the Columbia Basin began soon after the first listings of Columbia Basin anadromous salmonids under the ESA in 1991-1992. The first hatchery consultation and Biological Opinion (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 et al. 1995). This opinion determined that hatchery actions jeopardize listed Snake River salmon and required implementation of reasonable and prudent alternatives to avoid jeopardy.

A new opinion was completed on March 29, 1999, after Upper Columbia River steelhead were listed (NMFS 1997) and following the expiration of the previous opinion on December 31, 1998 (NMFS 1999). This opinion concluded that federal and non-federal hatchery programs jeopardize Lower Columbia River steelhead and Snake River steelhead protected under the ESA and described measures and conditions necessary to avoid jeopardy. Soon after, NMFS reinitiated consultation when Lower Columbia Chinook salmon, Upper Columbia 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 for hatchery programs in the (1) Upper Willamette, (2) Middle Columbia, (3) Lower Columbia, (4) Snake River, and (5) Upper Columbia, with the Upper Columbia to be NMFS' first priority (Smith 1999). Between August 2002 and October 2003, consultations under the ESA were completed for about twenty hatchery programs in the Upper Columbia. For the Middle Columbia, NMFS completed a draft opinion and distributed it to hatchery operators and funding agencies for review on January 4, 2001, but completion of consultation was put on hold pending several important basinwide review and planning processes.

The jump in ESA listings during the mid to late 1990s triggered a period of investigation, planning, and reporting across multiple jurisdictions; this served to complicate, at least from a resources and scheduling standpoint, hatchery consultations. A review of federally funded hatchery programs ordered by Congress was underway at about the same time that the 2000 Federal Columbia River Power System (FCRPS) opinion was issued (NMFS 2000a). Reasonable and Prudent Alternative (RPA) 169 of the FCRPS opinion called for the completion of NMFS-approved hatchery operating plans (i.e., Hatchery and Genetic Management Plans (HGMPs)) by the end of 2003. The RPA required the Action Agencies to facilitate this process, first by assisting in the development of HGMPs, and then by helping to implement identified hatchery reforms. Also at this time, a new *U.S. v. Oregon* Columbia River Fisheries Management Plan (CRFMP), which included goals for hatchery management, was under negotiation and new information on the status and recovery goals for salmon and steelhead was emerging from Technical Recovery Teams. ESA consultations and an opinion were completed in 2007 for nine hatchery programs that produce a substantial proportion of the total salmon and steelhead hatchery releases into the Columbia River annually (NMFS 2007c). These programs are located in the Lower and Middle Columbia and are operated by the United States Fish and Wildlife Service (USFWS) and by the Washington Department of Fish and Wildlife (WDFW). In the opinion NMFS determined that operation of the programs would not jeopardize salmon and steelhead protected under the ESA because broodstock collection activities would not handle listed fish except for a very small number that would be immediately released; handling of steelhead at the Warm Springs NFH would allow for the removal of non-endemic steelhead; disease protocols minimize disease occurrences such that levels tend to be below levels found in naturally produced populations; ecological interactions between listed species and hatchery produced individuals would be limited through release strategies; and because sound facility design and operational policies greatly limit effects on critical habitat.

In 2008, NMFS published a biological opinion for the FCRPS, including Reasonable and Prudent Alternatives (RPAs) for the FCRPS to avoid jeopardizing ESA-listed salmon and steelhead in the Columbia Basin and a Supplemental Comprehensive Analysis (NMFS 2008d; NMFS 2008e). Hatchery Action RPA number 39 requires the completion of "consultation under the ESA on the operation of hatchery programs funded by the FCRPS Action Agencies including the submittal of updated and complete HGMPs (Hatchery and Genetic Management Plans)". The schedule in RPA 39 for completing ESA consultations for hatchery programs was July 2009 for hatchery programs in the Upper Columbia, January 2010 for programs in the Middle Columbia, and August 2010 for programs in the Snake River Basin.

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 Upper Columbia affecting ESA-listed salmon and steelhead concurrently" (Walton 2008). In November 2008, NMFS expressed again the need for re-evaluation of the Upper Columbia River hatchery programs and provided a "framework for ensuring that these hatchery programs are in compliance with the Federal Endangered Species Act" (Jones 2008). NMFS also "promised to share key considerations in analyzing HGMPs" and provided those materials to interested parties in February 2009 (Jones 2009). On March 5, 2009, NMFS notified Federal Action Agencies and state, tribal, and federal hatchery operators of its intent to "conduct a series of consultations to ensure that hatchery programs in the Middle Columbia River are in compliance with the ESA, with the National Environmental Policy Act (NEPA), and with RPA 39 of the FCRPS opinion.

On April 28, 2010, NMFS wrote a guidance letter (Walton 2010) to comanagers, hatchery operators, and hatchery funding agencies that described how NMFS "has been working with comanagers throughout the Northwest on the development and submittal of fishery and hatchery plans in compliance with the Federal Endangered Species Act (ESA)." NMFS stated "[i]n 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 began preconsultation discussions on the Snake River fall Chinook salmon hatchery programs with the Washington Department of Fish and Wildlife (WDFW) and the Nez Perce Tribe (NPT) at a meeting in Lapwai, Idaho, on February 25, 2011. NMFS received a draft HGMP for the Snake River Fall Chinook salmon Lyons Ferry, Fall Chinook salmon Acclimation Program, and Idaho Power Company programs on March 4, 2011; and a draft HGMP for the Snake River Fall Chinook salmon Nez Perce Tribal hatchery program on March 10, 2011 (Table 1). NMFS responded by providing comments back to the principal operators, WDFW and NPT, in emails dated March 11 and March 18, 2011, respectively(Busack 2011b; Busack 2011a). Revised HGMPs and an Addendum were submitted to NMFS for review on May 11, 2011 (NPT 2011; WDFW et al. 2011), and a revised Addendum (WDFW and NPT 2011) was submitted July 18, 2011. NMFS accepted the HGMPs and Addendum on July 18, 2011. The applications were made available for a 30-day public comment period on July 22, 2011 (76FR43986), and formal consultation began August 23, 2011. Both HGMPs contained current annual operating plans as appendices. In addition, NMFS received the 2011-2012 Lyons Ferry Hatchery Annual Operation Plan (WDFW 2011), an expanded description of NPT plans for trapping broodstock on the South Fork of the Clearwater River (Hesse and Johnson 2012), and expanded description of NPT juvenile monitoring activities (Vogel 2012). Information from these documents has been incorporated into this opinion.

1.3. Proposed Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies. 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.

The proposed action is the issuance of two research/enhancement permits under Section 10(a)(1)(A) of the Endangered Species Act (permits 16607 and 16615). The proposed permits (attached) authorize the operation of hatchery programs for Snake River fall Chinook salmon conducted at Lyons Ferry Hatchery, Irrigon Hatchery, Oxbow Hatchery, and Nez Perce Tribal Hatchery. All activities necessary for broodstock collection, rearing, acclimation, and RM&E of Snake River fall Chinook salmon at sites and facilities affiliated with these four hatcheries are also authorized by the permits. The effects of the issuance of the two permits are fully described in the summary of the underlying activities presented below.

This is a site-specific hatchery program consultation undertaken pursuant to RPA 39 of the FCRPS biological opinion (NMFS 2008d). RPA 39 required the FCRPS Action Agencies to continue funding hatchery programs and in doing so to adopt programmatic criteria for these funding actions which incorporate best management practices. This programmatic action was evaluated as a factor in the final opinion. To implement the programmatic action, the Action Agencies and the funding recipients are expected to engage in site-specific consultations on each hatchery program to implement the programmatic criteria and evaluate the effects of the individual programs on listed species. This action accomplishes four of those site-specific consultations.

NMFS describes a hatchery program as a unit of fish propagated for a distinct purpose. The purpose of the proposed Snake River fall Chinook salmon hatchery programs is to increase the viability of the natural populations and to provide returning adult fish for harvest. The four hatchery programs described in this document use ESA-listed Snake River fall Chinook salmon as broodstock. 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 under development for the Snake River Fall Chinook salmon Evolutionarily Significant Unit (ESU) and with the 2008-2017 *U.S. v. Oregon* Management Agreement as modified in January 2009 (*U.S. v. Oregon* 2009).

The review of the Snake River fall Chinook salmon hatchery programs under consideration here is a tiered decision consistent with the programmatic consultation on hatchery programs funded by the Action Agencies in the FCRPS biological opinion (NMFS 2008d). The programmatic nature of the FCRPS consultation was a factor that resulted in a finding of no jeopardy for the FCRPS RPA. The site-specific actions described herein are consistent with the programmatic best management practices and guidance criteria required under RPA 39 in the FCRPS biological opinion. This consistency with the programmatic consultation, as well as NMFS' site-specific assessment of the four Snake River fall Chinook salmon hatchery programs, informs the conclusions presented in this document.

Three of the programs included in the proposed action are funded by the Bonneville Power Administration (BPA) through the Lower Snake River Compensation Plan (LSRCP), which is managed by the USFWS, or through the Northwest Power and Conservation Council's Fish and Wildlife Program. The fourth program is funded by the Idaho Power Company as part of a mitigation agreement for the Hells Canyon Complex dams. The programs are operated by the WDFW, NPT, IDFG, and ODFW. The direct and indirect effects of this action and related activities are considered in this consultation.

NMFS has identified several actions that are interrelated and/or interdependent with the proposed action, at least in part. These include monitoring and evaluation of the effects of fall Chinook salmon hatchery operations in the Snake River, and limited aspects of the operation of Irrigon and Oxbow Hatcheries. These actions briefly involve facilities which operate year-round in support of numerous hatchery programs in accordance with their larger mission. The overall operations of these facilities are separate federal authorizations not included in the proposed action, and not otherwise interrelated to or interdependent with the proposed action, apart from the brief involvement considered below.

The four programs listed in Table 1 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 contain a considerable amount of detail on fish cultural methods beyond that presented in this section. 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 Snake River Fall Chinook salmon Lyons Ferry/Fall Chinook salmon Acclimation Program/Idaho Power Company HGMP (WDFW et al. 2011), or the Snake River Fall Chinook salmon Nez Perce Tribal Hatchery HGMP (NPT 2011). All aspects of the programs except for certain new and expanded RM&E 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.

1.3.1. Overview of Snake River Fall Chinook salmon hatchery programs

The first intensive effort to culture Snake River fall Chinook salmon was begun in the early 1960s at Oxbow Hatchery by the Idaho Power Company as mitigation for losses caused by the Hells Canyon Dam complex. This effort was plagued by high adult mortality and poor returns, and ceased in 1970 (Abbott and Stute 2003). The subsequent large-scale effort that exists today began in 1976 with the implementation of the Lower Snake River Compensation Plan (LSRCP), which called for a large fall Chinook salmon program at a new hatchery to be constructed (Lyons Ferry Hatchery), partially funded by the IPC. At the time, the Snake River fall Chinook salmon run was so small that an egg-bank program was considered necessary to prevent extinction before the new hatchery could be completed. To implement the egg-bank program, adult fish were collected at Ice Harbor Dam and juveniles were released in the Lower Columbia and the Snake rivers. As egg-bank fish returned to the Lower Columbia, they were also used as broodstock along with the fish from Ice Harbor Dam. This program ceased in the fall of 1984, when Lyons Ferry Hatchery (LFH) (operated by WDFW) became operational. Bugert et al. (1995) provide a good summary of the egg-bank program.

The initial focus of Snake River fall Chinook salmon hatchery operations was to provide fish for harvest as mitigation for the losses caused by the construction and operation of the four Lower Snake River Dams. Fish were released only at LFH, which is located in the Lower Monumental reservoir well below most of the remaining area available for natural spawning. Over time the Snake River fall Chinook salmon hatchery effort has grown in size and become more focused on supplementation, with an increasing proportion of fish released above LGR. A major change in this direction was the 1995 implementation of the Fall Chinook Acclimation Program (FCAP). This program involves acclimated releases at sites on the Snake and the Clearwater rivers at facilities operated by the Nez Perce Tribe. In 2002, the Nez Perce Tribal Hatchery (NPTH) began culture of fall Chinook salmon with the intent of supplementing the Clearwater River, and a direct (non-acclimated) stream release by WDFW near Couse Creek on the Snake River occurred. Direct releases of fall Chinook salmon into the Grande Ronde River began in 2005 as an effort to boost returns to that area. Coincident with these efforts, added mitigation releases have also occurred. By 2000, enough eggs were available at Lyons Ferry to begin to support the IPC program, which releases fish near Hells Canyon Dam. The expansion of releases has resulted in satellite hatcheries operated by the Oregon Department of Fish and Wildlife (ODFW) being used for rearing the required number of juvenile fish. The collective fall Chinook salmon hatchery effort is characterized by the operators as integrated recovery/mitigation. Of the 5.5 million fish released at full program capacity, 88% are released above LGR (where the majority of natural production habitat remains), and of these, 75% are acclimated before release.

Although all four programs were developed as mitigation for hydropower development, operationally they vary in intent. The NPTH and FCAP programs are directed completely at supplementation. The off-site releases from LFH (Couse Cr. and Grande Ronde R.) and the IPC releases can be considered partial supplementation. The other LFH releases are not supplementation efforts.

Interim and long-term collective goals for the Snake River fall Chinook salmon hatchery programs set by the operators both for hatchery-origin and natural-origin returns are as follows (WDFW et al. 2011):

Hatchery-Origin Return Goals

- The interim total return target based on current production levels and survival is 15,484 hatchery-origin fish above Lower Monumental Dam: 9,988 from LSRCP[1], 3,206 from NPTH, and 2,290 from IPC.

- The long-term total return goal is 24,750 hatchery-origin fish above Lower Monumental Dam: 18,300 from LSRCP, 3,750 from NPTH, and 2,700 for IPC.

Natural-Origin Return Goals

- Achieve ESA delisting by attaining interim population abundance in the Snake River ESU of at least 3,000 natural-origin spawners, with no fewer than 2,500 distributed in the mainstem Snake River (as recommended by the ICTRT).

- Interim goal is 7,500 natural-origin fall Chinook salmon (adults and jacks) above Lower Monumental Dam.

- Long-term goal is 14,360 natural-origin fall Chinook salmon (adults and jacks) above Lower Monumental Dam.

Production goals, release sizes, release locations, life stage and marking of released fish for all four Snake River fall Chinook salmon hatchery programs are all established through the *U.S. v. Oregon* process and are documented in Tables B4B of the *U.S. v. Oregon* Management Agreement (*U.S. v. Oregon* 2009). Broodstock are collected jointly for LFH (which also supplies eggs for the FCAP and IPC programs) and NPTH at Lower Granite Dam (LGR), with approximately 70% going to LFH and approximately 30% going to NPTH. During the period of broodstock collection, listed Snake River steelhead pass the dam in large numbers and may be intercepted by trapping operations for fall Chinook salmon. Small numbers of listed Snake River spring\summer Chinook salmon and Snake River sockeye salmon may also pass the dam during fall Chinook salmon broodstock collection (FPC adult data, accessed 3/12/2012) (Section 2.4.3.1). The operators intend for virtually all fall Chinook salmon broodstock fish to be collected at LGR, but additional broodstock fish required to meet the release needs of the *U.S. v. Oregon* Management Agreement are collected at the two hatcheries themselves, and collection at a weir on the South Fork Clearwater River is planned. Fish are released as yearlings or as

[1] FCAP and the Lyons Ferry program are often referred collectively to as the LSRCP program.

subyearlings. The current production goal for LFH and the programs it supplies is 900,000 yearlings and 3,200,000[2] subyearlings, consisting of 15 release groups. The release groups are prioritized as described in the *U.S. v. Oregon* Management Agreement (*U.S. v. Oregon* 2009; Table B4B); eggs are not allocated to a group until the needs of all higher priority groups have been met. Releases from the programs based at LFH occur at seven different locations on the Snake and Grande Ronde rivers. The current fall Chinook salmon production goal for NPTH is 1,400,000 subyearlings, released at four sites on the Clearwater River. Figure 1 shows the location of all Snake River fall Chinook salmon hatchery facilities.

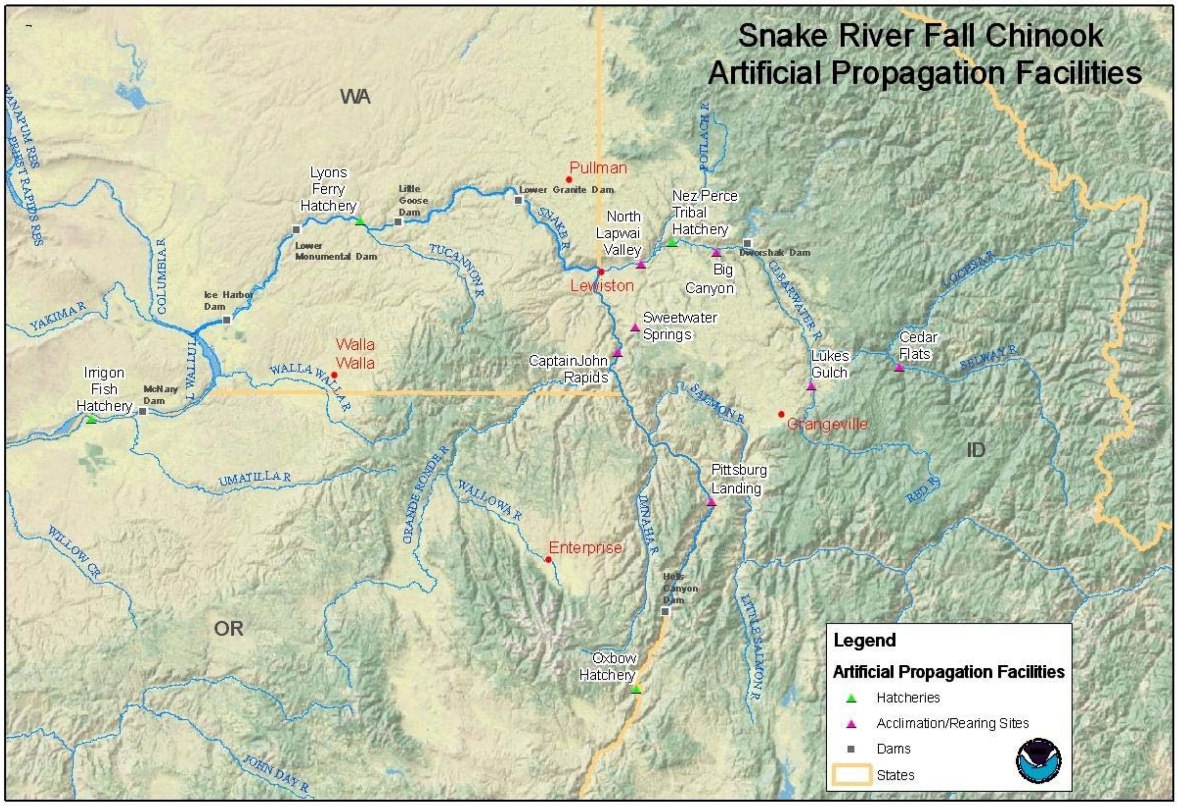

Figure 1. Map of Snake River fall Chinook salmon hatcheries and acclimation facilities

1.3.1.1. Programs Supported by Lyons Ferry Hatchery: Lyons Ferry, Fall Chinook Acclimation, and Idaho Power Company Programs

The LFH, Fall Chinook Acclimation Program (FCAP), and IPC programs described in (WDFW et al. 2011) have separate funding and program authorizations but are implemented by managers in a highly coordinated and integrated fashion. Each program has specific goals, but all three depend on broodstock collected for and eggs incubated at LFH. In the HGMP (WDFW et al. 2011) the LFH program and FCAP are frequently collectively referred to as the Lower Snake River Compensation Plan (LSRCP) Fall Chinook salmon program. We follow that convention as appropriate in the discussion below. The IPC program is referred to in some earlier documents as the Oxbow Hatchery program.

[2]An additional 328,000 subyearlings will be released in 2012, the final release for a transportation study.

Annually, up to 4,800 adult[3] fall Chinook salmon are collected as broodstock for the three programs. Additionally, about 2,000 more hatchery-origin fish are collected for run-reconstruction through expansion of CWT recoveries. As mentioned previously, although the intent is to collect all broodstock at the LGR trap, broodstock can be collected at LFH as well. In the past up to 50% of broodstock has been collected at LFH in some years.

Trapping protocols at LGR vary somewhat from year to year because of expected run size and sex composition of the return, but the general intent is to systematically sample and collect broodstock from across the full extent of the run at LGR. The current trapping permit allows up to 20% of the run to be trapped, but typically 10-15% is trapped. Trapping begins as early as August 18, but often not until early September because of concerns for fish health due to high water temperatures. Trapping usually ends the third week in November as very few fish pass LGR after November 20. However, trapping has taken place into early December when the returns and hatchery broodstock collections were very low (WDFW 2012). Trapping may end sooner than November 20 if broodstock needs have been met. The trap is checked at least daily.

Fish collected for broodstock fish are 100% electronically sampled before spawning. Those that can be identified as originating out-of-basin are typically not used for spawning in an effort to conserve 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. Up to 30% of the broodstock can consist of natural-origin Snake River fish, provided this does not exceed 20% of the natural-origin returns in the population. The estimated proportion of natural-origin adults in the broodstock based on scale analysis has ranged from 0.1 to 12.2 from 2004 to 2008, with a mean of 7.2%. In recent years the use of scale pattern analysis to determine origin has been discontinued because of uncertainty about the accuracy of the determinations. Parentage-based profiling will be used to distinguish unmarked in-basin hatchery-origin fish from natural-origin and unmarked strays in the future (Section 1.3.2.2). Beginning with returns in 2016, all in-basin hatchery returns will be identifiable. Any unmarked fish not assigned to in-basin hatchery returns will be assigned as natural-origin after the stray out-of-basin component is estimated based on associated CWTs. Spawning begins in mid-October and continues into early December annually. Single-pair matings are done with some reuse of males. Fish are chosen non-randomly for mating, with a deliberate effort to use older fish as broodstock (Section 2.4.4.3.1).

Natural-origin Snake River fall Chinook salmon emigrate predominantly as subyearlings, but also emigrate as yearlings, possibly as a response to anthropogenically induced changes in water temperature (Connor et al. 2002; Connor et al. 2005). Both yearling and subyearlings are released by the programs supported by LFH, a practice that has generated considerable discussion (Section 2.4.4.3.2). Overall, the production targets for the three programs are 900,000

[3] For purposes of this opinion and the resulting section 10 permits we define adults as fall Chinook salmon that are at least 3 years old and that have spent at least 2 years in the ocean. Fish that spend only one year in the ocean, Called "jacks" or "1-salts" represent a natural life history and are thought to contribute to natural production at a low but relatively constant level. These fish are almost exclusively males (1-salt females are called jills). Jack returns are highly variable and cannot be accurately forecasted. In-season management and take monitoring will classify fish less than 57 cm (FL) as jacks. Post-season reporting will be based on estimated ocean age.

yearlings and 3.2 million subyearling fall Chinook salmon. Fish produced by these three programs are released at seven locations along the Snake River and its tributaries. Table 2 presents a summary of production release targets, including agreed upon tags and marks, to meet the adult return goals for all three programs listed above.

Table 2. Snake River fall Chinook salmon release targets for the Lyons Ferry, FCAP, and IPC programs (adapted from Table 4 of WDFW et al. 2011). Priority is ranking in Table 4B4 of *U.S. v. Oregon* (2009). Not shown are two passage-study releases (250K and 78K, priorities 12 and 14) that will not occur beyond 2012. CWT=coded-wire tag, Ad=adipose fin clip.

Program	Rearing Facility	Release Number	Release Location	Life stage	Mark§	Priority
Lyons Ferry	Lyons Ferry	450,000	On-station	yearling	225K CWT, Ad 225K CWT,	1
Lyons Ferry	Lyons Ferry	200,000	On-station	subyearling	200K CWT, Ad	5
Lyons Ferry	Lyons Ferry	200,000	Direct stream evaluation near Captain John Rapids	subyearling	200k CWT, Ad	11
Lyons Ferry	Irrigon FH	400,000	Grande Ronde River	subyearling	200K CWT, Ad 200K unmarked	13, 16
FCAP	Lyons Ferry	150,000	Pittsburg Landing	yearling	70K CWT, Ad 80K CWT	2
FCAP	Lyons Ferry	150,000	Big Canyon	yearling	70K CWT, Ad 80K CWT	3
FCAP	Lyons Ferry	150,000	Captain John Rapids	yearling	70K CWT, Ad 80K CWT	4
FCAP	Lyons Ferry	500,000	Captain John Rapids	subyearling	100K CWT, Ad 100K CWT 300K Unmarked	6
FCAP	Lyons Ferry	500,000	Big Canyon	subyearling	100K CWT, Ad 100K CWT 300K Unmarked	7
FCAP	Lyons Ferry	400,000	Pittsburg Landing	subyearling	100K CWT, Ad 100K CWT 200K Unmarked	8,10
IPC	Oxbow†	200,000	Hells Canyon Dam	subyearling	200K CWT, Ad	9
IPC	Irrigon	800,000	Hells Canyon Dam	subyearling	200K CWT 600K Ad only	15,17
Total	Yearlings	900,000				
	Subyearlings	3,200,000				
†These fish will be reared at Irrigon until the intake at Oxbow is screened						

All the yearlings and 2.2 M (69%) subyearlings released by the three programs are marked to identify them as hatchery-origin fish: with coded-wire tags (CWTs), adipose-fin clips (Ad), or both. Thus, 76% of the smolts are marked in some fashion. However, only adipose-clipped fish (52% of the production) are visually identifiable as hatchery-origin fish with an external mark. Approximately 24% of the total production has no internal or external mark. Parentage-based tagging has been implemented as part of the new RM&E measures (Section 1.3.2.2) as a means of being able to identify hatchery-origin fish, regardless of physical tagging status.

1.3.1.1.1. Lyons Ferry Hatchery Program

The LFH program was authorized by the Water Resources Development Act of 1976 to offset losses caused by the construction and operation of the four Lower Snake River dams and navigation lock projects. The program is funded by LSRCP (a USFWS program funded by BPA). The hatchery is located on the Snake River at RM 59 between Lower Monumental Dam and Little Goose Dam directly below the Palouse River confluence in Franklin County, Washington (Figure 1). The hatchery is operated by the WDFW. The Lyons Ferry program was originally designed to provide 73,200 hatchery adult fall Chinook salmon for harvest, and 18,300 adult hatchery fall Chinook salmon to the area above Ice Harbor Dam. In addition, another 14,360 naturally produced fall Chinook salmon were expected to return annually to the Snake River Basin (as part of the LSRCP mitigation plan).

The LSRCP Fall Chinook salmon program was originally designed to provide a total of 91,500 adult hatchery fall Chinook salmon as shown in Table 3, plus an annual return to the Snake River of 14,360 naturally produced fall Chinook salmon.

Table 3. Snake River fall Chinook salmon goals (WDFW et al. 2011).

Component	Number of Adults
Escapement to Project Area (above Ice Harbor Dam)	18,300
Tribal/Commercial Harvest	54,900
Recreational Harvest	18,300
Total	**91,500**

While that overall goal remains, the subsequent ESA listings and negotiations with fisheries managers have developed the following production and management objectives through 2017 (WDFW et al. 2011):

1. To contribute to the coast-wide ocean fisheries in accordance with Pacific Salmon Treaty.
2. To contribute to the recreational, commercial and/or tribal fisheries in the mainstem Columbia River consistent with agreed abundance-based harvest rate schedules established in the 2008 – 2017 *US v. Oregon* Management Agreement.
3. To spawn enough fish to retain 4.75 million eggs (WDFW 2009) to assure that production goals as stated in *US v. Oregon* are met. Fecundities vary depending upon return age classes and run composition, but generally 1,400-2,000 females would need to be spawned to make production goals. In order to produce enough fish to meet harvest goals, many more fish would need to be trapped, spawned, and reared. Major construction additions would need to occur at LFH and changes to the production tables would need to occur in order to meet harvest mitigation goals.

4. To estimate the number of LSRCP, FCAP, and IPC program fish returning to the basin, the run composition must be estimated. For this task, an additional 2,000 hatchery-origin fish must be recovered so coded wire tag information can be decoded.

5. To provide tribal and non-tribal fisheries in the Snake River consistent with co-manager goals.

6. To contribute to hatchery and natural-origin return goals identified in the Snake River Fall Chinook salmon Management Plan (Zimmerman and unspecified coauthors 2006).

The Lyons Ferry program annual production target is 800,000 subyearling and 450,000 yearling fall Chinook salmon. Yearlings are released in mid-April at a target size of 10 fish per pound (fpp) (45 g); subyearlings are released in late May to late June at a target size of 50 fpp (9 g). Release sizes and dates vary from year to year (WDFW et al. 2011; Tables 45 and 46). All yearling production is reared until release at LFH. The subyearling production is split because of limited rearing space. Half of the eggs designated for subyearling production (400,000) remains at LFH, while the other half is transferred as eyed eggs to Irrigon Hatchery (operated by ODFW) for incubation and rearing. Irrigon Hatchery is located off the mainstem Columbia River near Irrigon, Oregon. In the past, Umatilla Hatchery and Dworshak National Fish Hatchery have also been used to rear fish for the transportation study. It is possible that these (or other local) facilities may be used to support fall Chinook salmon artificial production in the future, but is not planned.

Both the Lyons Ferry and Irrigon hatcheries use wells to supply water for incubation and rearing. Water passes through an aeration system before passing through rearing tanks or ponds. After passing through rearing areas at hatchery facilities, water is discharged directly to the river. During cleaning events, waste water passes through a pollution abatement pond to settle out solids before being returned to the surface water next to the facility.

LFH includes 37 raceways as well as a 2.1 acre pond for rearing juvenile fall Chinook salmon on-station. Raceway use is guided primarily by rearing density targets. Raceways are used to rear fall Chinook salmon to fingerling size, and then the yearling production group is transferred to the pond for rearing. The hatchery also includes eight adult holding ponds, an enclosed spawning building, and an enclosed incubation facility outfitted with egg tray stacks. Water is supplied to LFH by eight pumps capable of supplying 118.5 cubic feet per second (53,200 gallons per minute) flow at a constant 52°F.

Irrigon Hatchery has an enclosed egg incubation area with egg tray stacks and 68 fiberglass indoor rearing tanks. The facility also has 32 outside raceways, some of which would be used for fall Chinook salmon rearing. Water is supplied to the Irrigon Hatchery by two wells capable of delivering 21,000 gallons per minute (gpm) year-around, and possibly up to 25,000 gpm based on water rights and design capacity. Water flows through an upper series of raceways and is reused in the lower series before discharge.

Routine disease monitoring and prophylaxis occurs at both Lyons Ferry and Irrigon Hatcheries. All adults captured for broodstock are injected with erythromycin to prevent bacterial kidney disease, and are also treated with a formalin flush every other day during holding to reduce the incidence of fungus. During spawning, females are sampled and tested for bacterial kidney disease to provide enough eggs for shipment outside Washington State (FCAP and IPC programs) as required by Northwest fish health protocols, and for the other yearling releases (Section 2.4). Additionally, 60 females are sampled for viral pathogens. LFH has experienced outbreaks of bacterial gill disease in the past, and is expected to continue to have some mortality attributable to the disease. Bacterial kidney disease has been detected in juvenile fall Chinook salmon in the past, but is not now considered a problem.

1.3.1.1.2. Fall Chinook salmon Acclimation Program

Construction of the final rearing and/or acclimation facilities for the Clearwater and Snake rivers, by the U.S. Army Corps of Engineers was authorized by Congress (Public Law 103-316) in 1994 for the LSRCP. Operations at three acclimation facilities - one on the Clearwater River and two on the Snake River - were developed under the Fall Chinook Acclimation Program (FCAP), funded through BPA. The target production levels (1.4 million subyearlings and 450,000 yearlings) are defined in the 2008-2017 *U.S. v. Oregon* Agreement (*U.S. v. Oregon* 2009) and summarized in Table 2. The immediate goal of the FCAP program is to ensure that the Snake River fall Chinook salmon above LGR are not extirpated. Long-term goals of the program are to increase the natural population of Snake River fall Chinook salmon spawning above LGR, sustain long-term preservation and genetic integrity of this population, keep the ecological and genetic impacts of non-target fish within acceptable limits, assist with the recovery and delisting of Snake River fall Chinook, and provide harvest opportunities for both tribal and non-tribal anglers.

Fall Chinook salmon for FCAP are all reared at LFH, but are released from three separate acclimation sites (Pittsburgh Landing, Captain John Rapids, and Big Canyon) which are dedicated solely to this program. All three sites were chosen primarily because of proximity to known fall Chinook salmon spawning areas and because of accessibility. At all three sites acclimation occurs in two phases: yearling and then subyearling. The intent is to acclimate yearlings for four to six weeks and subyearlings for a minimum of three weeks. Timing of transfers and releases is coordinated among co-managers in an Annual Operation Plan process. Typically yearlings are transferred to the acclimation sites in late February-early March and released in mid-April. Subyearlings are transferred to the facilities in early-May and released in late-May. The target release size for FCAP subyearlings is 50 fpp (9g), and for yearlings is 10 fpp (45g).

The Pittsburg Landing acclimation site is located on the Idaho side of the Snake River at RM 215 in the Hells Canyon National Recreation Area near Whitebird, Idaho. The site consists of 16 circular aluminum tanks, 20 feet in diameter and 4 feet deep. The site pumps water directly from the Snake River to the acclimation tanks and effluent from the tanks is discharged directly into the Snake River.

The Big Canyon acclimation site is located at RM 35 near Peck, Idaho on the Lower Clearwater River 4 miles downstream of the confluence with the North Fork Clearwater River. The site consists of 16 circular aluminum tanks, 20 feet in diameter and 4 feet deep. Like Pittsburg Landing, the site pumps water directly from the Clearwater River to the acclimation facility; and effluent is discharged back into the river.

The Captain John Rapids acclimation site is located at on the Washington side of the Snake River between Asotin, Washington, and the mouth of the Grande Ronde River at RM 164. The site includes a single 0.17 acre in-ground, lined pond. Water is pumped from the river into the pond and effluent is discharged directly into the river.

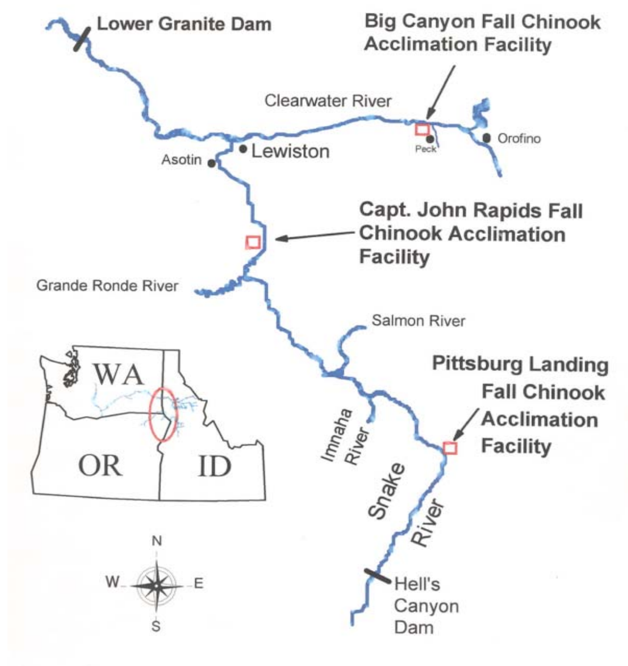

Figure 2. Map of FCAP facilities (WDFW et al. 2011).

1.3.1.1.3. Idaho Power Company Program

The Idaho Power Company (IPC) Program is a mitigation program for fall Chinook salmon losses caused by the construction and ongoing operation of the Hells Canyon Complex dams (Brownlee, Hells Canyon, and Oxbow). The programs mitigation goal is to release 1.0 million fall Chinook salmon subyearlings annually. Based on survival targets, the long-term regional goal is to return 2,700 adult fall Chinook salmon above LGR from this level of production. Broodstock for the program is collected at the LGR trap concurrent with collection of broodstock for all other fall Chinook salmon production. Rearing will occur at both Oxbow Hatchery (operated by IDFG) and Irrigon Hatchery (operated by ODFW) (Table 2). All fall Chinook salmon reared for IPC program are released in the mainstem Snake River below Hells Canyon Dam in May at a target release size of 50fpp (9g). Release dates are variable, and typically multiple releases occur (WDFW et al. 2011; Table 47).

Oxbow Hatchery has been used to rear some of the IPC fish in the past, but its use as part of the IPC fall Chinook salmon program has been suspended until its intakes are screened to reduce risk to bull trout. Until that time, all IPC production will be reared at Irrigon Hatchery. Oxbow Hatchery received eyed eggs from LFH in December. Eggs were incubated on 54º F well water in vertical stack incubators. Juveniles were reared in two large (130’ x 6’ x 4’d) concrete raceways. Well water and river water are plumbed to the raceways in order to achieve required flows and control water temperature. After screening is completed, Oxbow operations will continue as they have in the past.

Irrigon Hatchery facility details are described in the LFH portion of the program above. Though the IPC and LFH portions of the program are listed separately, the details of rearing at Irrigon are identical.

1.3.1.2. Nez Perce Tribal Hatchery Program

The NPTH Fall Chinook salmon program is funded by the BPA under the Columbia Basin Fish and Wildlife Program to mitigate the effects of the Federal Columbia River Power System on fall Chinook salmon. The goals of NPTH are defined as follows:

- Protect, mitigate, and enhance Columbia River subbasin anadromous fish resources;
- Develop, reintroduce, and increase natural spawning populations of salmon within the Clearwater River subbasin;
- Provide long-term harvest opportunities for Tribal and non-Tribal anglers within Nez Perce Treaty lands within four generations (20 years) following project completion;
- Sustain long-term fitness and genetic integrity of targeted fish populations;
- Keep ecological and genetic impacts on non-target populations within acceptable limits; and
- Promote Nez Perce Tribal Management of NPTH facilities and production areas within Nez Perce Treaty lands.

The overall goal stated by the operators is to produce and release fish that will survive to adulthood, provide harvest opportunities established under *U.S. v. Oregon* for tribal and recreational fisheries, return to the Snake Basin and spawn in the Clearwater River subbasin, and produce viable offspring that will support future natural production and maintain genetic integrity. The interim numerical goal of the NPTH Fall Chinook salmon program is to return 3,206 adult fall Chinook salmon, and the long-term goal is to return 3,750 adult fall Chinook salmon to the area above Lower Monumental Dam.

Annually, the operators collect up to 1,052 adult fall Chinook salmon for broodstock. Though broodstock goals specific to NPTH are separate from the Lyons Ferry broodstock goals, broodstock for the two hatcheries are collected at LGR at the same time, usually with about 70% of the fish going to LFH and 30% to NPTH, but always as per an agreed-upon annual operating plan.

The operators intend to collect nearly all broodstock at the LGR trap, some trapping of adult fall Chinook salmon may occur at NPTH annually. No program targets are set for the proportion of broodstock collection that can occur at the hatchery facility. Some broodstock trapping is also intended to occur at a new temporary picket weir placed just above the mouth of the South Fork Clearwater River. The weir will be installed no later than October 1 and removed around December 1.

The operators have set a goal of integrating 30% natural-origin returns into the broodstock, provided this does not exceed 20% of the total natural-origin population; however, the proportion of natural-origin broodstock is limited by how many fish are available in the run and captured in the LGR trap. The estimated proportion of natural-origin adults in the NPTH broodstock, based on scale analysis, has ranged between 8% and 22% between 2004 and 2008, and has averaged 15 percent. Not all hatchery-origin fish are externally marked, so there is uncertainty about accuracy of the estimates of hatchery and natural proportions. Genetic samples have been taken of all fall Chinook salmon broodstock fish at NPTH since 2009, which will speed implementation of the parentage-based tagging planned to facilitate improving accuracy of these estimates.

Spawning of fall Chinook salmon at NPTH is as described for LFH, with minor differences (Section 2.4.4.1.1). The intent of the fall Chinook salmon program is to take eggs across the entire run, and build release groups represented by multiple takes whenever possible. Whenever possible, eggs from early spawned females will be used for to support an early returning run to the South Fork Clearwater and Selway rivers (Table 3). However, the direct release from NPTH into the Clearwater River is the highest priority in the event of an egg shortage, and that goal will always be met before meeting the goals of either the Luke's Gulch or Cedar Flats acclimation programs.

Fish disease protocols are basically the same as those at LFH. At spawning, every female is sampled for bacterial kidney disease. In addition, ovarian fluid samples are tested for viruses and tissue samples are taken for various bacterial assays and to detect the pathogen causing whirling disease. Eggs from females with high test results may be culled to limit the potential for outbreak of the disease in juveniles. Health examinations occur throughout the rearing of fall Chinook salmon at the main NPTH facility as well as all the acclimation sites. Five to ten fish are sacrificed monthly from each facility for examination and disease testing. In addition, 60 fish are sacrificed at each facility before release.

The NPTH production goal is 1.4 million subyearling smolts. Adults are spawned at the hatchery, and eggs remain at NPTH for rearing. An overview of production, which is defined in *U.S. v. Oregon* (2009), is provided in Table 4, below.

Table 4. Nez Perce Tribal Hatchery fall Chinook salmon production groups. Adapted from (NPT 2011; Table 5). All fish are released as subyearlings. CWT=coded-wire tag; Ad=adipose fin clip.

Life History	Release Location(s)	Release Number	Marking
Standard	On station	500,000	100K Ad, CWT 200K CWT only 200K Unmarked
Early-spawning	Luke's Gulch	200,000	100K Ad, CWT 100K CWT only
Early-spawning	Cedar Flats	200,000	100K Ad, CWT 100K CWT only
Standard	North Lapwai Valley	500,000	100K Ad, CWT 200K CWT only 200K Unmarked
Total		**1,400,000**	

Early rearing for all release groups is at NPTH. One group of 500,000 remains at NPTH until release, and is reared and acclimated in raceways and ponds. Another group of 500,000 is reared in indoor rearing tanks at NPTH until transfer to the North Lapwai satellite facility for acclimation in late March or early April, and released there. The remaining 400,000 are transferred in mid-February to the Sweetwater Springs satellite facility, then transferred to the Luke's Gulch and Cedar Flats satellites in April for acclimation and release. For all groups the target release size is 50 fpp (9g). The target release date for all groups except the North Lapwai group is June 15, by which the fish should have been acclimated eight weeks. At the North Lapwai facility warm temperatures and low flow typically force an earlier release in May to avoid poor fish rearing conditions.

Overall, 71.4% of hatchery fish from NPTH are marked in some fashion (CWT only or CWT and adipose fin clip); 28.6% of the total release are released with adipose fin-clips that allow visual identification of hatchery-origin fish. Of the releases without adipose fin-clips, 60% are marked with coded-wire tags.

The main NPTH facility uses 28 indoor fiberglass rearing tanks for rearing. The hatchery uses both groundwater (pump capacity of 930 gpm) and surface water (pump capacity of 4500 gpm) pumped from the Clearwater River for incubation and rearing.

The North Lapwai Valley satellite facility is located on Lapwai Creek upstream from its confluence with the Clearwater River, just north of Lapwai, Idaho. The acclimation facility uses both ground water and surface water from Lapwai Creek to support fish on-site during acclimation. Disease monitoring as well as continuous water quality monitoring (temperature and dissolved oxygen) occurs here and at the other acclimation-sites.

The Sweetwater Springs satellite facility is located on Sweetwater Creek (a tributary of Lapwai Creek) near Waha, Idaho. In addition to rearing, the facility may be used to hold adult broodstock before spawning if additional holding space is needed. The facility uses surface water collected from a spring to maintain water flow through the facility.

The Lukes Gulch satellite facility is located on the South Fork Clearwater River south of Stites, Idaho. The facility uses both deep well water and surface water from the South Fork Clearwater River to support fish on-site during acclimation.

The Cedar Flats satellite facility is located on the Lower Selway River, about 5 miles east of its confluence with the Lochsa River, which forms the Middle Fork Clearwater River. The facility uses only pumped surface water from the Selway River to support fish on-site during acclimation.

1.3.2. Research, Monitoring, and Evaluation Activities

1.3.2.1. Current Activities

Because of the importance of Snake River fall Chinook salmon as a single-population ESU, the importance 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 quite extensive and comprehensive compared to many other hatchery monitoring efforts in the Columbia Basin. The Snake River fall Chinook salmon hatchery RM&E effort is far too complex to describe in detail in this document. An overview is provided below; for more detail see the HGMPs and Addendum (NPT 2011; WDFW and NPT 2011; WDFW et al. 2011).

Performance standards for hatchery programs detailed in the HGMPs are based on multiple documents that have resulted from Columbia Basin planning in the last few years. The Northwest Power Conservation Council (NPCC) Artificial Production Review (1999) provides a basic framework for evaluating hatchery effectiveness by creating nine categories of standards: 1) legal mandates, 2) harvest, 3) conservation of wild/naturally produced spawning populations, 4) life history characteristics, 5) genetic characteristics, 6) quality of research activities, 7) artificial production facilities operations, and 8) socio-economic effectiveness. Aspects of the monitoring program directed at evaluation of the supplementation effort are based on the framework for integrated hatchery RM&E developed by the Ad Hoc Supplementation Workgroup (AHSWG) (AHSWG 2008). The AHSWG framework is structured around three categories of research monitoring and evaluation: 1) implementation and compliance monitoring, 2) hatchery effectiveness monitoring, and 3) uncertainty research. The hatchery effectiveness category addresses regional questions relative to both harvest augmentation and supplementation hatchery programs and defines a set of management objectives specific to supplementation projects.

The framework uses a common set of standardized performance measures as established by the Collaborative System wide Monitoring and Evaluation Project (CSMEP). The operators feel that adoption of this suite of performance measures and definitions across multiple study designs will facilitate coordinated analysis of regional monitoring and evaluation efforts, which are needed to address management questions and critical uncertainties associated with the relationships between harvest augmentation and supplementation hatchery production, and ESA-listed stock status/recovery. However, the operators also feel that the AHSWG framework represents only a portion of the activities needed for how hatcheries are operated throughout the region. Thus, the performance indicators for Snake River fall Chinook salmon (NPT 2011; WDFW et al. 2011, Tables 2 and 1, respectively) represents the union of performance standards described by the NPCC in 1999, regional questions for monitoring and evaluation for harvest and supplementation programs, and performance standards and testable assumptions as described by the AHSWG (AHSWG 2008). Definitions (AHSWG 2008) of relevant performance measures and their relation to the indicators are provided in Tables 2 and 3 of NPT (2011) and WDFW et al. (2011), respectively.

In addition to detailed monitoring of hatchery performance measures, three major areas of monitoring yield data that are integral to evaluating population performance at VSP parameters (McElhany et al. 2000): adult abundance, harvest, and juvenile abundance and distribution. Each involves considerable challenges. At present 19 studies are being conducted that are specifically designed to evaluate Snake River fall Chinook salmon. Monitoring is funded through BPA, the Lower Snake River Compensation Plan, Idaho Power Company, and the U.S. Army Corps of Engineers (WDFW and NPT 2011). Ongoing Projects critical to the Snake River fall Chinook salmon hatchery program performance monitoring effort are listed in Table 5.

Table 5. Projects critical to Snake River Fall Chinook salmon hatchery program performance monitoring

Funding Entity/Project Number	**Project Title**
BPA: 198201301	Coded Wire Tag-Pacific States Marine Fisheries Commission (PSMFC)
BPA: 198201302	Coded Wire Tag-Oregon Department of Fish and Wildlife (ODFW)
BPA: 198201304	Coded Wire Tag-Washington Department of Fish and Wildlife (WDFW)
BPA: 198335003	Nez Perce Tribal Hatchery Monitoring and Evaluation (M&E)
BPA: 198712700	Smolt Monitoring by Non-federal Entities
BPA: 199102900	Research, monitoring, and evaluation of emerging issues and measures to recover the Snake River fall Chinook salmon ESU
BPA: 199801004	Monitor and Evaluate (M&E) Performance of Juvenile Snake River fall Chinook salmon from the Fall Chinook Acclimation Project
BPA: 200500200	Lower Granite Dam Adult Trap Operations
IPC	Fall Chinook salmon spawning ground surveys, PIT- tagging, and run-reconstruction
LSRCP -WDFW	LFH evaluations - WDFW
COE	Window Counts – Lower Granite Dam

Adult abundance is estimated by window counts at the four Lower Snake dams, trapping at LGR, and by redd counts in all spawning aggregate areas. A static stratified trapping rate at LGR is established pre-season annually, and in-season adjustments may occur to accommodate fish handling limitations. 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 and SARs for both hatchery and wild fish. Run-reconstruction estimates were substantially modified in 2003 to increase the accuracy and precision of estimated returns of both hatchery and natural fish and are undergoing further modification (Section 1.3.2.2). LGR estimates do not encompass the entire mainstem Snake River population of fall Chinook salmon, however, so multiple-pass extensive area aerial redd count surveys were initiated in 1988. 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. Carcass recovery is limited due to the large river size and only occurs in the Clearwater River Basin. Age-structure of spawners estimated from scale samples and known marks of hatchery releases are obtained from sub-samples at LGR and from carcass recoveries in the Tucannon River. Sex ratio of spawners is estimated the same way as is age-structure.

Monitoring 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 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 other tags. A recent attempt to use scale pattern analysis for this purpose has been abandoned because of unreliability or results, but parentage-based tagging (Section 1.3.2.2) is being implemented. Using this method, it should be possible to identify nearly all in-basin hatchery returns of unmarked fish in the near future.

Harvest of Snake River fall Chinook salmon is substantial and extensive, occurring in ocean, mainstem, and in limited tributary fisheries. As fisheries expand, the management agencies coordinate appropriate sampling programs, generally through the coded-wire tag program, to document hatchery fish harvest and estimate natural population impacts.

Abundance and distribution information on juveniles is limited. Abundance information of wild juveniles is not available for any spawning aggregate. 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 (May through April) 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 limited to the Clearwater River and the Upper and Lower Snake River spawning aggregates. However, estimates of survival for wild, surrogate hatchery production, and NPTH subyearling production must be characterized by combining probability of emigration and survival. Distribution information is collected for the Clearwater River and for the Upper and Lower Snake River through beach seining.

The proposed action includes juvenile monitoring activities by NPT that have previously been permitted as parts of projects 4 and 5 under section 10 permit 1134 (NMFS 2011g). Monitoring occurs in the lower reaches of the Clearwater, Imnaha, and Grande Ronde 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).

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. PIT-tag detection arrays will be in place to monitor migration, and remote controlled aircraft will be used to monitor and document spawning. These activities are not expected to result in additional take of listed species.

1.3.2.2. New and Expanded RM&E Activities

At present, Snake River fall Chinook salmon constitute a single-population ESU (NMFS 2005b), and most of the fish in the population are of hatchery-origin. Thus, monitoring the effects of the hatchery programs on natural production is thus 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. As a result, information that would describe the effects of hatchery production or inform future management of hatchery actions to help minimize impacts is incomplete.

Partly in recognition of this monitoring need and of the difficulty in monitoring this population, two reasonable and prudent alternative (RPA) measures in the 2008 FCRPS Biological Opinion deal in part or entirely with the effects of the hatchery programs on the natural production of Snake River fall Chinook salmon. RPA action 64 calls for relative reproductive success studies in salmon and steelhead populations in the Upper Columbia and Snake Basins, and calls specifically for a relative reproductive success study of Snake River fall Chinook salmon. RPA action 65 calls specifically for research into the effects of the hatchery programs on the Snake River fall Chinook salmon ESU. NMFS convened a multi-agency workshop in 2010 to develop conceptual study designs for the two RPA actions. The working group identified key informational gaps and suggested some relevant research paths, but concluded that no readily implementable designs for either action were available for Snake River fall Chinook salmon (Peven 2010).

Though ongoing RM&E detailed in the HGMPs provides much valuable information, NMFS requested in pre-consultation that additional RM&E measures be developed to address some of the information gaps surrounding the effects of the hatchery programs on natural production of Snake River fall Chinook salmon. In response, the applicants prepared an addendum to supplement the HGMPs. In general, the Addendum identifies research, monitoring, and evaluation that would help address uncertainties regarding the status of the natural-origin population of Snake River fall Chinook salmon and the impacts that may occur as a result of the artificial propagation activities outlined in the HGMPs.

The Addendum outlines a large collection of ideas and suggests several potential RM&E measures for resolving identified information gaps. However, the Addendum was not intended to be an implementation document, and the measures discussed were not prioritized or evaluated for feasibility. After the Addendum was developed, additional meetings were held among NMFS, the resource managers, and the funding agencies to identify which measures would be implemented as part of the overall proposed action.

NMFS, the resource managers, and the funding agencies arrived at a list of eight priority research, monitoring, and evaluation measures that would be used to gather multiple data sets:

- Parentage-based tagging of fish collected for broodstock
- Run-reconstruction
- Fall-back at LGR
- Release-site fidelity
- Spawning, rearing, and overwintering locations
- Juvenile life-cycle modeling
- Genetics of subpopulation structure
- Research findings and adaptive management symposium

Parentage-based tagging, run-reconstruction, and the fall-back study are aimed at better accounting. As previously mentioned, current estimates of the proportion of hatchery-origin fish on the spawning grounds are imprecise because not all fish produced by the hatcheries are marked. Parentage-based tagging effectively genetically marks all the fish that are progeny of previously sampled fish. Unmarked returning adults can be compared genotypically to all the broodstock fish of the previous generation. Those that cannot be assigned to broodstock parents or identified as out-of-basin stray adults, based on CWT identification, would be identified as being of natural-origin. This method would allow better estimates of hatchery/wild proportions than those now available. The ongoing run-reconstruction effort would reexamine past estimates and improve future estimates of the number of fish passing LGR and of hatchery/wild proportions. The adult fall-back study would further refine spawner abundance estimates, as some fish pass above the dam, then fall-back and do not reascend, while others pass upstream again and may be recounted, potentially confounding fish counts and run-reconstruction efforts.

The release-site fidelity; spawning, rearing and overwintering locations; juvenile life cycle modeling, and genetics of subpopulations studies are directed more at understanding population and subpopulation dynamics as affected by artificial propagation. The release-site fidelity study will build on the earlier radio-tagging work by Garcia et al. (2004) that examined the faithfulness with which fish return to their release area. This is important for understanding what level subpopulation structure is possible with the current hatchery production. The spawning, rearing, and overwintering location study will use mass spectroscopy of otoliths to identify differentiate fish from different areas, a technique which has shown considerable promise with Snake River fall Chinook salmon (Hegg 2011). This will contribute to understanding the productivity and capacity of specific areas that may correspond to subpopulation structure. The genetic subpopulation work would update the earlier data, expanding by knowledge of where in the basin the fish originated, to determine if the small signal of possible subpopulation structure seen in earlier studies is holding steady, increasing (indicating increasing substructure), or decreasing (indicating loss of substructure).

The juvenile life cycle modeling will substantially expand ongoing efforts to study juvenile production. A portion of the run of natural-origin yearling juvenile fall Chinook salmon, which contribute largely to adult returns, passes LGR during the winter, when juvenile sampling facilities are not operated (Tiffan et al. 2012). The study will result in passage estimates during the winter, making year-around estimates of juvenile abundance possible.

The final measure is the methodical collection, review, and synthesis of information from the new and ongoing studies to guide further management measures. This would culminate in a symposium in 2016. This measure is likely imperative given the importance of the Snake River fall Chinook salmon population, the challenges of understanding its dynamics, and the need to apply new information when the hatchery program permits are due for renewal.

Collectively the new RM&E measures are intended to 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. Some, such as the parentage-based tagging, will not provide information for years, whereas others, such as those that are aimed at more precise estimates of the fish passing LGR run-reconstruction and fall-back – will provide useful information as soon as they are implemented.

1.4. Action Area

"Action area" means all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR 402.02).The action area for the analysis of the effects of the proposed activities will primarily focus on the Lower Snake and Clearwater River watersheds where the hatchery programs are located. The Snake River fall Chinook salmon ESU is affected by the hatchery programs listed in Table 1 and the Snake River Spring/Summer Chinook salmon ESU, Snake River Sockeye Salmon ESU, and Snake River Steelhead DPS could all be potentially affected by those hatchery programs. NMFS has initiated formal section 7 consultation on the effects of issuing the permits on ESA-listed bull trout (*Salvelinus confluentus*).

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. Approximately 22-25[4]% of the fish released by these programs will be reared at Irrigon Hatchery, which is outside the Snake Basin. 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. Similarly, plans call for 200,000 fish to be reared at Oxbow Hatchery, which is in the Snake River Basin, but is above Hells Canyon Dam, which is a total barrier to anadromous fish. Thus, Oxbow Hatchery will be included in the action area for facility effects only.

Releases from the proposed programs constitute approximately 20% of all hatchery salmon and steelhead released into the Snake Basin. As ecological interactions are possible with listed

[4] The higher value reflects usage of Irrigon for all IPC production; once Oxbow Hatchery is screened and some production shifts to there, the lower value will be correct.

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 2.4.5.1).

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 2012b). However, the numbers of Snake River fish 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.

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 on which they depend. Section 7(a)(2) of the ESA requires federal agencies to consult with the United States Fish and Wildlife Service, NMFS, or both, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Section 7(b)(3) requires that at the conclusion of consultation, the Service provide an opinion stating how the agencies' actions will affect listed species or their critical habitat. If incidental take is expected, Section 7(b)(4) requires the provision of an incidental take statement specifying the impact of any incidental taking, and including reasonable and prudent measures 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. The adverse modification analysis considers the impacts on the conservation value of the designated critical habitat.

"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 a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR 402.02).

This biological opinion does not rely on the regulatory definition of 'destruction or adverse modification' of critical habitat at 50 CFR 402.02. Instead, NMFS has relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat[5].

We will use the following approach to determine whether the proposed action described in Section 1.3 is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Identify the rangewide status of the species and critical habitat likely to be adversely affected by the proposed action.
- Describe the environmental baseline for the proposed action.
- Analyze the effects of the proposed actions.
- Describe any cumulative effects.
- Integrate and synthesize the above factors to assess the risk that the proposed action poses to species and critical habitat.
- Reach jeopardy and adverse modification conclusions.
- If necessary, define a reasonable and prudent alternative to the proposed action. Because this opinion reaches a no-jeopardy conclusion, a reasonable and prudent alternative was not developed.

2.2. Rangewide Status of the Species and Critical Habitat

This section defines the biological requirements of each listed species affected by the proposed action, and the status of designated critical habitat relative to those requirements. Listed species facing a high risk of extinction, and critical habitats with degraded conservation value are more vulnerable to the aggregation of effects considered under the environmental baseline, the effects of the proposed action, and cumulative effects. Conversely, listed species facing a lower risk of extinction, and critical habitats with better conservation value, are less vulnerable to the aggregation of effects considered under the environmental baseline, the effects of the proposed action, and cumulative effects. Documents describing the listing status, critical habitat, and salmon and steelhead life histories are summarized in Table 6.

[5] Memorandum from William T. Hogarth to Regional Administrators, Office of Protected Resources, NMFS (Application of the "Destruction or Adverse Modification" Standard Under Section 7(a)(2) of the Endangered Species Act) (November 7, 2005).

Table 6. Federal Register notices for final rules that list threatened species, designate critical habitats, or apply protective regulations to listed species considered in this consultation.

Species	Listing Status	Critical Habitat	Protective Regulations
Chinook salmon (*Oncorhynchus tshawytscha*)			
Snake River fall-run	Threatened 6/28/05; 70 FR 37160	12/28/93; 58 FR 68543	6/28/05; 70 FR 37160
Snake River Spring/Summer-run	Threatened 6/28/05; 70 FR 37160	10/25/99; 64 FR 57399	6/28/05; 70 FR 37160
Steelhead (*O. mykiss*)			
Snake River	Threatened 1/05/06; 71 FR 834	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Sockeye salmon (*O. nerka*)			
Snake River	Endangered 6/28/05; 70FR37160	12/28/93; 58 FR 68543	6/28/05; 70 FR 37160

"Species" Definition: In order to describe a species' status, it is first necessary to define what "species" means in this context. Traditionally, one thinks of the ESA listing process as pertaining to entire taxonomic species of animals or plants. While this is generally true, the ESA also recognizes that the listing unit must at times necessarily be a subset of the taxonomic species. In these instances, the ESA allows a subspecies or a "distinct population segment" (DPS) of a species to be listed. Snake River steelhead constitute a DPS of the taxonomic species *Oncorhynchus mykiss.* For anadromous species of the genus *Oncorhynchus* other than steelhead (i.e., those species ordinarily called "salmon"), distinct population segments for purposes of the ESA are defined as evolutionarily significant units (ESUs) (Waples 1991) and listings are by ESU. Snake River spring/summer and fall Chinook salmon constitute ESUs of the taxonomic species *O. tshawytscha*, and as such are considered "species" under the ESA; similarly, Snake River sockeye salmon constitute an ESU of the taxonomic species *O. nerka,* and are considered a "species" under the ESA.

The Interior Columbia Technical Recovery Team (ICTRT) has developed a hierarchical approach for determining ESU-level viability criteria (Figure 2). Briefly, an ESU is divided into populations (McElhany et al. 2000). The risk of extinction of each population is evaluated, taking into account population-specific measures of abundance, productivity, spatial structure, and diversity. Populations are then grouped into ecologically and geographically similar strata (referred to as Major Population Groups [MPG] by the ICTRT), which are evaluated on the basis of population status. In order to be considered viable, generally an MPG must have at least half of its historically present populations meeting their population-level viability criteria (McElhany et al. 2006). At the ESU-level, the ICTRT recommends that each of the ESU's MPGs also be viable.

In assessing status, NMFS starts with the information used in its most recent decision to list for ESA protection the salmon and steelhead species considered in this opinion, and also considers more recent data, where applicable, that are relevant to the species' rangewide status. Recent information from recovery plans is often relevant and is used to supplement the overall review of the species' status. This step of the analysis tells NMFS how well the species is doing over its entire range in terms of trends in abundance and productivity, spatial distribution, and diversity. It also identifies the potential causes of the species' decline.

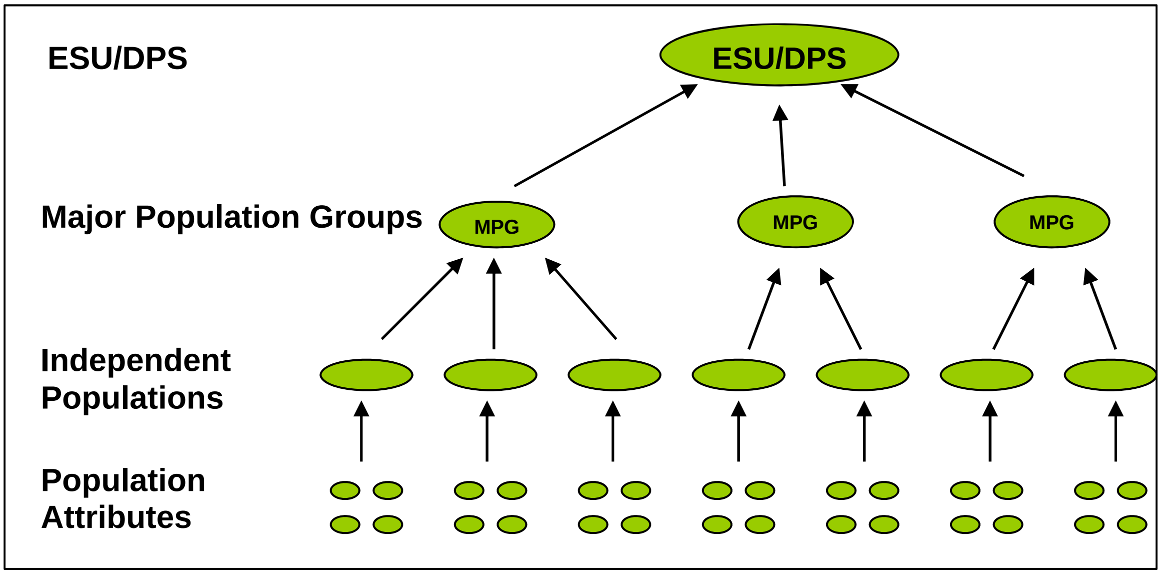

Figure 2. Hierarchical approach to ESU/DPS viability criteria and the evaluation of affects of a proposed action on an ESU or DPS.

The status review in this document starts with a description of the general life history characteristics and the population structure of the ESU, including the applicable strata or major population groups (MPG). We review available information on the VSP criteria including abundance, productivity and trends (information on trends supplements the assessment of abundance and productivity parameters), and spatial structure and diversity. We also summarize available estimates of extinction risk that are used to characterize the viability of the populations and ESU, and the limiting factors and threats. We also review available information on the status of the MPGs and individual populations within the action area, and their critical habitat.

Recovery plans are an important source of information that describe, among other things, the status of the species and its component populations, limiting factors, recovery goals and actions that are recommended to address limiting factors. Recovery plans are not regulatory documents. Consistency of a proposed action with a recovery plan therefore does not by itself provide the basis for a no jeopardy determination. However, recovery plans do provide an all-H perspective that is important when assessing the effects of an action. It is therefore useful to summarize the status of the recovery planning process before proceeding with the substance of the biological opinion.

A recovery plan for the Snake River fall Chinook salmon ESU is in the preliminary stages of development as part of a multi-species plan for the Snake River Domain. The recovery plan for the Snake River Domain will address all threats and limiting factors that impact the species' status, including hydroelectric operations, harvest, habitat use and artificial propagation as well as the emerging threats of climate change and contaminants. It will also provide criteria that represent conditions, which if met, would result in a delisting determination (delisting criteria), and management actions as may be necessary to achieve recovery. NMFS intends to complete this recovery plan in early 2014.

2.2.1. Critical Habitat

Critical habitat has been designated for the salmon and steelhead species that would be affected by the proposed hatchery programs. Critical habitat includes the stream channel within each designated stream reach with the lateral extent defined by the ordinary high-water line. NMFS reviews the status of designated critical habitat affected by the proposed action by examining the condition and trends of primary constituent elements (PCEs) throughout the designated area. The PCEs consist of the physical and biological features identified as essential to the conservation of the listed species in the documents that designate critical habitat. The PCEs for three species of Snake River salmon are shown in Table 7, and the PCEs for Snake River steelhead are described in the paragraphs following the table.

Table 7. PCEs identified for Snake River sockeye, spring/summer Chinook, and fall Chinook salmon (NMFS 1993).

Habitat Component	Sockeye Salmon	Spring/Summer Chinook salmon	Fall Chinook salmon
Spawning and juvenile rearing areas	1) spawning gravel 2) water quality 3) water quantity 4) water temp. 5) food 6) riparian veg. 7) access	1) spawning gravel 2) water quality 3) water quantity 4) cover/shelter 5) food 6) riparian veg. 7) space	Same as spring/summer Chinook salmon (Dauble et al. 2003)
Juvenile migration corridors	1) substrate 2) water quality 3) water quantity 4) water temp. 5) water velocity 6) cover/shelter 7) food 8) riparian veg. 9) space 10) safe passage	Same as sockeye	Same as sockeye
Areas for growth and development to adulthood	Ocean areas – not identified	Same as sockeye	Same as sockeye
Adult migration corridors	1) substrate 2) water quality 3) water quantity 4) water temp. 5) water velocity 6) cover/shelter 7) riparian veg. 8) space 9) safe passage	Same as sockeye	Same as sockeye

(NMFS 2005a) identified the following PCEs for the nine other species of Columbia Basin salmonids including Snake River steelhead.[6]

[6] A fifth category, "nearshore marine areas," is not applicable to Columbia Basin salmonids

- Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development. These features are essential to conservation because without them the species cannot successfully spawn and produce offspring.

- Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and 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. These features are essential to conservation because without them, juveniles cannot access and use the areas needed to forage, grow, and develop behaviors (e.g., predator avoidance, competition) that help ensure their survival.

- Freshwater migration corridors free of obstruction 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. These features are essential to conservation because without them juveniles cannot use the variety of habitats that allow them to avoid high flows, avoid predators, successfully compete, begin the behavioral and physiological changes needed for life in the ocean, and reach the ocean in a timely manner. Similarly, these features are essential for adults because they allow fish in a non-feeding condition to successfully swim upstream, avoid predators, and reach spawning areas on limited energy stores.

- Estuarine areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation. These features are essential to conservation because without them juveniles cannot reach the ocean in a timely manner and use the variety of habitats that allow them to avoid predators, compete successfully, and complete the behavioral and physiological changes needed for life in the ocean. Similarly, these features are essential to the conservation of adults because they provide a final source of abundant forage that will provide the energy stores needed to make the physiological transition to fresh water, migrate upstream, avoid predators, and develop to maturity upon reaching spawning areas.

2.2.2. Snake River Chinook salmon ESUs

Two distinct ecological types of Chinook salmon are generally recognized: "stream-type" and "ocean-type" (Healey 1991). Ocean-type Chinook salmon return to natal streams within a few days to weeks before spawning in the fall. These fish typically begin downstream migration within a few days following emergence, reside in fresh water for no more than 3 months, and reside in coastal ocean waters 3 to 4 years before maturing. Ocean-type Chinook salmon typically spawn in large mainstem rivers such as the Clearwater and Snake rivers, and construct redds in coarse gravel areas where there is upwelling or high inter-gravel flow. Snake River fall Chinook salmon predominantly exhibit an ocean-type life history.

In contrast, stream-type Chinook salmon return to natal streams in spring or summer, several months before spawning in the fall. These fish typically reside in fresh water for 2 years following emergence, reside in the ocean for 2 to 3 years, and exhibit extensive offshore ocean migrations. Stream-type Chinook salmon typically spawn in moderate to large-sized streams in shallow gravel bars at the downstream end of pools. During freshwater rearing, juvenile Chinook salmon disperse into tributary streams near their natal streams, and are often concentrated near the mouths of stream confluences. Habitats used by juvenile stream-type Chinook salmon and their feeding habits are similar to those described for steelhead. In general, Chinook salmon tend to occupy streams with lower gradients than steelhead, but there is considerable overlap between the distributions of the two species. Snake River spring/summer Chinook salmon exhibit a stream-type life history.

2.2.2.1. Snake River Fall Chinook salmon ESU

The Snake River fall-run Chinook salmon ESU includes fish spawning 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. Historically, this ESU included two large additional populations spawning in the mainstem of the Snake River upstream of the Hells Canyon Dam complex. The spawning and rearing habitat associated with the current extant population represents about 10-15% of the total historical habitat available to the ESU (NMFS 2008e). Snake River fall Chinook salmon were originally listed under the ESA as threatened in 1992, and the listing was reaffirmed in 1995 (NMFS 2005b).

2.2.2.1.1. Population Structure

The Snake River fall-run Chinook salmon ESU is a single population in one MPG that spawns and rears in the mainstem Snake River and its tributaries below Hells Canyon Dam. 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 two of the historical populations. Hatcheries mitigating for losses caused by the dams have played a major role in the production of Snake River fall Chinook salmon since the 1980s.

Snake River fall Chinook salmon spawning and rearing occurs primarily in larger mainstem rivers, such as the Salmon, Snake, and Clearwater rivers. Historically, the primary fall-run Chinook salmon spawning areas were located on the Upper mainstem Snake River (Connor et al.

2005). A series of Snake River mainstem dams blocks access to the Upper Snake River, which has substantially reduced spawning and rearing habitat for Snake River fall-run Chinook salmon. 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 Lower Granite 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 Chinook salmon also spawn in smaller streams such as the Potlatch River, and Asotin and Alpowa Creeks and they may be spawning elsewhere. The vast majority of spawning today occurs upstream of LGR, with the largest concentration of spawning sites in the mainstem Snake River (~60%) and in the Clearwater River, downstream from Lolo Creek (~30%).

2.2.2.1.2. Life History

As a consequence of losing access to historic spawning and rearing sites heavily influenced by influx of ground water in the Upper Snake River and effects of dams on downstream water temperatures, fall 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 fall Chinook salmon survival. Before alteration of the Snake River Basin by dams, fall Chinook salmon exhibited a largely ocean-type life history, where they migrated downstream during their first-year. Today, fall 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.

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 fall Chinook salmon. Some limited spawning occurs in all these areas, although returns to the Tucannon River are predominantly releases and strays from the LFH program.

2.2.2.1.3. Trends

The current condition of Snake River fall Chinook salmon is described in Good et al. (2005) and Ford et al. (2011). The Snake River fall-run Chinook salmon ESU does not meet the ESU-level viability criteria (the non-negligible risk of extinction over 100-year time period), based on current abundance and productivity information, but recent numbers are approaching the (ICTRT 2007b) recovery abundance threshold of 3,000 spawners (i.e., to meet viability goals for abundance at <5% risk of extinction). This ESU has been reduced to a single remnant population with a narrow range of available habitat. However, the overall adult abundance has been increasing from the mid-1990s, with substantial growth since the year 2000 (Figure 3). The 10-year total average adult return to LGR (2000-2009, hatchery- and natural-origin combined has risen to 12,288, higher than the previous decade (1990 to 1999) average of 1,995. In 2010, the total escapement to LGR was over 42000. Similarly, the 10-year average (2000 to 2009) for natural-origin fish over LGR has risen to 2,588, several times that of the previous decade (1990 to 1999) average of 509. In 2010, escapement of natural-origin adults was estimated at over 9500. Fall Chinook salmon redd counts in the Snake River Basin have risen from only 45 redds counted in 1991 to a high of 5626 in 2010 (Arnsberg et al. 2011). Since 2002 redd counts in the Clearwater, Grande Ronde, Salmon, and Imnaha rivers have been at least 500 and reached 852 redds in 2004 (Garcia et al. 2007). It is uncertain how well growth in natural production is tracking the overall increases. Figure 3 suggests that natural production was plateauing or declining relative to overall production in the last few years through 2009. This was reflected in the status review of Ford et al. (2011). This pattern has not held for 2010-2011, years for which a new run-reconstruction method (Young et al. 2012) has been used. The new method – discussed in detail in Section 1.3.2.2 – will be applied to previous years as far back as 2003, which may further modify perceptions of the relative proportion of natural-origin fish in the run.

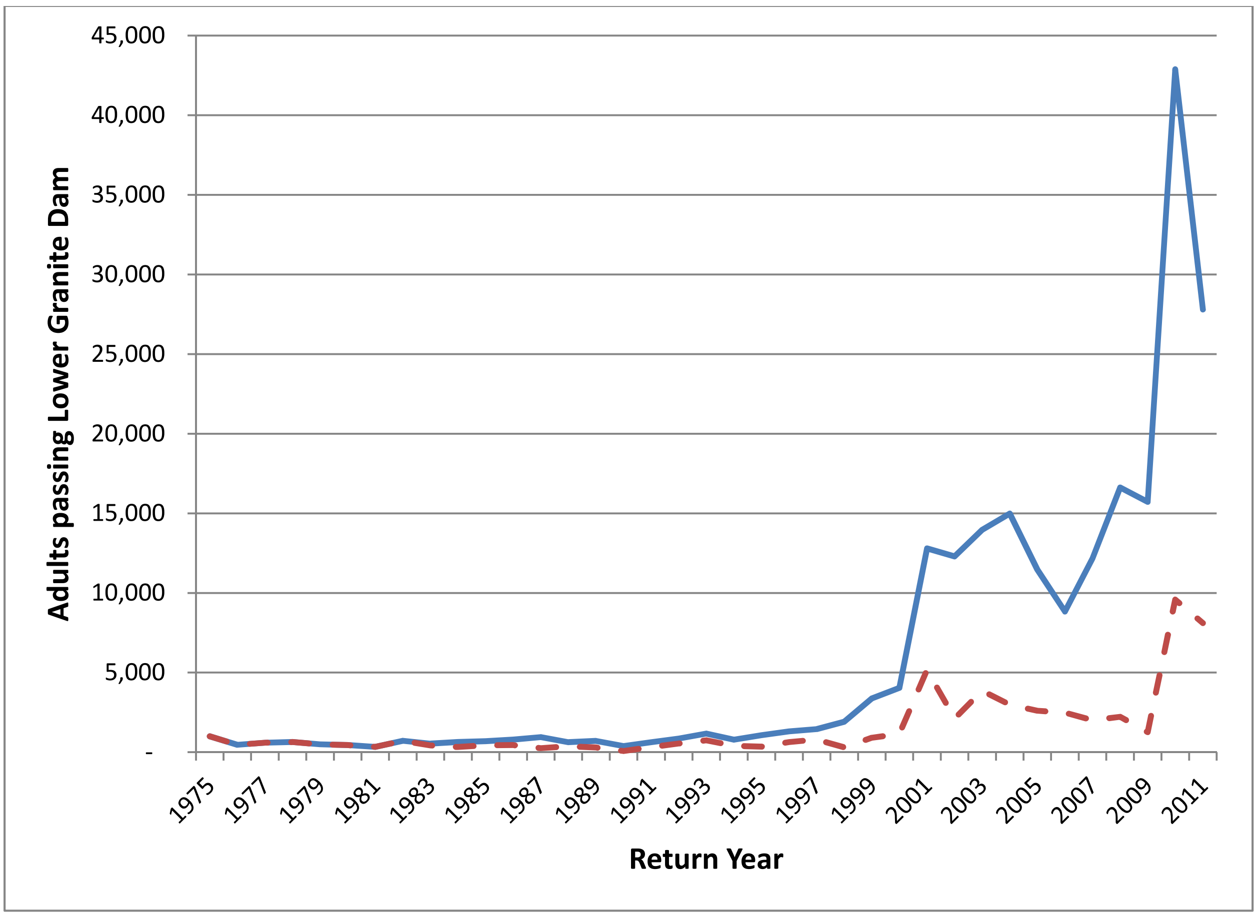

Figure 3. Numbers of adult (> 57cm FL) fall Chinook salmon crossing LGR from 1975 to 2011 (Cooney 2012). Solid line denotes total returns, dashed line denotes estimated natural-origin returns. Data compiled from (WDFW and ODFW 2011) and LFH annual reports. Data for 2011 are from run-reconstruction workgroup (Young et al. 2012) and should be considered preliminary.

2.2.2.1.4. Limiting Factors and Threats

The key limiting factors and threats for the Snake River fall Chinook salmon 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 Chinook salmon were generally poor during the early part of the last 20 years.

2.2.2.1.5. Status of Snake River Fall Chinook salmon Critical Habitat

Designated critical habitat (NMFS 1993) for Snake River fall Chinook salmon includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence of the Columbia and Snake rivers; all Snake River reaches from the confluence of the Columbia River upstream to Hells Canyon Dam; 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 those above impassable natural falls and Dworshak and Hells Canyon Dams) in the following subbasins: Clearwater, Hells Canyon, Imnaha, Lower Grande Ronde, Lower North Fork Clearwater, Lower Salmon, Lower Snake, Lower Snake-Asotin, Lower Snake-Tucannon, and Palouse. The Lower Columbia River corridor is among the areas of high conservation value to the ESU because it connects every population with the ocean and is used by rearing/migrating juveniles and migrating adults. The Columbia River estuary is a unique and essential area for juveniles and adults making the physiological transition between life in freshwater and marine habitats. 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) (NMFS 1993).

The general trend for critical habitat for all species is included in Section 2.2.1.

2.2.2.2. Snake River Spring/Summer Chinook salmon ESU

The Snake River Spring-Summer 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 fifteen artificial propagation programs. The ESU was first listed under the ESA in 1992, and the listing was reaffirmed in 2005(NMFS 2005b).

2.2.2.2.1. Life History

Snake River spring/summer Chinook salmon exhibit a stream-type life history and Snake River fall Chinook salmon exhibit an ocean-type life history (Myers et al. 1998). Stream-type Chinook salmon adults return to natal streams several months before spawning in spring or summer. They typically reside in fresh water for 2 years following emergence, reside in the ocean for 2 to 3 years, and exhibit extensive offshore ocean migrations. Stream-type Chinook salmon typically spawn in moderate to large-sized streams in shallow gravel bars at the downstream end of pools.

During freshwater rearing, juvenile Chinook salmon disperse into tributary streams near their natal streams, and are often concentrated near the mouths of stream confluences. In general, Chinook salmon tend to occupy streams with lower gradients than steelhead, but there is considerable overlap between the distributions of the two species.

Historically, the Snake River drainage is thought to have produced more than 1.5 million adult spring/summer Chinook salmon in some years during the late 1800s (Matthews and Waples 1991). By the 1950s, the abundance of spring/summer Chinook salmon had declined to an annual average of 125,000 adults, and continued to decline through the 1970s. Returns were variable through the 1980s, but declined farther in the 1990s. In 1995, only 1,797 spring/summer adults returned. Returns at LGR (hatchery and wild fish combined) dramatically increased after 2000, with 185,693 adults returning in 2001. The large increase in 2001 was due primarily to hatchery returns, with only 10% of the returns from fish of natural-origin.

The causes of oscillations are uncertain, but may be 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 altered by Snake and Columbia River Dams, increased smolt mortality from poor downstream passage conditions, and competition with hatchery fish; and widespread alteration of spawning and rearing habitats. Spawning and rearing habitats are commonly impaired in places from factors such as agricultural tilling, water withdrawals, sediment from unpaved roads, timber harvest, grazing, mining, and alteration of floodplains and riparian vegetation. Climate change is also recognized as a possible factor in Snake River salmon declines (Tolimieri and Levin 2004; Scheuerell and Williams 2005).

2.2.2.2.2. Population Structure

The ICTRT identified 27 extant and 4 extirpated populations of the Snake River spring/summer Chinook salmon that historically used the accessible tributary and upper mainstem habitats within the Snake River drainages (ICTRT 2003). The populations are aggregated into five extant MPGs based on genetic, environmental, and life-history characteristics, which are described below.

Estimates of natural-origin abundance for the most recent five-year brood cycle are available for 24 populations in the Snake River Spring/Summer Chinook salmon ESU (Table 8). Relative to the previous BRT assessment, escapements are higher by more than 25% for 13 populations, lower by more than 25% for six populations, and within 25% for five populations.

Table 8. Recent five-year geometric mean estimates of total and natural-origin spawning escapement for Snake River spring/summer Chinook salmon populations, organized by MPG. Estimates for all periods based on most current population level data sets (Ford et al. 2011).

Population (organized by major population group)	Natural Spawning Areas								
	Total Spawners (5 year geometric mean, *range*)			Natural Origin (5 year geometric mean)			% Natural Origin (5 year average)		
	Listing (1992-1996)	*Prior (1997-2001)*	Current (2005-2009)	*Listing (1992-1996)*	*Prior (1997-2001)*	Current (2005-2009)	*Listing (1992-1996)*	*Prior (1997-2001)*	Current (2005-2009)
Lower Snake River									
Tucannon	120	176 (51–894)	469 (161–1676)	66	68 (5-672)	276 (116-682)	56%	40%	53%
Grande Ronde/Imnaha									
Wenaha	260	303 (84-899)	364 (293-478)	93	274 (69-756)	325 (270-430)	49%	92%	95%
Lostine/Wallowa	118	265 (132-689)	812 (443-1778)	73	218 (120-541)	267 (131-668)	70%	88%	41%
Minam	180	277 (149-608)	460 (313-765)	88	262 (142-547)	414 (301-697)	63%	97%	95%
Catherine Creek	69	103 (43-512)	205 (143-275)	38	95 (43-382)	80 (42-122)	63%	95%	34%
Upper Grande Ronde	76	34 (4-83)	109 (17-419)	33	33 (4-83)	19 (13-43)	55%	100%	33%
Imnaha	482	855 (387-2282)	1094 (727-1996)	225	347 (158-1119)	196 (127-281)	50%	46%	25%
South Fork									
Secesh	171	341 (101-1395)	428 (191-956)	166	308 (86-1228)	362 (162-811)	97%	96%	93%
EF/Johnson Cr	87	186 (55-1257)	266 (141-589)	84	146 (45-1018)	113 (63-244)	97%	93%	46%
SF Mainstem	689	1399 (926-2529)	1046 (901-1231)	392	712 (453-1644)	443 (374-585)	58%	58%	47%
Middle Fork									
Bear Valley	86	285 (78-739)	295 (158-440)	86	274 (73-733)	274 (152-408)	100%	100%	100%
Marsh Creek	27	67 (1-507)	115 (67-182)	27	69 (0- 497)	105 (61-165)	100%	100%	100%
Sulphur Creek	9	20 (0-102)	45 (15-126)	9	20 (0-102)	43 (14-118)	100%	100%	100%
Loon Creek	7	67 (15-635)	37 (19–100)	7	65 (14–611)	34 (18–94)	100%	100%	100%
Camas Creek	7	34 (9-294)	89 (41-291)	7	33 (9-282)	83 (39-263)	100%	100%	100%
Big Creek	29	121 (49–690)	109 (44–248)	29	117 (46–662)	101 (42–233)	100%	100%	100%
Chamberlain Cr	150	184 (23-1329)	471 (360–558)	150	179 (23-1308)	437 (321-517)	100%	100%	100%
Upper Salmon									
Lower Salmon Mainstem	32	97 (44-231)	118 (94-221)	32	82 (37-195)	100 (79-186)	100%	100%	100%
Lemhi River	25	141 (69–607)	53 (38–74)	25	139 (69–582)	53 (38–73)	100%	100%	100%
Pahsimeroi River	49	126 (72-306)	266 (139-633)	11	96 (72–233)	156 (80-316)	39%	58%	68%
Upper Salmon Mainstem	82	214 (83-1108)	380 (187-638)	67	203 (98-567)	263 (152-408)	83%	78%	79%
East Fork Salmon	43	137 (79-402)	214 (77-385)	26	114 (60-354)	188 (68-339	61%	95%	100%
Valley Creek	12	43 (14–177)	81 (54–163)	12	42 (13-171)	79 (53–158)	100%	100%	100%
Yankee Fork	6	15 (2-95)	24 (4-341)	6	14 (2-90)	23 (4-324)	100%	100%	100%

The Middle Fork and the Upper Salmon MPGs have the most populations with relatively large increases although each also has a population that decreased by more than 50%. The majority of populations in the South Fork and the Lower Grande Ronde MPGs were within 25% of the geometric mean abundance estimates (1997-2001) reported in Good et al. (2005).

2.2.2.2.3. Trends

The general trend in adult salmon returns from 1975 to 1999 was a gradual population decline with episodic oscillations. McClure et al. (2003) estimated the mean population growth rate from 1965 through 2000 for spring/summer Chinook salmon to be from 0.93 to 0.97, depending on the amount of error from hatchery fish counted as wild fish. A population growth rate slightly less than 1.0 is characteristic of a gradual decline in population size, where the population will eventually become extinct unless factors causing the decline are remedied. However, since the year 2000 and since McClure et al.'s (2003) work, there have been a number of years with higher spring/summer Chinook salmon returns, and the 5-year average (2005-2009) has risen to 45,895 adults over LGR. The Supplemental Comprehensive Analysis (NMFS 2008e) states that abundance has been stable or increasing on average over the last 20 years (Figure **4**).

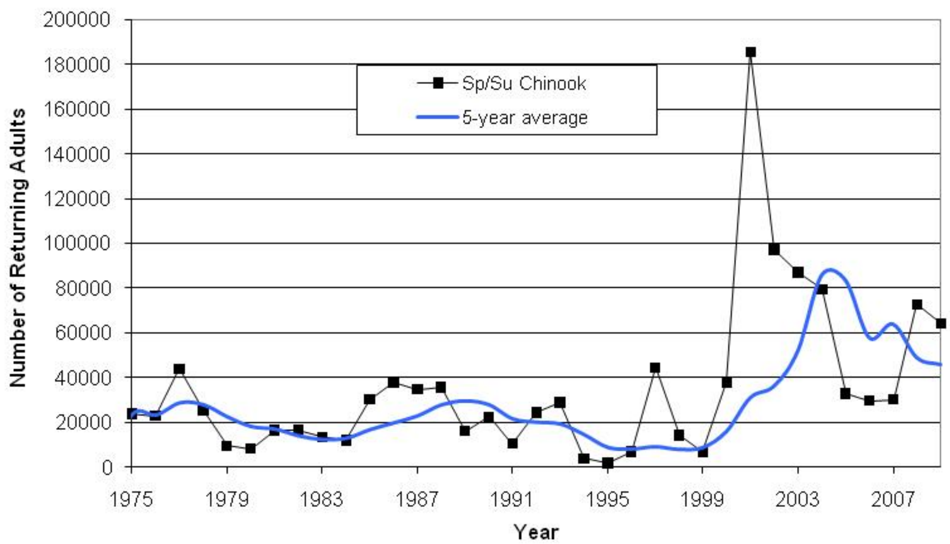

Figure 4.Number of spring/summer Chinook salmon crossing LGR from 1975 to 2009.

In 2010, 122,981 Snake River spring/summer Chinook salmon passed over LGR.

The previous BRT review (Good et al. 2005) analyzed abundance data series compiled for a set of index areas distributed across the ESU. Those data series generally covered the period beginning in the early 1960's and ending with the 2001 return year.

The ICTRT coordinated the development of representative time series for most populations in this ESU using expansions from index area redd counts and weir estimates (Ford et al. 2011). The current ICTRT data series extend the time period of record through at least the 2008 return year for populations across all the MPGs in the Snake River Spring/Summer Chinook salmon ESU.

The overall viability ratings for all the populations in the Snake River Spring/Summer Chinook salmon ESU remain at High Risk after the addition of more recent-year abundance and productivity data. Under the approach recommended by the ICTRT, the overall rating for an ESU depends upon population level ratings organized by MPG within that ESU. The following brief summaries describe the current status of populations within each of the extant MPGs in the ESU, contrasting the current ratings with assessments previously done by the ICTRT using data through the 2003 return year.

Short-term population trends in total spawner abundance were generally positive over the period 1995 to 2008, with some differences in magnitude for populations within different MPGs. Trends for most populations in the Middle Fork and Upper Salmon MPGs are strongly positive. Two populations in the Middle Fork MPG (Marsh Creek and Loon Creek) along with one (Lemhi River) in the Upper Salmon MPG had relatively flat trends in total abundance since 1995. Short-term trends in total abundance for the South Fork MPG were also positive but at lower levels than in the Middle Fork and Upper Salmon MPGs, with the exception of a relatively strong trend in the East Fork South Fork population. In the Grande Ronde MPG, three of the populations exhibited moderately positive trends, the remaining three had relatively flat or slightly negative trajectories in total spawning abundance since 1995. The single extant population in the Lower Snake MPG, the Tucannon River, had a strongly positive trend. Relative to the short-term trends corresponding to the time periods analyzed by the 2005 BRT, updated trends are higher for a majority of the populations. For three populations (Catherine Creek, Imnaha River, and Lemhi River), the most recent short-term trends were slightly positive but are substantially below the prior estimates.

The generally positive short-term trend indices are largely driven by a common temporal pattern in the spawning abundance estimates across populations in this ESU. The starting point for the current short-term trend index is 1995, which corresponds to an extreme low in returns within almost all the individual population series. Those low returns were the result of extremely low survivals for production from the 1990-1991 brood years. The series also include relatively high abundance estimates in 2001-2003, reflecting the above average survivals for production from spawning in the late 1990s. Spawning escapements in the most recent years in each series are generally well below the peak returns but above the extreme low levels in the mid-1990s. Relatively long time series of annual spawning abundance are available for most extant Snake River spring/summer Chinook salmon populations. Recent return levels are consistently lower than returns in the early years across all series. When expressed as an average annual rate for each population, the decline in spawning escapements averages from 3% to 13% per year. Additional details on specific MPGs are presented in the following sections.

2.2.2.2.4. Lower Snake MPG

Abundance and productivity remain the major concern for the Tucannon River population. Natural spawning abundance (10-year geometric mean) has increased but remains well below the minimum abundance threshold for the single extant population in this MPG. Poor natural productivity continues to be a major concern (Ford et al. 2011).

2.2.2.2.5. Grande Ronde/Imnaha MPG

The Wenaha, Lostine/Wallowa and Minam River populations showed substantial increases in natural abundance relative to the previous ICTRT review, although each remains below their respective minimum abundance thresholds. Geometric mean productivity estimates remain relatively low for all populations in the MPG. The Upper Grande Ronde population is rated at high risk for spatial structure and diversity while the remaining populations are rated at moderate (Ford et al. 2011).

2.2.2.2.6. South Fork Salmon MPG

Natural spawning abundance (10 year geometric mean) estimates increased for the three populations with available data series. Productivity estimates for these populations are generally higher than estimates for populations in other MPGs within the ESU. Viability ratings based on the combined estimates of abundance and productivity remain at high risk, although the survival/capacity gaps relative to moderate and low risk viability curves are smaller than for other ESU populations. Spatial structure/diversity risks are rated moderate for the South Fork mainstem population (relatively high proportion of hatchery spawners) and low for the Secesh River and East Fork South Fork populations (Ford et al. 2011).

2.2.2.2.7. Middle Fork Salmon MPG

Natural-origin abundance and productivity remains extremely low for populations within this MPG. As in the previous ICTRT assessment, abundance and productivity estimates for Bear Valley Creek and Chamberlain Creek (limited data series) are the closest to meeting viability minimums among populations in the MPG. Spatial structure/diversity risk ratings for Middle Fork populations are generally moderate, largely driven by moderate ratings for genetic structure assigned by the ICTRT because of uncertainty arising from the lack of direct samples from within the component populations (Ford et al. 2011).

2.2.2.2.8. Upper Salmon MPG

Abundance and productivity estimates for most populations within this MPG remain at very low levels relative to viability objectives. The Upper Salmon River mainstem has the highest relative abundance and productivity combination of populations within the MPG. Spatial structure/diversity risk (SS/D) ratings vary considerably across the MPG. Four of the eight populations are rated at low or moderate risk for overall spatial structure and diversity and could achieve viable status with improvements in average abundance/productivity. The high SS/D risk rating for the Lemhi population is driven by a substantial loss of access to tributary spawning/rearing habitats and the associated reduction in life history diversity. High SS/D ratings for Pahsimeroi River, East Fork Upper Salmon, and Yankee Fork are driven by a combination of habitat loss and diversity concerns related to low natural abundance combined with chronically high proportions of hatchery spawners in natural areas (Ford et al. 2011).

2.2.2.2.9. Limiting Factors and Threats

Limiting factors for the Snake River spring/summer Chinook salmon include the federal and private hydropower projects, predation, harvest, the estuary, and tributary habitat. Ocean conditions have also affected the status of this ESU. These conditions have been generally poor for this ESU over the at least the last four brood cycles, improving only in the last few years.

2.2.2.2.10. Status of Snake River Spring/Summer Chinook salmon Critical Habitat

Designated critical habitat for Snake River spring/summer Chinook salmon includes all Columbia River estuarine areas and river reaches proceeding 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 (NMFS 1993). Critical habitat also includes river reaches presently or historically accessible (except those above impassable natural falls, including Napias Creek Falls, and Dworshak and Hells Canyon dams) in the following subbasins: Hells Canyon, Imnaha, Lemhi, Little Salmon, Lower Grande Ronde, Lower Middle Fork Salmon, Lower Salmon, Lower Snake-Asotin, Lower Snake-Tucannon, Middle Salmon-Chamberlain, Middle Salmon-Panther, Pahsimeroi, South Fork Salmon, Upper Middle Fork Salmon, Upper Grande Ronde, Upper Salmon, and Wallowa. The Lower Columbia River corridor is among the areas of high conservation value to the ESU because it connects every population with the ocean and is used by rearing/migrating juveniles and migrating adults. The Columbia River estuary is a unique and essential area for juveniles and adults making the physiological transition between life in freshwater and marine habitats. 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) (NMFS 1993). Designation did not involve rating the conservation value of specific watersheds as was done in subsequent designations (NMFS 2005a).

The general trend of status of critical habitat for all species is included in Section 2.2.1.

2.2.3. Snake River Steelhead DPS

Snake River Basin steelhead were listed as threatened in 1997 (62 FR 43937). The listing was revised in 2006 (71 FR 834), after a review of the relationship between wild steelhead, hatchery steelhead, and resident rainbow trout. The revised Snake River Basin Steelhead DPS includes all natural-origin populations of steelhead in the Snake River Basin of southeast Washington, northeast Oregon, and Idaho, and six hatchery programs, and includes fish from four programs in Idaho (Dworshak National Fish Hatchery, Lolo Creek, North Fork Clearwater, and East Fork Salmon River).

The species *Oncorhynchus mykiss* exists both as a resident form that lives only in freshwater (rainbow trout) and an anadromous form that spawns in freshwater and matures in the ocean (steelhead). NMFS has defined DPSs of steelhead to include only the anadromous members of the species (NMFS 2005b). Our approach to assessing the current status of a steelhead DPS is based on evaluating information about the abundance, productivity, spatial structure, and diversity of the anadromous component of this species (Good et al. 2005; NMFS 2005b). Many steelhead (*O. mykiss)* populations along the West Coast of the U.S. co-occur with conspecific populations of resident rainbow trout. We recognize that there may be situations where reproductive contributions from resident rainbow trout may mitigate short-term extinction risk for some steelhead DPSs (Good et al. 2005; NMFS 2005b). We assume that any benefits to an anadromous population resulting from the presence of a conspecific resident form will be reflected in direct measures of the current status of the anadromous form.

2.2.3.1. Life History

Like all salmonid species, steelhead are cold-water fish (Magnuson et al. 1979) that survive in a relatively narrow range of temperatures, which limits the species distribution in fresh water to northern latitudes and high elevations. Adult Snake River steelhead return to the Snake River Basin from late summer through fall, where they hold in larger rivers for several months before moving upstream into smaller tributaries. Steelhead live primarily off stored energy during the holding period, with little or no active feeding (Shapavolov and Taft 1954; Laufle et al. 1986). Adult dispersal toward spawning areas varies with elevation, with the majority of adults dispersing into tributaries from March through May, with earlier dispersal at lower elevations, and later dispersal at higher elevations. Spawning begins shortly after fish reach spawning areas, which is typically during a rising hydrograph and prior to peak flows (Thurow 1987).

Steelhead typically select spawning areas at the downstream end of pools, in gravels ranging in size from 0.5 to 4.5 inches in diameter (Laufle et al. 1986). Juveniles emerge from redds in 4 to 8 weeks, depending on temperature. After emergence, fry have poor swimming ability. Steelhead fry initially move from the redds into shallow, low-velocity areas in side channels and along channel margins to escape high velocities and predators (Everest and Chapman 1972), and progressively move toward deeper water as they grow in size (Bjornn and Reiser 1991). Juveniles typically reside in fresh water for 2 to 3 years, or longer, depending on temperature and growth rate (Mullan et al. 1992). Juvenile steelhead in the Snake Basin appear to reside in fresh water for no more than 2 years, a conclusion based on the absence or low numbers of *O. mykiss* greater than 2 years of age in inventories by Chandler and Richardson (2005), Kucera and Johnson (1986), and Fuller et al. (1984). Smolts migrate downstream during spring runoff, which occurs from March to mid-June in the Snake River Basin, depending on elevation.

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

2.2.3.2. Population Structure

The Interior Columbia Basin Technical Recovery Team (ICTRT) identified 24 extant populations within this DPS (Table 9), organized into 5 MPGs (ICTRT 2003). The ICTRT also identified a number of potential historical populations associated with tributary habitat above the Hells Canyon Dam complex on the mainstem Snake River, a barrier to anadromous migration. In addition, the ICTRT concluded that small tributaries entering the mainstem Snake River below Hells Canyon Dam may have historically been part of a larger population with a core area now cut off from anadromous access. That population would have been part of one of the historical upstream MPGs.

All populations in this DPS return in the summer and are therefore referred to as "summer-run," in contrast to "winter-run" steelhead in some other DPSs. Inland steelhead in the Columbia River Basin are commonly referred to as either A-run or B-run, based on migration timing and differences in age and size at return. A-run steelhead are believed to occur throughout the steelhead streams in the Snake River Basin, and B-run steelhead are thought to reproduce only in the Clearwater and Salmon rivers.

With the exception of the Tucannon River, all the populations within this DPS are associated with tributaries above LGR. Annual counts of steelhead passing LGR along with estimates of the relative proportions of hatchery and natural-origin are available and can be used as an index of trends in aggregate production.

Table 9. Characteristics of MPGs and independent populations for the Snake River Basin Steelhead DPS.

MPG	Population	Life History	Size & Complexity	Threshold Abundance	Minimum Productivity	Population Viability Rating
Lower Snake	Tucannon	A-Run	Intermediate	1,000	1.2	High Risk
	Asotin	A-Run	Intermediate	1,000	1.14	High Risk
Imnaha River	Imnaha River	A-Run	Intermediate	1,000	1.15	Maintained
Grande Ronde	Upper Mainstem	A-Run	Large	1,500	1.10	Maintained
	Lower Mainstem	A-Run	Intermediate	1,000	1.14	Viable/Maint.
	Joseph Creek	A-Run	Basic	500	1.27	Highly Viable
	Wallowa River	A-Run	Intermediate	1,000	1.15	Maintained
Clearwater River	Lower Mainstem River	A-Run	Large	1,500	1.14	Maintained
	North Fork Clearwater	B-Run	Very Large	-	-	Extirpated
	Lolo Creek	A & B-Run	Basic	500	1.14	High Risk
	Lochsa River	B-Run	Intermediate	1,000	1.14	High Risk
	Selway River	B-Run	Intermediate	1,000	1.14	High Risk
	South Fork Clearwater	B-Run	Intermediate	1,000	1.14	High Risk
Salmon River	Little Salmon/Rapid	A-Run	Basic	500	1.27	Maintained
	Chamberlain Creek	A-Run	Basic	500	1.27	High Risk
	Secesh River	B-Run	Basic	500	1.27	High Risk
	South Fork Salmon	B-Run	Intermediate	1,000	1.14	High Risk
	Panther Creek	A-Run	Basic	500	1.27	High Risk
	Lower Middle Fork	B-Run	Intermediate	1,000	1.14	High Risk
	Upper Middle Fork	B-Run	Intermediate	1,000	1.14	High Risk
	North Fork	A-Run	Basic	500	1.27	Maintained

MPG	Population	Life History	Size & Complexity	Threshold Abundance	Minimum Productivity	Population Viability Rating
	Lemhi River	A-Run	Intermediate	1,000	1.14	Maintained
	Pahsimeroi River	A-Run	Intermediate	1,000	1.14	Maintained
	East Fork Salmon	A-Run	Intermediate	1,000	1.14	Maintained
	Upper Mainstem	A-Run	Intermediate	1,000	1.14	Maintained

2.2.3.2.1. Lower Snake MPG

This MPG includes two populations. The ICTRT example recovery scenario requires that both meet viability criteria, and that one reach high viability.

2.2.3.2.2. Imnaha MPG

This MPG consists of a single population, which the ICTRT example recovery scenario requires to meet high viability criteria.

2.2.3.2.3. Grande Ronde MPG

This MPG includes four populations. The ICTRT example recovery scenario requires that two meet criteria for viability, and one of these to meet high viability criteria. It further stipulates that one of these must be the Upper Grande Ronde population, and the other the Joseph Creek or Lower Grande Ronde population.

2.2.3.2.4. Clearwater MPG

This MPG includes five extant and one extirpated (North Fork Clearwater River) populations. The ICTRT example recovery scenario includes the Lower Clearwater River (large-size) and two out of the following three populations (Lochsa River, Selway River, and South Fork Clearwater River).

2.2.3.2.5. Hells Canyon MPG

This MPG is considered extirpated; however it is still accessible to anadromous fish. If fish in this area are descended from one or more historical populations, maintaining this genetic legacy would contribute to overall ESU diversity in light of the limited distribution and size of extant populations (ICTRT 2007a) though this area represents only a small portion of the MPG.

2.2.3.2.6. Salmon River MPG

This relatively large MPG includes 11 extant and 1 extirpated (Panther Creek) populations. The ICTRT example recovery scenario for this MPG includes consideration for historical population size, inclusion of both major life history patterns (A- and B-run timing), and achieving a distribution of viable populations across the region occupied by extant populations. The scenario includes Chamberlain Creek, the Upper Middle Fork, and the South Fork populations along with three additional populations, at least two of which should be large or intermediate in size.

2.2.3.3. DPS Trends

The two-population level data sets available for the DPS both show a drop in total abundance since the previous review (Upper Grand Ronde and Joseph Creek) (Ford et al. 2011). Natural-origin abundance in Joseph Creek is also down relative to the previous review, while natural-origin abundance for the Upper Grande Ronde River is up. Both populations have relatively high proportions of natural-origin spawners.

The most recent five-year geometric mean total run (wild plus hatchery-origin) to LGR was up substantially from the corresponding estimates for the prior BRT review and the time period leading up to listing (Ford et al. 2011). Natural-origin and hatchery-origin returns each showed increases, although hatchery fish increased at a higher rate. Both the aggregate A-run and B-run estimates have increased relative to the levels associated with prior assessments. A large proportion of the hatchery run over LGR returns to hatchery racks or is removed by hatchery-selective harvest before reaching spawning areas. As a result, the hatchery proportions in the aggregate run over LGR are not indicative of the proportions in spawning escapements into most population tributaries. Monitoring the relative contribution of hatchery returns to spawning in natural areas, particularly those areas near major hatchery release sites is a high priority for improving future assessments in the DPS.

Longer-term trend estimates for the populations differ slightly (Ford et al. 2011). Both series begin with estimates for the early 1970s and extend through 2009. The average trend over the full time period was a negative 1 to 5% per year for the Upper Grande Ronde and a positive 1-4% per year for Joseph Creek across the range of long-term trend metrics. Estimates of annual spawning escapements into the Upper Grande Ronde River fluctuated around lower levels for a prolonged period except for a peak in the mid-1980s and an increase in the most recent two years. Estimated escapements in Joseph Creek were generally lower in the 1970s, and fluctuated around higher levels after also peaking in the mid-1980s. The aggregate LGR abundance estimates are available for years back to 1986-87 cycle. The general trend in returns has been slightly positive across all groups.

Population-specific adult population abundance is generally not available for Snake River Basin steelhead due to difficulties conducting surveys in much of their range. However, to supplement the few population-specific estimates that are available, the ICTRT used LGR counts of A-run and B-run steelhead and apportioned those to A-run and B-run populations proportional to intrinsic potential habitat (Ford et al. 2011). The TRT generated 10-year geometric mean abundance estimates for two populations in the Grande Ronde MPG and reported average A-run and average B-run abundance as an indicator for the other populations. Abundance data for individual populations and MPGs for the Snake River Basin Steelhead DPS are further discussed in Ford et al. (2011).

Figure 5 shows the 1975 to most recent abundance and 5-year trend averages for the aggregate of all steelhead populations above LGR. The yearly returns have been increasing since 1975, with peaks in 1986, 1989, and 1992, and very strong peaks in 2001 and 2009. The 2009 adult return was substantially higher than any return during the 1975 to 2009 period. The 5-year trend average has also been steadily increasing, with a general increase beginning about 1980, and then a stronger increase beginning in 2001. Natural-origin adults have experienced a similar increase in yearly returns.

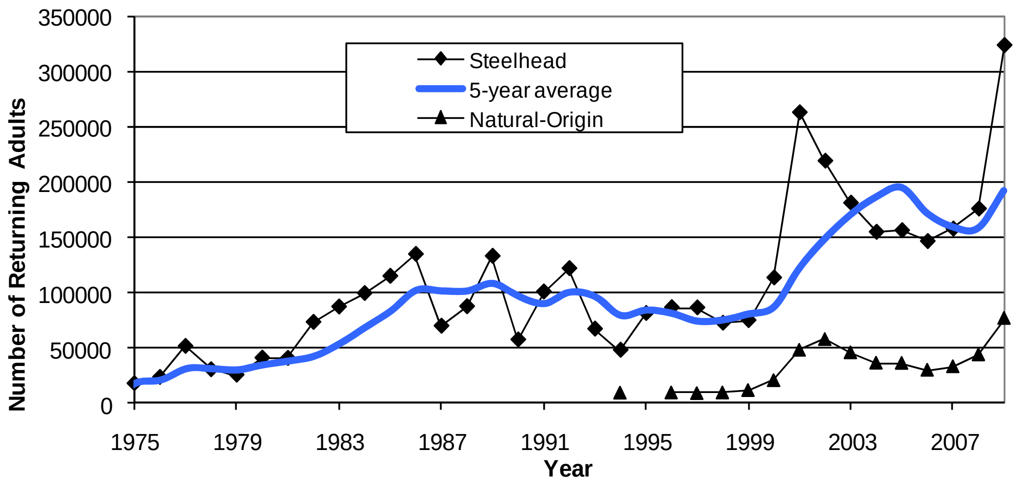

Figure 5. Snake River Basin Steelhead DPS Abundance and 5-Year Average at LGR.

The 10-year average of all adult steelhead passing LGR from 2000 to 2009 is 188,715 adults while the 10-year average for natural-origin steelhead for the same period is 42,576 adults. The latest 10-year averages have been increased substantially by higher returns since 2001, and particularly by the 2009 run, which had 323,388 total steelhead and 76,121 natural-origin steelhead crossing LGR.

The current status summaries (Ford et al. 2011) characterize the long-term (100-year) extinction risk – calculated from productivity and natural-origin abundance estimates of populations for R/S productivity estimates – as "High" (>25% 100-year extinction risk) for all eight B-run populations and three (of 16) A-run populations. The TRT defines the quasi-extinction threshold (QET) for 100-year extinction risk as fewer than 50 spawners in four consecutive years in these analyses (QET=50) (Ford et al. 2011). Most A-run populations are characterized as having "moderate" risk (6% to 25% 100-year extinction risk). One A-run population in the Grande Ronde MPG (Joseph Creek) is characterized as having a "very low" risk of long-term extinction (<1% risk).

2.2.3.4.Limiting Factors and Threats

Historically, the key limiting factors for the Snake River Basin steelhead included hydropower projects, predation, harvest, hatchery effects, and tributary habitat. Ocean conditions have also affected the status of this DPS. Ocean conditions generally have been poor over at least the last 20 years, improving only in the last few years.

2.2.3.5. Status of Snake River Steelhead Critical Habitat

Designated critical habitat for the Snake River steelhead DPS includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence of the Columbia and Snake rivers as well as specific stream reaches in the following subbasins: Hells Canyon, Imnaha River, Lower Snake/Asotin, Upper Grande Ronde River, Wallowa River, Lower Grande Ronde, Lower Snake/Tucannon, Lower Snake River, Upper Salmon, Pahsimeroi, Middle Salmon-Panther, Lemhi, Upper Middle Fork Salmon, Lower Middle Fork Salmon, Middle Salmon-Chamberlain, South Fork Salmon, Lower Salmon, Little Salmon, Upper Selway, Lower Selway, Lochsa, Middle Fork Clearwater, South Fork Clearwater, and Clearwater (NMFS 2005b).

The general trend of status of critical habitat for all species is included in Section 2.2.1.

2.2.4. Snake River Sockeye Salmon ESU

Snake River sockeye salmon (*O. nerka*) are listed as endangered under the ESA, and is the most imperiled species in the northwest region and the Columbia River Basin. This ESU includes all anadromous and residual sockeye salmon from the Snake River Basin, Idaho, as well as artificially propagated sockeye salmon from the Redfish Lake Captive Broodstock Program. The Snake River Sockeye Salmon ESU comprises a single MPG and a single aggregate population that spawns and rears in Redfish, Pettit, and Alturas lakes in the Sawtooth Valley. This population aggregate is the last remaining in a group of what were likely to have been independent populations occupying the Sawtooth Valley lakes. The Snake River Sockeye Salmon ESU was listed as endangered in 1991, and reaffirmed as endangered in 2005 (NMFS 2005b) .

2.2.4.1. Life History

Adult sockeye salmon enter the Columbia River in late-May through July and normally pass Bonneville Dam from June 1 to July 31, and LGR from June 25 to August 30, on their 900-mile migration to their spawning grounds of the Upper Salmon River near Stanley, Idaho. Adult Snake River sockeye salmon arrive at Redfish Lake in August and September. The adults are lake spawners, spawning along the lake shoals. Juveniles typically rear in the lake for 1 to 3 years after emergence from the gravel.

Juvenile sockeye salmon migrate from the Sawtooth Valley lakes during late April through May. Pit-tagged smolts from Redfish Lake generally pass LGR during mid-May to mid-July. Anadromous sockeye salmon may spend from 1 to 4-years in the ocean before returning to fresh water to spawn. Although sockeye salmon are primarily anadromous, some populations that spend their entire life cycle in fresh water without a period in the ocean. Unlike steelhead, the resident form of Snake River sockeye salmon is included in the ESU (NMFS 2005b).

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

2.2.4.2.Critical Habitat for Snake River Sockeye Salmon

The designated critical habitat for Snake River sockeye salmon includes all Columbia River estuarine areas and river reaches upstream to the confluence of the Columbia and Snake rivers; all Snake River reaches from the confluence of the Columbia River upstream to the confluence of the Salmon River; all Salmon River reaches from the confluence of the Snake River upstream to Alturas Lake Creek; Stanley, Redfish, Yellow Belly, Pettit, and Alturas lakes (including their inlet and outlet creeks); Alturas Lake Creek; and that portion of Valley Creek between Stanley and Lake Creek and the Salmon River.

The general trend of status of critical habitat for all species is included in Section 2.2.1 above.

2.2.4.3. Trends

Sockeye salmon were historically numerous in many areas of the Snake River Basin. However, intense commercial harvest of sockeye along with other salmon species beginning in the mid-1880s, the existence of Sunbeam Dam as a migration barrier between 1910 and the early 1930s, the eradication of sockeye from Sawtooth Valley lakes in the 1950s and 1960s, the development of mainstem hydropower projects on the Lower Snake and Columbia rivers in the 1970s and 1980s, and poor ocean conditions in 1977 through the late 1990s probably combined to reduce the stock to a very small remnant population.

By the time Snake River sockeye salmon were listed in 1991, the species had declined to the point that there was no longer a self-sustaining, naturally-spawning anadromous sockeye salmon population. It is not yet clear whether the existing program retains sufficient genetic diversity to successfully adapt to the range of variable conditions that occur within its natural habitat; however, the program has been successful in its goals of preserving important lineages of Redfish Lake sockeye salmon and in preventing extinction in the near term. The broodstock program reduces the risk of domestication by using a spread-the-risk strategy by outplanting prespawning adults and fertilized eyed eggs, as well as juveniles raised in the hatchery.

The ICTRT considers this species to be at very high risk of extinction. The extremely low number of natural spawners and reliance on the captive broodstock program illustrates the high degree of risk faced by this population. Between 1991 and 1998, all 16 of the natural-origin adult sockeye salmon that returned to the weir at Redfish Lake were incorporated into the Redfish Lake Captive Broodstock Program for Redfish and the other Sawtooth Valley lakes. The program has used multiple rearing sites to minimize chances of catastrophic loss of broodstock and has produced several hundred thousand eggs and juveniles, as well as several hundred adults, for release. The broodstock program reduces the risk of domestication by using a spread-the-risk strategy, by outplanting prespawning adults and fertilized eyed eggs as well as raising juveniles in the hatchery.

Although residual sockeye salmon have been identified in Redfish and Pettit lakes, adults produced through the captive propagation program support most of the ESU. The progeny of adults that spawn in the lakes and juveniles that hatch successfully from the eyed eggs are likely to have adapted to the lake environment rather than become "domesticated" to hatchery rearing conditions.

Sockeye salmon returned in comparatively large numbers in 2008 and 2009. Figure 6 shows the numbers of sockeye salmon crossing LGR from 1975 to 2009. The count over LGR for 2010 was 2,201, which is the largest return in the last 25 years (Ford et al. 2011).

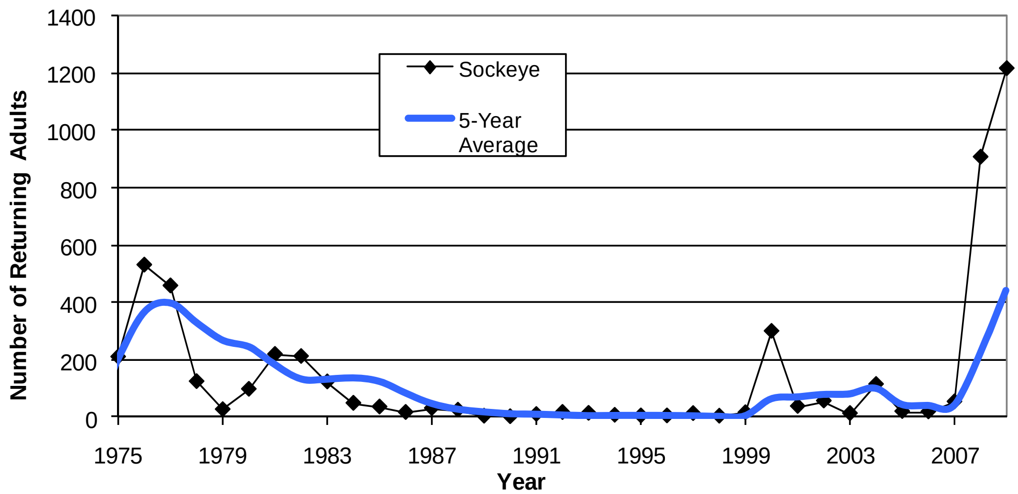

Figure 6. Numbers of sockeye salmon crossing Lower Granite Dam from 1975 to 2009.

2.2.4.4.Limiting Factors and Threats

The largest factor limiting the recovery of this ESU is risk due to catastrophic loss and loss of genetic diversity, because of the severe decline in abundance. It is not yet clear whether the existing population retains sufficient genetic diversity to successfully adapt to the range of variable conditions that occur within its natural habitat. However, based on pedigree data, it appears that 95% of the genetic variation originally present in the sockeye population has been preserved in the captive brood program, and in that sense the program has been more successful than several other captive breeding programs for endangered species (Kalinowski et al. 2012). More detailed discussion of limiting factors and threats can be found in the Environmental Baseline section (2.3).

2.2.4.5. Status of Snake River Sockeye Salmon Critical Habitat

Designated critical habitat for SR sockeye salmon includes: all Columbia River estuarine areas and river reaches proceeding upstream to the confluence of the Columbia and Snake rivers; all

Snake River reaches from the confluence of the Columbia River upstream to the confluence of the Salmon River; all Salmon River reaches from the confluence of the Snake River upstream to Alturas Lake Creek; Stanley, Redfish, Yellow Belly, Pettit, and Alturas lakes (including their inlet and outlet creeks); Alturas Lake Creek; and that portion of Valley Creek between Stanley Lake Creek and the Salmon River (NMFS 1993). The Lower Columbia River corridor is among the areas of high conservation value to the ESU because it connects every population with the ocean and is used by rearing/migrating juveniles and migrating adults. The Columbia River estuary is a unique and essential area for juveniles and adults making the physiological transition between life in freshwater and marine habitats. 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) (NMFS 1993). Designation did not involve rating the conservation value of specific watersheds as was done in subsequent designations (NMFS 2005a).

The general trend for critical habitat for all species is included in Section 2.2.1 above.

2.2.5. Summary of Snake River Salmon and Steelhead Status and Trends

In summary, habitat loss and modification are believed to be major factors determining the status of salmonid populations. Conservation and recovery of Pacific Northwest salmon and steelhead depend on having diverse habitats with connections among those habitats. The salmonid life cycle involves adults maturing in the ocean, migrating back to their home streams and spawning, embryos incubating, fry emerging, juveniles growing, and smolts migrating to the estuary to acclimate to saltwater and moving out into the ocean. Each phase may require use of and access to distinct habitats. Loss of habitat reduces the diversity in salmon and steelhead life histories, which influences the ability of these fish to adapt to natural and man-made change. Salmon and steelhead need freshwater habitat that includes:

- Cool, clean water
- Appropriate water depth, quantity and flow velocities
- Upland and riparian (stream bank) vegetation to stabilize soil and provide shade
- Clean gravel for spawning and egg-rearing
- Large woody debris to provide resting and hiding places
- Adequate food
- Varied channel forms

Overall, the extinction risk for Snake River salmon and steelhead remains high, but abundance of all three species described in this opinion has increased in the past decade. Such increases need to be sustained for several generations to diminish the extinction risk and to withstand severe downturns in population size from climate anomalies or other natural events.

2.2.6. Climate Change

Climate change is likely to have negative implications for the conservation value of designated critical habitats in the Pacific Northwest (CIG 2004; Scheuerell and Williams 2005; Zabel et al. 2006; ISAB 2007). Average annual Northwest air temperatures have increased by about 1ºC since 1900 or about 50% more than the global average warming 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, these effects may have the following physical impacts within about the next 40 years (ISAB 2007):

- Warmer air temperatures will result in a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a shift to more rain and less snow, the snow packs will diminish in those areas that typically accumulate and store water until the spring freshet.
- With a smaller snowpack, these watersheds will see their runoff diminished and exhausted 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 will continue to rise, especially during the summer months when lower stream flow and warmer air temperatures will contribute to the warming regional waters.

These changes will not be spatially homogeneous across the entire Pacific Northwest. Areas with elevations high enough to maintain temperatures well below freezing for most of the winter and early spring will be less affected. Low-lying areas that historically have received scant precipitation contribute little to total streamflow and are likely to be more affected. Project climate changes may have long-term effects that include, but are not limited to, depletion of cold water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, premature emergence of fry, and increased competition among species (ISAB 2007).

To mitigate for the effects of climate change on listed salmonids, the ISAB recommends planning now for future climate conditions by implementing protective tributary, mainstem, and estuarine habitat measures, as well as protective hydropower mitigation measures. Recommendations include increased summer flow augmentation from cool/cold storage reservoirs to reduce water temperatures or to create cool water refugia in mainstem reservoirs and the estuary; the protection and restoration of riparian buffers, wetlands, and floodplains; removal of stream barriers; implementation of fish ladders; and assurance of high summer and autumn flows.

2.3. Environmental Baseline

The "environmental baseline" includes the past and present impacts of all federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

The discussion of the environmental baseline for this action takes place in the greater context of the environmental baseline discussed in detail in Chapter 5 of the Supplemental Comprehensive Analysis (SCA), which NMFS hereby incorporates by reference (NMFS 2008e, Chapter 5). Chapter 5 of the SCA provides 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. In addition, chapter 5 of the SCA evaluates the effects of those ongoing actions on designated critical habitat. In this section of the opinion, NMFS updates the SCA's analysis of the effects of past and ongoing human and natural factors on the current status of the species, their habitats, and the associated ecosystems for those aspects of the environment that apply to the current proposed action and action area.

In addition to Chapter 5 of the SCA (NMFS 2008e), the environmental baseline for this opinion includes relevant actions and their effects, from the FCRPS and Reclamation biological opinion, as well as the biological opinion associated with the 2008 *U.S. v. Oregon* Agreement (NMFS 2008d; NMFS 2008c).

2.3.1. Hydropower System Effects

General information on the effects of past and continuing operation of dams and reservoirs located in the mainstem Columbia and Snake rivers' migratory corridor on listed species of salmon and steelhead and their designated critical habitat can be found in the SCA of the FCRPS opinion (NMFS 2008e). The majority of the FCRPS effects occur outside of the action area considered in this opinion. However, the action area is strongly influenced by the four Lower Snake dams, and the three Hells Canyon dams. The four Snake River fall Chinook salmon hatchery programs in the proposed action all were developed to compensate for losses caused by the hydropower system.

Effects of the hydropower system relevant to the proposed action area are: blocked and inundated habitat effects; mainstem and migratory corridor effects including juvenile passage delays and mortality and juvenile transport projects, and adult passage mortality effects; mainstem hydrologic effects (flow regulation); and mainstem water quality (temperature, turbidity, and pollutants. For details specific to each of these effects, refer to section 5.1 of the SCA.

The four Lower Snake dams: Ice Harbor, Lower Monumental, Little Goose, and Lower Granite, are in the action area. Nearly all populations of listed Snake River salmonids spawn and rear upstream of Lower Granite Dam, the most upstream of the four. Counts of fish at Lower Granite Dam are used as abundance estimates for salmon and steelhead, and form the basis for a number of management decisions. Dworshak Dam is not in the action area, but it plays an important role in the life history of Snake River fall Chinook salmon due to its effects on water temperature in the Clearwater River (Connor et al. 2005; Williams et al. 2008). Hells Canyon Dam is an upstream boundary of the action area, and also plays an important role in temperature and flow in the action area.

Passage improvements throughout the Snake River migration corridor have occurred (NMFS 2011a). Surface passage routes (spillway weirs) for juvenile migrants were installed at Little Goose Dam (2009), Lower Monumental Dam (2007), McNary Dam (two weirs in 2007), and John Day Dam (two weirs in 2008). A spillway wall was installed at The Dalles Dam in 2010 to improve juvenile egress conditions (and survival) downstream of the dam.

Previously installed surface passage routes continue to operate along with voluntary spill at Lower Granite (2003), Ice Harbor (2005), and Bonneville Dam (2004). Voluntary spill for juvenile fall Chinook salmon passage has occurred at the Snake River dams since 2006.

Cool water is released from Dworshak Dam on the North Fork Clearwater River between July and September to reduce temperatures for migrating adults and juvenile fall Chinook salmon. Also, U.S. Bureau of Reclamation and Idaho Power Company release water to augment flows during the summer migration period. Lastly, Idaho Power Company's Hells Canyon Complex is operated to maintain stable spawning flows for fall Chinook salmon and ensure that winter load following operations do not dewater fall Chinook salmon redds.

NMFS feels that all these recent hydro modifications benefit all listed Snake River salmon species, and will into the future if they are continued. However, continuation of flow modifications is not guaranteed.

2.3.2. Habitat Effects

2.3.2.1. General

NMFS funds several large-scale habitat improvement programs that will affect the future status of the species considered in this opinion and their designated critical habitat throughout the region. These programs provide non-federal partners with resources needed to accomplish statutory goals or, in the case of non-governmental organizations, to fulfill conservation objectives. Because projects often involve multiple parties using federal funds, it can be difficult to distinguish between projects with a federal nexus (and, hence, will be explicitly evaluated prior to implementation for effects on ESA-listed species) and those that can be properly described as cumulative effects. Further, many of the actions for which funding has been identified have not yet begun their implementation phases and may still need additional analysis of effects after refinement to their design has occurred. For example, many of the projects submitted by the States of Washington, Oregon, and Idaho actually received funding through the Pacific Coast Salmon Recovery Fund (NMFS 2007b), the Restoration Center Programs (NMFS 2004), or the Mitchell Act-funded Irrigation Diversion Screening Program (NMFS 2000c). NMFS describes the objectives of these programs here, but, to the extent that these programs have not yet been implemented or evaluated under the ESA, their effects will be considered in Section 2.5, Cumulative Effects.

Pacific Coastal Salmon Recovery Fund

Congress established the Pacific Coastal Salmon Recovery Fund (PCSRF) to contribute to the restoration and conservation of Pacific 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 Congressional PCSRF appropriations 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 and conservation. NMFS has established memoranda of understanding (MOUs) with the states of Washington, Oregon, California, Idaho, and

Alaska, and with three tribal commissions on behalf of 28 Indian tribes; Northwest Indian Fisheries Commission, Klamath River Inter-Tribal Fish & Water Commission, and the Columbia River Inter-Tribal Fish Commission. These MOUs establish criteria and processes for funding priority PCSRF projects. The PCSRF has made important progress in achieving program goals, as indicated in Reports to Congress, workshops, and independent reviews.

NOAA Restoration Center Programs

NMFS has consulted with itself on the activities of the NOAA Restoration Center in the Pacific Northwest (NMFS 2004). These include participation in the Damage Assessment and Restoration Program (DARP), Community-based Restoration Program (CRP), and Restoration Research Program. As part of the DARP, the RC participates in pursuing natural resource damage claims and uses the money collected to initiate restoration efforts. The CRP is a financial and technical assistance program which helps communities to implement habitat restoration projects. Projects are selected for funding in a competitive process based on their ecological benefits, technical merit, level of community involvement, and cost-effectiveness. National and regional partners and local organizations contribute matching funds, technical assistance, land, volunteer support or other in-kind services to help citizens carry out restoration.

Mitchell Act-funded Irrigation Diversion Screening Programs

Through annual cooperative agreements, NMFS funds three states agencies to operate, maintain, and construct fish screening facilities at irrigation diversions and to operate and maintain adult fishways (NMFS 2000c). The agreements are with Oregon Department of Fish and Wildlife, Idaho Department of Fish and Game, and Washington Department of Fish and Wildlife. The program also funds research, monitoring, evaluation, and maintenance of existing fishway structures, primarily those associated with diversions.

2.3.2.2. Specific to Snake River Basin

In recent years, significant habitat restoration and protection actions at the federal, state, and local levels have been implemented throughout the Snake River Basin to improve degraded habitat and restore fish passage. While these are expected to benefit the survival and productivity of the targeted populations, ongoing improvements in the monitoring, evaluation, and reporting of habitat metrics and fish population response will be needed to document the effectiveness of habitat restoration actions. Recovery projects throughout the Snake River Basin include:

- Improved fish passage and increased access to high quality habitat
- Riparian vegetation restoration through fencing and planning
- Instream habitat improvements
- Screening of irrigation diversions
- Land acquisitions to protect existing habitat

Most of these projects were accomplished with cooperation and/or funding from: the Washington Salmon Recovery Funding Board (for projects in the SE Washington), NMFS Pacific Coastal Salmon Recovery Fund for projects in all three states, Habitat Conservation Plans, Bonneville Power Administration, U.S. Army Corps of Engineers, U.S. Forest Service, U.S. Bureau of Land

Management, Bureau of Reclamation, the Oregon Watershed Enhancement Board for projects in Northeast Oregon, local Soil and Water Conservation Districts in all three states, and other federal, state, and local landowners. Some of these key habitat improvements that have been implemented since the previous status review include:

- Restoration of stream flows and passage improvements in the Upper Salmon River;
- Designation of fish as a beneficial use for water allocations in Idaho;
- Development and implementation of Snake River Management Unit plans and proposed recovery actions:
- U.S. Natural Resource Conservation Service – Implementation of Wildlife Habitat Incentives Program (WHIP) and Environmental Quality Incentives Program (EQIP) projects in Idaho.
- U.S. Forest Service and Bureau of Land Management –PACFISH /INFISH Biological Opinion improvements in watershed management and annual monitoring of progress.
- Habitat Conservation Plans in Plum Creek, Upper Snake, and Lemhi River Basins.
- Development of the Northeast Oregon Snake River Management Unit Draft Recovery Plan, including identification of priority limiting factors and proposed recovery actions used by partners implementing tributary habitat restoration projects.
- Implementation of FCRPS Reasonable and Prudent Actions by the FCRPS Action Agencies, including analyses identifying priority areas and actions.
- Negotiation and implementation of the Columbia Basin Fish Accords providing funding for restoration and recovery actions.
- Continuation of the BPA-funded Columbia Basin Water Transaction Program to increase stream flow in rivers and streams.
- Continued implementation of fish screening programs for water transfer sites.

In addition, NMFS has streamlined the implementation of restoration activities throughout the region by completing several programmatic ESA section 7 consultations that cover projects implemented that are specifically designed to improve fish habitat (NMFS 2012). Below, we briefly summarize two noteworthy restoration and protection programmatic consultations that have aided in the completion of habitat restoration actions in the Snake River Basin.

Programmatic section 7 consultations with the Army Corps of Engineers (COE) for stream restoration and fish passage authorizing nine categories of actions have been completed (NMFS 2012):

- Boulder placement
- Fish passage restoration
- Spawning gravel restoration
- Large wood restoration
- Off- and side-channel habitat restoration
- Piling removal
- Set-back existing berms, dikes, and levees,
- Stream bank restoration

- Water control structures

Additional section 7 consultations with other federal agencies have been completed that expand on this list of restoration program activity types to a total of 19 types of actions (NMFS 2012):

- Large wood, boulder, and gravel placement
- Reconnection of existing side channels and alcoves
- Head-cut stabilization and associated fish passage
- Bank restoration
- Fish passage culvert and bridge projects
- Irrigation screen installation and replacement
- In-channel nutrient enhancement
- Floodplain overburden removal
- Reduction of recreational impacts
- Estuary restoration
- Riparian vegetation treatment (non-commercial, mechanical)
- Riparian and upland juniper treatment (non-commercial)
- Riparian vegetation treatment (controlled burning)
- Riparian area invasive plant treatment
- Riparian exclusion fencing (with water gaps and stream crossings)
- Riparian vegetation plantings
- Road treatments
- Removal of legacy structures
- Fisheries, hydrology, geomorphology, wildlife, botany, and cultural surveys in support of aquatic restoration.

Other programmatic consultations have been completed for restoration activities within the region, but are focuses on small scale projects in small watersheds. While some water quality benefits may result from the implementation of these actions, most occur where Snake River fall Chinook are unlikely to benefit directly, but may provide benefits to other listed salmon species.

NMFS believes that these projects will benefit the viability of the affected populations by improving abundance, productivity, and spatial structure. Some restoration actions will have negative effects during construction, but these are expected to be minor, occur only at the project scale, and persist for a short time (no more and typically less than a few weeks). Other types of federal projects, including grazing allotments, dock and pier construction, and bank stabilization will be neutral or have short- or even long-term adverse effects on viability.

2.3.3. Hatchery Effects

Hatcheries have operated in the Pacific Northwest for more than a century, providing fish for recreational and commercial fisheries. The first Pacific Northwest hatcheries were built to compensate for declining wild fish populations due to overexploitation, but gradually they began to be used as mitigation for the impact of development on salmon and steelhead populations. All salmon and steelhead hatcheries in the action area were built as mitigation for hydroelectric development. Over the last few decades hatcheries have been increasingly used for population conservation. Hatcheries are a very important feature of salmon and steelhead conservation and management in the Action Area: of the 23.6 million outmigrating juveniles from listed salmon and steelhead populations in the Snake River Basin in 2011, 80% were produced by hatcheries (Dey 2012).

Hatchery production of salmon and steelhead in the Snake River Basin occurs as mitigation for mainstem hydroelectric dam construction and operation. The major hatchery programs are funded through the Lower Snake River Fish and Wildlife Compensation Plan (LSRCP), Bonneville Power Administration (BPA), Idaho Power Company (IPC), Corp of Engineers (COE), and U.S. Fish and Wildlife Service (USFWS).

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 Idaho and 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 Tribe 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 the Idaho Power Company (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 FWS and NPT. BPA directly funds NPTH, and is funding the development of the Crystal Springs Hatchery, which will be operated by the Shoshone-Bannock Tribes, and the Springfield Hatchery, which will be operated by IDFG, 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 (*U.S. v. Oregon* 2008). Production of all species discussed in this opinion may be increased, decreased, or relocated by the *U.S. v. Oregon* parties. However, no major changes are expected during the term of the permits.

Other hatchery consultations in this region have not been completed. Thus, future impacts of these operations are unknown. However, these hatchery operations and any associated effects are ongoing and therefore must be taken into account. Given the differences in spawning and rearing locations between fall Chinook salmon and spring/summer Chinook salmon, sockeye salmon, and steelhead in the Snake River Basin, the bulk of the effects of the proposed action on these three other species is expected to come as a result of ecological interactions in the migration corridor: the mainstem Snake and Clearwater rivers. So the size and timing of releases, and size of fish released, is of critical importance. Expected hatchery releases for 2012 of spring\summer Chinook salmon, steelhead, and sockeye salmon into the Snake River Basin are summarized in Table 10, Table 11, and Table 12, respectively. The pattern of sockeye salmon releases differs from that of the other species in that one release is of eggs, two are of captive brood adults, and one is of returning adults intercepted at LGR and then transported to Redfish Lake. Another difference is that two of the facilities involved – Oxbow and Burley/Manchester – are located outside the Snake River Basin. Multiple rearing locations and multiple life stages at release are strategies specifically intended to reduce the risk of catastrophic events and to enhance diversity of life history during early recovery.

Table 10. Projected 2012 releases (in thousands, rounded to the nearest thousand) of spring and summer Chinook salmon into the Snake River Basin (data supplied by WDFW, IDFG and NPT; compiled by R. Turner, NMFS).

Facility	Number	Run Time	Life Stage	Release size- (fish/lb.)	Release Date	Location
Rapid River	418	Spring	Yearling Smolt	20.0	3/19-3/22	Upper Snake
NPTH	150	Spring	Pre Smolt	34.0	10/3-10/17	Clearwater
NPTH	400	Spring	Parr	117.0	6/25-6/29	MF Clearwater
Clearwater	415	Spring	Yearling Smolt	20.0	April	MF Clearwater
Clearwater	300	Spring	Parr	117.0	July	MF Clearwater
Kooskia	620	Spring	Yearling Smolt	23.0	3/24-4/4	MF Clearwater
Clearwater	642	Spring	Yearling Smolt	16.0	3/22-3/29	MF Clearwater
NPTH	75	Spring	Pre Smolt	29.0	10/2-10/16	SF Clearwater
McCall	106	Summer	Yearling Smolt	27.0	3/14-4/5	SF Clearwater
Clearwater	1,123	Spring	Yearling Smolt	16.0	3/28-4/6	SF Clearwater
Clearwater	206	Summer	Yearling Smolt	16.0	3/26-3/27	SF Clearwater
NPTH	195	Spring	Yearling Smolt	20.0	4/1-4/15	Lower Clearwater
Pahsimeroi	1,033	Summer	Yearling Smolt	15.0	4/1-4/22	Upper Salmon
Sawtooth	1,261	Spring	Yearling Smolt	23.0	4/6	Upper Salmon
Sawtooth	197	Spring	Yearling Smolt	26.0	4/19-4/20	Upper Salmon
McCall	1,022	Summer	Yearling Smolt	18.5	3/22-3/25	SF Salmon
Rapid River	2,700	Spring	Yearling Smolt	20.0	3/12-4/27	Little Salmon
Tucannon	30	Spring	Pre Smolt	65.0	May	Tucannon
Tucannon	225	Spring	Yearling Smolt	11.3	April	Tucannon
Lookingglass	420	Spring	Yearling Smolt	25.0	4/14	Imnaha
Lookingglass	250	Spring	Yearling Smolt	25.0	4/15	U. Grande Ronde
Lookingglass	250	Spring	Yearling Smolt	25.0	4/15	Lostine
Lookingglass	150	Spring	Yearling Smolt	25.0	4/14	Catherine
Lookingglass	250	Spring	Yearling Smolt	20.0	4/14	Lookingglass
Total	**12,438**					

Table 11. Projected 2012 releases (in thousands, rounded to the nearest thousand) of steelhead into the Snake River Basin (data supplied by WDFW, IDFG and NPT; compiled by R. Turner, NMFS).

Facility	Number	Life Stage	Release Size (fish per lb.)	Date	Location
Niagara Springs	527	Yearling Smolt	6.0	3/19-3/27	Upper Snake
Clearwater	727	Yearling Smolt	4.5	4/9-4/13	SF Clearwater
Hagerman	1,407	Yearling Smolt	3.6-4.0	4/13-5/17	Upper Salmon
Magic Valley	1,125	Yearling Smolt	4.5	4/9-5/2	Upper Salmon
Niagara Springs	830	Yearling Smolt	5.0	3/27-4/13	Upper Salmon
Magic Valley	415	Yearling Smolt	4.5	4/13-4/19	Little Salmon
Niagara Springs	425	Yearling Smolt	4.5-5.0	4/16-4/25	Little Salmon
Cottonwood	177	Yearling Smolt	4.5	April	Grande Ronde
Tucannon	202	Yearling Smolt	4.5	April	Lower Snake
Lyons Ferry	141	Yearling Smolt	4.5	April	Lower Snake
Irrigon	215	Yearling Smolt	5.0	4/29	Imnaha
Irrigon	800	Yearling Smolt	4.0	4/10-5/8	Wallowa
Total	**6,991**				

Table 12. Projected 2012 releases of sockeye salmon into the Snake River Basin (data supplied by WDFW, IDFG, and NPT; compiled by R. Turner, NMFS). All release locations are in the Stanley Basin in the Upper Salmon River Basin.

Facility	Number	Life Stage	Release Size (fish per lb.)	Date	Location
Eagle	50,000	Eggs	NA	12/1	Alturas Lake
Eagle	10,000	Subyearling	60	7/12	Redfish Lake
Sawtooth	10,000	Subyearling	80	10/6	Redfish Lake
Sawtooth	10,000	Subyearling	80	10/6	Pettit Lake
Oxbow (Ore.)	85,000	Yearling Smolt	10	5/12	Redfish Lake Cr.
Sawtooth	80,000	Yearling Smolt	20	5/12	Redfish Lake Cr.
Burley Cr./Manchester	175	Adult	0.3	9/10	Redfish Lake
Eagle	405	Adult	0.3	9/10	Redfish Lake
Lower Granite Dam	1,000	Adult	0.3	9/10	Redfish Lake
Total	**246,580**				

2.3.4. Harvest Effects

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 the continuing jurisdiction of the U.S. District Court for the District of Oregon in the case of *U.S. v. Oregon*, No. 68-513 (D. Oregon, continuing jurisdiction case filed in 1968). Harvest effects pertinent to discussion of the environmental baseline are thoroughly addressed in the *U.S. v. Oregon* Harvest Biological Opinion (NMFS 2008c), but we provide a brief discussion here, excerpted from (NMFS 2011d). Table **13** 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 13. Expected incidental take (as proportion of total run-size) of listed anadromous salmonids for non-Indian and treaty Indian fisheries under the *U.S. v. Oregon* 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

While the general principles for quantifying treaty fishing shares are well established, their application to individual runs during the annual spring and fall fishing seasons is complicated. Annual calculations of allowable harvest rates depend (among other things) on estimated run sizes, on the mix of stocks, on application of the ESA to mixed-stock fisheries, on application of the "conservation necessity principle" to regulation of treaty fisheries, and on the effect of both the ESA and the conservation necessity principle on treaty and non-treaty allocations. While the precise quantification of treaty fishing rights during a particular fishing season often cannot be established by a rigid formula, any existing treaty fishing rights remain in force and must be accounted for in the environmental baseline.

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 inriver fisheries can be expressed as exploitation rates. The total exploitation rate for Snake River fall Chinook salmon has declined greatly since the ESA listing. Total exploitation rates averaged 75% from 1986 to 1991, and 45% from 1992 to 2006.

Snake River spring/summer Chinook salmon are grouped for management purposes with Upper Columbia spring Chinook salmon as "upriver" spring Chinook salmon and are not subject to ocean fisheries. Upriver spring Chinook salmon were subject to average harvest rates of 55% from 1938 to 1973. As the stocks declined, it became apparent that these harvest rates were not sustainable. By the mid-1970s, the spring season fisheries that targeted upriver stocks were largely eliminated. Harvest rates in all mainstem commercial, recreational, and ceremonial and subsistence fisheries have averaged just over 8% since then. The last mainstem fisheries targeting upriver summer Chinook salmon stocks, including the summer component of the SR ESU, occurred in 1964. Harvest rates have not exceeded 10% since 1973 and have averaged less than 3% since 1974. In 2005, the management period separating upriver spring and summer Chinook salmon stocks was adjusted. Snake River spring and summer Chinook salmon are now managed as a unit and subject to similar harvest rates.

Steelhead are classified for harvest management purposes as A-run or B-run, based on fork length, with A-run steelhead < 78 cm and B-run steelhead ≥ 78 cm. B-run steelhead generally are subject to higher harvest rates, because they are larger, and thus more susceptible to catch in gillnets, and because their run timing coincides with the timing of the fall Chinook salmon fisheries. The yearly total incidental catch of A-run steelhead in tribal fisheries has averaged 6.4% and has ranged from 4.1-12.4% since 1998. The total yearly incidental catch of A-run steelhead in non-Indian fisheries has averaged 1.6% and has ranged from 1.0 to 1.9% since 1999. The impacts on A-run steelhead from the SR steelhead DPS have benefited from protections provided to B-run steelhead in the *U.S. v. Oregon* Agreement. The incidental take of B-run steelhead from non-treaty fisheries has averaged 1.4% of the run since 1998, and has ranged from 1.1 to 2.0%.The treaty-Indian fall season fisheries impacts for B-run steelhead have averaged 17.9% from 1990 to 2003, and 12.2% from 1998 to 2006.

Since 1986, recreational anglers in the Columbia Basin have been required to release unmarked, wild steelhead. Wild steelhead are still subject to mortality associated with catch-and-release, but implementation of mark-selective fisheries has greatly reduced the impact on wild steelhead from recreational fisheries.

No directed harvest of Snake River sockeye salmon occurs, but they are incidentally taken in Columbia fisheries.

The *U.S. v. Oregon* parties can change harvest rates through the management process, but no substantive change is expected for any species during the period of the permits.

2.4. Effects of the Action on the Species and Designated Critical Habitat

In this section, we evaluate the expected impacts of the proposed action on listed salmon and steelhead in the action area. The steps used in this consultation to evaluate the risks hatchery programs pose to listed species are a refined version of the procedures used in NMFS (2011e) incorporating scientific information that continues to be developed since that prior opinion.

In this section, we will:

1) Describe the general risks that hatchery programs can pose to natural-origin salmon and steelhead (Section 2.4.1), and identify those risks associated with the proposed action that could potentially adversely affect listed salmon and steelhead in the action area.
2) Analyze the impacts on individual listed salmon and steelhead in the action area from each of the hatchery programs, under the risks identified in step 1, above – noting that the effect that each general risk has on natural-origin fish (from no impact to adversely impact) will depend on the program, the program's location, species propagated, and other factors (Section 2.4.1.1).

2.4.1. Factors to be considered

The "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.

As already stated in this opinion (Section 1.3), these proposed hatchery programs originated as mitigation for impacts from hydroelectric development within the Snake and Columbia River Basins to salmon production, and now are an interrelated mix of harvest augmentation and supplementation efforts. In the course of operation these actions will intentionally result in the direct take of listed Snake River fall Chinook salmon and may result in the indirect take of other listed salmon and steelhead. The applicants have proposed protective measures that will minimize the extent of this take. The analysis in Section 2.4.1.1considers whether or not the four hatchery programs pose substantial risk to the likelihood of the continued survival and recovery of the listed salmon and steelhead ESUs/DPSs, or adversely modify their critical habitat. Before that analysis, the remainder of this section summarizes how various aspects hatchery programs can impact naturally produced populations, and what the potential effects of those impacts on individuals, populations, and species might be.

The NMFS biological opinion on eight USFWS hatchery programs (NMFS 2007c) refined a list of general types of adverse effects of hatchery operations and hatchery production on population viability that were developed through a number of salmon and steelhead hatchery consultations

(NMFS et al. 1995; NMFS 1999; NMFS 2002b; NMFS 2002a; NMFS 2003) and from reviews of hatchery programs in the Columbia River Basin and the Northwest: *Upstream: Salmon and Society in the Pacific Northwest* (NRC 1996); *Return to the River: Restoration of Salmonid Fishes in the Columbia River Ecosystem* (ISG 1996); *Review of Salmonid Artificial Production in the Columbia River Basin: As a Scientific Basis for Columbia River Production Programs* (ISAB 1998); *Artificial Production Review – Report and Recommendations of the Northwest Power Planning Council* (NPPC 1999); *A Conceptual Framework for conservation Hatchery Strategies for Pacific Salmonids* (Flagg and Nash 1999); *Hatchery Reform: Principles and Recommendations (HSRG (Hatchery Scientific Review Group) 2004)* ; *Propagated Fish in Resource Management* (Nickum et al. 2005); and a framework for determining hatchery effects (NMFS 2007a). NMFS (2007c) identified the following general risks categories for hatchery programs:(1) operation of hatchery facilities, (2) broodstock collection, (3) genetic introgression, (4) disease, (5) competition/density-dependent effects, (6) predation, (7) residualism, (8) nutrient cycling, (9) masking, (10) fisheries, and (11) monitoring and evaluation/research. NMFS (2007c) goes on to describe these risks in detail and also identifies those measures that could be taken to minimize the effects of these risks on listed species.

Since the completion of the opinion on the USFWS hatchery programs (NMFS 2007c), we have reviewed the 11 general risk categories and modified the list based on the SCA (NMFS 2008e, Appendices C, D, and I) , and on recent published papers (e.g., AHSWG 2008; Fraser 2008; McClure et al. 2008; Naish et al. 2008; Kostow 2009). A revised risk structure was used in the opinion on the Umatilla hatchery programs (NMFS 2011e) and is used here as well. These changes are reflected in the reformation of categories and subcategories of risks associated with hatchery facilities and hatchery production described in Table 14.

Some changes reflect the expanding knowledge of and concern for genetic effects and ecological interactions between hatchery-produced fish and natural-origin populations, while other changes reflect changes in general hatchery practices. For example, masking occurs when returning adult hatchery fish stray into natural spawning areas and cannot be distinguished from natural-origin fish, confounding the ability to determine the annual abundance of naturally produced fish. This can lead to an over-estimation of the actual abundance and productivity of the natural population, and to an inability to assess the health and production potential of the critical habitat for that population. This was a greater risk in the past when only a small percentage of the annual hatchery releases were marked. Beginning in the early 2000s, increased hatchery production for harvest augmentation was externally marked to support selective fisheries and for monitoring escapement to the spawning grounds. The majority of the hatchery production for conservation purposes is now internally marked so that they can avoid harvest in selective fisheries yet can be identified at weirs and on the spawning grounds. Because of the high level of marking that is now occurring in the Columbia River Basin, masking has declined as a major risk to listed populations. Marking has now become a concern primarily because if it is not at levels adequate to meet goals for monitoring the hatchery program and its effects on natural-origin populations (Table 14), so it is more appropriately dealt with as an aspect of monitoring risk.

NMFS reviewed the categories and subcategories of potential effects of hatchery facilities and hatchery production on listed species described in NMFS and determined that the effects of the proposed hatchery programs on listed species are limited to a specific number of categories and subcategories (Table 15). Not all of the other effects would be expected to occur, some would not be measurable, and others were considered in previous consultations. This determination was based on the description of the hatchery programs as provided by the HGMPs, Addendum, and annual operating plans.

Table 14. General categories and subcategories of potential risks posed by hatchery operations and hatchery production.

Current (NMFS 2007c; NMFS 2011e)		Revised		Description
Hatchery Operations		**Facility effects**		Impacts from existence and basic operation of hatchery
	Hatchery facility failure		General facility failure	Impacts on listed fish in the hatchery and fish in wild by electrical failure, flooding, fire, etc.
	Hatchery water intake impacts		Water intake	Impacts on environment from water withdrawal and to fish in stream from screening/impingement
	Hatchery effluent discharge impacts		Effluent	Impacts on environment from water quality changes, and disease incidence caused by effluent
			Structures	Impacts on physical stream environment from physical existence of hatchery structures (e.g., gravel buildup from weirs) and fish movement blockages caused by structures
Broodstock Collection		**Fish removal**		Impacts on the target population and non-target population caused by removal of fish for culture (usually will be adults but could be juveniles or eggs)
	Collection method		Collection	Injury and death to target and non-target individuals caused by collection (will include discussion of different collection methodologies)
	Adult removal		Demographic	Risk posed to natural-origin component from decreasing numbers due to taking fish into hatchery
Genetic Introgression		**Genetic**		Losses of fitness and decreases in diversity caused by genetic mechanisms
	Genetic drift		Loss of within-population diversity	Diversity/fitness loss caused by genetic drift, non-representative sampling, and inbreeding depression
	Inbreeding depression			
	Loss of diversity among populations		Outbreeding effects	Fitness/diversity change caused by gene flow from other populations (outbreeding depression and loss of among-population diversity)
	Domestication selection		Hatchery-induced selection	Fitness loss and phenotypic change caused by differences between the hatchery and natural environment (includes intentional selection and relaxation of selection), and sampling "errors" during fish culture

Current (NMFS 2007c; NMFS 2011e)		Revised		Description
		Ecological interactions		
Disease			Disease	Disease risk to target and non-target populations from commingling with diseased hatchery fish
Competition/Density Dependence			Competition	Productivity loss in target and non-target populations from competition for limited resources caused by released hatchery fish (includes competition due to residualism)
Predation			Predation	Productivity loss in target and non-target populations from predation by released hatchery fish (includes predation due to residualism)
Residualism				
Nutrient cycling			Marine-derived nutrients	Productivity decreases due to under- or over-abundance of Marine Derived Nutrients from hatchery carcasses
Fisheries		**Harvest**		Mortalities in target and non-target populations due to harvest
Monitoring and evaluation		**Monitoring and evaluation**		
Masking			Marking/masking	Loss of monitoring precision due to inadequate marking rate and type
			Methodology	Injury and death caused by monitoring activities
			Adequacy	Risk of undetected impacts from low power or not monitoring all areas necessary (including inadequate equipment)
			Adaptive management	Decreased ability to respond in timely manner to new information on effectiveness of programs

Table 15. Risk categories and subcategories and decision to further analyze these risks when evaluating the effects of the proposed Snake River fall Chinook salmon hatchery programs on listed species in the action area. Those shaded will be evaluated in Section 2.4.

Category	**Subcategory**	**Risk to Snake River Fall Chinook salmon**	**Risk to Snake River spring/summer Chinook salmon, Snake River sockeye salmon, and Snake River Steelhead**
Facility Effects	General facility failure	Propagation of this species is the focus of the proposed hatchery programs and monitoring	None of these species are propagated as part of the proposed hatchery programs and monitoring.
	Water intake	Water intake at hatchery facilities may impact juvenile fall Chinook salmon and rearing habitat.	Water intake at hatchery facilities unlikely to impact these species or their rearing habitat.
	Effluent	Level of production from acclimation ponds is not sufficient to require NPDES permit.	Level of production from acclimation ponds is not sufficient to require NPDES permit.
	Structures	Proposed temporary weir on SF Clearwater may affect passage.	Proposed temporary weir on SF Clearwater may affect passage.
Fish Removal	Collection	Proposed programs collect natural-origin fall Chinook salmon for broodstock and catch and release others	During fall Chinook salmon broodstock collection trapping of steelhead is common, trapping of the other two species rare.
	Demographic	Proposed programs are a major factor in demographics of fall Chinook.	No expected demographic impacts on these species from proposed hatchery programs and monitoring.
Genetic	Within-population diversity	Hatchery programs are the major determinant of effective size of fall Chinook salmon and may be impacting subpopulation structure.	No expected impacts on within-population diversity to these species from proposed hatchery programs and monitoring.
	Outbreeding effects	Proposed programs may have both potential positive and negative outbreeding effects on fall Chinook salmon.	No expected outbreeding impacts on these species from proposed hatchery programs and monitoring.
	Hatchery-induced selection	Proposed programs are expected to have selective effects.	No expected selective impacts on these species from proposed hatchery programs and monitoring
Ecological Interactions	Disease	Program is intensively managed to prevent disease transmission.	Program is intensively managed to prevent disease transmission
	Competition	Competition may occur between hatchery-origin and natural-origin fall Chinook salmon.	Competition may occur between listed juvenile steelhead and hatchery fall Chinook salmon juveniles from the proposed programs.

Category	Subcategory	Risk to Snake River Fall Chinook salmon	Risk to Snake River spring/summer Chinook salmon, Snake River sockeye salmon, and Snake River Steelhead
	Predation	Predation by released hatchery fall Chinook salmon on natural-origin fall Chinook salmon is unlikely.	Predation on these species by fall Chinook salmon released from the proposed programs is unlikely.
	Marine Derived Nutrients	Marine-derived nutrients from returning hatchery fall Chinook salmon adults are expected to benefit natural fall Chinook salmon production.	Marine-derived nutrients from returning hatchery fall Chinook salmon adults may provide benefit to natural production of these species.
Harvest		Harvest impacts of the proposed hatchery programs on all these species have been considered in (NMFS 2008c)	
Monitoring and Evaluation	Marking/masking	~75% of fall Chinook salmon produced by hatchery programs will be internally or externally marked; rest will be identifiable by parentage-based tagging.	Marking of fall Chinook salmon from proposed hatchery programs will have no effect on these species
	Methodology	Proposed M & E activities may cause injury and death to individual fall Chinook salmon.	Proposed M & E activities may cause injury and death to individuals of these two species
	Adequacy	Proposed M &E activities adequate to measure risks to fall Chinook salmon.	Proposed M & E activities adequate to measure risks to these two species.
	Adaptive management	Operation of the four hatchery programs have been and will continue to be well integrated, as well as integrated with ongoing research on the population in general. Cooperation among operators, Action Agencies, and other researchers interested in Snake River fall Chinook salmon is exemplary. Coordination meetings held twice a year are well attended, usually with participation from at least WDFW, ODFW, IDFG, NPT, USFWS, LSRCP, and IPC. Additional meetings focused on development of annual operational plans are held. LSRCP programs are reviewed on a regular basis. A Snake River fall Chinook salmon review is planned for 2013. A Snake River fall Chinook salmon symposium in 2016 is planned as part of the new RM&E measures (Section 1.3.2.2). This symposium will synthesize the findings of all previous and ongoing research to provide a basis for future management	

2.4.2. Facility Effects

Risks to listed salmon and steelhead species, in the action area, can result from the operation of hatchery facilities, as well as associated acclimation facilities. As identified in Table 15, risks associated with the operations of fish culture facilities can be both environmental effects and take associated with catastrophic facility failures. What follows is an assessment of these risk factors.

2.4.2.1. General facility failure effects

Fish hatchery operations are completely dependent on constant, adequate water supplies. Interruption or failure to the water supply systems can risk total loss of all fish on hand, either in the form of direct mortality, adults on hand and juveniles in culture, or from reduced productivity due to emergency early releases of the program fish.

All facilities involved in these Snake River fall Chinook salmon programs have staff available 24 hours a day, when fish are on hand, to deal with facility emergencies, up to and including facility failure. All facilities also have backup or redundant water supplies and/or backup power generation capabilities for supply pumps.

Although no hatchery operation is free of risk from facility failure, the Snake River fall Chinook salmon hatchery facilities are well staffed and equipped for emergencies, so do not appear to pose risk. Risk from facility failure is also decreased by rearing and releasing at multiple locations.

2.4.2.2. Hatchery water intake effects

Facilities used for fall Chinook salmon rearing use a combination of water sources are shown in Table 16.

Table 16. Water sources and usage by facilities used for culture of Snake River fall Chinook salmon.

Hatchery Facility	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
Lyons Ferry Hatchery	118.1	0	118	Ground-water	28	24	Snake River
Nez Perce Tribal Hatchery	12.1	10	2.1	Ground-water and Clearwater River	4.5	37	Clearwater River
Oxbow Hatchery	19.1	17.9	1.2	Ground-water and Snake River	4.4	25	Snake River
Irrigon Hatchery	47	0	47	Ground-water	5	10	Columbia River
Pittsburgh Landing Acclimation Facility	4.5	4.5	0	Snake River	4.5	100	Snake River
Big Canyon Acclimation Facility	4.5	4.5	0	Clearwater River	4.5	100	Clearwater River
Captain John Rapids Acclimation Facility	5.6	5.6	0	Snake River	5.6	100	Snake River
Lukes Gulch Acclimation Facility	2.8	2.2	0.6	South Fork Clearwater River	2.8	100	South Fork Clearwater River
Sweetwater Springs Satellite Facility	2.2	2.2	0	Upland spring	2.2	100	West Fork Sweetwater Creek
Cedar Flats Acclimation Facility	2.2	2.2	0	Selway River	2.2	100	Selway River

Hatchery Facility	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
North Lapwai Valley Acclimation Facility	5	1.4	3.6	Ground-water and Lapwai Creek	5	100	Lapwai Creek

Eleven hatchery facilities are currently used in the Snake River fall Chinook salmon hatchery programs. Two of the facilities use groundwater exclusively (LFH and Irrigon Hatchery). A water permit is required for groundwater withdrawal within Washington, Idaho, and Oregon, and all hatchery wells used by hatchery facilities supporting the Snake River fall Chinook salmon hatchery programs are permitted by the states (IDWR 2012; OWR 2012; WDOE 2012). Unless groundwater withdrawals have been shown to have a direct connection to surface water levels through direct connection of the surface and ground water, it is unlikely that groundwater withdrawals impact any ESA-listed salmonids, unless the water withdrawal is later discharged into surface water. NMFS is not aware of a direct connection between groundwater withdrawals at LFH, Irrigon Hatchery, the NPTH, or the North Lapwai Valley Acclimation Facility and surface water impacts. As a result, impacts on ESA-listed salmonids from these facilities from water quality are limited to effluent discharge (Section 2.4.2.3).

Of the eleven hatchery facilities mentioned above, six of the acclimation facilities use surface water exclusively (Pittsburg Landing, Big Canyon, Captain John Rapids, Sweetwater Springs Satellite, Lukes Gulch, and Cedar Flats Acclimation Facilities), and four facilities use both groundwater and surface water (NPTH, Oxbow Hatchery, and North Lapwai Valley Acclimation Facility). All hatchery facilities have current permits/water rights (IDWR 2012; OWR 2012; WDOE 2012).

Surface water withdrawals for hatcheries within spawning and rearing areas can diminish stream flow, impede migration, and affect the spawning behavior of listed fish. Water withdrawals may also affect other stream-dwelling organisms that serve as food for juvenile salmonids by reducing the amount of quality habitat and through displacement and physical injury. Hatchery intakes must be screened to prevent fish injury from impingement or permanent removal from streams. To prevent these outcomes, water rights issued for regional hatcheries are conditioned to prevent salmon migration, rearing, or spawning areas from becoming de-watered. Hatcheries can also be designed to be non-consumptive. That is, water used in the facility can be returned near the point of withdrawn to minimize effects on naturally produced fish and other aquatic fauna.

The risks associated with surface water withdrawals can generally be minimized by ensuring that complying with applicable water right permits is sufficient for the protection of ESA-listed salmonids and their habitat within the action area. Additionally, ensuring that intakes meet NMFS screening criteria, which set forth standards that help minimize the risk of entrainment or impingement to juvenile salmonids occurring in the area of the intake operation.

All facilities associated with the Snake River fall Chinook salmon hatchery programs operate under applicable state or federal water rights for both surface and well water supplies. All facilities are also either already compliant with the appropriate NMFS screening criteria, or will be in compliance before being used for production in this program.

LFH (WDFW) is located along the Snake River (RM 59), below the Palouse River, in Franklin County, Washington. It is a well-water supplied facility with no surface water withdrawal.

Pittsburg Landing, Big Canyon, and Captain John Rapids Acclimation Facilities use surface water exclusively, and each uses between 4.4 cfs and 5.6 cfs diverted directly from mainstem Snake or Clearwater rivers, which have minimum flows of 10,000 cfs (USGS 2012, accessed 5/11/2012). At maximum, this represents a change in volume of less than 0.1 % of the total stream flow. In addition, the distance between the water withdrawal and discharge is less than 300 feet, and all water diverted from these rivers (minus evaporation) would be returned after it circulating through the facility. Therefore, the only potentially impacted segment of the river would be the short distance between the water intake and discharge structures. This impact is likely difficult to measure, and habitat available to ESA-listed salmonids would not change perceptibly.

Sweetwater Springs Satellite Facility uses a spring that originates from West Fork Sweetwater Creek with a flow of between 0.45 cfs and 8.9 cfs seasonally. No fish are present at the point of diversion. Though the facility can use up to 2.2 cfs (between 25 and 100 % of the flow), all 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. 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.

The Cedar Flats Acclimation Facility uses water from the Selway River, which has a mean flow of 3,813 cfs (USGS 2012, accessed 5/11/2012). Water use at the facility would be 2.2 cfs, which represents use less than 0.1 % of the water in the Selway River. All water (minus evaporation) would be returned to the Selway River within 300 feet after circulating through the acclimation facility. Therefore, the only segment of the river that may be impacted would be the short distance between the water intake and discharge structures. This impact is likely difficult to measure, and habitat available to ESA-listed salmonids would not change perceptibly.

NPTH, Oxbow Hatchery, and North Lapwai Valley Acclimation Facility use both groundwater and surface water. The Nez Perce Tribal Facility uses 10 cfs of water from the Clearwater River, which had a minimum flow of 1,260 cfs in 1971 (USGS 2012, accessed 5/11/2012). Water use at the facility would represent at most less than 1 % of the water in the Clearwater River. All water (minus evaporation) would be returned to the Clearwater River within 300 feet after circulating through the facility. Therefore, the only potentially impacted segment of the river would be the short distance between the water intake and discharge structures. This impact is likely difficult to measure, and habitat available to ESA-listed salmonids would not change perceptibly.

The Oxbow Hatchery uses 17.9 cfs of water from the Snake River, which had a minimum mean flow of 11,500 cfs downstream at Hells Canyon Dam (USGS 2012, accessed 5/11/2012). Because the facility is above Hells Canyon Dam, no ESA-listed anadromous salmonids are present at the point of diversion. Water use at the facility would at most be less than 0.2 % of the water in the Snake River. All water (minus evaporation) would be returned to the Snake River within 300 feet after circulating through the facility. Therefore, the only segment of the river that may be impacted would be the short distance between the water intake and discharge structures. This impact is likely difficult to measure, and no ESA-listed salmonids would be in the area to experience an effect if there were one. This hatchery is above dams with no anadromous fish access.

The Lukes Gulch Acclimation Facility uses 2.8 cfs of water from the South Fork Clearwater River, which had a minimum mean flow in the spring of 585 cfs (USGS 2012, accessed 5/11/2012). Water use at the facility would at most represent less than 0.4 % of the water in the South Fork Clearwater River. All water (minus evaporation) would be returned to the Clearwater River within 300 feet after circulating through the facility. Therefore, the only segment of the river that may be impacted would be the short distance between the water intake and discharge structures. This impact is likely difficult to measure, and habitat available to ESA-listed salmonids would not change perceptibly.

The North Lapwai Valley Acclimation Facility uses 1.4-5 cfs of water from Lapwai Creek, which had a minimum mean flow in the spring of 119 cfs (USGS 2012, accessed 5/11/2012). At maximum, water use at the facility would represent 4.2 % of the water in Lapwai Creek. All water (minus evaporation) would be returned to Lapwai Creek within 300 feet after circulating through the facility. Therefore, the only segment of the creek that may be impacted would be the short distance between the water intake and discharge structures. This impact is likely difficult to measure, and habitat available to ESA-listed salmonids would not change perceptibly.

2.4.2.3. Effluent effects

All LSRCP fall Chinook salmon program facilities are operated consistent with National Pollution Discharge Elimination System (NPDES) permit standards. The purpose of the Clean Water Act (CWA) is to restore the physical, biological, and chemical integrity of the waters of the United States using two basic mechanisms: (1) direct regulation of discharges pursuant to permits issued under the National Pollution Discharge Elimination System (NPDES) and section 404 (discharge of dredge or fill materials); and (2) the Title III water quality program.

The Federal Clean Water Act (CWA) regulates discharges of dredged or fill material into waters of the United States. Each state, where hatchery operations occur, is responsible for issuing and reporting on National Pollutant Discharge Elimination Systems (NPDES) permits. The threshold applied for fish hatchery operations under the CWA is that any facility that rears 20,000 lbs of fish or more and discharges effluent into navigable waters must obtain a permit.

All facilities associated with these programs are properly permitted, under NPDES, if necessary. LFH (WDFW), NPTH (NPT) and Irrigon hatchery (ODFW) all fall under NPDES permitting requirements (greater than 20,000 lbs reared) and have current and maintained permits.

The Oxbow hatchery (IDFG/IPC) effluent is discharged into Pine Creek or the Snake River in compliance with U.S. Environmental Protection Agency (USEPA) discharge requirements.

The Fall Chinook salmon Acclimation Project facilities: Pittsburg Landing, Captain John and Big Canyon, and the NPT acclimation sites: North Lapwai, Luke's Gulch and Cedar Flats—all rear total fish poundages that are less than the NPDES minimum threshold (20,000 lbs).

While the intent of the CWA is to reduce the pollution in navigable waters of the US, standards where not set specifically to avoid effects on ESA-listed anadromous salmonids. Therefore, compliance with NPDES permit criteria does not solely ensure that impacts on ESA-listed salmonids will be minimized or avoided. Because of this, NMFS has included the following discussion regarding the discharge of hatchery effluent into the waters next to each facility.

Hatchery production could affect several water quality parameters in the aquatic system. Concentrating large numbers of fish within hatcheries could produce effluent with elevated temperature, ammonia, organic nitrogen, total phosphorus, biochemical oxygen demand (BOD), pH, and suspended solids levels (Sparrow 1981; Kendra 1991; Cripps 1995; Bergheim and Åsgård 1996; Michael 2003). Chemical use within hatcheries could result in the release of antibiotics (a therapeutic), fungicides, and disinfectants into receiving waters (Boxall et al. 2004; Martínez Bueno et al. 2009; Pouliquen et al. 2009). Other chemicals and organisms that could potentially be released by hatchery operations are PCBs, DDT and its metabolites (Missildine et al. 2005; HSRG 2009a), pathogens (HSRG 2004; HSRG 2009a), steroid hormones (Kolodziej et al. 2004), anesthetics, pesticides, and herbicides.

Hatchery facility waste products include uneaten food, fecal matter, soluble metabolites (e.g., ammonia), algae, parasitic microorganisms, drugs, and other chemicals (Kendra 1991; Bergheim and Åsgård 1996; IDEQ 2009). Fish hatchery facility wastewater commonly includes suspended solids and settleable solids (those that settle out of suspension), as well as nutrients, such as various forms of nitrogen (e.g., ammonia) and phosphorus (Michael 2003). Effluent water quality could affect the health and productivity of receiving waters. Some of the chemical or physical parameters having the greatest potential to impact receiving waters are temperature, nitrogen, phosphorus, dissolved oxygen, pH, and sediment, as described below (IDEQ 2002).

All eleven hatchery facilities used in the Snake River fall Chinook salmon hatchery programs discharge effluent into surface water next to the each facility. A key element of determining the effect of effluent discharge, is determining the proportional volume of effluent that is being discharged by location.

Pittsburg Landing, Big Canyon, and Captain John Rapids Acclimation Facilities use surface water exclusively, which keeps facility water at a very similar temperature to the water it will be discharged into. These facilities discharge between 4.4 cfs and 5.6 cfs directly into the mainstem Snake or Clearwater rivers, which have minimum flows of 10,000 cfs (USGS 2012, accessed 5/11/2012). At maximum, this represents a total contribution of less than 0.1 % of the total streamflow. Water spends less than an hour in the facilities before being discharged. Fish are fed less during acclimation, reducing both food and fecal waste. Medicated feed is not used at acclimation facilities, reducing antibiotic input. Because the waste discharged is biological, temperatures are similar both within the facility and the adjacent river, and monitored for suitability for fall Chinook salmon rearing, impacts are expected to be low or undetectable. It is likely that any discharge would dilute quickly within the much larger river systems, and any detectable difference would be localized and small. This impact is likely difficult to measure, and habitat available to ESA-listed salmonids would not change perceptibly.

Sweetwater Springs Satellite Facility can discharge up to 2.2 cfs into the West Fork Sweetwater Creek. West Fork Sweetwater Creek facility uses a spring that flows seasonally between 0.45 cfs and 8.9 cfs. Therefore, the discharge can be between 25 and 100 %of the flow in the West Fork Sweetwater Creek. Both intake of water and discharge of effluent occur in areas where no fish are present. Fish are fed less during acclimation, reducing both food and fecal waste. Medicated feed is not used at acclimation facilities, reducing antibiotic input. Because the waste discharged is biological, temperatures are similar both within the facility and the adjacent creek, and monitored for suitability for fall Chinook salmon rearing, and ESA-listed anadromous salmonids would be exposed only to diluted effluent downstream from the facility, impacts are expected to be low or undetectable. Therefore, the discharge would not result in a hydrologic change where fish are present and habitat available to ESA-listed salmonids would not change perceptibly.

The Cedar Flats Acclimation Facility discharges be 2.2 cfs into the Selway River, which has a mean flow of 3,813 cfs (USGS 2012, accessed 5/11/2012), which represents use less than 0.1 % of the water in the Selway River. Fish are fed less during acclimation, reducing both food and fecal waste. Medicated feed is not used at acclimation facilities, reducing antibiotic input. Because the waste discharged is biological, temperatures are similar both within the facility and the adjacent river, and monitored for suitability for fall Chinook salmon rearing, impacts are expected to be low or undetectable. It is likely that any discharge would dilute quickly within the much larger river systems, and any detectable difference would be localized and small. This impact is likely difficult to measure, and habitat available to ESA-listed salmonids would not change perceptibly.

The Nez Perce Tribal Facility discharges 12.1 cfs into the Clearwater River, which had a minimum flow of 1,260 cfs in 1971 (USGS 2012, accessed 5/11/2012). At maximum, water discharge from the facility would represent less than 1 % of the water in the Clearwater River. Medicated feed is used at the hatchery, however feeding protocols are used to minimize the amount of food that would not be eaten. The majority of the medicated feed would be ingested and metabolized, and thus not released directly. Because the waste discharged is predominantly biological, temperatures are similar both within the facility and the adjacent river, and monitored for suitability for fall Chinook salmon rearing, impacts are expected to be low or undetectable.

This impact is likely difficult to measure, and habitat available to ESA-listed salmonids would not change perceptibly.

The Oxbow Hatchery discharges up to 19.1 cfs into the Snake River, which had a minimum mean flow of 11,500 cfs downstream at Hells Canyon Dam (USGS 2012, accessed 5/11/2012). Because the facility is above Hells Canyon Dam, no ESA-listed anadromous salmonids are present at the point of discharge. At maximum, water discharge from the facility would represent less than 0.2 % of the water in the Snake River. It is likely that any discharge would dilute quickly within the much larger river systems, and any detectable difference would be localized and small. The only segment of the river that may be impacted is outside of the accessible range of ESA-listed anadromous salmonids, and they are unlikely to experience any impact downstream. This impact is likely difficult to measure, and no ESA-listed salmonids would be in the area to experience an effect if there was one.

The Lukes Gulch Acclimation Facility discharges up to 2.8 cfs into the South Fork Clearwater River, which had a minimum mean flow in the spring of 585 cfs (USGS 2012, accessed 5/11/2012). Water discharge from the facility would at most represent less than 0.5 % of the water in the South Fork Clearwater River. Fish are fed less during acclimation (reducing both food and fecal waste). Medicated feed is not used at acclimation facilities (reducing antibiotic input). Because the waste discharged is biological, temperatures are similar both within the facility and the adjacent river, and monitored for suitability for fall Chinook salmon rearing, impacts are expected to be low or undetectable. It is likely that any discharge would dilute quickly within the much larger river systems, and any detectable difference would be localized and small. This impact is likely difficult to measure, and habitat available to ESA-listed salmonids would not change perceptibly.

The North Lapwai Valley Acclimation Facility discharges 5 cfs of water into Lapwai Creek, which had a minimum mean flow in the spring of 119 cfs (USGS 2012, accessed 5/11/2012). Water discharged from the facility would at most represent less than 4.2 % of the water in Lapwai Creek. Fish are fed less during acclimation (reducing both food and fecal waste). Medicated feed is not used at acclimation facilities (reducing antibiotic input). Because the waste discharged is biological, temperatures are similar both within the facility and the adjacent river, and monitored for suitability for fall Chinook salmon rearing, impacts are expected to be low or undetectable. It is likely that any discharge would dilute quickly within the much larger river systems, and any detectable difference would be localized and small. This impact is likely difficult to measure, and habitat available to ESA-listed salmonids would not change perceptibly.

Generally, facilities involved in fall Chinook salmon production and acclimation discharge proportionally small volumes of water with predominantly biological waste into large water bodies that quickly dilute to low or undetectable levels. In addition, the discharges come from facilities that specifically raise ESA-listed stocks of anadromous salmonids using the water in question, and have very low mortality rates while they are exposed to water within the facilities prior to dilution. Facilities associated with fall Chinook salmon production are not in primary spawning and rearing areas for other ESA-listed anadromous salmonids, where sensitive life stages of these salmonids will be found.

2.4.2.4. Facility structure effects

LFH adult trap: This trap is a volunteer trap, located at LFH, on the North shore of the Lower Snake River. There is no weir associated with facility and it does not impede migration of fish upstream. Fish that enter the trap ascend a ladder to a trap. The trap is checked and emptied every day, during trapping season. Fish in the trap are crowded and sorted into holding ponds, or returned to the river, via a series of diverting chutes. Fish that are diverted into the holding ponds, either purposefully, or by misidentification, may be held up to 24 days before they are sorted for collection or return to the river.

LGR adult trapping facility: The adult trapping facility, at the LGR, is operated under the authority of the NMFS. The trap diverts the entire LGR Dam fish ladder, for timed trapping intervals, and also when targeted PIT-tags are encountered ("sort by code"), into the trapping facility. In the past, take associated with the operation of this facility, during the collection of fall Chinook salmon broodstock, has been covered under Section 10 permit 1530.

NPTH adult trap: This adult trap is a volunteer trap, with a ladder and holding ponds, located on the North shore of the Clearwater River. There is no weir associated with facility and it does not impede migration of fish upstream. During trapping season, the trap is checked and emptied daily.

SF Clearwater adult weir: The potential impacts of weir rejection, fall-back, and injury from the operation of a weir or trap can be minimized by allowing unimpeded passage for a period each week. Trained personnel can reduce the impacts of weir or trap operation by removing debris, preventing poaching, and ensuring safe and proper facility operation. Delay and handling stress may also be reduced by holding fish for the shortest time possible (less than 24 hours) and any fish not needed for broodstock should quickly be allowed to recover from handling and be immediately released upstream to spawn naturally.

The NPT proposes to operate this weir 24 hrs/day and seven days a week, between October 1 and December 1. All fish captured in the trap, regardless of species or listing status, will be processed, collected or passed above or below the weir, within 24 hrs of initial trapping.

2.4.2.5. Overall facilities risk assessment

The facilities associated with the Snake River fall Chinook salmon hatchery programs are numerous and spread broadly throughout the greater Snake River and Clearwater River Basins. Many of the facilities are small in size and only operated on a seasonal basis.

Four full-time facilities are utilized, at least partially, by these programs: LFH, NPTH, Irrigon Hatchery, and Oxbow Hatchery. While all these facilities produce (in addition to this program) other hatchery program fish, in total poundages large enough to require pollution discharge permitting, they all have current NPDES permits, along with sampling and reporting requirements, intended to minimize any risks associated with elevated levels of organic compounds in the hatchery effluent.

All facilities included in the proposed action, both fulltime and seasonally-operated, have properly permitted water rights for their water supply systems. The water right for surface water withdrawal stipulates the allowable volume of water that can be withdrawn by the right holder. As discussed above, the volume of water withdrawn under the current water rights permits is not expected to de-water any streams or rivers or reduce the availability of habitat available for ESA-listed anadromous salmonids. Therefore, exercising the currently permitted water rights managed at the hatchery facilities is expected to minimize risks that the hatchery facilities pose to listed salmonids from water withdrawals.

All facilities included in the proposed action, both fulltime and seasonally-operated, have properly screened intake structures. These structures meet NMFS screening criteria. 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.

The facilities involved in these programs are all structured and operated in a manner that NMFS considers risk averse. The handling and processing of live, listed salmonids, entering any of the facility structures, occurs in an expedited manner, with minimal handling. Overall the effects to listed salmonids from the facilities involved in these programs is expected to be minimal and below levels of concern.

2.4.3. Fish Removal

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 risks, as described below, include direct and indirect take of ESA-listed salmon populations through physical removal actions and the potential demographic risks posed by removing productive individuals from depressed populations.

2.4.3.1. Collection Effects

Impacts on target and non-target species can occur during the collection of adults for broodstock. Impacts on adult salmonids can vary depending on the method of collection, which can include taking volunteers returning to the hatchery; using a weir; or using a fish ladder-trap combination associated with a barrier, such as a dam. Trapped fish are counted and either retained for use in the hatchery or released to spawn naturally after being held for up to a few weeks. These broodstock collection efforts can directly or indirectly take ESA-listed species through the physical activities of trapping, removal, handling, sampling, tagging, transport and lethal spawning of fish for the hatchery broodstock.

Most indirect take associated with collection efforts occurs at LGR, so it is important to understand the trap operations. Trapping has two purposes: collection of fall Chinook salmon for broodstock collection and run-reconstruction, and steelhead run-reconstruction. Both activities were previously authorized by permit 1530. The sampling rate is determined preseason based on run estimates for fall Chinook salmon and steelhead, and is weighted heavily by fall Chinook salmon broodstock collection needs. Thus, the trapping rate for other species passing the dam during the period of fall Chinook salmon broodstock collection – steelhead, spring/summer Chinook salmon, and sockeye salmon – is in part dependent upon fall Chinook salmon broodstock collection needs. Because fall Chinook salmon collection is the largest driver of sampling rate, and because it is unfeasible to cleanly distinguish the take of any of these species attributable to the fall Chinook salmon operations from that attributable to the steelhead sampling operation, we analyze as a collection effect the trapping of any steelhead, spring/summer Chinook salmon, or sockeye salmon during the period of fall Chinook salmon collection.

Snake River Fall Chinook salmon

Collection of broodstock for these programs can occur at up to four different facilities throughout the Snake Basin. The primary objective, as described in the program HGMPs, is to have the entire broodstock collection for the Snake River fall Chinook salmon program (LFH, FCAP, NPTH, and IPC components) occur at the LGR trap, which is operated by the NMFS. This trap collects run-of-the-river samples of the returning fish and has the highest probability of collecting natural-origin adults. Annual limits on the total trapping rate (adjusted annually, usually near 10%) can limit the number of adult fall Chinook salmon that can be collected at LGR for the program. This can necessitate additional collection at the LFH trap and/or at the NPTH, in order to meet program egg-take and release objectives. Trapping occurs at LFH annually to collect additional broodstock fish if necessary.

Table 17 and Table 18 provide estimates of the total annual collection levels of total and natural-origin Snake River fall Chinook salmon for these programs.

Additionally, development of an "Early-spawning" component to the NPTH program will utilize a seasonal weir on the South Fork Clearwater River to collect adults for broodstock (Hesse and Johnson 2012). Provided returns to the Clearwater River are sufficient, the operation of this South Fork Clearwater weir is expected to eventually provide 176 broodstock fish (assuming 1:1 sex ratio), enough to produce all the juveniles needed for the Lukes Gulch and Cedar Flats releases, a total of 400,000 (Table 4). The broodstock fish trapped on the South Fork Clearwater River will be used in place of fish that would otherwise be collected at LGR or NPTH, and collection is subject to the same limitations on take of natural-origin fish (maximum of 30%) in place at the other trapping sites (Section 2.4.4.3.3).

Table 17. Annual estimates of total Snake River fall Chinook salmon collected during program broodstock collection activities 1991-2011

Brood	Total Fall Chinook salmon collected at LGR and LFH			Total Fall Chinook salmon collected at NPTH			Total
Year	Female	Male	Jack	Female	Male	Jack	
1991	269	238	148	-	-	-	655
1992	293	185	154	-	-	-	632
1993	126	125	140	-	-	-	391
1994	168	243	510	-	-	-	921
1995	349	505	1,884	-	-	-	2,738
1996	499	609	501	-	-	-	1,609
1997	485	381	769	-	-	-	1,635
1998	815	1,274	1,201	-	-	-	3,290
1999	1,448	1,371	934	-	-	-	3,753
2000	1,112	1,757	1,332	-	-	-	4,201
2001	1,519	2,200	455	-	-	-	4,174
2002	1,856	1,858	811	-	-	-	4,525
2003	1,164	1,428	1,596	131		68	4,387
2004	1,681	2,298	710	163	388	175	5,415
2005	1,783	1468	7,014	78	66	51	10,460
2006	882	1331	1,690	23	42	76	4,044
2007	1867	2518	2328	53	62	2061	8889
2008	1607	2782	2042	211	497	571	7710
2009	1471	1833	1302	278	229	5111	10224
2010	1496	1546	213	0	0	0	3255
2011	1598	916	587	137	129	257	3624

Source: WDFW et al. (2011) and NPT (2011).

Incidental take of other ESA-listed species during program broodstock collection is expected to be at very low levels annually.

Snake River Spring/Summer Chinook Salmon

Fall Chinook salmon broodstock collection at LGR Dam generally starts August 18 and runs through December 1. Trapping may end earlier if full production needs have been met, and it has been extended into December during years of low adult returns. Low numbers of spring/summer Chinook salmon may still be passing the dam during the period of fall Chinook salmon broodstock collection, and thus may be trapped and returned within minutes to the river. Occasionally, spring/summer Chinook salmon are misidentified as fall Chinook salmon and shipped to LFH. In these cases, it is not until the fish dies or is seen at spawning that the fish is identified as a spring/summer Chinook. By then the fish is in too poor of condition to be returned to the spawning grounds and thus is kept from spawning in the wild. The LFH adult trap does not open until September 1 to avoid trapping spring/summer Chinook salmon. The average number of CWT spring/summer Chinook salmon incidentally caught between 2005-2008 during fall Chinook salmon trapping was five fish from LFH and seven fish from LGR Dam. ESA-listed spring/summer Chinook salmon may also be trapped at NPTH during fall Chinook salmon trapping operations, however none have occurred to date, and spring/summer Chinook salmon in the Clearwater River are not listed under the ESA.

Snake River Steelhead

Large numbers of ESA-listed Snake River summer steelhead adults are trapped at LGR for ISEMP monitoring, an activity previously covered by permit 1530 and currently covered by a letter of determination (NMFS 2011b). The intent of this trapping is to sample a constant proportion of the run. The rate is set annually by the operators and has been around 10% in recent years. This trapping period includes the time span during which fall Chinook salmon are being collected for broodstock and run-reconstruction. As mentioned above, because the trapping rate is based largely on fall Chinook salmon broodstock collection needs, we are considering the trapping of steelhead during this time as incidental take. Sampling after trapping is direct take covered under the letter of determination. We consider the effects of the trapping steelhead negligible.

Listed steelhead may also be trapped incidentally during fall Chinook salmon broodstock collection at LFH because of simultaneous collection of broodstock for a nonlisted steelhead hatchery program. At LFH, all incidentally trapped, listed steelhead, captured during fall Chinook salmon collection, are guided into a holding pond with the fall Chinook. It is possible for these fish to be held up to 24 days before they are initially sorted. After sorting, they will be moved to the steelhead raceways, held an additionally for a chemical withdrawal period from the handling anesthetic, then released into the Snake River. The recent (2002-2011) average number of natural-origin steelhead trapped at LFH has been less one or two fish annually.

Up to 10 Snake River steelhead may also be incidentally trapped and released during fall Chinook salmon broodstock collection at NPTH. Between 200 and 400 steelhead are expected to be trapped and released at the seasonal collection weir on the SF Clearwater River.

Snake River Sockeye Salmon

Although the sockeye salmon run is usually nearly over by the time fall Chinook salmon broodstock collection commences at LGR (FPC adult data, accessed 3/12/2012), small numbers of sockeye salmon can be expected to be encountered at the trap. Although none have been reported, it is reasonable to assume that up to five may be trapped and then immediately released. To date, no incidental trapping of Snake River sockeye salmon has been reported at LGR, LFH, or NPTH during fall Chinook salmon broodstock collection, and none is expected in the future. In addition, no sockeye salmon are expected to be trapped at the South Fork Clearwater weir.

Table 18. Estimated numbers of Snake River natural-origin fall Chinook salmon collected for program broodstock and the percentage of the run at large collected.

Brood	**Total estimated Natural-origin Fall Chinook salmon collected at LGR***			**LGR Total**	**Total estimated Natural-origin Fall Chinook salmon collected at LFH**			**LFH Total**	**Total estimated Natural-origin Fall Chinook salmon Collected at NPTH**			**NPTH Total**	**Total**	**Est Nat. run size****	**% of Natural run removed**
Year	**Female**	**Male**	**Jack**		**Female**	**Male**	**Jack**		**Female**	**Male**	**Jack**				
2003	-	-	-	-	4	5	2	11	1	-	-	1	12	3868	**0.31**
2004	226	46	19	291	10	1	-	11	12	45	-	57	359	5115	**7.02**
2005	145	241	11	397	1	3	-	4	-	5	-	5	406	3110	**13.05**
2006	172	129	1	302	5	7	1	13	-	1	-	1	316	2749	**11.50**
2007	119	159	-	278	1	3	-	4	1	-	-	1	283	2045	**13.83**
2008	173	127	-	300	-	-	-	-	2	-	-	2	302	2155	**14.01**
														Avg	**9.95**

* Includes combined total of fish transported to LFH and NPTH
Source: WDFW et al. (2011) Tables 16,19-21

Collection Effect Risk Assessment

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 1000, during the early years of the program, to over ten thousand in recent years. The vast majority of these collected fish are hatchery-origin returns. On average, during the 2003-2008 collection years, 280 natural-origin adults were collected for the programs, representing just under 10 % of the natural-origin return over LGR Dam.

Take levels of other ESA-listed species in the Snake River Basin from fish removal activities associated with the Snake River fall Chinook salmon hatchery programs are near zero with the exception of steelhead and pose negligible risk to these species. Many adult steelhead will be encountered during broodstock collection for fall Chinook salmon, but this take is expected to result in few or no mortalities and thus poses minimal risk to the Snake River steelhead DPS.

2.4.3.2. Demographic Effects

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 (NMFS 2008e). 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 (NMFS 2008b). 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 (WLCTRT and ODFW 2006). At present, low abundance is not a concern in this population, with recent adult returns to LGR averaging 16130 (range 4036-42881) (Section 2.2.2.1.3). 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, would need about 5,050 fish. When factoring in handling and holding mortality and hatchery adults utilized for run-reconstruction estimates, this total increases to upwards of 5,600 fish. 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 collected for broodstock are set at up to 20 % of the return. Additionally hatchery fish and a smaller number of natural-origin fish are collected at the LFH trap annually. Recent years have seen large overall runs of both fall Chinook salmon and summer steelhead returning the Snake Basin. This has limited the ability to trap at rates approaching this limit, due to the inability to efficiently handle the volume of fish at the trap.

Based on average hatchery SAR values present in the program HGMPs for brood years 1998-06[1], the number of hatchery fish returning to the Snake River Basin for each fish utilized in the broodstock is just over six recruits per spawner. If river recruitment is calculated using total fish collected for the program (broodstock, surplus, handling and holding mortality), the rate of return is reduced to just over three recruits per spawner. Both of these figures represent positive production from the hatchery program; numbers would be even higher if harvest was included in calculations. No estimates of the productivity of the naturally spawning fish are available for comparison.

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 LGR trap-rate and 10-12% in recent years) that can be handled, sampled and/or collected for use as program broodstock, further reduce the demographic risk concerns for this population.

We conclude that demographic risk to other ESA-listed species in the Snake River Basin from fish removal activities associated with the Snake River fall Chinook salmon hatchery programs is negligible.

2.4.4. Genetic Effects

Genetic change occurs by four processes: 1) mutation, 2) genetic drift, 3) gene flow, and 4) selection. Populations, natural or artificial, experience all four at once. In a biological opinion, however, effects of hatchery programs must be broken down into analyzable chunks. We thus consider three categories of change that largely encompass the basic processes, within-population diversity, outbreeding effects, and hatchery-induced selection, recognizing interdependencies among them in terms of impacts. For purposes of this opinion we consider the effect of mutation to be so small as to be unmeasurable. In the within-population diversity category we include the effects of genetic drift on levels of diversity, fitness loss due to inbreeding depression, and subpopulation structure. In the outbreeding effects category we include changes to among-population diversity and outbreeding depression. The hatchery-induced selection category includes all effects due to differences in selective regimes between the hatchery and natural environments, intentional or unintentional. The suite of effects we call hatchery-induced selection is often called domestication or domestication selection in the scientific literature (e.g., Doyle 1983; Fraser 2008; Naish et al. 2008) and in other NMFS documents (e.g., Hard et al. 1992; NMFS 2011e).[7]

In analyzing the three categories of genetic effects of hatchery operations on salmon and steelhead populations, we view these effects within a common conceptual framework consisting of three elements. Figure 7 presents the framework with the three elements represented as geometrical axes. The first element is genetic change caused to the fish produced by the hatchery program as a result of hatchery practices or of aspects of the hatchery environment. The second element is transmission of these genetic changes. Unless the population is entirely maintained in the hatchery, the risk posed by the genetic effects of the hatchery programs depends on their transmission to the natural spawning component of the population through interbreeding of hatchery-origin and natural-origin fish. The transmission element is the focus of many hatchery reform concepts that set guidelines for proportions of hatchery-origin fish on the spawning grounds and natural-origin fish in hatchery broodstock. The third element is the length of time that these hatchery operations causing the genetic changes have been underway. This aspect of genetic effects is very important, because unlike many other types of effects, genetic changes to populations may be cumulative.

[7] For purposes of this opinion we have chosen to use the term "hatchery-induced selection" rather than "domestication" because we have found that in discussion of hatchery risk the latter term tends to create confusion and polarize discussion. In the minds of many fisheries professionals, the term domestication connotes the concept of many years of adaptation in captivity to totally artificial conditions, and thus seems inappropriate when applied to a species which spends most of its life in the wild.

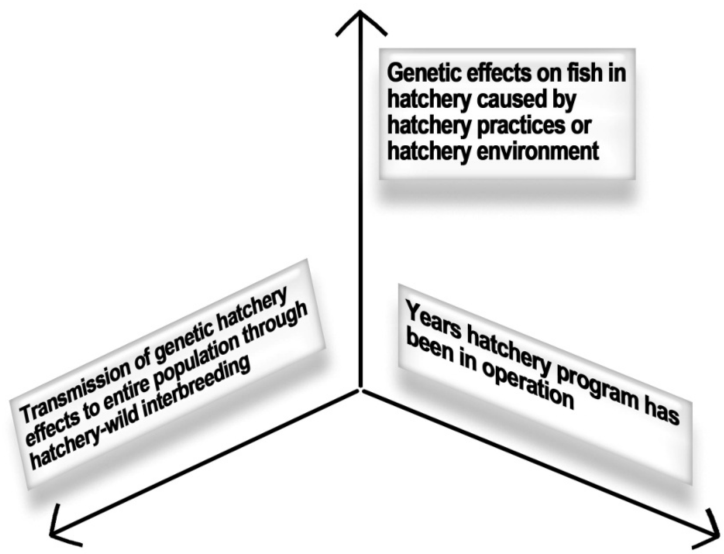

Figure 7. Conceptual framework for analysis of genetic effects of hatchery programs on natural populations.

The total genetic impact on the population under analysis is the result of movement along these three axes. Thus, conceivably a hatchery program that causes substantial genetic change to the fish under culture may have little genetic impact on the total population if the amount of interbreeding between hatchery- and natural-origin fish is low. In contrast, a hatchery program that causes little genetic change to the fish under culture may have a substantial genetic impact on the total population if the amount of interbreeding between hatchery- and natural-origin fish is high. Additionally, cumulative impacts may be greater for an older program than a younger one, even if its "movement" along the effects and transmission have been less. The fact that hatchery programs typically change in many respects over time poses a serious real-world challenge to this conceptual framework that must be considered in analysis. In some form, the current Snake River fall Chinook salmon hatchery effort has existed since 1976, about nine generations (assuming a generation length of 4 yrs), but it has varied greatly in size and probable effect on the population during that time.

In all three categories of genetic effects we analyze below in the Snake River fall Chinook salmon hatchery programs, transmission of the genetic effect of the hatchery practices and environment is a major concern, inferred from the apparent high proportion of hatchery-origin fish on the spawning grounds, and low level of natural-origin fish in the hatchery broodstocks. Because this is typically discussed in terms of hatchery-induced selection, this topic will be discussed in detail below (Section 2.4.4.3.4).

2.4.4.1. Effects on Within-Population Diversity

2.4.4.1.1. Effective Population Size

Loss of within-population genetic diversity (variability) is a reduction in quantity, variety and combinations of genetic material in a population (Busack and Currens 1995). The primary mechanism for loss of within-population diversity is genetic drift. Population genetic theory predicts that all populations will experience genetic drift, a random loss of diversity due to population size. The rate of loss is determined not by the population's census size (N), but by its effective population size (N_e), which can be considerably smaller. For a population to maintain genetic diversity reasonably well, the effective size should be in the hundreds (e.g., Lande and Barrowclough 1987), and diversity loss can be severe if N_e drops to a few dozen.

Inbreeding, the mating of closely related individuals (e.g., sibs, half-sibs, cousins) can be a consequence of small population size (the smaller the population, the more likely that animals 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. This phenomenon is called inbreeding depression. The lowered fitness of fish due to inbreeding depression accentuates the genetic risk problem, helping to push a small population toward extinction.

Because the term effective size is general, and may be used over varying time frames, in analysis it is useful to use a derivative of effective size called effective number of breeders (N_b) (Waples 1990), which essentially refers to the relative contributions of parents to a cohort that is being analyzed. Hatchery programs, simply by virtue of creating more fish, can increase N_b, but can also directly depress it by two principal methods. One is by the simple removal of fish from the population so that they can be used in the hatchery. If a substantial portion of the population is taken into a hatchery, the hatchery becomes responsible for that portion of the effective size. Should the operation fail, however, the effective size of the population will be reduced. N_b can also be reduced considerably below the census number of broodstock by using a skewed sex ratio, spawning males multiple times (Busack 2007), and by pooling gametes. Pooling semen is especially problematic because when semen of several males is mixed and applied to eggs, a large portion of the eggs may be fertilized by a single male (Gharett and Shirley 1985; Withler 1988). Factorial mating schemes, in which fish are systematically mated multiple times, can be used to increase N_b (Fiumera et al. 2004; Busack and Knudsen 2007).

Analytical approaches to the transmission of N_b effects of the hatchery to the entire population by the interbreeding of hatchery-origin and natural-origin fish were provided by Ryman and Laikre (1991) and Wang and Ryman(2001). In a group of spawners in which a proportion x consists of hatchery-origin fish with N_{bH} and the natural-origin spawners have effective size N_{bN}, then the overall N_b is given by equation 1:

$$\frac{1}{N_b} = \frac{x^2}{N_{bH}} + \frac{(1-x)^2}{N_{bN}} \quad (1)$$

This equation illustrates how the hatchery N_b drives the overall N_b when the proportion of hatchery-origin fish on the spawning grounds is high. If the hatchery N_b is small relative to the proportion of hatchery-origin fish on the spawning grounds (i.e., large returns from few spawners), the overall N_b can be depressed substantially over what would be expected based purely on the numbers of spawners (Ryman and Laikre 1991; Ryman et al. 1995).

N_b can be estimated from genetic data by several methods (e.g., Hill 1981; Waples 1990; Wang 2009). It can also be estimated from census numbers using a number of standard equations , but accurate estimation requires knowledge of the variance of family size, which is usually unknown. Variance of family size usually causes large differences between the census number and effective number of breeders. A simple equation for N_b that is often used hatchery operations uses the total number of spawners, and the number of males and females:

$$N_b = \frac{4N_m N_f}{N_m + N_f} \quad (2)$$

Other than differences caused by the sex ratio, this equation does not include an adjustment for the variance of family size. However, the equation is a useful index of the effect of sex ratio on N_b. If N_m is expressed as a proportion k of N_f, the equation becomes $N_b = \frac{4kN_f}{1+k}$. The effect of various levels of k is shown in Table 19.

Table 19. N_b expressed in terms of N_f when N_m =k N_f.

k	N_b
1	$2N_f$
0.75	$1.71N_f$
0.5	$1.33N_f$
0.33	N_f
0.25	$0.8N_f$

The actual impact of extensive male reuse at LFH is shown in Table 20. Until the implementation in 2009 of preferential use of large males, sex ratios were close to 1:1. Similar patterns occur at NPTH: in 2011 229 males and 439 females were used (NPT 2012), resulting in an estimated N_b of 602, 69% of what would have been achieved with one male per female.

Table 20. Broodstock contributing to Snake River fall Chinook salmon production at LFH 2002-2011 (WDFW et al. 2011; updated information from Milks 2012a).

Year	Females	Males	Jacks	N_b	Proportion of N_b achievable with 1 male per female
2002	1,322	1,089	171	2581	0.98
2003	794	619	234	1645	1.04
2004	1,331	1,178	156	2665	1.00
2005	1518	1099	96	2675	0.88
2006	786	693	88	1567	1.00
2007	1557	1432	125	3114	1.00
2008	1309	1266	0	2574	0.98
2009	1293	811	22	2026	0.78
2010	1238	996	0	2208	0.89
2011	1251	410	0	1235	0.49

Understanding the impact of this reduction on the entire population is complicated, because the ratio of effective number of breeders to census breeders in hatchery returnees is unknown. However, Marshall and Small 2010 provide genetically based N_b estimates for many brood years of natural-origin juvenile and mixed hatchery-origin and natural-origin adult Snake River fall Chinook salmon. Estimates for juveniles range from a few hundred to thousands (Figure 8), and estimates differ relatively little between juvenile and adult samples, although estimates from adults are slightly higher (Marshall and Small 2010, Figure 10). Based on the assumed high proportion of hatchery-origin fish on the spawning grounds (~0.7, Ford et al. 2011) equation 1 would indicate that overall N_b is highly dependent on the hatchery N_b. Thus, a substantial reduction in hatchery N_b could cause a substantial reduction in population N_b.

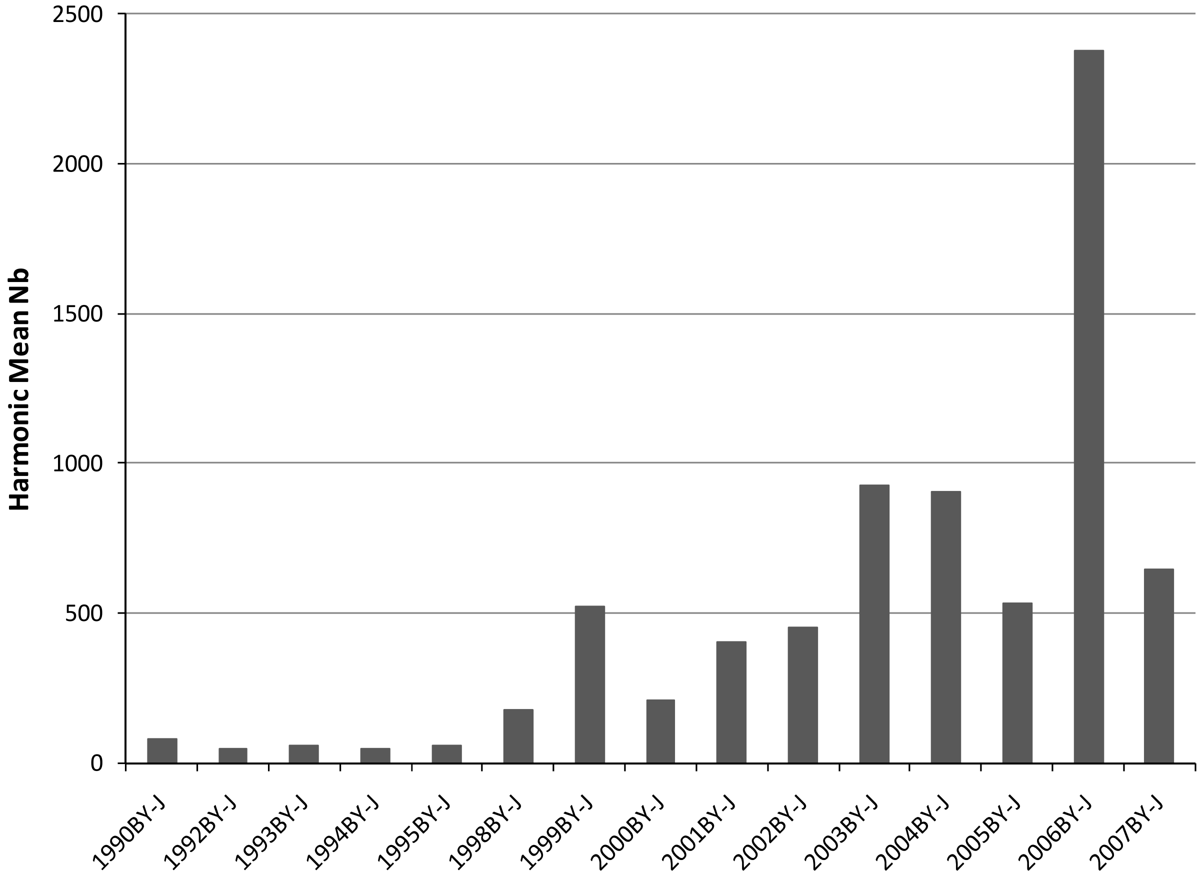

Figure 8. Harmonic mean estimated effective number of breeders (N_b) by brood year for wild Snake River juvenile fall Chinook salmon samples. Values are harmonic means of estimates calculated from linkage disequilibrium and temporal methods (Marshall and Small 2010, Figure 8).

Genetic data (Marshall and Small 2010) on Snake River fall Chinook salmon indicate that population effective size on a per generation basis – N_b x generation time (Waples 1990) – is in the thousands. Given existing guidelines for effective sizes required to maintain genetic diversity the current practice of multiple use of males in these programs, even if it does reduce N_b 50% from what would be achieved with equal numbers of the two sexes, does not pose a risk to the ESU. However, despite assertions that N_b levels of a few hundreds per year are adequate safeguards against genetic drift even in populations that naturally are or were at much higher levels (Tringali and Bert 1998), the fact remains that the larger the effective size, the higher the amount of diversity that can be maintained. In populations of conservation interest, no matter what N_b is in the hatchery, avoiding major N_b reductions is recommended.

2.4.4.1.2. Subpopulation Structure

Although the Snake River fall Chinook salmon ESU currently consists of a single extant population occupying possibly only 10-15% of historical habitat (NMFS 2008e), the geographical expanse of spawning and rearing habitat is large (e.g., Lower Salmon River, Lower Clearwater River, and about 110 miles of the Lower Snake River between Lower Granite reservoir and Hells Canyon Dam). A recent review of the literature (Fraser et al. 2011) found evidence of adaptation in salmonids at considerably smaller geographical scales. Furthermore, the geographical separation of at least some discrete major spawning areas suggests that subpopulation structure is possible provided homing fidelity is sufficiently high. There is limited information on homing fidelity in Snake River fall Chinook salmon (Garcia et al. 2004) suggesting that fish tend to home to area of release. There is also some genetic data by Marshall and Small (2010) that suggests some level of non-random mating (higher than expected number of significant heterozygote deficiencies: their Table 5). Thus there appears to potential for subpopulation structure in Snake River fall Chinook salmon. However, there is no direct evidence it historically existed, or if under current conditions it could exist. It cannot exist without adequate homing fidelity and without adequate local productivity and capacity. While some promising preliminary information is available on homing fidelity, there is none on localized population dynamics.

There is no recovery plan yet in place for Snake River fall Chinook salmon, but current recovery planning encourages development and maintenance of subpopulation structure, especially in ESUs or DPSs with small numbers of populations. The best example is the effort to protect the White River subpopulation of the Wenatchee spring Chinook salmon (NMFS 2008b). Even if subpopulation structure was not an explicit recovery goal for Snake River fall Chinook salmon, subpopulation structure would increase the diversity rating of the ESU, and the increased local adaptation may increase overall natural productivity. A critical difference between the White River situation and Snake River fall Chinook salmon, of course is that the White River is an identifiable subpopulation, whereas the current and historical extent of subpopulation structure in the Snake River fall Chinook salmon population is unknown.

With the exception of the South Fork Clearwater portion of NPT production, the current and proposed programs are not operated in a way that can be expected to conserve subpopulation structure in the Snake River fall Chinook salmon population, an observation made in recent reviews (HSRG 2009a; USFWS 2011). Except for LFH, where 12% of the fish are released, all releases are above LGR and dispersed in such a way to provide some support for subpopulation structure (e.g., FCAP facilities are all sited at major spawning areas). Even the LFH releases may support spawning in the Tucannon River. However, with the exception of the South Fork Clearwater trap, broodstock collection is done in such a way to intercepted commingled groups of fish from different spawning areas and release sites. As many broodstock fish as possible are collected at LGR, which is below all the major production areas. LFH, 50 miles downstream from LGR, also has the potential to trap commingled fish. Fish collected at NPTH are less likely to be a mixture.

The commingled collection of broodstock fish from different sources is not an insurmountable obstacle to maintenance of subpopulation structure if the fish are identifiable by source. Identification by source of natural-origin fish may be possible, though not on a real-time basis, through either genetic methods of elemental analysis of otoliths or scales (Feyrer et al. 2007; Hegg 2011; Johnson et al. 2012) provided the differences between groups are large enough. Identification by release site of hatchery-origin fish is possible with release-site specific tags. There are substantial technical and logistical challenges to applying these approaches to Snake River fall Chinook salmon. The same is true of attempting broodstock collection to avoid commingling, on a larger scale than is currently planned (i.e., SF Clearwater). But operations to support subpopulation structure must also include separate rearing of the various groups, another substantial challenge. Management of the hatchery programs to date and that proposed in the HGMPs emphasizes maintenance of Snake River fall Chinook salmon as a single population. Within that management framework are efforts to increase spatial structure and general adaptation by widely dispersed release locations, by NPT's attempts to foster earlier spawning in the Clearwater River (NPT 2011), and possibly by release of both yearling and subyearling fish (discussed below), but development or maintenance of subpopulation structure is not planned.

Three new RM&E activities are proposed to clarify the status of and potential for subpopulation structure in Snake River fall Chinook salmon: release-site fidelity; spawning, rearing, and overwintering locations and genetics of subpopulation structure. This information will greatly assist managers and recovery planners in determining the feasibility and value of managing the hatchery programs to support subpopulation structure in this population.

Although the proposed action does not support maintenance of subpopulation structure in the Snake River fall Chinook salmon population, this does not rise to the level of a significant risk to the population at this time because of the current hypothetical previous existence of, or future potential for, subpopulation structure, and the lack of a current clearly defined recovery need for subpopulation structure in this population.

2.4.4.2.Outbreeding Effects

Outbreeding effects are the consequence of gene flow from one population into another. Two types of outbreeding effects are recognized. One is a diversity effect. While gene flow from one population into another may increase the level of genetic diversity in the recipient population (e.g., Ayllon et al. 2006), it will also reduce genetic differentiation between the donor and recipient population (e.g., Vasemagi et al. 2005). The second effect is outbreeding depression, a reduction in fitness caused by the gene flow through altered allele frequencies and breakdown of co-adapted gene complexes (Edmands and Timmerman 2002; Edmands 2007; McClelland and Naish 2007).

The available theoretical and empirical data on outbreeding effects (Naish et al. (2008) and McClelland and Naish (2007)) are inadequate for development of scientifically sophisticated criteria for "safe" levels of gene flow. A NMFS-sponsored workshop in 1995 (Grant 1997), concluded that a gene flow rate of greater than 5 % between local and non-local populations would quickly lead to replacement of neutral and locally-adapted genes. NMFS continues to apply the Grant (1997) guideline that less than 5 % of the naturally spawning population consists of hatchery fish from different populations. It is important to note, however, that the proportion of strays on the spawning ground may not be a good indicator of gene flow because stray hatchery fish may not successfully interbreed with the recipient population, proportional to their relative abundance in the population (e.g., Saisa et al. 2003; Blankenship et al. 2007). Probable reasons for poorer breeding success of hatchery strays are differences in run and spawn timing, and reduced survival of their progeny (e.g., Reisenbichler and McIntyre 1977; Leider et al. 1990; McLean et al. 2003; McLean et al. 2004; Williamson et al. 2010).

Gene flow can occur naturally through straying (Quinn 1993; Quinn 1997; Quinn 2005a). Natural straying serves a valuable purpose in nature in reducing loss of diversity through genetic drift and in recolonization, but hatchery-origin fish may exhibit an increased tendency to stray relative to natural-origin fish (Grant 1997; Quinn 1997; Marshall et al. 2000; Jonsson et al. 2003; Goodman 2005), resulting in unnatural gene flow patterns (sources or rates). Rearing and release practices and ancestral origin of the hatchery stock can all play a role in straying of hatchery fish (Quinn 1997). Hatcheries may also inadvertently create strays by trapping "dip-ins", fish that entered a tributary downstream of, or "overshot" their natal stream (Keefer et al. 2008) but still intended to spawn in their natal stream or hatchery.

Hatchery operations other than trapping may also cause gene flow by using nonnative fish, either directly releasing them (in effect causing strays) or through egg transfers. The Snake River fall Chinook salmon programs have always used native fish, however, so the main concern is straying and trapping of dip-ins. In the early years of Lyons Ferry operations, substantial proportion of fish, strays or dip-ins, from other hatchery programs were incorporated in the broodstock (Bugert et al. 1995). This realization eventually resulted in the cessation of trapping at Ice Harbor Dam in favor of LGR in 1994 (Mendel et al. 1996). In the late 1980s, large numbers of fish from the Umatilla and Bonneville fall Chinook salmon hatchery programs were included in the LFH broodstock, reaching a high of 43% in 1989 (Bugert et al. 1990).

In 1990, strict control of non-Snake fish at LGR and the hatcheries began. No returnees from the 1989 brood year were used for releases into the Snake Basin, a policy which constrained broodstock size for several years. CWT-containing fish passing LGR were automatically shunted into the trap and the tags read before spawning. Only returnees from Snake River fall Chinook salmon releases were used as broodstock for releases into the Snake River Basin; no unmarked fish were included. Eggs from non-native programs were discarded or shipped to other programs outside the Snake Basin. The major contributor to non-Snake interceptions at the LGR trap during this time was the Umatilla fall Chinook salmon program. The problem was alleviated by the implementation of 100% marking of Umatilla releases beginning in 1994, and by substantial reductions in the Umatilla program (Hayes and Carmichael 2002).

How much the Snake River fall Chinook salmon population has been effected by gene flow and measures to control it are unclear. Because LGR is below the spawning grounds, and is the last point at which population composition data is collected and fall-back may occur, the true stray rate of Umatilla-origin and other non-Snake fish onto the spawning grounds is unknown. Additionally, their reproductive success is unknown. But it is likely, given the difference in encounter rate of non-Snake fish at LGR and IHR, and the possibility that even some trapped fish at LGR were dip-ins, that non-Snake fish were included into the broodstock at a higher rate than they appeared on the spawning grounds. Additionally, the non-Snake fish could easily have had higher reproductive success in the hatchery than they would have had in the wild, the genetic consequences of which would have been magnified because of the preponderance of hatchery-origin fish on the spawning grounds. Genetic data show changes in frequency at allozyme loci, making the genetic profile of the population closer to that of Upper Columbia fall Chinook salmon (Bugert et al. 1995), although statistically significant differences remain (Marshall et al. 2000). The genetic profile of the hatchery broodstock at LFH did not change significantly between 1977 and 1991 (Bugert et al. 1991). (Bugert et al. 1995) feel the hatchery programs have been important factors in conserving the genetic integrity of the Snake River fall Chinook salmon population.

In 2000, near-complete exclusion of CWT-tagged fish from passage over LGR, was replaced with a random sampling approach. Starting in 2003, the trap is opened and closed on a regular schedule multiple times per hour. Untagged fish are included in the broodstock in an attempt to reach the goal of 30% natural-origin fish. Matings are tracked so that the eggs resulting from matings involving non-Snake fish can be removed after tags are read, if desired. Non-Snake fish are excluded if production goals can be met without them, but may be used at up to 5% to meet production needs. Table 21 shows the trapping rate and usage rate of non-Snake fish at LFH for 2004-2011. The pattern of inclusion demonstrated by Table 21 indicates that the average rate is considerably lower than the 5% gene flow rate publicized by NMFS (Grant 1997), so this practice does not pose a significant threat to the population. In fact, the Snake fall Chinook salmon programs are quite risk averse with respect to controlling inflow of non-native genetic material.

Table 21. Percentage of trapped fish consisting of strays and percentage of Snake River fall Chinook salmon hatchery production at LFH from strays (Milks 2012b).

Return year	Strays as proportion of trapped fish	Strays as proportion of production
2004	5.4%	0.0%
2005	6.3%	0.0%
2006	3.3%	0.4%
2007	2.3%	0.0%
2008	3.5%	0.1%
2009	1.3%	0.1%
2010	5.4%	0.3%
2011	2.5%	1.2%

2.4.4.3.Effects of Hatchery-Induced Selection

Hatchery-induced selection is caused by hatchery practices and the hatchery spawning and rearing environment differing from that of the natural environment to the point that they alter natural selective regimes. This can range from relaxation of selection that would normally occur in the wild, to selection for different characteristics in the hatchery and natural environments, to intentional selection for desired characteristics (Waples 1999). The literature on effects of hatchery-induced selection caused by salmon and steelhead hatchery programs has recently been reviewed by Naish et al. (2008) and Fraser (2008). The consequence of hatchery-induced selection can be changes in a variety of traits – behavioral, physiological, morphological, and life-history – but the changes in individual traits are commonly dealt with in aggregate in terms of their effect on fitness.

There is considerable uncertainty about the impact of hatchery-induced selection. Although there are studies noting both large and small fitness effects (Berejikian and Ford 2004), the empirical information is inadequate to allow prediction of fitness loss in any particular situation, especially one like that which exists, where gene flow is in both directions over several generations. Empirical data is beginning to become available on reversal of anthropogenically induced genetic change (e.g., Bosch et al. 2007; Conover et al. 2009), but it is insufficient to allow generalization about the extent to which fitness loss from hatchery-induced selection can be reversed, or how fast the reversal could occur. A growing concern worldwide is that strong anthropogenic selection pressures can cause genetic change from which recovery could take generations (Waples et al. 2007).

An especially relevant source of uncertainty is the fact that most of the empirical evidence of fitness loss due to domestication comes from steelhead, a species that is reared in the hatchery environment for an extended period – one to two years – before release. At this point no results are available of fitness studies or even relative reproductive success studies from Chinook salmon with subyearling life histories, such as Snake River fall Chinook salmon[8]. Selection may be expected to be stronger in fish that have longer residence in the hatchery environment, such as steelhead, stream-type Chinook salmon and coho salmon, than those with shorter hatchery residence, such as pink, chum and ocean-type Chinook salmon. If this is true, the fitness impact of hatchery-induced selection may be considerably less in the species with short residence times than in the species that are cultured for longer periods. The Recovery Implementation Science Team (RIST 2009) considered this issue and concluded that while less response in hatchery-induced selection may be expected in subyearling than yearling outmigrants because of a shorter residence in the hatchery, the difference may not be that great due to factors that are independent of hatchery residence time. Additionally a recent study of coho salmon (Theriault et al. 2011) found no difference in reproductive success in the wild between fish that were raised to yearlings and those that were released as fry, again suggesting that hatchery residence time may not be a major factor. The authors concluded that relaxation of sexual selection caused by not allowing mate choice was likely the major cause of fitness loss.

NMFS' current thinking on the genetic risk of hatchery operations and the uncertainties about that risk, especially the risk of hatchery-induced selection are stated in (NMFS 2011f):

> At this time, based on the weight of available scientific information, NMFS believes that artificial breeding and rearing is likely to result in some degree of genetic change and fitness reduction in hatchery fish and in the progeny of naturally spawning hatchery fish relative to desired levels of diversity and productivity for natural populations. Hatchery fish thus pose a threat to natural population rebuilding and recovery when they interbreed with fish from natural populations. That risk is outweighed under circumstances where demographic or short-term extinction risk to the population is greater than risks to population diversity and productivity. However, the extent and duration of genetic change and fitness loss and the short and long-term implications and consequences for different species, for species with multiple life-history types, and for species subjected to different hatchery practices and protocols remains

[8] This general concern has been raised by NMFS, and specifically for Snake River fall Chinook salmon in RPA actions 64 and 65 of the FCRPS Biological Opinion

unclear and should be the subject of further scientific investigation. As a result, NMFS believes hatchery intervention is a legitimate and useful tool to help avert, at least in the short-term, salmon and steelhead extinction, but otherwise managers should seek to reduce interactions between hatchery and natural-origin fish as the risk of extinction is reduced consistent with the overall recovery of the ESU, implementation of treaty Indian fishing rights, non-Indian fisheries, and harmony with other applicable laws and policies.

Salmon and steelhead hatchery programs in the Pacific Northwest vary widely in approach – from streamside incubator to captive broodstock – and thus in perceived selective environment they present (Busack et al. 2005). The Snake River fall Chinook salmon hatchery programs can be considered "typical" hatchery programs in that they collect broodstock at a trap or as volunteers to the hatcheries, release smolts, and follow standard hatchery practices in doing so. However, three practices that must be discussed in terms of risk addressed below.

2.4.4.3.1. Mating Protocols

Traditionally the mating protocols at both hatcheries have been largely random 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% (Table 22).

Table 22. Number of matings of minijacks, jacks, and jills contributing to broodstock at LFH, 2000-2010 (Milks et al. 2012, Table 12).

Year	0-salt	1-salt jack	1-salt jill	Number of matings containing jack x jill mating	% of total matings with 0 and/or 1-salt parentage
2000	195	609	157	127	80.4
2001	9	875	67	47	67.6
2002	5	348	6	4	31.8
2003	3	527	78	63	74.5
2004	34	941	254	204	77.6
2005	13	610	58	26	45.3
2006	1	525	123	94	70.6
2007	0	1136	477	405	82.9
2008	0	348	78	31	30.2
2009	1	547	513	152	70.3
2010	0	38	2	0	3.2
Average	**24**	**591**	**165**	**105**	**57.7**

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 over-representation 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), but also by recent 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 a modeling study (Hankin et al. 2009) showing that random mating with respect to size and age results in a population of younger, smaller fish. The current mating protocol at LFH with respect to size and age is as follows (WDFW 2011, Appendix D). The procedure is the same at NPTH except the minimum fish size is 70 cm FL (with some smaller fish being spawned)(Becky Johnson, pers. comm., May 18, 2012), while at LFH the minimum size is 65 cm FL to allow for subyearling jacks to be included. Spawning at LFH begins with larger sized fish ≥ 80 cm FL then the size criteria is relaxed to allow smaller fish to contribute to maximize the spawning population size.

- Jacks (1salts) may be incorporated in broodstock up to 15% (subyearling jacks)
- For adult males. Only two-salt and older age males are spawned.
- Older age males will be used on multiple females. Untagged males >80 cm FL may be used on multiple females. Any male used multiple times must be used on at least one large female
- Females will generally be mated to males that are larger than themselves

The potential effective size impact of reuse of males was already discussed in Section 2.4.4.1.1. The selective effect of this practice is less clear. Compensation for many previous years of including probably far too many 1-salt fish, and for biased broodstock trapping because of fishery impacts seems reasonable. However, the near exclusion of jacks may be too simplistic in view of recent research that demonstrates that jack contributions can vary widely (Williamson et al. 2010; Theriault et al. 2011; Schroder et al. 2012) and in some circumstances jack mating success can be frequency-dependent (Berejikian et al. 2010). And too much reliance on the results of Hankin et al. (2009) may be unwise. Not only did Hankin et al. assume lower jack contribution rates than are suggested by the research just cited, they also assumed that assortative mating (e.g., larger fish mating with larger fish) is common in Chinook salmon. Although size-assortative mating has been documented in salmonids in which large size disparities exist between the sexes (Foote and Larkin 1988; Maekawa et al. 1994), it has not been documented in Chinook salmon, and evidence to the contrary exists for its occurrence in pink salmon and steelhead (Dickerson et al. 2004; Seamons et al. 2004).

Salmonids in nature certainly do not mate randomly (e.g., Quinn 2005b; Pitcher and Neff 2007; Labonne et al. 2009; Berejikian et al. 2010; Weir et al. 2011; Schroder et al. 2012). The challenge is to develop an alternative to random mating that addresses the issues this population and these hatchery programs in a manner that conserves fitness. The current protocols seem unlikely to cause substantial impacts on fitness of the Snake River fall Chinook salmon population and may be helpful over the near term. However, because of the effective size implications already discussed, a broader discussion of the mating protocols may be valuable.

2.4.4.3.2. Implications of Yearling Releases

The Snake River fall Chinook salmon population predominantly exhibits a subyearling life history, but the hatchery programs have been releasing and intend to continue under the proposed action, 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 have been 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). (Connor et al. 2005) suggest that because the yearling life history is now reasonably common in nature that the release of hatchery yearlings may be not an issue. The basic question is to what extent might the release of yearlings be a selective force on the Snake River fall Chinook salmon, as opposed to mimicking a natural, evolving (Williams et al. 2008) situation?

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 (Table 20) 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. Research is underway into the genetic determination of juvenile life history in Snake River fall Chinook salmon (Waples et al. 2011). Preliminary results suggest that forced yearling outmigrants tend to produce faster-growing progeny, which would then be expected to mature earlier, according to the model of Thorpe et al. (1998). Thus, the situation is probably not as simple as hatchery yearlings tending to produce yearling outmigrants.

NMFS feels, as have previous reviewers, that the genetic implications of yearling hatchery releases for the Snake River fall Chinook salmon is a concern, but we further find that it is unlikely to have substantial consequences for the population during the period of the permit. We also feel the risk is buffered by the fact that the genetic determination of juvenile life history in this population is the subject of ongoing research that may be used to guide the operators in the future regarding the proportion of yearling releases.

2.4.4.3.3. Use of Early-Spawning Fish in the South Fork Clearwater River

As part of the NPTH effort to supplement the South Fork Clearwater River, when the run size is large enough, adults will be trapped for broodstock at a temporary picket weir near the mouth of the river (Hesse and Johnson 2012). The trapping effort, which will take no more than one third of the returnees if 66 or more redds are observed, with natural-origin fish comprising no more than 30% of the fish taken, will increase as the number of returnees to the South Fork Clearwater increase.[9] The intent is to eventually produce enough juveniles for the entire Lukes Gulch production goal, and for all the Cedar Flats production as well, a total of 400,000 fish (Table 4).

This approach is consistent with other supplementation efforts to reintroduce fish to vacated or underutilized habitat, such as the effort in the Yakima River Basin to encourage spring Chinook salmon spawning in the Teanaway River (Fast and Craig 1997). The effort is modest: at full production only 7.7% of the overall Snake River fall Chinook salmon production and only 9.4% of the subyearling releases, so there is no risk of diverting a large portion of the hatchery production into a program that could prove unsuccessful. Finally, the program is a positive step toward development or enhancement of subpopulation structure (Section 2.4.4.1.2). This aspect of the program does not pose a genetic risk to Snake River fall Chinook salmon at this time.

2.4.4.3.4. Transmission of Effects of Hatchery-Induced Selection

The major hatchery-induced selection concern under the proposed Snake River fall Chinook salmon hatchery programs is not the selective environment of the hatcheries and hatchery practices, but rather than the perceived large proportion of hatchery-origin fish in the population.

The uncertainties involved here must be acknowledged at the outset of this discussion. There is considerable uncertainty both about the number of fish on the spawning grounds, and about the proportion of fish that are of hatchery-origin. Abundance data from the spawning grounds consists only of incomplete aerial and underwater redd counts, and some carcass recoveries in the Clearwater River. The best estimates of the number of fish on the spawning ground are thus counts of fish passing over LGR. These counts are biased by an unknown prespawning mortality rate and by fall-back without reascension; i.e., fish passing LGR, then dropping back down below and the dam and not returning. This phenomenon is not well understood, but a current summary has been provided by (Rosenberger 2012). Annual rates of fall-back vary, but percentages of fall-back by hatchery group appear consistent (i.e. a specific hatchery group, such as LFH onstation releases accounts for about the same proportion of total fall-backs each year). Jacks appear to fall-back at a much higher rate than adults, although a significant number of adults exhibit this behavior as well. Among hatchery groups, it appears that the prevalence of fall-back is highest in the LFH onstation yearlings, but the onstation subyearlings have not been tagged at a high enough rate to assess them. Due to low sample sizes it is difficult to assess fall-back of natural fish, however the rate is assumed to be low. Fall-back rates will be specifically addressed by a proposed new study (Section 1.3.2.2).

Counts are also biased by the assumption that the LGR sampling regime, which opens the trap a specified percentage of the time, traps that same percentage of the run (Young et al. 2012). Recently the operators discovered that passage rates determined by window counts did not agree with those determined by sampling rates. The sampling rate bias is being addressed by current and proposed run-reconstruction RM&E activities.

Considerable uncertainty also exists about the proportion of hatchery-origin fish on the spawning

[9] Fish from NPTH releases began returning to the area in 2011 (Hesse and Johnson 2012).

ground, which is assumed to the proportion in the run at LGR, corrected for broodstock collection. At full production, ~25% of the hatchery-origin fish are unmarked. In the past, the proportion of unmarked fish that were of hatchery-origin was estimated using expansions of coded-wire tag recoveries. More recently this method was modified used scale-pattern analysis, an approach which has been shown to be unreliable (WDFW and NPT 2011), so estimates on hatchery-natural fractions from 2006 to 2009 based on this method should be viewed with caution. The same imprecisions apply to estimates of natural-origin fish used as broodstock. The run-reconstruction process underway and proposed to continue is reanalyzing these years and will be developing new estimates based on CWT expansions in the past. However, CWT expansion estimates are still subject to considerable error. Much better estimates of hatchery-natural fractions would be possible if all the hatchery fish were marked, but as the current marking regime now in place is stipulated by the *U.S. v. Oregon* Agreement, program operators have proposed the use of parentage-based tagging (PBT) as one of the new RM&E activities.

Under this scheme, all fish used for broodstock will be genotypically sampled. The genotypes of trapped returning unmarked adults will be compared to potential parents among the previously sampled broodstock fish. Any fish that cannot be paired with parents will be considered a natural-origin fish. The technique is theoretically very powerful for matching parents and progeny (Anderson and Garza 2006) and the concept has been proven (Steele et al. 2011; Young et al. 2011). Unmarked fish released from other hatcheries will still be unidentifiable, but this would still be a problem if 100% of the fish released by the proposed programs were to be marked.

Because of these uncertainties the genetic influence of the hatchery programs may in fact be considerably lower than suggested by the proportion of hatchery-origin fish on the spawning grounds and the proportion of natural-origin fish in the hatchery broodstocks. And the reproductive success of the hatchery-origin fish in the natural environment can be expected to be lower than that of natural-origin fish, making the genetic impact of the hatchery-origin fish less than what would be expected based on their numbers. Even considering all these factors, however, the effective proportion of hatchery fish (pHOS) on the spawning grounds is certainly well above 50%. The proportion of natural-origin fish in the broodstocks (pNOB), which could be expected to ameliorate the effect of the high proportion of hatchery-origin fish on the spawning grounds (Lynch and O'Hely 2001; Ford 2002), is estimated at about 7% in recent years. The Hatchery Scientific Review Group (HSRG) has developed a metric relating these two proportions called proportionate natural influence (PNI) (Mobrand et al. 2005; HSRG 2009b; Paquet et al. 2011). Currently the Snake River fall Chinook salmon population has an estimated PNI of 0.06 (WDFW et al. 2011). The HSRG recommends a PNI of at least 0.67 for control of hatchery-induced selection in populations of high conservation concern (HSRG 2009b), so apparent hatchery influence in the Snake River fall Chinook salmon population is considerably higher than HSRG recommends. However, the (HSRG 2009a) did not make any specific recommendations regarding PNI in its review of this population.

The concept of a high proportion of hatchery-origin fish on the spawning grounds constituting a genetic risk is not a new idea, but much of the current discussion about the genetic risk of hatchery fish on the spawning grounds, including gene flow guidelines and the terminology (pHOS, pNOB, PNI) originated with the HSRG’s application of a model developed by Ford

(2002). Since much of the current concern about the proportion of hatchery-origin fish on the spawning grounds stems from the recent regional HSRG review, it is useful to examine the model and assumptions used in applying it.

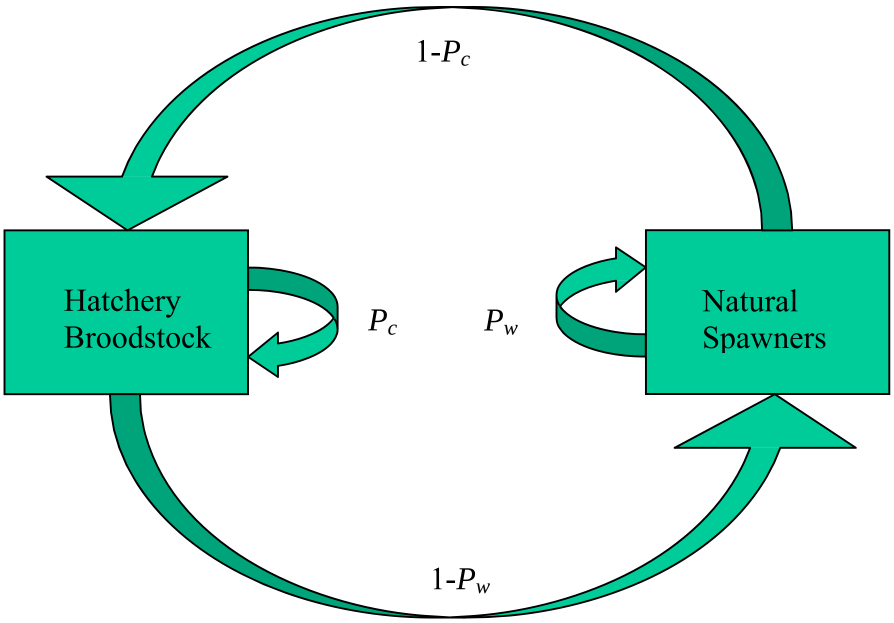

Figure 9. Gene flow paths in a population in which hatchery-origin and natural-origin fish interbreed (adapted from Lynch and O'Hely (2001) with notation from Ford (2002)). P_w and 1- P_w represent proportions of natural spawners that are natural-origin and hatchery-origin fish, respectively. P_c and 1- P_c represent proportions of broodstock that are hatchery-origin and natural-origin fish, respectively.

The Ford model allows the user to determine where a trait equilibrium point will be for a specified set of conditions of gene flow, heritability[10], optima, and selection strength[11]. But it can easily be shown using Ford's (2002) equilibrium equations that for a given heritability and selection strength, PNI is determined by the ratio of the gene flow rates.

The Ford model is a simplified version of reality, so assumptions have to be made in using it to provide management insights for real populations. The most important of these derives from the fact that the model is a single-trait model, when in reality hatchery-induced selection is a multiple trait phenomenon, and requires knowledge of heritabilities, selection strengths, trait optimum values for the two environments and gene flow rates. To use the model fully we would need to know how many traits were involved, their heritabilities, selection strengths, optima, and other details, most of which are unknown (RIST 2009). The HSRG gene flow guidelines for integrated hatchery programs were developed by assuming that the single-trait approach was workable and by capitalizing on the determination of PNI by gene flow rates, so knowledge of the other parameters was not necessary. In doing this, the HSRG assumed equal heritabilities

[10] Heritability is the proportion of phenotypic variation a trait expresses that is under genetic control and thus can respond to selection.
[11] Selection strength is the intensity with which fitness declines as distance between the trait value and its optimum increases.

and selection strengths in the two environments; assuming differences would result in different pHOS and pNOB values to achieve a specified PNI. But the most important assumption they made was to assume that pHOS and pNOB (corrected for reproductive success if possible) are reasonable estimates for gene flow rates ($1\text{-}P_w$ and $1\text{-}P_c$, respectively in Figure 9). While there is no reason to suspect that pHOS and pNOB are not at least good indices of the real gene flow rates, this needs to be evaluated. Other assumptions within the Ford model that could affect its applicability to real management situations are being explored by Baskett and Waples (In press). More research of this sort is greatly needed, as there is likely never to be adequate funding for thoroughly researching the relative impacts of different gene flow regimes experimentally.

A possibly more intuitive approach than the Ford model to the potential genetic impact of the high proportion of hatchery-origin fish on the spawning grounds is to consider mating dynamics under different proportions of hatchery-origin fish on the spawning grounds. Figure 10 shows the expected proportion of mating types with different levels of pHOS, assuming random mating. Under this assumption, the mating proportions are given by the expansion of $(pNOS + pHOS)^2$. Most matings consist of two natural-origin parents (NxN) until pHOS rises above 0.29.

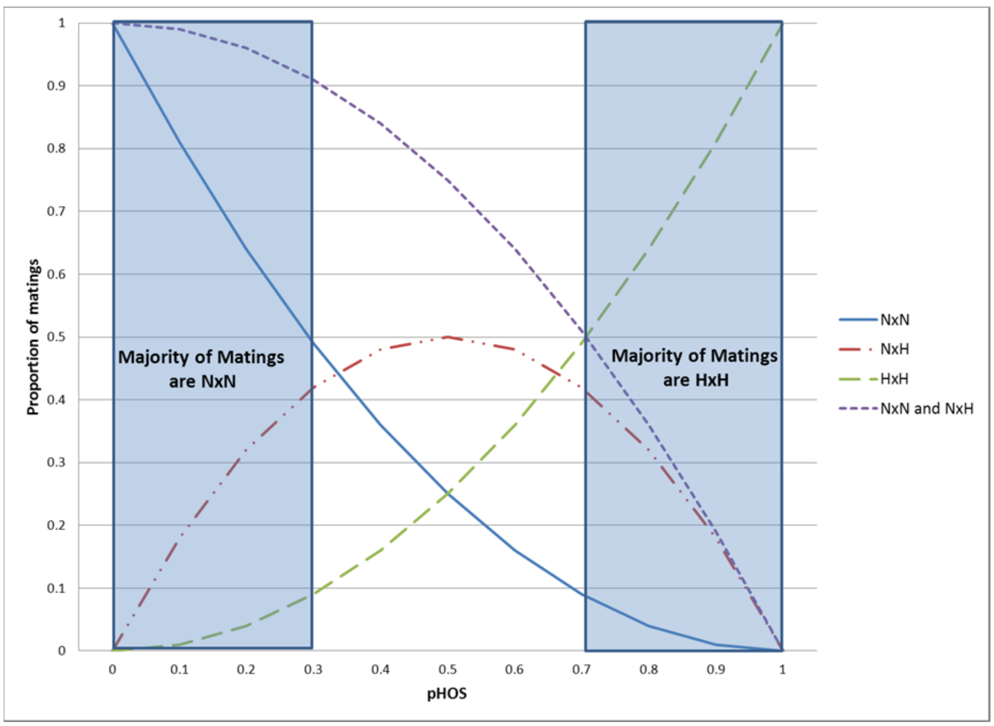

Figure 10. Expected proportion of mating types by fish origin as a function of pHOS

At a pHOS level of 0.71, most matings are HxH, with the proportion of NxN matings being 0.09. Another way to look at this is in terms of parentage: the probably of a natural-origin fish having resulted from a given mating type is the probability of that mating type in its brood year. It seems reasonable that adaptation to an environment requires that those produced there have an opportunity to reproduce there. This simple analysis shows how that possibility decreases with increasing pHOS, and moreover shows that in a system with high levels of pHOS, it is easily possible for almost all spawners to be the progeny of hatchery-origin fish spawning in the wild. For example, the probability of a natural-origin fish having had two natural-origin parents if pHOS was 0.5 among the parents is 0.25, but the probability drops to 0.04 if pHOS among the parents was 0.8.

This simple analysis is subject to assumptions both of random mating and equal reproductive success of both types of fish. As mentioned in Section 2.4.4.3.1, mating is not random, and RRS studies have not been done for Snake River fall Chinook salmon because of feasibility issues (Peven 2010), but given the pHOS levels observed in Snake River fall Chinook salmon, RRS would have to be extraordinarily low and mating extremely nonrandom with respect to origin to conclude that NxN matings dominate or that a substantial proportion of natural-origin fish have resulted from natural-origin parents in the Snake River fall Chinook salmon population.

Thus, both according to HSRG criteria and the simple mating type/parentage model, the opportunity for transmission of the effects of hatchery-induced selection to the population is high. In addition, recent genetic data indicate no distinction between the natural-origin and hatchery-origin components of the population (Marshall and Small 2010), suggesting substantial gene flow between them. The question that NMFS must address in this opinion is whether this constitutes a significant risk. An obvious demonstration of reduced fitness would be a decline in productivity. Figure 11 presents recruits/spawner and adult escapement for 1975 to 2007. No trend is apparent. Productivity seems to have decreased as spawner abundance has increased in recent years, but it fluctuated considerably before that, and the 2007 productivity is a considerable increase that is accompanied by high abundance. The relationship between density and productivity will hopefully become clearer as information from additional brood years is available.

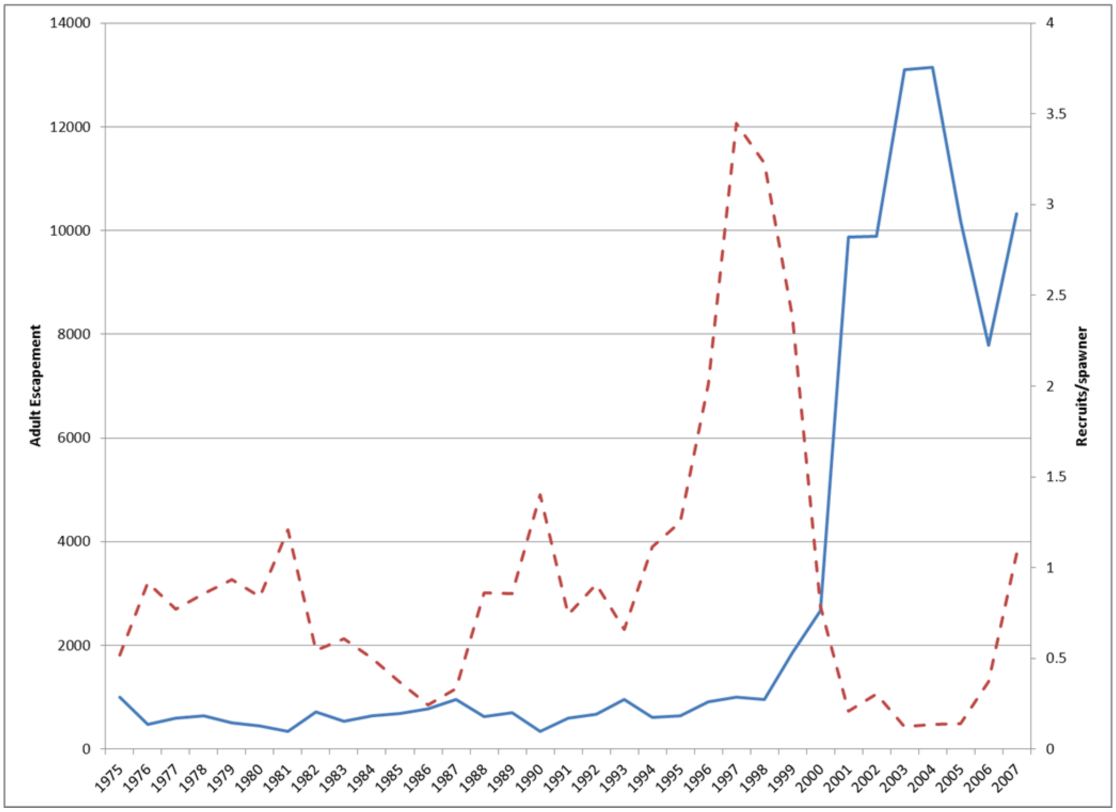

Figure 11. Adult fall Chinook salmon escapement (solid line) and productivity (recruits/spawner) (dashed line) from 1975 to 2007 (data from T. Cooney, NWFSC).

Another possible indicator of fitness issues is the relative number of hatchery-origin and natural-origin returns. Figure 12 shows total escapement of adults over LGR, escapement of natural-origin adults, and numbers of fish released from 1979 to 2011. In presenting the release numbers with the escapement information, our intention here is to show general trends. The number of fish released in a given year contributes to adult returns 2-5 years later, and this lag is not represented in the figure. The number of fish released dropped considerably in the early 1990s because of stray removal (Section 2.4.4.2), but have increased since the mid-1990s. Escapement has also increased during that time. The relationship between the two is complex: large releases fuel large returns, but because of abundance-driven broodstock collection limitations, large returns also fuel large releases, until capacity has been reached. Only in recent years have release numbers approached the full programmed *U.S. v. Oregon* objective of 5.5 million (Table 3).

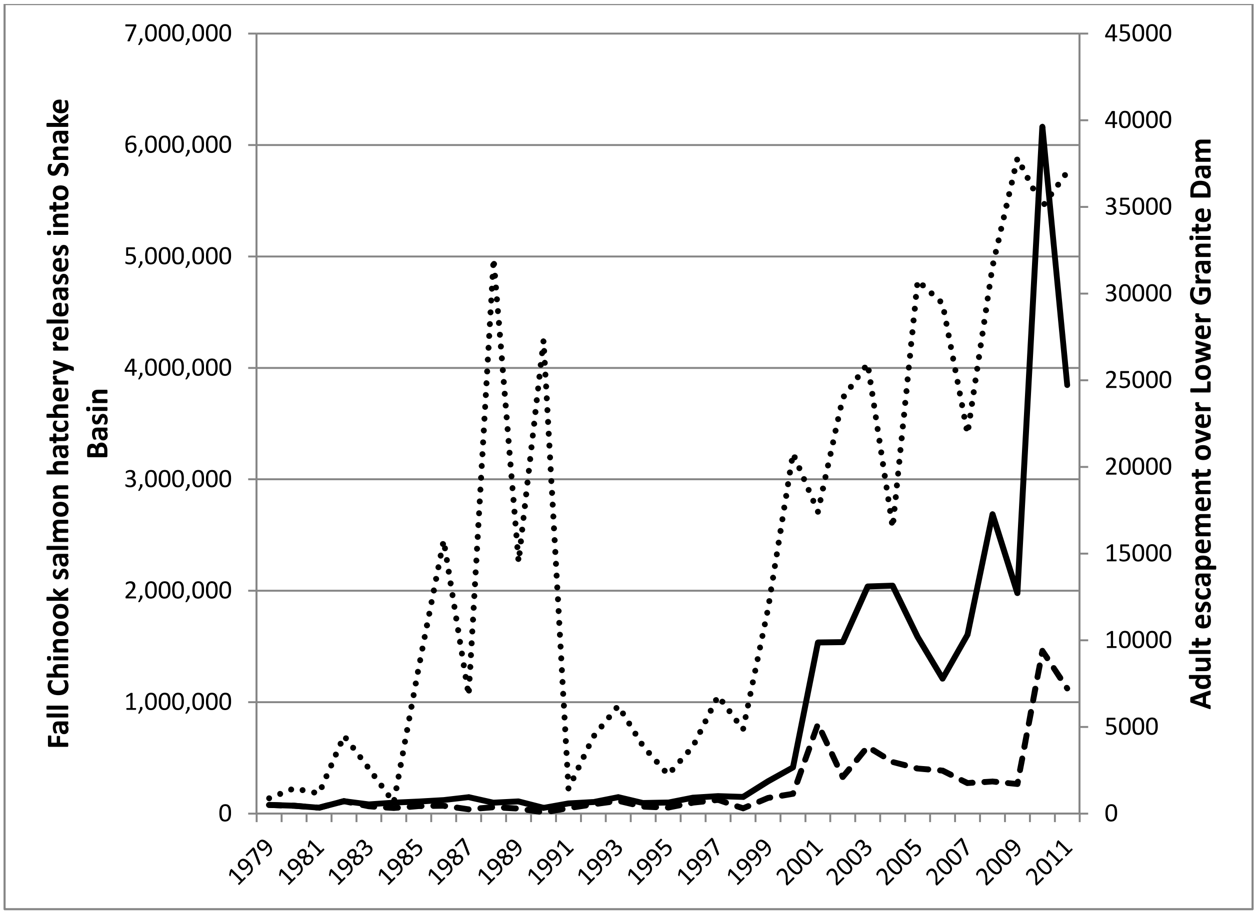

Figure 12. Fall Chinook salmon adult salmon escapement (solid line=total, dashed line=natural-origin) over LGR, and total fall Chinook salmon releases (dotted line) from 1979 to 2011. Data for 2010-2011 are a result of new run-reconstruction methods. Data from other recent years may change when the new method is applied.

Aside from this synergy, as (Cooney and Ford 2007) point out, there are several possible contributing causes to the increased abundance, including reduced harvest rates, improved in-river rearing and migration conditions, the development of life history adaptations to current conditions, and improved ocean conditions benefiting the relatively northern migration pattern. Another important contributor is increased hatchery production beginning in the mid-1990s made possible by the decrease in number of stray fish. Assuming a 3-4 year lag would be appropriate for the release curve, it appears that the pattern of increasing abundance began before the increase in hatchery production was reflected on the spawning grounds. Cooney and Ford (2007) concluded that there was insufficient information available to assess the relative contributions of the various possible factors, and this is still true.

Natural-origin returns appear to not track with the overall increase in returns, showing a nearly linear decline from 2003 to 2009. When this consultation began, and when the most recent 5-year review (Ford et al. 2011) was being prepared, this decline suggested that there may a declining trend in productivity. Natural-origin returns rebounded in 2010 and 2011, but these calculations were developed using a new run-reconstruction methodology (Young et al. 2012).

As part of the new RM&E measures (Section 1.3.2.2), this approach will be applied to previous years at least as far back as 2003, and it is possible that the estimated number of natural-origin adults may increase. Thus the recent decline may actually not be real; natural production may be tracking the overall increase in returns.

If revised run-reconstruction does show that natural production is tracking the overall population increases, the possibility that this population is responding positively to supplementation cannot be ruled out. NMFS has long recognized and endorsed the use of hatchery programs as a tool for reducing extinction risk, but has continued to question their value in increasing natural production beyond the near term because of the potential for genetic erosion of productivity. Given these considerations, the question we face for any supplementation program aimed at recovery for a listed population is at what point the genetic risk outweighs the demographic benefit, and the hatchery efforts should be scaled back. Uncertainties about the general magnitude and reversibility of impacts due to hatchery-induced selection make identification of this "inflection point" difficult. Population responses to supplementation may provide insights, however, if habitat and other determinants of productivity and capacity are sufficiently stable. If the inflection point has been reached, natural production may remain static or decline relative to hatchery production. If the inflection point has not been reached, natural production can be expected to increase.

The pattern that Snake River fall Chinook salmon population is following is unclear due to many uncertainties, but it may be responding positively to the hatchery effort in terms of increased natural production. In general, our approach to any program with this high an apparent level of hatchery influence is to recommend reductions in the number of hatchery-origin fish on the spawning grounds. But documented cases of hatchery programs causing increases in natural-origin returns are uncommon. More common are cases, such as the Imnaha spring/summer Chinook salmon program (Carmichael et al. 2011) or Methow spring Chinook salmon (Murdoch et al. 2012), where no increase has been detected. The Snake River fall Chinook salmon population may then provide a rare opportunity to see a clear trend in natural production in a population undergoing supplementation, and that opportunity would be lost if major changes were made to program management during the period of the permit. Considering the age of the hatchery program, the possible incremental loss of productivity due to hatchery-induced selection will be unlikely to pose significant risk to the population during that period. NMFS feels the risk posed will be outweighed by the scientific benefits that could be applied to this or other populations, and that the risk will be further contained by inclusion in the proposed action of an appropriate pHOS "early warning" trigger.

2.4.5. Ecological Effects

Ecological effects that pose risks to natural salmonids occur when the presence of hatchery fish detrimentally affects how wild fish interact with others of their own species, with their environment, or with other species. However, not all ecological interactions, generated by artificially produced salmonids are negative for natural populations. The negative ecological effects of hatchery programs are most severe when wild and hatchery fish share a limited environment for a substantial period of time (Kostow 2009). Ecological interactions between hatchery and natural-origin fish include competition, predation, disease transmission, and marine derived nutrients. The level of these effects and any risks they pose are not always know or even quantifiable and may, in some cases, be deemed acceptable, given the goal of the hatchery program.

Evaluation of risk of ecological risk is often dependent on relative fish size. In this section we had to work with a mix of length and weight data. For conversions from one to the other, we relied on (Piper et al. 1982).

2.4.5.1.Competition

Competition for food and space between hatchery and natural-origin salmonids may occur in spawning and/or rearing areas, the migration corridor, and in the marine habitat. Of all the potential interactions between hatchery and wild salmonids, competition uniquely and regularly occurs at all life stages and associated habitats, thus raising concerns about the impact of hatchery fish on the management and recovery of wild salmon populations (Tatara and Berejikian 2012). Competition may result from direct interactions, in which hatchery-origin fish interfere with access to limited resources by natural-origin fish (density-dependent competition), or indirect interactions, as when utilization of a limited resource by hatchery-origin fish reduces the amount available for natural-origin fish. These impacts are assumed to be greatest in the spawning and nursery areas and at points of highest fish density (release areas) and to diminish as hatchery smolts disperse (USFWS 1994).

Hatchery juveniles may be in fresh water for only a short period of time if they are actively smolting and quickly move into the ocean after they are released. However, agencies also release hatchery fish in presmolt stages, ranging from emergent fry to parr, and these juveniles need to rear in fresh water before smolting (Kostow 2009). Weber and Fausch (2003) noted that displacement of wild fish by hatchery fish has also been directly observed in streams among steelhead or rainbow trout by (Pollard and Bjornn 1973) and McMichael et al. (1999; 2000), coho salmon by (Nielsen 1994), and Chinook salmon – but only when the hatchery fish were larger – by (Peery and Bjornn 1996). In an assessment of the potential ecological impacts of hatchery fish production on naturally produced salmonids, the Species Interaction Work Group (SIWG 1984) concluded that naturally produced steelhead, coho salmon, and Chinook salmon are all potentially at "high risk" to competition (both interspecific and intraspecific) from hatchery fish of any of these three species. In contrast, the risk of naturally produced pink, chum, and sockeye salmon to competition from hatchery salmon and steelhead was judged to be low. However, (Tatara and Berejikian 2012) noted that intraspecific competition is expected to be greater than interspecific because of greater niche overlap between conspecific hatchery and wild fish. They also noted, based on work in Riley et al. (2004), that in cases where the instream location and distribution of wild Chinook salmon, coho salmon, steelhead, and cutthroat trout were monitored before and after small scale releases of hatchery Chinook salmon and coho salmon, few if any changes in wild fish density, group size, microhabitat use, and size were observed, suggesting the ecological niche of wild fish did not change when hatchery fish were released and low potential for interspecific competition.

For adult salmon and steelhead, effects from competition between hatchery-origin and natural-origin fish are assumed to be greatest in the spawning areas where competition for mates and spawning habitat occurs (USFWS 1994). Hatchery-origin females compete with natural-origin females for spawning sites and hatchery-origin males compete with natural-origin males for female mates. Although there is evidence that natural-origin fish have a competitive advantage over hatchery-origin fish in these situations (Fleming and Gross 1993; Berejikian et al. 1997), it is likely that the cost of this interaction, in terms of lower survival of spawners and deposited eggs, will be higher when hatchery-origin fish are present in substantial numbers (NMFS 2010 and references therein).

The overall number of hatchery-origin Snake River fall Chinook salmon to be released from these programs under the proposed action is considerable—5.5 million overall, with 4,850,000 released above LGR (Table 2). This area constitutes the majority of the remaining spawning and rearing area for this population. Additionally, evidence that a large proportion (0.51) of the annual hatchery subyearling releases (the majority of the total release number) above LGR over-wintered in the reservoir (although not necessarily in Lower Granite reservoir) and attained significant growth before final emigration downstream of LGR (Connor et al. 2005) , raises concerns for substantial directly competitive interactions between the hatchery releases and naturally produced fall Chinook salmon. The degree of concern depends on how limiting rearing habitat is, and this is unknown for Snake River fall Chinook salmon.

ESA-listed juvenile Snake River spring/summer Chinook salmon have been observed rearing in the mainstem Snake River above LGR (Connor et al. 2002), although the overall proportion of Snake River spring Chinook salmon that rear in the mainstem is not estimated. This indicates some level of spatial and temporal overlap between rearing fall and spring Chinook salmon juveniles and presumably some level of competition for resources, potentially limited. This conspecific interaction may be important due to the number of fall Chinook salmon, including hatchery subyearling releases, which utilize the over-wintering life history.

Sockeye salmon smolts from Redfish Lake in 2011 averaged 108 mm FL (range 89-178) and 103 mm FL (range 83-163) (Peterson et al. 2012), for natural and hatchery fish, respectively, so in the size range where competition is possible with fall Chinook, provided they overlap in time, space, or food habits. Temporal overlap is a certainty, with sockeye migrating from the lakes from late April through May, and arriving at LGR 6 to 14 days later (Hebdon et al. 2003; Willard et al. 2005), but there seems to be no protracted reservoir residence. In 2001, the median travel time for both natural and hatchery smolts from Redfish Lake was about 10 days (Hebdon et al. 2003). Sockeye salmon are pelagic planktivores (Burgner 1991; Quinn 2005a), implying a considerable degree of habitat partitioning between sockeye and fall Chinook salmon. Like steelhead, sockeye salmon have not been encountered in river or reservoir surveys of fall Chinook salmon juveniles, which could be both an indicator of the speed with which they emigrate, habitat partitioning, and their relative scarcity. Given our current information, the risk of measurable ecological interactions with fall Chinook salmon is negligible.

There is also potential for indirect competitive interactions between program fish and other listed species in the Snake River Basin. Direct competition between program fall Chinook salmon and other species, mainly listed steelhead and bull trout, is likely not consequential due to low niche habitat overlap between species (Tatara and Berejikian 2012). Outmigrating steelhead are considerably larger than outmigrating Chinook salmon, making competition unlikely. In 2010, PIT-tagged but otherwise unmarked steelhead sampled at LGR averaged 201mm FL (sd=33), whereas adipose-clipped yearling and subyearling Chinook averaged 139 (sd=16) and 110 (sd=20) mm FL, respectively (FPC smolt data, accessed 8/22/2012).

There is a high level of uncertainty regarding the capacity of the Snake River Basin for overall natural salmon production. Attaining capacity estimates for fall Chinook salmon and other species should be a primary focus of future RM&E work. Once these capacities are estimated, potential necessary changes to all these programs can be assessed. In the meantime, measures to minimize the proportion of hatchery-origin juveniles that remain in the Snake River system due to delayed migration and/or over wintering in the Lower Snake reservoir are recommended.

2.4.5.2. Predation

Risks to naturally produced salmonids attributable to direct predation (direct consumption) or indirect predation (increases in predation by other predator species due to enhanced attraction) can result from hatchery releases. Direct predation risks from hatchery releases are likely a combination of prey abundance, in this case naturally produced salmonid juveniles in the Snake River Basin, and the size of the prey in relation to the predator fish—predators tend to prey on food items from less than or equal to 0.33 (Parkinson et al. 1989) to 0.5 of their length (Pearsons and Busack 2012). Due to their location, size, and time of emergence, newly emerged natural salmonid fry are likely to be the most vulnerable to predation by hatchery fish. Their vulnerability is believed to be greatest as they emerge and decreases somewhat as they move into shallow shoreline areas (USFWS 1994). Emigration out of hatchery release areas and foraging inefficiency of newly released hatchery smolts may minimize the degree of predation on salmonid fry, at least for hatchery steelhead preying on juvenile spring/summer Chinook salmon (USFWS 1994). The Species Interaction Work Group (SIWG) (1984) categorized species combinations as to whether there is a high, low, or unknown risk that direct predation by hatchery fish will have a negative impact on productivity of naturally produced salmonids (Table 23).

Table 23. Risk of hatchery salmonid species predation on naturally produced salmonid species in freshwater areas (SIWG 1984). Hatchery-origin Chinook salmon are highlighted for reference.

Hatchery Species	Naturally Produced Species					
	Pink Salmon	Chum Salmon	Sockeye Salmon	Coho Salmon	Chinook salmon	Steelhead
Pink Salmon	L	L	L	L	L	L
Chum salmon	L	L	L	L	L	L
Sockeye Salmon	L	L	L	L	L	L
Coho Salmon	H	H	H	U	U	U
Chinook salmon	H	H	H	U	U	U
Steelhead	H	H	H	U	U	U

Note: “H” = High risk; “L” = Low risk; and “U” = Unknown risk of a significant impact occurring.

Naman and Sharpe (2012) reviewed 14 studies of predation by yearling hatchery salmonids on subyearling wild fish. They found the level of predation generally to be low, but also found areas of localized heavy predation under certain circumstances, and concluded that managers can effectively reduce predation risks by minimizing the spatial and temporal overlap of the predator and prey populations. However, because even low predation rates could seriously impact prey populations that are at low numbers, they also recommend reducing the number of hatchery fish released in these situations. However, their review did not include any studies directed at predation by Chinook salmon. In a study designed to look at the feeding habits of yearling Snake River Chinook salmon smolts trapped at LGR, Muir and Coley (1996) found no fish in the stomach contents of the emigrating yearling Chinook salmon smolts. (Rondorf et al. 1990), examining the dietary composition of mainstem Columbia River subyearling Chinook salmon in the reservoir behind McNary Dam, also showed the vast majority (>91%) of the prey items consumed were insects and crustaceans. The remaining 9% was a combination of various trace species including embryonic fish not identified.

Busack et al. (2005) cited two studies estimating hatchery Chinook salmon predation rates on both juvenile Chinook salmon and steelhead (Sholes and Hallock 1979), evaluated hatchery Chinook salmon predation rates in the Feather River, CA and estimated a potential predation rate of 1.3 Chinook salmon consumed per hatchery fish. The second study, Pearsons et al. (2005) (cited in Busack et al. 2005) initially examined predation by residual (present after June 1) hatchery spring Chinook salmon releases in the Yakima River (WA) and found no evidence of consumption of juvenile Chinook salmon or steelhead. This work was later completed and formalized in annual report to the Bonneville Power Administration (Pearsons et al. 2008). With additional sampling years and earlier sampling dates added to the 2005 work, Pearsons found that despite the presence of ample numbers of prey sized *O. mykiss* and Chinook salmon there was little evidence of substantial piscivory by residualized spring Chinook salmon in the Yakima Basin. Pearsons (2008) also concluded that the differences (lower) in the level of predation observed in his work, (Sholes and Hallock 1979), and (Hawkins and Tipping 1999) could be based on differences in prey density in the studies, forced hatchery releases versus volitional and the average size of the hatchery fish released. Pearsons' Yakima work utilized volitionally released fish averaging 120mm FL.

Mobrand et al. (2005) concluded that hatchery reared chum, pink, sockeye, and ocean-type Chinook salmon are unlikely to prey on wild salmonids due to their relatively small size at release and/or their non-piscivorous feeding habits and that yearling coho, stream-type. Chinook salmon and steelhead smolts have the greatest likelihood of preying on wild salmonids fry due to their large relative size at release.

Large concentrations of migrating hatchery fish may attract predators (birds, fish, and seals) and consequently contribute indirectly to predation of emigrating naturally produced fish (Steward and Bjornn 1990). The presence of large numbers of hatchery fish may also alter naturally produced salmonid behavioral patterns, potentially influencing their vulnerability and susceptibility to predation (USFWS 1994). Hatchery fish released into naturally produced fish production areas, or into migration areas during naturally produced fish emigration periods, so may pose an elevated, indirect predation risk to commingled listed fish. Alternatively, a mass of hatchery fish migrating through an area may overwhelm established predator populations, providing a beneficial, protective effect to co-occurring listed naturally produced fish.

Few studies in the literature focus specifically on the predation rates of hatchery Chinook salmon on natural salmonid prey. In the instance where it has been physically estimated – Pearson et al. (2005) (cited in Busack et al. 2005) – no evidence of predation on Chinook salmon or steelhead juveniles was observed. This study, however, focused on sampling residual hatchery spring Chinook salmon after June 1, which may not be completely applicable in assessing the risk these fall Chinook salmon subyearling and yearling releases present.

Snake River fall Chinook salmon spawning and rearing grounds are broadly distributed in the Snake Basin. Elevation and water source differences can have a significant effect on the temperature regimes that these various reaches experience. The effect of this is a wide range of emergence dates and initial growth trajectories. Connor et al. (2002) looked at juvenile fall Chinook salmon life history patterns in the Upper and Lower Snake River and Lower Clearwater River and measured differences in emergence and growth between locations, by date. They estimated the median (multi-year) emergence timing (<45mm) for the different reaches for fall Chinook salmon as roughly April 22, May 1 and June 16 for the Upper Snake, Lower Snake and Clearwater, respectively. Median (multi-year) parr size (>45mm) timing for the different reaches for fall Chinook salmon were roughly May 15, May 29 and June 25 for the Upper Snake, Lower Snake and Clearwater, respectively.

The subyearling smolt releases from these programs release or plant juvenile hatchery Chinook salmon between 103-111 mm long (42-50 fpp), from May 1 through June, annually. Based on a potential prey size calculation of between 30-50% of the predator fish's length, program subyearling fish could consume prey items from 31-56 mm. Chinook salmon fry and early parr (≤56mm) in all reaches are potential prey size for subyearling hatchery Chinook salmon releases during the month of May. Natural Chinook salmon fry and early parr in the Lower Snake and Clearwater rivers reaches are potential prey size during the month of June as well.

These programs release or plant juvenile hatchery Chinook salmon between 165-176 mm long (10-12 fpp), from April 1 through mid-April, annually. Based on a potential prey size calculation of between 30-50% of the predator fish's length, program yearling fish could eat prey items from 50-88 mm. Natural Chinook salmon parr from the earliest emerging fish may be of a size to be potential prey for yearling hatchery Chinook salmon releases during the first half of April.

Offspring of naturally spawning fall Chinook salmon make up the majority of wild salmonid fry and parr that inhabit the shorelines of the Snake and Lower Clearwater rivers (Connor et al. 2002). Direct predation by hatchery fall Chinook salmon on other ESA-listed fish species and conspecifics is likely a low risk. Although there are certainly temporal overlaps between program fish and these other populations during emigration, the sizes of these species, when entering the mainstem areas of the Snake Basin, is large enough to minimize direct predation concerns. Spring Chinook salmon and steelhead tend to remain in tributary waters until substantial juvenile growth has taken place—multiple seasons, in the case of steelhead. We presume that direct predation risk to listed Snake River sockeye is also low due to the lack of spatial overlap with any sockeye spawning and rearing habitat and locations of the hatchery fall Chinook salmon releases. Additionally, the sockeye emigration from their lacustrine rearing habitats, as multi-year smolts, from areas where interactions with hatchery Chinook salmon could occur reduces any direct predation risk. They also are above the size range where predation is theoretically possible: in 2011 natural and hatchery smolts from Redfish Lake averaged 108 mm FL (range 89-178) and 103 mm FL (range 83-163) (Peterson et al. 2012).

As with all hatchery releases, these program releases bring with them the risk of indirect predation. And while there may be an effect of lower susceptibility for natural-origin juveniles, from abundant hatchery fish, the greater concern is the predator-attraction effect that these release can have. That is, when hatchery fish are abundant over a short time frame, they can serve to distract or sate predators that would otherwise be eating naturally produced fish, but if the hatchery fish abundance continues for a longer period, predator numbers can be increased, resulting in greater predation on all fish present, including the natural-origin fish. While the overall program release number is substantial, the individual release numbers are smaller and spread broadly through the Snake Basin. This structure, combined with the planned use of volitional release, with the exception of the Grande Ronde and Captain John direct stream releases, minimize the large pulse effect of the releases. This is expected to help minimize the attraction of large groups of predatory fish and birds.

Based on the available literature for both the general predation risks that hatchery salmonids pose to other natural fish, the Snake River-specific information on prey availability during the post-release period and the limited evaluation of the dietary behaviors of subyearling and yearling fall Chinook salmon smolts, an assessment of low to moderate risk is warranted. Regionally, additional research is needed to validate the general hatchery salmonid predation risk assumptions. The use of the geographically broad release locations and the continued use of volitional release strategies for the majority of the releases will help lower overall predation risk, both direct and indirect.

2.4.6. Monitoring and Evaluation

Monitoring and evaluation programs are necessary to determine the performance of hatchery programs. The Artificial Production Review (NPPC 1999) listed four criteria for evaluating hatchery programs:

- Has the hatchery achieved its objectives?
- Has the hatchery incurred costs to natural production?
- Are there genetic impacts associated with the hatchery production?
- Is the benefit greater than the cost?

Historically, hatchery performance was determined solely on the hatchery's ability to release fish (NPPC 1999); this was further expanded to include hatchery contribution to fisheries (e.g., Wallis 1964; Wahle and Vreeland 1978; Vreeland 1989). Past program-wide reviews of hatchery programs in the Northwest have indicated that monitoring and evaluation have not been adequate to determine if the hatchery objectives are being met (NFHRP 1994; ISG 1996; NRC 1996; HSRG 2004). The lack of adequate monitoring and evaluation has resulted in the loss of information that could have been used to adaptively manage the hatchery programs (NRC 1996).

Under the ESA, monitoring and evaluation programs for hatchery production are not only necessary for adaptive management purposes but are required to ensure that hatchery programs do not limit the recovery of listed populations. Monitoring and evaluation of hatchery programs are necessary to determine if management actions are adequate to reduce or minimize the impacts of the general effects discussed previously (Tables 8 and 9), and to determine if the hatchery is meeting its performance goals. Monitoring and evaluation activities will occur within the hatchery facilities as well as in the natural production areas. Monitoring and evaluation within the hatchery can include measurements to evaluate hatchery production (e.g., survival, nutrition, size at age, condition, disease prevention, genetic makeup, total released, percent smolted, and mark/tag retention).

Hatchery supplementation programs are intended to promote the viability of natural-origin populations as the factors limiting viability are reduced by using hatchery fish to increase the number of natural spawners, but supplementation programs must be monitored to ensure that long-term fitness is being conserved. Genetic and life-history data may need to be collected from the natural population to determine if the hatchery population has diverged from the natural population and if the natural population has been altered by the incorporation of hatchery fish into the spawning population. Possible sampling methods include the use of weirs, electro-fishing, rotary screw traps, seines, hand nets, spawning ground surveys, snorkeling, radio tagging, and carcass recovery. Each sampling method can be used to collect a variety of information. Sampling methods can adversely impact listed fish, both those targeted for data collection and those taken incidentally.

Though necessary to evaluate impacts on listed populations from hatchery programs, monitoring and evaluation programs should be designed and coordinated with other plans to maximize the data collection while minimizing take of listed fish. NMFS has developed general guidelines to reduce impacts when collecting listed adult and juvenile salmonids (NMFS 2000b; NMFS 2008a) that have been incorporated as terms and conditions into section 10 and section 7 permits for research and enhancement (e.g., NMFS 2007c). Additional monitoring principles for supplementation programs have been developed by the (AHSWG 2008).

As previously mentioned (Section 1.3.2), a number of ongoing and planned RM&E activities target Snake River fall Chinook salmon within the action area. The monitoring and evaluation activities directly related to the proposed hatchery programs are so closely linked to activities to determine the status of the Snake River fall Chinook salmon in general, that impacts from the monitoring activities associated with the hatchery programs are indistinguishable from the monitoring impacts from the other actions in the Snake River Basin.

2.4.6.1. Marking/Masking

In listed populations, the presence of unmarked hatchery-origin fish complicates assessment of natural production; this effect is commonly referred to as masking. Here we deal both with the risks to the population from marking of hatchery-origin fish and with the risks to the population from less than complete marking of hatchery-origin fish. Although the marking methods may have other monitoring uses as well, here we are solely concerned with their use in identifying fish as to origin (hatchery/natural).

At present only 76% of the fish produced by the hatchery programs are marked in some way. Although estimates of the proportion of the returning unmarked fish that are of hatchery-origin can be made through coded-wire tags, certain assumptions have to be made and the expansion method has inherent imprecision. The extent to which this constant fractional marking adds to the uncertainty surrounding the proportion of hatchery-origin fish on the spawning grounds and proportion of natural-origin fish in the broodstock has been mentioned many times in this opinion. Full marking greatly improves estimates of hatchery/natural proportions, and thus reduces risks to the population from lack of this information. Parentage-based tagging (PBT) has been proposed as a way to mark in effect 100% of the hatchery without application of physical tags. There is no doubt that application of PBT will improve these estimates.

PBT will not supplant current marking, however. As shown in Table 2 and Table 4, about 4.1 million juveniles will be marked with adipose clips, CWTs, or both. The estimated mortality rate from tagging is less than 0.1%. The risk these rates pose to the population is negligible, and is far outweighed by the benefit of having the hatchery production unambiguously identified. PBT of adults also poses a negligible risk, requiring only a fin clip. No mortalities are expected from PBT sampling of returning fish.

PBT offers tremendous potential opportunities for genetic research, but current plans are to use it in these programs as a simple surrogate for physical marking or tagging, without a need for information in real time. Given the uncertainties in general about the true abundance of natural-origin returns, and the added precision that complete marking would provide (Hinrichsen et al.

2012), marking or tagging of all released fish would be a more powerful, less logistically complex method. In terms of analysis of effects, however, the PBT approach is quite acceptable, putting the population at no additional risk, and will substantially reducing uncertainty. However, it is important to note that PBT is not applicable in real time. Although the turnaround time can be as short as two or three days, any actual management of fish by origin, such as determining whether to include or exclude from broodstock, would require that fish or gametes be held until a decision can be made on their disposition. In addition, any subsequent monitoring of unmarked fish where definite identification as to origin is desirable (e.g., carcasses in spawning ground surveys) would require additional genetic sampling.

2.4.6.2. Methodology

Monitoring in the proposed action falls into two categories: that directly associated with fish culture, which focuses more on the immediate effects of culture methods, and monitoring not directly associated with fish culture, which is aimed at post-release performance of the hatchery fish and the effects of the hatchery program on natural production.

The proposed RM&E directly related to fish culture uses well-established (e.g., AHSWG 2008) methods and protocols. Mortality rates of 15% are expected both for the egg-fry and fry-smolt stage; of this 60 fish per release group is expected to result from the monitoring itself. These rates pose no risk to the population.

Methodology for RM&E associated with the hatchery programs but not directly related to fish culture, both the existing work and that proposed, is varied, but all the methods are well established, and have been applied to Snake River fall Chinook salmon before without problems. These include use of PIT-tags, radio or acoustic tags, screw traps, seines, weirs, adult traps, genetic analysis of small tissue samples, and elemental analysis of otoliths.

The primary effect of the proposed RM&E activities on listed species is to capture, handle, and release fish. This leads to stress and other sub-lethal effects that are difficult to assess in terms of their impact on individuals, let alone entire species. The following subsections describe the types of activities being proposed. Each is described in terms broad enough to apply to all the permits. The effects of the activities are well documented and discussed in detail below.

The proposed research activities will have no measurable effects on the listed salmonids' habitat. The actions are therefore not likely to jeopardize any of the listed salmonids by reducing the ability of that habitat to contribute to their survival and recovery.

Observing/Harassing

For some parts of the proposed studies, listed fish would be observed in-water (e.g., by snorkel surveys or 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 the fishes’ behavior. Fry and juveniles frightened by the turbulence and sound created by observers are likely to seek temporary refuge in deeper water, or behind/ under rocks or vegetation. In extreme cases, some individuals may leave a particular pool or habitat type and then return when observers leave the area. At times, the research involves observing adult fish, which are more sensitive to disturbance. During some of the research activities discussed below, redds may be visually inspected, but would not be walked on. Harassment is the primary form of take associated with these observation activities, and few if any injuries (and no deaths) are expected to occur particularly in cases where the researchers observe from the stream banks rather than in the water. There is little a researcher can do to decrease these small effects except to avoid disturbing sediments and gravels, and, to the extent possible, avoid disturbing the fish. Disturbed fish should be allowed the time they need to reach cover.

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. Based on experience, NPT anticipates that mortality from handling will be 0.4% (NPT 2011).

Fin clipping

Fin clipping can involve part or all of one or more fins. When entire fins are removed, it is expected that they will never grow back. A permanent mark can also be made when the fin end or a few fin rays are clipped. Marks can also be made by punching holes or cutting notches in fins, severing individual fin rays (Welch and Mills 1981), or removing single prominent fin rays (Kohlhorst 1979). Although researchers have used all fins for marking, the current preference is to clip the adipose, pelvic, or pectoral fins. Many studies have examined the effects of fin clips on fish growth, survival, and behavior. The results of these studies are somewhat varied; however, it can be said that fin clips do not generally alter fish growth. Studies comparing the growth of clipped and unclipped fish generally have shown no differences between them (e.g., Brynildson and Brynildson 1967). Moreover, wounds caused by fin clipping usually heal quickly especially those caused by partial clips.

Mortality among fin-clipped fish is also variable. Mortality may occur during the marking process, especially if fish have been handled extensively. The degree of mortality also depends on which fin is clipped. Recovery rates are generally higher for adipose- and pelvic-fin-clipped fish than for those that have pectoral, dorsal, or anal fin clipped (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). Adipose- and pelvic-fin-clipped coho salmon fingerlings can have as high as a 100% recovery rate (Stolte 1973). RM&E activities in the proposed action include clipping the adipose fin on a large proportion of the fish released and in some cases a small portion of the caudal fin. Based on experience, the Nez Perce Tribe anticipates that mortality from all marking and tagging will less than 1% and mortality from capturing and handling alone will be 0.4% (NPT 2007).

Tagging

In addition to fin clipping, passive integrated transponder (PIT)-tagging, coded wire tagging, and radio-tagging 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. In general, 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 (e.g., Prentice and Park 1984; Prentice et al. 1987; Rondorf and Miller 1994). More recently, in a study between the tailraces of LGR and McNary Dam (225 km), (Hockersmith et al. 2000) concluded that the performance of yearling Chinook salmon was not adversely affected by gastrically - or surgically implanted sham radio tags or PIT-tags. However, (Knudsen et al. 2009) found that over several brood years, PIT-tag induced smolt-adult mortality in Yakima spring Chinook salmon averaged 10.3% and was as high as 33.3%.

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

Fish with internal tags often die at higher rates than fish tagged by other means because tagging is a complicated and stressful process. Mortality is both acute (occurring during or soon after tagging) and delayed (occurring long after the fish have been released into the environment). Acute mortality is caused by trauma induced during capture, tagging, and release. It can be reduced by handling fish as gently as possible. Delayed mortality occurs if the tag or the tagging procedure harms the animal in direct or subtle ways. Tags may cause wounds that do not heal properly, may make swimming more difficult, or may make tagged animals more vulnerable to predation (Howe and Hoyt 1982; Matthews and Reavis 1990; Moring 1990). Tagging may also reduce fish growth by increasing the energetic costs of swimming and maintaining balance Based on experience, the Nez Perce Tribe anticipates that mortality from production marking and tagging will be 0.1% (NPT 2011) and from 1.0% from other monitoring (Vogel 2012). Take of listed salmon and steelhead associated with the various monitoring methodologies is presented in Table **24**.

Table 24. 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
Adult Carcass SR fall Chinook salmon - Adipose fin in-tact	Spawning Survey, Carcass sampling	Lower Snake, Lower Salmon Clearwater, Grande Ronde, and Imnaha	1,500 (0 mortalities)	0	0

2.4.6.2.1. Adequacy

A major issue in using hatcheries for recovery is the uncertainty surrounding their ecological and genetic effects on natural production. Thus, every hatchery program is fraught with uncertainty about these risks, and about the tradeoff between these risks and demographic benefit. Carrying out the RM&E to address these risks is invariably expensive, rarely logistically simple, and often requires years of effort. In addition, doing the RM&E more often than not conflicts with production. For example, the density-dependent effect of a large number of hatchery fish on the spawning grounds or elsewhere might well be explored by varying hatchery production cyclically, something that would be difficult to justify if the population was perceived to be at risk demographically. As a result, hatchery programs vary a great deal in level and type of monitoring. It could be argued that although several programs in the Columbia-Snake Basin include strong monitoring programs (e.g., YKFP, Johnson Cr., Imnaha), there is none that adequately monitors all the possible risks and benefits of interest. The model that has developed is one of representative monitoring of key issues assuming widespread applicability of results. At the same time, NMFS has recognized the importance of targeted monitoring of specific issues in key populations. This was also a theme of the multi-agency Ad Hoc Supplementation Work Group (AHSWG 2008).

The high hatchery influence on the Snake River fall Chinook salmon population is a particular concern to NMFS because it is a single-population ESU, and as such, its status with respect to viability is very important. As a result, RPA 65 in the FCRPS Biological Opinion calls for studies on the effect of the hatchery programs on the Snake River fall Chinook salmon ESU. A workshop was convened on how such studies might be conducted (Peven 2010), and workshop members were unable to develop implementable designs. Afterwards, a small workgroup consisting of NMFS and the operators was charged with investigating how the question could be explored with incremental changes to the current management. This group concluded that given the importance of the population and hatchery programs and the uncertainties surrounding them, incremental changes for RM&E purposes could not be justified without additional studies (NMFS 2011c). The package of new RM&E measures, combined with ongoing measures, will not provide a complete understanding of the effects of the hatchery programs on the population, but will provide additional information that will allow finer scaled monitoring efforts aimed at the major question, and as well will allow decisions about program management to be made with considerably less uncertainty. In addition, by continuing status quo operations for a few more years, any demographic trends that may be developing will become better defined. In terms of risk, the proposed RM&E package reduces risk to the population from what it has been in that it will allow better decisions to be made toward recovery.

2.5. Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation (50 CFR 402.02). Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act. For the purpose of this analysis, the action area is that part of the Columbia River Basin described in the section 1.4, above. Future federal actions, including the ongoing operation of the hydropower systems, hatcheries, fisheries, and land management activities will be reviewed through separate section 7 consultation processes. Non-federal actions that require authorization under section 10 of the ESA, and are not included within the scope of this consultation, will be evaluated in separate section 7 consultations.

The Snake River Fall Chinook Salmon Recovery Plan currently being developed will describe in detail the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to listed Snake River fall Chinook salmon, Snake River spring/summer Chinook salmon, and Snake River steelhead. Future tribal, state and local government actions will likely to be in the form of legislation, administrative rules, or policy initiatives, and land use and other types of permits. Government and private actions may include changes in land and water uses, including ownership and intensity, any of which could impact listed species or their habitat. Government actions are subject to political, legislative and fiscal uncertainties. These realities, added to geographic scope of the action area which encompasses numerous government entities exercising various authorities and the many private landholdings, make any analysis of cumulative effects difficult.

Non-federal actions on listed species are likely to continue affecting listed species. The cumulative effects in the action area are difficult to analyze considering the geographic landscape of this opinion, and the political variation in the action area, the uncertainties associated with local government and private actions, and the changing economies of the region. Whether these effects will increase or decrease is a matter of speculation; however, based on the trends discussed above, there is the potential for adverse cumulative effects to increase. Although state, tribal, and local governments have developed plans and initiatives to benefit listed fish, they must be applied and sustained in a comprehensive way before NMFS can consider them "reasonably foreseeable" in its analysis of cumulative effects.

2.6. Integration and Synthesis

This section is the final step of NMFS' assessment of the risk posed to species and critical habitat from implementing the proposed action. In this section, we add the effects of the action (Section 2.4) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5) to formulate the agency's biological 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 for the conservation of the species. These assessments are made in full consideration of the status of the species and critical habitat (Section 2.2).

2.6.1. Snake River Fall Chinook salmon

The four potential categories of impacts of the proposed hatchery programs on listed fall Chinook salmon in the Snake River Basin are demographic, genetic, ecological, and monitoring. After a review of potential impacts from hatchery programs in general (Table 15), other impacts were not considered likely to occur so were not the subject of detailed effects analysis.

Broodstock collection for the four hatchery programs and run-reconstruction activities collectively result in the capture and retention of as many as 7500 returning Snake River fall Chinook salmon, including up to 30% natural-origin fish. Mortalities associated with capture are negligible, as is prespawning mortality. The hatchery programs return many more adults than are collected. Moreover, the hatchery program is far more productive than the naturally spawning fish. This high productivity of the hatchery programs has allowed them to grow, and the number of natural-origin fish has increased from a low of 78 fish in 1990 to more than 10000 in recent years. There is some evidence that the number of natural-origin fish has plateaued or even slightly declined in recent years, but there is also considerable uncertainty about the relative numbers of returning natural-origin and hatchery-origin fish during those years. The proposed run-reconstruction and fall-back RM&E activities will clarify this situation. Although it is not clear how much of the dramatic recent increase in natural production can be attributed to the hatchery programs, the hatchery programs provide a net demographic benefit to the population. NMFS has acknowledged these benefits in the SCA (NMFS 2008e).

With so much of the total production of Snake River fall Chinook salmon originating in the hatchery, and with the high proportion of fish hatchery-origin fish on the spawning grounds, genetic impacts of the hatchery programs are a major concern. The hatchery programs may be affecting the population genetically in the areas of within-population diversity, outbreeding effects, and hatchery-induced selection. In the category of impacts on within-population diversity, there are two concerns: effective size and subpopulation structure. The proposed non-random mating strategy, employed to counter previous overrepresentation of younger-aged fish may well be a good approach to limiting some aspects of hatchery-induced selection. However, in implementation it may also be decreasing the effective size of the population, so this situation should be evaluated and monitored. Maintenance or development of subpopulation structure in this population will be valuable in helping it achieve the viability level required to consider it recovered. The current broodstock collection procedure of capturing nearly all fish downstream from the spawning grounds almost certainly results in the mating of fish originating from different areas, either spawning grounds or release sites. This likely impedes development of or maintenance of subpopulation structure, if it exists. However, there is little evidence that subpopulation structure exists now or has existed in this population. The proposed release-site fidelity; spawning, rearing, and overwintering locations; and genetics of subpopulation structure RM&E activities (Section 1.3.2.2) will clarify this issue.

Outbreeding impacts from the hatchery programs on Snake River fall Chinook salmon have occurred because of the original trapping operation at Ice Harbor Dam and straying from other programs. However, the hatchery programs have also been an effective means of limiting gene flow into the population. In terms of gene flow into other populations, hatchery fish from the program stray locally into nonlisted populations with which they share some ancestry, and stray irregularly at negligible levels into other populations (some listed), so appear to pose little risk to them.

The major genetic concern about these proposed Snake River fall Chinook salmon hatchery programs is the potential impact on productivity from hatchery-induced selection. While we have no evidence that hatchery programs for Snake River fall Chinook salmon present a more selective environment than hatchery programs in general, the proportion of hatchery-origin fish on the spawning grounds of the Snake River Fall Chinook salmon ESU is a concern. There is considerable uncertainty about the number of fish on the spawning grounds, and about the proportion of fish that are of hatchery-origin. The genetic influence of the hatchery programs may in fact be considerably lower than suggested by the proportion of hatchery-origin fish on the spawning grounds and the proportion of natural-origin fish in the hatchery broodstocks. In addition, the reproductive success of the hatchery-origin fish in the natural environment can be expected to be lower than that of natural-origin fish. However, the proportion of hatchery fish on the spawning grounds is certainly well above 50%. Although research on ocean-type Chinook is lacking, a large and growing body of literature supports the notion that the effects of hatchery-induced selection on fitness in salmonids can be substantial. The available data and theory are inadequate to state definitively what level of hatchery influence would be appropriate for this population, but the current level and that expected under the proposed action are a concern.

NMFS has long recognized the value of hatchery programs as a tool for controlling extinction risk, but questions their value in increasing natural production beyond the near term boost to prevent extinction because of the potential for genetic erosion of productivity. Given these considerations, the question NMFS faces for any supplementation program for a listed salmon or steelhead population is at what point in the demographic trajectory of a population the genetic risk outweighs the demographic benefit and suggests that the hatchery efforts should be scaled back. The current uncertainties about the general magnitude and reversibility of domestication impacts make identification of this "inflection point" very difficult. Population responses to supplementation may provide insights, however, if habitat and other determinants of productivity and capacity are sufficiently stable. If the inflection point has been reached, natural production may remain static or decline relative to hatchery production. If the inflection point has not been reached, natural production can be expected to increase. Which of these patterns the Snake River fall Chinook salmon population is demonstrating is unclear, but the population may be responding well to the supplementation efforts begun in the mid-1990s, and if so, is one of the few cases in which a positive response is apparent. NMFS feels that operating the hatchery programs and associated RM&E efforts as proposed over the period of these permits presents little risk of fitness loss and possibly considerable benefit to our understanding of the biology of this population, the effects of supplementation in this population, and the effects of supplementation in general. Moreover, NMFS feels that substantial departure from the proposed action at this point may actually result in a loss of important information about the population's response to supplementation that can be used to inform future management of this population and of other populations under supplementation.

Parallel to the genetic concern about the size of the hatchery program relative to natural production is the concern that the programs may lead to adverse competition effects. The hatchery programs have undoubtedly had substantial ecological benefits. The general increase in fish on the spawning grounds has increased spatial structure. The hatchery programs have probably also provided large ecological benefits by increasing the supply of marine-derived nutrients and in improving the condition of the spawning gravel. But it is possible that the large numbers of hatchery-origin fish returning to spawn may be depressing natural productivity ecologically through increased competition for space and resources at either the adult or juvenile stage. Possibly this is now being seen in decreased size of natural-origin juveniles (Connor and Tiffan 2010). As NMFS recognizes the value of hatchery programs as a tool for controlling extinction risk, we also question their value in increasing natural production beyond the near term boost to prevent extinction because of the potential for ecological interactions to limit natural production. The inflection point argument presented above applies equally to ecological interactions. We feel that declines in productivity associated with supplementation programs are likely to have both ecological and genetic causes. For the same reasons described above, we feel that operating the hatchery programs and associated RM&E efforts as proposed over the period of these permits presents little demographic risk from competition and may provide considerable benefit to our understanding of the biology of this population, the effects of supplementation in this population, and the effects of supplementation in general. As in the case of genetic impacts, NMFS feels that substantial departure from the proposed action at this point may actually result in a loss of important information about the population's response to supplementation, given that a downturn in natural production could arise either from genetic causes, ecological causes, or more likely, a combination of the two.

Based on the information provided in the HGMPs and Addendum, NMFS believes that the current level of impacts from the proposed monitoring and evaluation activities within the Lower Snake River Basin will have a negligible impact on listed Snake River fall Chinook salmon, and will provide critical information that will guide management and recovery planning in the future. NMFS will require annual reports of the take associated with the monitoring and evaluation projects so that any changes in take can be monitored to determine if addition evaluation or reinitiation of consultation is needed.

Because nearly all fish that researchers capture and release for monitoring recover shortly after handling with no long-term ill effects, the effect of the action we consider here is the potential mortality. In terms of abundance of the ESU, the potential mortality levels are very low. An effect of the research that cannot be quantified is how it would help benefit and conserve the species. We expect the RM&E activities to generate lasting benefits to conservation of the listed fish. The majority of the projects in the proposed action focus on monitoring and evaluating actions recommended for the conservation of the listed species.

These effects would be spread out over various channels and tributaries of the Snake River Basin. Therefore, no population is likely to experience a disproportionate amount of these losses. The RM&E would likely have only a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

NMFS has determined that the potential negative impacts on natural-origin Snake River fall Chinook salmon will not rise to the level of a serious adverse effect on the ESU during the time period covered by the permits, and that these effects will be sufficiently monitored to determine if further action is needed. The analysis above has considered recovery planning documents and the potential effects of the proposed propagation programs on Snake River fall Chinook salmon, combined with other ongoing activities within the Action Area, and determined that the proposed hatchery programs will not appreciably reduce the likelihood of survival and recovery in the wild by reducing the reproduction, number, or distribution of the Snake River fall Chinook salmon ESU.

2.6.2. Snake River Spring/Summer Chinook salmon

The potential impacts of the proposed action described in Section 2.4 on listed Snake River spring/summer Chinook salmon occur primarily during research and monitoring activities, though there are also rare instances of capture of adults during broodstock trapping operations at

LGR, occasional capture of juveniles during monitoring operations and from competition among juveniles in the migration corridor.

Trapping and handling at the LGR trap is limited to a small proportion of the run annually, with a very low mortality rate. Though the impact occurs only during the latter portion of the run, the low mortality rate is likely to have only a very small impact on abundance, and likely no measurable impact on productivity, spatial structure or diversity. Therefore, the total impact is not expected to affect the ESU disproportionally.

Because nearly all fish that researchers capture and release for monitoring recover shortly after handling with no long-term ill effects, the effect of the action we consider here is the potential mortality. In terms of abundance of the ESU, the potential mortality levels are very low. An effect of the research that cannot be quantified is how it would help benefit and conserve the species. We expect the RM&E activities to generate lasting benefits to conservation of the listed fish. The majority of the projects in the proposed action focus on monitoring and evaluating actions recommended for the conservation of the listed species.

These effects would be spread out over various channels and tributaries of the Snake River Basin. Therefore, no population is likely to experience a disproportionate amount of these losses. The research would likely have only a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

The analysis above, has considered draft recovery planning documents and the potential effects of the proposed action on Snake River spring/summer Chinook salmon populations, combined with other ongoing activities within the action area, and determined that the proposed artificial propagation programs will not appreciably reduce the likelihood of survival and recovery in the wild by reducing the reproduction, abundance, or distribution of the Snake River Spring/Summer Chinook salmon ESU.

2.6.3. Snake River Steelhead

The potential impacts of the proposed action described in Section 2.4 to listed Snake River steelhead occur primarily during research and monitoring activities, though there will be handling and some migration delay because of capture of adults during broodstock trapping operations at LGR, LFH, NPTH or on the South Fork Clearwater River, occasional capture of juveniles during monitoring operations and from competition among juveniles in the migration corridor.

Trapping and handling at the LGR trap is may handle up to 20% of the entire run annually; however the mortality rate is very low. The impact will occur throughout the majority of the entire the run, and will not disproportionally impact any specific segment of the ESU and will have a limited impact on spatial structure or diversity. The low mortality rate is likely to have only a very small impact on abundance, and likely no measurable impact on productivity. Therefore, the total impact is not expected to affect the ESU disproportionally.

Because nearly all fish that researchers capture and release for monitoring recover shortly after handling with no long-term ill effects, the effect of the action we consider here is the potential mortality. In terms of abundance of the ESU, the potential mortality levels are very low. An effect of the research that cannot be quantified is how it would help benefit and conserve the species. We expect the RM&E activities to generate lasting benefits to conservation of the listed fish. The majority of the projects in the proposed action focus on monitoring and evaluating actions recommended for the conservation of the listed species.

These effects would be spread out over various channels and tributaries of the Snake River Basin. Therefore, no population is likely to experience a disproportionate amount of these losses. The research would likely have only a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

The analysis above, has considered draft recovery planning documents and the potential effects of the proposed action on Snake River steelhead populations, combined with other ongoing activities within the action area, and determined that the proposed artificial propagation programs will not appreciably reduce the likelihood of survival and recovery in the wild by reducing the reproduction, abundance, or distribution of the Snake River Steelhead DPS.

2.6.4. Snake River Sockeye Salmon

The only potential impacts of the proposed action described in Section 2.4 to listed Snake River sockeye salmon are from handling at LGR and the potential for some migration delay because of capture of adults during broodstock trapping operations at LGR and competition among juveniles in the migration corridor. No sockeye salmon are expected to be captured or handled during juvenile research and monitoring activities.

All effects on sockeye salmon are expected to be very small. Trapping and handling at the LGR trap is limited to a very small proportion of the run annually, with an expected mortality of less than one fish per year. Though the impact occurs only during the latter portion of the run, this very low mortality rate is likely to have a miniscule effect on abundance, productivity, spatial structure and diversity. Therefore, the total impact is not expected to affect the ESU disproportionally.

The analysis above, has considered draft recovery planning documents and the potential effects of the proposed action on Snake River sockeye populations, combined with other ongoing activities within the action area, and determined that the proposed artificial propagation programs will not appreciably reduce the likelihood of survival and recovery in the wild by reducing the reproduction, abundance, or distribution of the Snake River sockeye ESU.

2.6.5. Critical Habitat

Critical habitat for the listed species was described in Section 2.2. The action area (Section 1.4) includes watersheds that have been designated as essential for spawning, rearing, juvenile migration, and adult migration. In the action area numerous factors affect primary constituent elements (PCEs), including, but not limited to: altered channel morphology and floodplain; excessive sediment; reduced spawning and rearing habitat; degraded water quality; reduced stream flow; and impaired passage. We do not expect the hatchery programs and associated monitoring will have substantial physical impacts on PCEs within the action area. For the most part, the facilities used for the proposed hatchery programs are located on large streams and will not lead to altered channel morphology and stability, reduced and degraded floodplain connectivity, excessive sediment, or the loss of habitat diversity. These facilities are designed and used such that they do not reduce access to spawning and rearing habitat, or increase water temperatures. All effects on PCEs will be due to the large number of hatchery fish produced, both at the juvenile and adult stages. Discussion of these effects draws heavily on material already presented in Sections 2.4.4 and 2.4.5.

One physical effect is possible; the greatly increased number of fall Chinook salmon adults returning because of the hatchery programs may improve the condition of the spawning gravel (Montgomery et al. 1996), thus increasing spawning habitat. All other effects on PCEs are biological. On the positive side, the greatly increased number of spawners may substantially increase the supply of food, especially in delivering marine-derived nutrients that are less abundant in the freshwater environment. This added nutrient boost to the ecosystem may benefit the food web well beyond the aquatic environment (e.g., Cederholm et al. 1999). On the negative side, the increased number of spawning hatchery-origin Chinook salmon creates more density, likely decreasing the per capita productivity of spawners (Figure 11). Salmon and steelhead populations are thought to be regulated by density-dependent processes, so decreased per capita productivity is expected even in completely wild populations. However, hatchery-origin spawners may depress productivity disproportionately (Buhle et al. 2009), putting natural-origin spawners, which should have more adaptive potential, at a disadvantage. It is not known if this unequal productivity situation is occurring in the Snake River fall Chinook salmon population. It is unclear, in fact, what the density situation is, because there is disagreement on the basin capacity. Redd numbers and distribution are increasing (Arnsberg et al. 2011), but it is not clear whether this is simple expansion into previously vacated habitat or fish density pushing spawners into marginal habitats. Marshall and Small (2010) demonstrated an increasing census size to effective size ratio, suggesting increasing variability in spawning success, which supports the marginal habitat hypothesis.

In the case of juveniles, there are two types of ecological effects, both related to density. First is the increased number of juveniles that are released from the hatchery programs. Many (especially the yearlings) move downstream, quickly, but those that do not and overwinter in the reservoir may compete with natural-origin juveniles and with each other for food and space. This may reduce the survival of natural-origin juveniles, which should have more adaptive potential. The other effect is the increased number of juveniles in the system as a result of hatchery fish spawning. If genetically they differ only slightly from the progeny of natural-origin parents, this may not be a concern, but it will be if the progeny of natural-origin parents are better adapted.

A final concern with respect to effects on fall Chinook salmon habitat is that if hatchery-induced selection is causing a fitness decline in the population, this is equivalent to reducing habitat while the time the fitness effect is present.

The possible effects of the proposed action on spring/summer Chinook salmon PCEs are very limited, largely confined to the adult and juvenile migration corridors, where there may be competition for space and food. There is also some reservoir residence of spring/summer

Chinook salmon while fall Chinook salmon are present, which creates added potential for competition for food and space. However, this may be considerably less than the impact on the spring/summer Chinook salmon PCEs caused by the hatchery large releases of spring/summer Chinook salmon (Table 10).

The possible effects of the proposed action on steelhead PCEs are much limited, largely confined to the adult and juvenile migration corridors, where there may be competition for space and food. But because of the size differences between outmigrating steelhead and outmigrating and overwintering fall Chinook salmon, this effect may be slight. However, this may be considerably less than the impact on the steelhead PCEs caused by the large hatchery releases of steelhead (Table 11).

Whatever ecological effects the programs will have on PCEs of all three species under the proposed action are already present. Now that the programs have reached their agreed upon sizes, ecological effects on PCEs will not change without a large environmental shift. As we argued elsewhere, the incremental genetic change that may occur in the permit period is negligible, so the possible habitat "reduction" due to fitness effects will be very small. Therefore the proposed hatchery programs and RM&E actions will not substantially affect habitat designated as essential for spawning, rearing, juvenile migration, and adult migration of listed salmon and steelhead in the action area.

2.6.6. Climate Change

The Snake River fall Chinook salmon population may be adversely effected by climate change (Section 2.2.6). A decrease in winter snow pack will reduce spring and summer flows, further exacerbating water quantity and water quality in primary rearing habitat located in the mainstem Snake and Clearwater rivers. The proposed hatchery programs are not expected to worsen these impacts. Reduced flow in sections of the rivers affected by withdrawals for some of the acclimation facilities may become a concern for the operation of the programs in the future. However, we expect that the water use permits issued to these acclimation facilities will take into account any necessary operational adjustments necessitated by the climate change as they are renewed.

2.6.7. Summary

After evaluating the effects of the proposed programs on listed species within the action area, NMFS determined that effects are limited to potentially impacting individuals within the populations annually and would not be expected to accumulate over time. The conclusions apply to both short-term and long-term effects of the proposed action. The effects predicted by this opinion are likely to remain at the low levels found herein each year. However, over a longer period of time (e.g., 24 years as described in the SCA (NMFS 2008e)), NMFS expects that changes in the status of the listed populations, changes in the habitat due to Recovery Plan actions, and changes in the environment due to climate change will lead to a reevaluation of the proposed programs and their effects on listed species pursuant to NMFS regulations at 50 CFR 402.16 (reinitiation of consultation).

2.7. Conclusion

After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action, issuance of section 10(a)(1)(A) permits for propagation and RM&E activities for Snake River fall Chinook salmon, is not likely to jeopardize the continued existence of the Snake River Fall Chinook salmon ESU, Snake River Steelhead DPS, Snake River Spring/Summer Chinook salmon ESU, or the Snake River Sockeye Salmon ESU, or to destroy or adversely modify their designated critical habitat.

2.8. Incidental Take Statement

Section 9 of the ESA and federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by regulation to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. For purposes of this consultation, we interpret "harass" to mean an intentional or negligent action that has the potential to injure an animal or disrupt its normal behaviors to a point where such behaviors are abandoned or significantly altered.[12] Section 7(b)(4) and Section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA, if that action is performed in compliance with the terms and conditions of this incidental take statement.

2.8.1. Amount or Extent of Take

Take of listed Snake River steelhead, Snake River sockeye salmon, and Snake River spring/summer Chinook salmon resulting from the proposed hatchery programs will occur as capture during broodstock collection at LGR, LFH, NPTH, and the South Fork Clearwater weir as well as capture and handling during juvenile research and monitoring activities. Take of ESA-listed species may also result from water withdrawals for the operation of the acclimation facilities, and from interspecies competition and predation when hatchery program juvenile salmon are released into the Snake River Basin (Section 2.4.5.1). The take occurring during broodstock collection and RM&E activities can be quantified as numbers or proportions of the run annually. However, the specific level of take associated with water withdrawals, interspecies completion, and predation is very difficult to quantify because of the inherent biological characteristics of aquatic species such as listed salmon and steelhead, the dimensions and variability of the Columbia River system, and the operational complexities of hatchery actions.

[12] NMFS has not adopted a regulatory definition of harassment under the ESA. The World English Dictionary defines harass as "to trouble, torment, or confuse by continual persistent attacks, questions, etc." The U.S. Fish and Wildlife Service defines "harass" in its regulations as an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.3). The interpretation we adopt in this consultation is consistent with our understanding of the dictionary definition of harass and is consistent with the U.S. Fish and Wildlife interpretation of the term.

Determining precise levels of mortality for juveniles and adults attributable to these portions of the proposed actions is, in most cases, not possible at present. Though the incidental take levels of juveniles and adults often cannot be measured directly, the magnitude and scope of possible impacts may be inferred through other measurements and monitoring and evaluation activities.

2.8.1.1. Water Withdrawals and Maintenance

As described above, the specific level of take associated with water withdrawals is very difficult to quantify because of the inherent biological characteristics of the listed salmon and steelhead, the dimensions and variability of the Columbia River system, and the operational complexities of hatchery actions. Determining precise levels of mortality for juveniles and adults attributable to these portions of the proposed actions is usually not possible. Though the incidental take levels of juveniles and adults often cannot be measured directly for specific artificial propagation programs, the need to investigate possible impacts can be inferred through other surrogate measurements.

Surrogate measurements of the impacts on ESA-listed steelhead and spring/summer Chinook salmon in the Snake River from the withdrawal of water for the hatchery and acclimation facilities is the flow that is removed during facility operations and screening of the surface water intake structures. NMFS assumes that the flow removed at each acclimation facility will not exceed that permitted by the Water Use Permits for each of the facilities. In addition, NMFS assumes that all surface water intake structures will comply with NMFS intake screening criteria.

In the case of the Snake River fall Chinook salmon hatchery programs, because water withdrawals are usually limited to amounts less than 1.2 % – and at most 5% – of available flow, and removed water (minus evaporation) is returned to the same water body very near the withdrawal point, NMFS believes changes in available habitat will be too small to be perceived, and thus impacts will be minimal. Because all intake screens will comply with NMFS screening criteria, and water withdrawals will be small, NMFS anticipates very low levels or imperceptible take such as impingement, altered behavior of juvenile salmon from attractant flows and likely no mortality.

Some water supply and ladder maintenance may occur in some years. Generally, maintenance will include the removal of rock and woody debris removal from ladders, traps, and intake structures, and cleaning or replacement of screens as needed. Maintenance will be performed in dry conditions or during an appropriate in-water work window that minimizes the likelihood that juvenile ESA-listed anadromous salmonids will be rearing in the area in large concentrations. During these activities, sediment may be suspended in the water, and fish in the area may be temporarily displaced. Though NMFS acknowledges that some take may occur for these actions, variations in type and timing of maintenance activities makes it difficult to quantify the specific amount of take expected as a result of these actions. We expect that take will be limited to the immediate area of work, and displacement of listed fish from noise and sediment will be limited to an area no more than 100 feet downstream from the work site, with no injury to or mortality of listed fish.

2.8.1.2. Broodstock Collection

NMFS anticipates that listed Snake River spring/summer Chinook salmon, Snake River steelhead, and Snake River sockeye salmon will be incidentally taken as a result of broodstock collection for the fall Chinook salmon hatchery programs. Snake River spring/summer Chinook salmon will be incidentally handled at the LGR trap and the LFH trap. Snake River steelhead will be incidentally handled at the LGR trap, LFH trap, NPTH, and the South Fork Clearwater weir. Snake River sockeye will be incidentally handled at the LGR trap. Take levels are described below by species and location, and summarized in Table 25.

Snake River spring/summer Chinook salmon

NMFS anticipates that listed Snake River spring/summer Chinook salmon will be incidentally trapped, handled, and passed at both LGR and LFH during the collection of broodstock for the proposed salmon programs. In addition, a few individuals may be misidentified as fall Chinook salmon and inadvertently collected as broodstock. Therefore, we quantify handling and collection mortality as described below.

Because most of the Snake River spring/summer Chinook salmon have passed LGR when broodstock collection begins, NMFS anticipates up to 100 adult Snake River spring/summer Chinook salmon will be incidentally trapped, handled, and passed at LGR. Of these, NMFS anticipates approximately 0.5 % will die because of handling mortality, and thus authorizes one Snake River spring/summer Chinook salmon mortality annually.

In addition to the handling mortality identified above, it is also possible that ESA-listed Snake River spring/summer Chinook salmon trapped at either LGR or LFH may be removed, held, transported, and eventually killed because they were misidentified as fall Chinook salmon at the time of broodstock collection. The estimated number of spring/summer Chinook salmon collected and killed during program broodstock/spawning actions at LFH fluctuates but has been as high as 7 between 2005-2007. Therefore, NMFS authorizes the killing of up to 10 Snake River spring/summer Chinook salmon annually as a result of misidentification.

Spring/summer Chinook salmon that are trapped or handled at either the NPTH or the South Fork Clearwater weir are assumed to be non-listed Chinook salmon from the Clearwater River Basin, and are not part of this incidental take statement.

Snake River Steelhead

During the collection of broodstock for the proposed salmon programs, listed Snake River steelhead may be incidentally trapped, handled, and passed at LGR, LFH, NPTH, and the South Fork Clearwater weir.

During fall Chinook salmon broodstock collection at LGR, up to 20 % of all steelhead returning to the Snake River Basin may be handled in the trap as they pass LGR. As a result, Snake River steelhead may be handled, sampled, and released, and NMFS expects 0.5 % (or 0.1 % of the entire natural-origin return) might die from handling.

Trapping at the SF Clearwater weir is expected to trap up to 2% of the total SF Clearwater steelhead run, and thus the Nez Perce Tribe estimated handling up to 400 natural-origin steelhead annually. Steelhead captured at the weir will be released either upstream or downstream of the weir depending on the direction of travel within 24 hours of capture. Because steelhead will be held for less than 24 hours and released, mortality should be low, and therefore NMFS assumes no more than 0.5 % of those trapped will die (up to two adult steelhead).

In addition, listed Snake River steelhead may also be inadvertently held at the LFH in broodstock holding ponds due to limitations of the trapping and sorting facilities at LFH. A chute and diversion system will occasionally shunt steelhead, into the fall Chinook salmon broodstock holding ponds. During broodstock sorting, steelhead are anesthetized with MS-222, which requires holding for 21 days before release. Incidental trap and retention of adult steelhead at LFH has typically been one or two fish annually, but may be as many as 10. Because they are held for a long period, NMFS assumes a 20% mortality rate (up to two adult steelhead).

Incidental retention of steelhead at trapped at NPTH has typically been one or two fish annually, but may be as many as 10 adult steelhead Adult steelhead are not anesthetized, and are released as soon as they are discovered. Because of the low numbers trapped annually, and the quick release, NMFS does not expect any adult steelhead to die as a result of trapping at NPTH.

Snake River sockeye salmon

During the collection of broodstock for the proposed salmon programs, listed Snake River sockeye salmon may be incidentally trapped, handled, and passed at LGR. Sockeye salmon are not expected to be encountered at LFH, NPTH, and the South Fork Clearwater weir, and therefore take is not authorized at these three locations.

Though broodstock collection at LGR begins when most sockeye salmon have passed LGR, some still ascend the ladder through September. Numbers vary annually, but up to 10 % of all sockeye salmon returning to the Snake River Basin may ascend the ladder during this time, and up to 20 % of those may be encountered in the trap. Therefore, NMFS expects that up to 2 % of the entire annual sockeye salmon returns may be handled and released, at LGR and NMFS expects 0.5 % of those to die from handling. In most years there will be no mortality.

The incidental take of listed Snake River fall Chinook salmon, Snake River spring/summer Chinook salmon, Snake River Basin steelhead, and Snake River sockeye salmon during collection of fall Chinook salmon at LGR, LFH, NPTH, and the South Fork Clearwater weir authorized by this opinion is identified in Table 25.

Table 25. 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	100 adults	2 Adults	
Spring/summer Chinook salmon – adipose fin intact[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	20 % of the entire annual return	0.5 % of those captured	
Steelhead – adipose fin intact [1]	Capture, handle, release	SF Clearwater weir	2 % of the SF Clearwater River run up 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		2% of the entire annual return	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.

2.8.1.3.Competition and Predation

Though NMFS acknowledges that some take may occur due to competition and predation, it is not feasible to quantitatively monitor the amount of take expected solely because of these actions. We expect that take will be proportional to the number of fish released from the programs annually, so we use release numbers and location, and size of fish released relative to natural-origin fish as a surrogate for the level of authorized take for competition and predation expected by the analysis in the opinion. Each of these details is subject to some variation, but the choice of location, size and number of fish released identified in the proposed action acts as a limit in competition and predation effects.

NMFS has determined that releases shall occur only at sites identified in the proposed action and that the number released shall not exceed 110% of the proposed production levels. Minor adjustments in production levels and release locations are permitted based on discussions during the development of the annual operation plan(s). Elements of the monitoring and evaluation plan (M&E) associated with these programs will monitor the outmigration of hatchery release from the action area and estimate the likely total proportion of reservoir-type individuals the hatchery fish comprise, relative to the naturally-produced fall Chinook salmon.

2.8.1.4. Monitoring and Evaluation

NMFS anticipates ESA-listed juvenile Snake River spring/summer Chinook salmon and Snake River steelhead will be incidentally taken as a result of implementing research and monitoring related to the fall Chinook salmon hatchery programs. Take will occur throughout the Snake River Basin, but primarily in the Lower Snake, Lower Salmon, Clearwater, Imnaha, and Grande Ronde subbasins. Take will occur by use of seines, fyke nets, trawls, screw traps and purse seines. The incidental take of juvenile listed Snake River spring/summer Chinook salmon and steelhead during RM&E activities authorized by this opinion is identified in Table 26.

Snake River spring/summer Chinook salmon

NMFS anticipates that listed Snake River spring/summer Chinook salmon will be trapped, anesthetized, handled, tagged, and have tissue samples taken during juvenile monitoring activities NMFS anticipates that up to 7,500 juvenile spring/summer Chinook salmon will be captured in seines, nets, and trawls, and 4,000 of those may be sampled or tagged. Of these, only 0.4% will die from handling mortality, and an additional 1% will die from sampling or tagging injuries. Thus, NMFS authorizes a total of 70 juvenile Snake River spring/summer Chinook salmon mortalities annually. Screw traps are operated in the Clearwater River, where spring/summer Chinook salmon are not listed, and no take exemption is necessary.

Snake River steelhead

NMFS anticipates that listed Snake River steelhead will be trapped, anesthetized, handled during juvenile fall Chinook salmon monitoring activities. NMFS anticipates that up to 500 juvenile steelhead will be captured in seines, nets, and trawls. In addition, NMFS anticipates that 300 juvenile steelhead will be captured in screw traps, and none of those will be sampled or tagged. In total, 800 juvenile steelhead will be captured and handled. Of these, only 0.4 % will die from handling mortality. Thus NMFS authorizes a total of 4 (2 for seines, nets, and trawls and 2 for screw traps) juvenile Snake River Basin steelhead mortalities annually.

In addition, Snake River steelhead adults may be caught in screw traps. Adults may be weary after long migrations and unable to avoid being captured. NMFS anticipates that up to 70 adult steelhead may be trapped and released. Of these, up to 10 may die as a result of already being in poor condition.

Snake River sockeye salmon

Snake River sockeye salmon are not expected to be present at juvenile monitoring locations, so no juvenile take is anticipated or exempted by this opinion.

Table 26. Incidental take of Snake River spring/summer Chinook salmon, Snake River sockeye salmon, and Snake River steelhead during juvenile monitoring activities.

Species	Take Activity	Capture Method and Location	Total Number Handled annually	Number marked/tagged annually	Total Killed annually
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 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

a. Nez Perce Tribe activities associated with snorkeling, seines, fyke nets, trawls, and purse seines, previously covered under Project #4 Section10 Permit 1134.

2.8.2. Effect of the Take

In Section 2.7, NMFS determined that the level of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to Snake River fall Chinook salmon, Snake River spring/summer Chinook salmon, Snake River steelhead, or Snake River sockeye salmon or result in the destruction or adverse modification of any of the species' critical habitat While the proposed action will result in the handling and mortality of many ESA-listed hatchery fish and some ESA-listed natural-origin fish, the effects of this take are not expected to jeopardize the continued survival of the listed species because:

- Facilities have minimal water requirements relative to the stream they are situated on Fish collected incidentally during fall Chinook salmon broodstock collection will be very few (spring/summer Chinook and sockeye salmon) or minimally handled (all species)
- Ecological interactions will be minimal because of time and space separation and/or habitat partitioning
- RM&E measures will affect primarily juveniles, and few losses are expected from them

These conclusions are explained below by category and where appropriate, by species.

2.8.2.1. Water Withdrawals and Maintenance

NMFS determined that the effects from hatchery facility operations, specifically water withdrawals for the operation of the hatcheries, acclimation facilities and the intake structures, would not be measurable and would not impact listed juvenile or adult Snake River spring/summer Chinook salmon, Snake River steelhead, or Snake River sockeye salmon in the Snake River Basin or their critical habitat. This was based on the location of the acclimation facility, the timing of operations, their design and the in-river conditions. Take, in terms of altering the essential behavioral patterns, including breeding, feeding, or sheltering of juveniles and adults of these four species, would not be likely to occur if the water withdrawals at the acclimation facilities comply with their water use permits and are properly screened.

2.8.2.2. Broodstock Collection

Snake River spring/summer Chinook salmon

Incidental take of Snake River spring/summer Chinook salmon primarily occurs in the form of capturing and handling returning adults for brief periods during broodstock collection activities. Overall, no more than 100 adults are likely to be handled in any year, and mortality will be less than 2 % of those handled annually. Therefore, total mortality will be less than 2 adult spring/summer Chinook salmon annually. Additionally, up to 10 adults may be mistakenly taken and killed for broodstock. The effect of this level of take is unlikely to be measurable at the population or ESU scale.

Snake River steelhead

Incidental take of Snake River steelhead primarily occurs in the form of capturing and handling returning adults for brief periods during broodstock collection activities. Overall, no more than 20% of the population is likely to be handled in any year, and of those handled, 0.5% may die. Therefore, the total mortality will be less than 0.1 % of the population annually. Additionally, up to 20 adults may be handled and passed at hatchery traps and weirs annually, of which 2 may die. The effect of this level of take is unlikely to be measurable at the population or ESU scale.

Snake River sockeye salmon

Incidental take of Snake River sockeye salmon primarily occurs in the form of capturing and handling returning adults for brief periods during broodstock collection activities. Overall, no more than 2 % of the population is likely to be handled in any year, and of those handled, 0.5% may die. Therefore, the total mortality will be less than 0.01 % of the population annually. In most years, no mortalities are expected to occur. The effect of this level of take is unlikely to be measurable at the population or ESU scale.

2.8.2.3.Competition and Predation

In this opinion, NMFS determined that the release of hatchery fall Chinook salmon, from the proposed Snake River programs, may pose a small but acceptable competition risk to listed spring/summer Chinook salmon in the Snake River. This competitive risk may occur if post-release program fish do not emigrate promptly from the action area. Specifically, high proportions of total hatchery releases that residualize in the Lower Snake mainstem, in particular the reservoir above LGR Dam, may increase this competitive interaction. Competitive interactions between program releases and ESA-listed Snake River steelhead and sockeye salmon are expected to be negligible.

NMFS determined that the risk of predation by program fish to ESA-listed steelhead and spring/summer Chinook and sockeye salmon is negligible. Low levels of potential prey-size fish at the time of program releases and a lack of evidence for freshwater piscivorous behavior in juvenile hatchery Chinook salmon (Section 2.4.5.2) led NMFS to this determination.

2.8.2.4.Monitoring and Evaluation

Snake River steelhead

NMFS determined the capture of 800 juvenile and 70 adult steelhead with a total of 4 juvenile and 10 adult steelhead mortalities annually will not significantly impact the overall status or viability of the Snake River DPS or any individual MPG of the population.

Snake River spring/summer Chinook salmon

NMFS determined the capture of 1,500 Snake River spring/summer Chinook salmon, and tagging of 100 with a total of 7 juvenile Snake River spring/summer Chinook salmon mortalities annually will not significantly impact the overall status or viability of the Snake River Spring/Summer Chinook salmon ESU or any individual MPG of the population.

2.8.3. 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 the impacts from the proposed hatchery programs on the Snake River Steelhead DPS, the Snake River Spring/Summer Chinook salmon ESU, and Snake River Sockeye Salmon ESU. The Action Agencies shall ensure that:

1. The operators implement the hatchery programs and associated RM&E measures as described in the submitted HGMPs and Addendum (NPT 2011; WDFW and NPT 2011; WDFW et al. 2011).
2. The operators manage their operations to limit the risk of adverse demographic, ecological, and genetic effects on listed Snake River steelhead and Snake River spring/summer Chinook salmon.
3. The operators follow criteria and guidelines specified in this opinion for their respective hatchery facilities, including associated trapping locations.
4. The operators follow criteria and guidelines specified in this opinion for their respective monitoring and evaluation activities within the Snake River Basin.
5. The operators provide reports to the Salmon Management Division annually for all Snake River fall Chinook salmon hatchery programs, and for all research, monitoring, and evaluation activities associated with the hatchery programs.
6. The operators comply with all permit requirements.

2.8.4. Terms and Conditions

The terms and conditions described below are non-discretionary, and the Action Agencies and operators must comply with them in order to implement the reasonable and prudent measures (50CFR 402.14). The Action Agencies and operators 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 are not complied with, the protective coverage of section 7(o)(2) will likely lapse.

The Action Agencies shall ensure that:

1a. Operators implement the hatchery programs as described in the submitted HGMPs and Addendum. The NMFS Salmon Management Division (SMD) must be notified, in advance, of any change in implementation of hatchery program operation and implementation or monitoring activities that potentially would result in increased take of ESA-listed species.

1b. The operators submit annual operation plans for both the Lyons Ferry Hatchery and Nez Perce Tribal Hatchery to SMD, for the following year, that are consistent with the terms and conditions within this incidental take statement and designed consistent with information on program performance provided by monitoring data.

2a. Operators manage the programs to promote the goals of the hatchery programs while minimizing impacts on listed Snake River steelhead and Snake River spring/summer Chinook salmon by limiting production to no more than 110% of levels described in the HGMPs, and releasing fall Chinook salmon only from location described in the HGMPs.

2b. Operators monitor the post-release performance of released fall Chinook salmon, including emigration speed and smolt-to-smolt survival rate, to inform understanding of the risk of ecological impacts from releases.

3a. All efforts will be made during broodstock trapping at all facilities to minimize impacts on listed species. During broodstock trapping operations, the mortality of intentionally and incidentally handled natural-origin salmon and steelhead must not exceed levels identified for each species. The trap will be operated as proposed in the annual operation plans.

3b. Water withdrawals at all facilities shall be via structures that meet or exceed NMFS water intake screening criteria. Water withdrawals will not exceed levels permitted by the Water Use Permits issued to each of the acclimation facilities.

3c. Operators handle listed fish with extreme care and keep them in cold water to the maximum extent possible during sampling and processing procedures. When fish are transferred or held, a healthy environment must be provided; e.g., the holding units must contain adequate amounts of well-circulated water. When using gear that captures a mix of species, the permit holder must process listed fish first, whenever possible, to minimize handling stress.

3d. Operators allow any NMFS employee or representative to inspect any records or facilities related to hatchery program monitoring, evaluation, and research activities.

4a. Operators ensure that listed species are taken only at the levels, by the means, in the areas, and for the purposes stated in the HGMPs and Addendum.

4b. Operators do not intentionally kill or cause to be killed any listed species unless the incidental take statement specifically allows intentional lethal take.

4c. Anesthetized fish are allowed to recover to the extent practicable based on facility limitations before being released. Fish that are only counted should remain in water and not be anesthetized if possible. Post-trapping mortality must be monitored to ensure mortality rates are within the amounts authorized by this incidental take statement.

4d. Operators use a sterilized needle for each individual injection when passive integrated transponder tags (PIT-tags) are inserted into listed fish.

4e. If the operators unintentionally capture any listed adult fish while sampling for juveniles, the adult fish are released without further handling and such take is reported.

4f. Operators when using backpack electrofishing equipment comply with NMFS' Backpack Electrofishing Guidelines (June 2000) available at *http://www.nwr.noaa.gov/ESA-Salmon-Regulations-Permits/4d-Rules/upload/electro2000.pdf*.

4g. Operators are responsible for any biological samples collected from listed species as long as they are used for research purposes. The operators may not transfer biological samples to anyone not listed in the HGMPs without prior written approval from NMFS.

4h. The person(s) actually doing the research carry a copy of this incidental take statement while conducting the authorized activities.

4i. Operators obtain all other federal, state, and local permits/authorizations needed for the research activities.

5a. All reports, as well as all other notifications required in the permits, be submitted to NMFS at:

NMFS – Salmon Management Division
Production and Inland Fisheries Branch
1201 N.E. Lloyd Boulevard, Suite 1100
Portland, Oregon 97232
Phone: (503) 230-5412

SMD prefers that documents be submitted electronically. The current point of contact for document submission is Craig Busack (craig.busack@noaa.gov), but this may change during the life of the permits.

5b. SMD is notified, as soon as possible, but no later than two days, after any authorized level of take is exceeded or if such an event is likely. This includes the take of any ESA-listed species not otherwise included in this incidental take statement. The Action Agencies shall ensure that the operators submit a written report detailing why the authorized take level was exceed or is likely to be exceeded.

5c. Operators provide SMD, by October 31 of each year, the Lyons Ferry Hatchery and Nez Perce Tribal Hatchery annual operation plans for the coming year.

5d. Operators provide SMD, by October 31 of each year, a monitoring and evaluation project operating plan for the coming year.

5e. Operators provide annual reports to SMD that summarize numbers, location, tag/mark information, for all species covered by the incidental takes statement. Reporting format should be coordinated to the extent possible with existing report formats required for other related actions.

6a. The operators, in effectuating the take authorized by this incidental take statement, are considered to have accepted the terms and conditions set forth herein and must be prepared to comply with the provisions of this incidental take statement, the applicable regulations, and the ESA.

6b. NMFS may revoke the incidental take statement if the authorized activities are not conducted in compliance with the statement and the requirements of the ESA or if NMFS determines that its ESA section 10(d) findings are no longer valid.

6c. SMD may amend the provisions of this incidental take statement after reasonable notice to the Action Agencies and operators.

6d. 50 CFR Section 222.23(d)(8) allows NMFS to charge a reasonable fee to cover the costs of issuing the permits under the ESA. The fee for these permits has been waived.

6e. Any falsification of annual reports or records pertaining to this incidental take statement is a violation of this incidental take statement.

2.9. 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 or regarding the development of information (50 CFR 402.02).

1. The Action Agencies, in cooperation with the operators, should continue to investigate the population dynamics of Snake River fall Chinook salmon.
2. The Action Agencies, in cooperation with the operators, should continue to improve anadromous fish habitat conditions within the Snake River Basin to support the recovery of salmon and steelhead populations.
3. The Action Agencies, in cooperation with the operators, should continue to investigate the genetic impacts of salmon and steelhead hatchery operations on natural production within the Snake River Basin to identify methods to minimize these impacts.
4. The Action Agencies, in cooperation with the operators, should continue to investigate the ecological impacts of salmon and steelhead hatchery operations on natural production within the Snake River Basin to identify methods to minimize these impacts.

2.10. Reinitiation of Consultation

As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded, (2) new information reveals effects of the agency action on listed species or designated 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 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 be required reinitiate consultation if there is significant new information indicating that genetic or ecological impacts beyond those considered in this opinion, are occurring from the operation of the proposed hatchery programs, or if the specific RM&E activities listed in the terms and conditions are not implemented. New information on genetic or ecological impacts potentially leading to reinitiation of consultation could come from the Snake River fall Chinook salmon hatchery programs, monitoring efforts on other salmon or steelhead hatchery programs, or from the peer-reviewed scientific literature. NMFS will consider an increase in the proportion of hatchery-origin adults in the run above LGR above a critical value as justification for reinitiation of consultation. The critical value will be the highest annual estimate (after adjustment by the new run-reconstruction method) for the proportion of hatchery-origin fish in the adult return for the period 2005 to 2010. The test metric will be the mean proportion of hatchery fish in the run of adult fall Chinook salmon above LGR for the most recent three years, beginning in 2013.

If the amount or extent of take considered in this opinion is exceeded, NMFS will reinitiate consultation. Once reinitiation begins, the Salmon Management Division will consult with the Action Agencies and the operators to determine specific actions and measures that can be implemented to address the take or, if required, implement further analysis of the impacts on listed species from the higher level of take.

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

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

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

3.1. Essential Fish Habitat Affected by the Proposed Action

The proposed action is the funding and implementation of four hatchery programs rearing and releasing fall Chinook salmon in the Snake River Basin, and to a lesser extent, RM&E efforts associated with these hatchery programs (Section 1.3). The action area of the proposed action includes habitat described as EFH for Chinook salmon. Because EFH has not been described for steelhead, the analysis of this section is restricted to the effects of the proposed action on EFH of Chinook salmon.

The area affected by the proposed action includes for purposes of hatchery facility operation and monitoring effects on adult and juvenile Chinook salmon and steelhead , the Snake River Basin from its confluence with the Columbia to the upstream extent of fall Chinook salmon distribution – the Snake River to Hells Canyon Dam and the Clearwater River to the lower reaches of the South Fork Clearwater, and lower reaches of tributary streams.

As described by (PFMC (Pacific Fishery Management Council) 2003):

> "Freshwater EFH for [C]hinook salmon consists of four major components, (1) spawning and incubation; (2) juvenile rearing; (3) juvenile migration corridors; and (4) adult migration corridors and adult holding habitat."

All four components of EFH may be affected by the proposed action through ecological interactions in adult and juvenile migration corridors, and in natural Chinook salmon spawning and rearing areas in the Snake River Basin and Clearwater River Basin as described above. Genetic effects, manifested as lowered productivity, might occur in spawning and rearing areas.

3.2. Adverse Effects on Essential Fish Habitat

The proposed action generally does not have effects on the major physical components of EFH. The action includes no permanent alterations to physical habitat, and only one temporary alteration – the South Fork Clearwater weir. Alterations are unlikely to occur because of water withdrawal or effluent discharge from the facilities.

Spawning and rearing locations and adult holding habitat are not expected to be affected by the operation of the programs, as no modifications to these areas would occur, and no structures that would impede migration are to be constructed to accomplish the proposed actions.

Water withdrawals are also unlikely to be a problem. Water withdrawal for hatchery operations can adversely affect salmon by reducing streamflow, impeding migration, or reducing other stream-dwelling organisms that could serve as prey for juvenile salmonids. Water withdrawals can also kill or injure juvenile salmonids through impingement upon inadequately designed intake screens or by entrainment of juvenile fish into the water diversion structures. The proposed hatchery programs include designs to minimize each of these effects. The amount of water removed for each of the facilities that use river water is consistent with water rights that are conditioned to prevent the streams from being de-watered. All intakes will be screened in compliance with NMFS screening criteria (NMFS 2008a).

The Pacific Fishery Management Council (PFMC (Pacific Fishery Management Council) 2003) recognized concerns regarding the "genetic and ecological interactions of hatchery and wild fish [which have] been identified as risk factors for wild populations." The biological opinion describes in considerable detail the impacts hatchery programs might have on natural populations (Section 2.4). These results are summarized below.

Potential effects on EFH are almost entirely due to the greatly increased number of fall Chinook salmon in the system, both juveniles and adults, because of the hatchery programs, as described in Section 2.6.5. With the exception of additional adults physically conditioning spawning gravel, all other effects on EFH are biological. The increased number of spawners may substantially increase the inflow of nutrients to the food web. However, the increased number of spawners creates more density, which may depress productivity.

The increased number of juveniles can have density effects on EFH directly through the increased number of juveniles that are released from the hatchery programs, and indirectly through the increased number of juveniles from hatchery-origin fish spawning in the wild. Both can cause an increase in competition for food or space, the former in the migration corridor, and the latter in rearing areas and in the migration corridor. Another concern with respect to effects on fall Chinook salmon habitat is that if hatchery-induced selection is causing a fitness decline in the population, this is equivalent to reducing habitat while the fitness effect is present.

The possible effects of the proposed action EFH for spring/summer Chinook salmon are largely confined to the adult and juvenile migration corridors, where there may be competition for space and food. There is also some reservoir residence of spring/summer Chinook salmon while fall Chinook salmon are present. The possible effects of the proposed action on EFH for steelhead are similarly confined to the adult and juvenile migration corridors, where there may be competition for space and food. However, because of the size differences between steelhead and fall Chinook salmon, this effect may be slight.

3.3. Essential Fish Habitat Conservation Recommendations

For each of the potential adverse effects by the proposed action on EFH for Chinook salmon, NMFS believes that the proposed action, as described in the HGMPs and Addendum (NPT 2011; WDFW and NPT 2011; WDFW et al. 2011) and the incidental take statement (Section 2.8), includes the best approaches to avoid or minimize those adverse effects.

As described in Section 2.4.2.2, water withdrawal for the proposed facilities, including acclimation site operations, would remove water from the Snake River, Clearwater River, and Sweetwater Springs Creek, but such reduction would be small, and would only occur over a very short distance at each of the sites. The proposed action includes appropriate steps to minimize the risks associated with water withdrawals, including complying with water right permits and meeting NMFS screening criteria (NMFS 2008a). At each location, the amount of water withdrawn would not exceed – and would usually be far below – 10% of the total stream flow, and so would not contribute to dewatering of the streambed or other adverse environmental effects. NMFS is not providing additional conservation recommendations to address these potential EFH effects; the Action Agencies shall ensure that the appropriate portion of the incidental take statement (reasonable and prudent measure 5, with its implementing terms and conditions) is carried out.

To address the potential effects on EFH of hatchery fish on natural fish in natural spawning and rearing areas, the (PFMC (Pacific Fishery Management Council) 2003) provided an overarching recommendation that hatchery programs:

"[c]omply with current policies for release of hatchery fish to minimize impacts on native fish populations and their ecosystems and to minimize the percentage of nonlocal hatchery fish spawning in streams containing native stocks of salmonids."

The biological opinion explicitly discusses the potential risks of hatchery fish on native fish populations and their ecosystems, and describes operation and monitoring appropriate to minimize these risks to Chinook salmon in the Snake River Basin as a result of the proposed action. NMFS is not providing additional conservation recommendations to address these potential EFH effects; the Action Agencies shall ensure that the appropriate portions of the incidental take statement (reasonable and prudent measures 3 and 4, with their implementing terms and conditions) are carried out.

NMFS expects that full implementation of the pertinent requirements described in the incidental take statement would protect, by avoiding or minimizing the adverse effects described in Section 3.2, designated EFH for Pacific coast salmon. Because of the nature of genetic effects, and the fact that the proposed action does not substantially change the amount of stream affected compared to similar actions in recent years, NMFS is not able to provide an estimate of the number of acres of EFH protected at this time.

3.4. Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, the federal agency must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation from NMFS. Such a response must be provided at least 10 days before 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, mitigating, or offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with NMFS Conservation Recommendations, the federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects [50 CFR 600.920(k)(1)].

In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, we ask that each action agency, in the pertinent statutory reply to the EFH portion of this consultation, clearly identify by number which conservation recommendation(s) are accepted.

3.5. Supplemental Consultation

EFH consultation will be reinitiated 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") specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, document compliance with the Data Quality Act, and certifies that this opinion has undergone pre-dissemination review.

4.1. Utility

NMFS has determined, through this ESA section 7 consultation on issuance of section 10(a)(1)(A) permits to operate four hatchery programs propagating Snake River fall Chinook salmon, that implementation of the programs will not jeopardize the affected ESUs and DPS, and will not destroy or adversely modify critical habitat. Therefore, NMFS can issue the permits. The intended users are the Bonneville Power Administration (funding entity), the Idaho Power Company (funding entity), and the WDFW, ODFW, IDFG, and NPT as operating entities. The scientific community, resource managers, and the stakeholders benefit from the consultation through the anticipated increase in returns of Snake River fall Chinook salmon, and through the collection of data on the effects of the programs on viability of Snake River fall Chinook salmon. This information will improve scientific understanding of hatchery-origin Chinook salmon effects that can be applied broadly within the Pacific Northwest area for managing risks associated with similar 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

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 referenced in the references section. The analyses in this biological opinion/EFH consultation contain more background on information sources and quality.

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

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

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