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

Four Lower Snake River Steelhead Hatchery Programs

NMFS Consultation Number: WCR-2017-6358

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

Affected Species and Determinations:

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

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

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

Issued By: FOR
Barry A. Thom
Regional Administrator

Date: 7/11/2017

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1. INTRODUCTION

The National Marine Fisheries Service (NMFS) describes a hatchery program as a group of fish that have a separate purpose and that may have independent spawning, rearing, marking, and release strategies (NMFS 2008c). The operation and management of every hatchery program is unique in time, and specific to an identifiable stock and its native habitat (Flagg et al. 2004). NMFS defines integrated hatchery programs as those that are reproductively connected or "integrated" with a natural population, promote natural selection over selection in the hatchery, contain genetic resources that represent the ecological and genetic diversity of a species, and are included in a salmon ESU or steelhead DPS. When a hatchery program actively maintains distinctions or promotes differentiation between hatchery fish and fish from a native population, then NMFS refers to the program as "isolated". They promote domestication or selection in the hatchery over selection in the wild and culture a stock of fish with different phenotypes (e.g., different ocean migrations and spatial and temporal spawning distribution) compared to the natural population.

The Proposed Actions by the federal agencies (see Section 1.3) consist of permitting and funding of the operation and maintenance of four hatchery programs rearing and releasing Snake River steelhead in the lower Snake River basin by the Washington Department of Fish & Wildlife (WDFW). Because the effects of the Federal agency actions are subsumed within the effects of the hatchery program operation, the details of each hatchery program are summarized in Section 1.3 of this biological opinion based on a Hatchery and Genetic Management Plan (HGMP), which was submitted to NMFS for review.

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

Program	HGMP Receipt	Program Operator*	Funding Agency	Program Type and Purpose	ESA Pathway
Grande Ronde Basin Summer Steelhead	May 2011	ODFW	USFWS**	Segregated Harvest	Section 7
Little Sheep Creek Summer Steelhead	May 2011	ODFW	USFWS**	Integrated Supplementation	Section 10(A(1)(a)
Lyons Ferry Summer Steelhead	March 21, 2011	WDFW	USFWS**	Segregated Harvest	Section 7
Tucannon River Summer Steelhead	January 24, 2011	WDFW	USFWS**	Integrated Supplementation	Section 10(A(1)(a)

*Primary operators are listed, but all programs are coordinated between the Oregon Department of Fish and Wildlife (ODFW), Confederated Tribes of the Umatilla Indian Reservation (CTUIR), Nez Perce Tribe (NPT), and the Washington Department of Fish and Wildlife (WDFW).

**The USFWS is the funding agency through the Lower Snake River Compensation Plan

1.1. Background

NMFS prepared the Biological Opinion (Opinion) and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the ESA of 1973, as amended (16 U.S.C. 1531, et seq.), and implementing regulations at 50 CFR 402. The opinion documents consultation on the action proposed by NMFS, and the USFWS LSRCP Office.

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

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

1.2. Consultation History

The first hatchery consultations in the Columbia Basin followed the first listings of Columbia Basin salmon under the ESA. Snake River sockeye salmon were listed as an endangered species on November 20, 1991 (56 FR 58619), Snake River spring/summer Chinook salmon and Snake River fall Chinook salmon were listed as a threatened species on April 22, 1992 (57 FR 14653), and the first hatchery consultation and opinion was completed on April 7, 1994 (NMFS 1994). The 1994 opinion was superseded by "Endangered Species Act Section 7 Biological Opinion on 1995-1998 Hatchery Operations in the Columbia River Basin, Consultation Number 383" completed on April 5, 1995 (NMFS 1995). This opinion determined that hatchery actions jeopardize listed Snake River salmon and required implementation of reasonable and prudent alternatives (RPAs) to avoid jeopardy.

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

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

The increase in ESA listings during the mid to late 1990s triggered a period of investigation, planning, and reporting across multiple jurisdictions and this served to complicate, at least from a resources and scheduling standpoint, hatchery consultations. A review of Federal funded hatchery programs ordered by Congress was underway at about the same time that the 2000 Federal Columbia River Power System (FCRPS) opinion was issued by NMFS (NMFS 2000a). The Northwest Power and Conservation Council (Council) was asked to develop a set of coordinated policies to guide the future use of artificial propagation, and RPA 169 of the FCRPS opinion called for the completion of NMFS-approved hatchery operating plans (i.e., HGMPs) by the end of 2003. The RPA required the Action Agencies to facilitate this process, first by assisting in the development of HGMPs, and then by helping to implement identified hatchery reforms. Also at this time, a new *U.S. v. Oregon* Columbia River Fisheries Management Plan (CRFMP), which included goals for hatchery management, was under negotiation and new information and science on the status and recovery goals for salmon and steelhead was emerging from Technical Recovery Teams (TRTs). Work on HGMPs under the FCRPS opinion was undertaken in cooperation with the Council's Artificial Production Review and Evaluation process, with CRFMP negotiations, and with ESA recovery planning (Foster 2004; Jones Jr. 2002). HGMPs were submitted to NMFS under RPA 169; however, many were incomplete and, therefore, were not found to be sufficient[1] for ESA consultation.

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

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

[1] "Sufficient" means that an HGMP meets the criteria listed at 50 CFR 223.203(b)(5)(i), which include (1) the purpose of the hatchery program is described in meaningful and measureable terms, (2) available scientific and commercial information and data are included, (3) the Proposed Action, including any research, monitoring, and evaluation, is clearly described both spatially and temporally, (4) application materials provide an analysis of effects on ESA-listed species, and (5) preliminary review suggests that the program has addressed criteria for issuance of ESA authorization such that public review of the application materials would be meaningful.

operators of each hatchery to address its obligations under the ESA in separate consultations, as required" (see NMFS 2008d, p. 5-40).

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

On April 28, 2010 (Walton 2010), NMFS issued a letter to "co-managers, hatchery operators, and hatchery funding agencies" that described how NMFS "has been working with co-managers throughout the Northwest on the development and submittal of fishery and hatchery plans in compliance with the Federal Endangered Species Act (ESA)." NMFS stated, "In order to facilitate the evaluation of hatchery and fishery plans, we want to clarify the process, including consistency with *U.S. v. Oregon*, habitat conservation plans and other agreements…." With respect to "Development of Hatchery and Harvest Plans for Submittal under the ESA," NMFS clarified: "The development of fishery and hatchery plans for review under the ESA should consider existing agreements and be based on best available science; any applicable multiparty agreements should be considered, and the submittal package should explicitly reference how such agreements were considered. In the Columbia River, for example, the *U.S. v. Oregon* agreement is the starting place for developing hatchery and harvest plans for ESA review…."

This opinion on the operation of four steelhead hatchery programs is based on a series of documents submitted to NMFS by the co-managers and the funding agencies. The co-managers have shared several drafts of the HGMPs since 2002. Minor program changes occurred as run sizes increased, regional hatchery reviews took place, and agreements were reached through forums such as *U.S. v. Oregon*. Multiple informal reviews of draft HGMPs occurred, and in 2011, co-managers submitted final HGMPs for formal consultation (Table 1). Once submitted, NMFS reviewed the HGMPs for sufficiency, and issued letters indicating that the HGMPs were sufficient for consultation (Jones Jr. 2011; Jones 2011a; Jones 2011b). This consultation evaluates the effects of the hatchery programs on all ESUs and DPSs of salmon and steelhead in the Columbia River Basin under the ESA, and their designated critical habitat. It also evaluates the effect of the programs on Essential Fish Habitat under the Magnuson-Stevens Fishery and Conservation Management Act.

The releases of fish from Lyons Ferry Hatchery (LFH) into the Touchet and Walla Walla Rivers were previously evaluated by NMFS (2007). However, recent information from the applicants suggests that fish from these releases move into the Tucannon Subbasin, contributing to the high proportion of hatchery-origin fish spawning naturally. Thus, the applicants have proposed changes to the release of steelhead from the LFH program into the Walla Walla Subbasin, and therefore all releases from the LFH program will be a part of the Proposed Action in this Opinion.

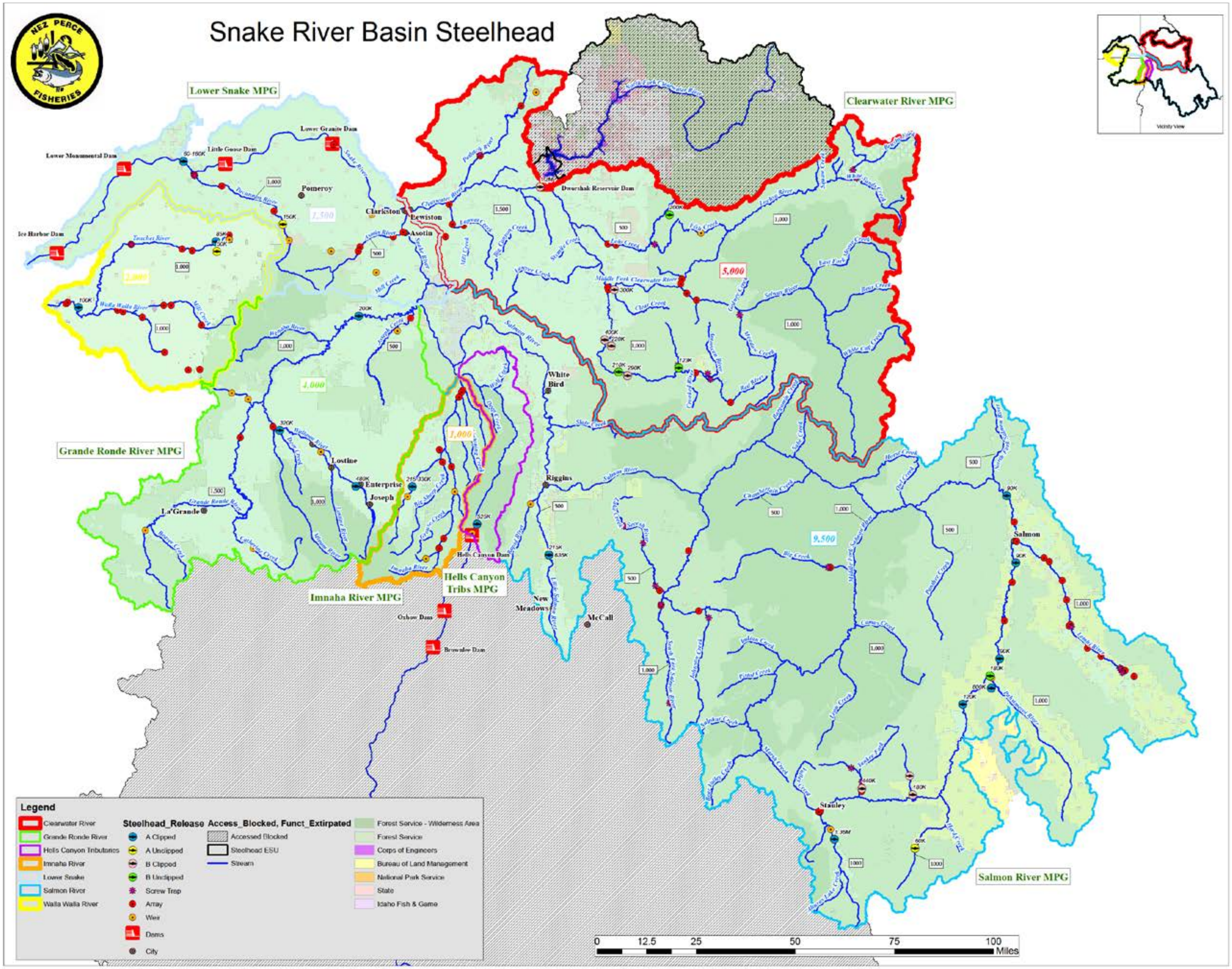
1.3. Proposed Action

"Action," as applied under the ESA, means all activities, of any kind, authorized, funded, or carried out, in whole or in part, by Federal agencies. For EFH consultation, "Federal action" means any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken by a Federal Agency (50 CFR 600.910).

There are two action agencies:

- The Proposed Action for the National Marine Fisheries Service (NMFS) is the issuance of two Endangered Species Act (ESA) section 10(a)(1)(A) permits for the enhanced propagation and survival of Snake River steelhead by the Tucannon River and Little Sheep Creek steelhead hatchery programs.
- The Proposed Action for the U.S. Fish and Wildlife Service (USFWS) is the funding of the operation and maintenance, and monitoring and evaluation, of all four steelhead hatchery programs through the Lower Snake River Compensation Plan (LSRCP), which is authorized by the Water Resources Development Act of 1976, (Public Law 94-587, Section 102, 94th Congress).

The objective of this opinion is to determine the likely effects on ESA-listed salmon and steelhead and their designated critical habitat resulting from these Federal actions. This Opinion will determine if the actions proposed by the operators comply with the provisions of sections 7 and 10(a)(1)(A) of the ESA. For Section 10, NMFS considers enhancing the propagation or survival of the affected species to mean improving the viability status of the species (McElhany et al. 2000) and/or reducing the species extinction risk. The duration of the Proposed Action of issuance of two Section 10 permits is 10 years from the date of issuance. More information on the management of each program follows in the description below.



Snake River Basin Steelhead
NEZ PERCE FISHERIES
Lower Snake MPG
Clearwater River MPG
Grande Ronde River MPG
Imnaha River MPG
Hells Canyon Tribs MPG
Salmon River MPG
Lower Granite Dam
Little Goose Dam
Lower Monumental Dam
Ice Harbor Dam
Dworshak Reservoir Dam
Hells Canyon Dam
Oxbow Dam
Brownlee Dam
Pomeroy
Clarkston
Lewiston
Asotin
White Bird
Riggins
Lostine
Enterprise
Joseph
La Grande
New Meadows
McCall
Salmon
Stanley
Legend
Clearwater River
Grande Ronde River
Hells Canyon Tributaries
Imnaha River
Lower Snake
Salmon River
Walla Walla River
Steelhead_Release
A Clipped
A Unclipped
B Clipped
B Unclipped
Screw Trap
Array
Weir
Dams
City
Access_Blocked, Funct_Extirpated
Accessed Blocked
Steelhead ESU
Stream
Forest Service - Wilderness Area
Forest Service
Corps of Engineers
Bureau of Land Management
National Park Service
State
Idaho Fish & Game
0 12.5 25 50 75 100 Miles

Figure 1. Location of facilities used in the Proposed Action (courtesy of the Nez Perce Tribe).

1.3.1. Proposed hatchery broodstock collection and mating

Two of the summer steelhead programs are integrated (Little Sheep, Tucannon) and two are segregated (Grande Ronde, LFH). For the ODFW Grande Ronde program, there is an ongoing effort to collect about 50 percent of the brood from fish returning early in October. The applicants state that incorporation of these fish into the brood may help to reduce straying of these fish into tributaries within the Mid-Columbia River.

For the Little Sheep program, the proportion of natural-origin broodstock can vary based on the natural-origin return. When the return is ≤ 100, 10 percent of the natural run would be used for broodstock. When the return is ≥ 100, 10 natural fish plus 40 percent of the return that exceeds 100 would used for broodstock. For example, a return of 150 natural-origin fish would result in 30 natural-origin adults for broodstock (NOB = (150-100) * 0.4 + 10).

For the Tucannon program, the proposed proportion of natural-origin broodstock (pNOB) would vary based on the number of natural-origin fish returning to the Tucannon weir (a sliding scale). As the number of natural-origin fish returning increases, so does pNOB. Broodstock numbers for each program component (conservation or mitigation) are in Table 3.

Spawning of fish in the integrated programs is generally factorial (two females are each mated with two males) to increase the odds of successful fertilization. In the Little Sheep program, at least one natural-origin fish is used in the factorial when possible. Single pair matings are sometimes used if not enough ripe males are available. Live spawning and release of natural-origin males at adult traps may also occur.

Table 2. Broodstock collection plans for the four summer steelhead hatchery programs.

Program	Origin	Collection Location	Collection Method	Collection Number	Collection Duration[2]	pNOB
Grande Ronde	Wallowa Hatchery stock[1]	Wallowa Hatchery; Deer Creek weir (Big Canyon satellite); Wallowa River, and Lower Granite Dam (early brood)	Ladder and adult trap; removable weir; hook and line (early brood)	480	February-June; October (early brood)	0
Little Sheep	Little Sheep Creek	Little Sheep Creek Facility	Removable weir	138	February-June	Up to 100 percent

Lyons Ferry	Wallowa Hatchery stock[1]	Cottonwood Creek, Wallowa Hatchery, and Big Canyon satellite, Lyons Ferry Hatchery	Removable weir; ladder and adult trap;	280	March-April	0
Tucannon	Tucannon River	Tucannon River	Metal sheet pile dam with ladder and adult trap, Removable hanging dam panels; hook and line	26 (conservation) 52 (mitigation)	February-May	See Table 3

[1]A mixture of stocks from the Snake River Basin.
[2]The end of the trapping season occurs when there are 10 consecutive days of no trapped steelhead; dates in the table are approximate.

Table 3. Proposed broodstock management plan for the Tucannon steelhead program.

Natural-origin Returns to Weir	Conservation Component[1]		pNOB	Mitigation Broodstock[1]		pNOB
	Natural	Hatchery		Natural	Hatchery	
< 50[2]	16	10	0.62	0	52	0.0
50-200	18	8	0.69	0	52	0.0
201-400	21	5	0.81	0	52	0.0
401-600	26	0	1.0	5	47	0.1
601-800	26	0	1.0	10	42	0.2
801-1000	26	0	1.0	15	37	0.29

[1] Up to 25 percent additional natural-and hatchery-origin steelhead may be captured and held to compensate for brood lost to disease or because of poor fertilization/fecundity. If not spawned, all natural fish will be returned upstream of the weir to spawn naturally.
[2]When natural-origin returns are so low that more than 40 percent of the broodstock or the conservation component could be comprised of hatchery-origin steelhead to meet full production, the operators will discuss broodstock composition plans with NMFS.

Weirs

The Wallowa, Little Sheep, and Big Canyon facilities all have permanent weirs that operate from February through June for steelhead collection and are checked at least twice a week during operation. Weirs at the Wallowa and Big Canyon facilities are also operated in October to collect broodstock for the early brood program. Operation details for weirs used for monitoring and evaluation in the Tucannon and Grand Ronde Subbasins were included in NMFS Biological Opinion for the spring/summer Chinook programs (NMFS 2016). A temporary weir installed between February and May on the Cummings Creek could also be used as a back-up broodstock collection location for the Tucannon program, and would be checked daily during operation. At Cottonwood Creek, a temporary weir and trap is installed annually from February-April for steelhead broodstock collection, with fish checked daily.

1.3.2. Proposed hatchery egg incubation and juvenile release

Steelhead propagated by these four programs may rear up to 10 percent over their target to offset the risk of losses. Excess juveniles may be outplanted into lakes with no access to anadromous waters. Excess juveniles from the Tucannon Hatchery program may also be outplanted as fry or fingerlings into the upper Tucannon River watershed.

Fish health staff monitor the fish throughout their rearing cycle for signs of disease. Mortalities are checked daily and live grab samples are taken monthly. Fish are also tested prior to transfer to acclimation sites and before release. Sampling, testing, and treatment/control procedures are outlined in multiple documents (IHOT 1995; NWIFC and WDFW 2006; Pacific Northwest Fish Health Protection Committee (PNFHPC) 1989).

Table 4. Proposed annual release protocols for each program. CWT = coded-wire tag; PIT = passive integrated transponder tag.

Program	Life Stage, Size and Number Released	Marking	Egg Incubation Location	Rearing Location	Acclimation Site; Duration	Volitional Release?	Release Location	Release Time
Grande Ronde	580,000 yearlings; 4 fpp	100% ad clip; 31% CWT	Wallowa Hatchery	Irrigon Hatchery	Wallowa Hatchery and Big Canyon Satellite; 3-7 weeks	Yes, first 24 hours	Wallowa River	April-May
	320,000 yearlings; 4 fpp	100% ad clip; 31% CWT	Wallowa Hatchery	Irrigon Hatchery	Big Canyon Satellite; 3-7 weeks	Yes, first 24 hours	Deer Creek	April-May
	1,200 unfed fry; 2800 fpp	None	Wallowa Hatchery	Irrigon Hatchery	None	No	Wallowa and Marr Ponds	Early June
Little Sheep	215,000 yearlings; 4.5 fpp	100% ad clip; ~8% CWT	Wallowa Hatchery	Irrigon Hatchery	Little Sheep Acclimation Facility; 4 weeks	Yes	Little Sheep Creek	April-May
Lyons Ferry[1,3]	100,000[2] yearlings; 4.5 fpp	100% ad clip; 3,000 PIT, ~20% CWT	Lyons Ferry Hatchery	Lyons Ferry Hatchery	Dayton Acclimation Facility; 9-13 weeks	Yes	Touchet River	April
	60,000[2] yearlings; 4.5 fpp	100% ad clip; 5,000 PIT; ~	Lyons Ferry Hatchery	Lyons Ferry Hatchery	Lyons Ferry Hatchery	Yes; 1-5 days	Snake River	April
	200,000[2] yearlings; 4.5 fpp	100% ad clip; 6,000 PIT, ~10% CWT	Lyons Ferry Hatchery	Lyons Ferry Hatchery	Cottonwood Acclimation Facility; 9-13 weeks	Yes	Grande Ronde River	April
Tucannon	150,000 yearlings, 4.5 fpp	Conservation: 100% CWT, 7,500 PIT	Lyons Ferry Hatchery	Lyons Ferry Hatchery	Tucannon Hatchery (5-9 weeks), Curl Lake Acclimation Facility (1-2 weeks)	Yes	Tucannon River	April
		Mitigation: 100% ad clip, ~25% CWT, 7,500 PIT	Lyons Ferry Hatchery	Lyons Ferry Hatchery	None	No	Tucannon River	April

[1]At least 20,000 fish from the various release groups combined are marked with a CWT.
[2]In the long-term, pending decisions about rearing of fish for multiple programs at Lyons Ferry Hatchery, both of these release groups will be terminated, but the Cottonwood Creek release group will increase by an additional 25,000 fish.
[3] Excess juveniles will be outplanted into lakes in southeast Washington with no access to anadromous waters.

1.3.3. Proposed adult management

For the two segregated programs (Grande Ronde, Lyons Ferry), no hatchery-origin returns are intended to spawn naturally (pHOS = 0). Hatchery fish are intended for harvest. Those captured at weirs, traps, and hatcheries surplus to broodstock needs will be used for human consumption (e.g., food banks), killed and buried, or in-stream nutrient enhancement. About 220 fish from the ODFW Grande Ronde program will be stocked into ponds with no access to anadromous waters for additional harvest opportunity.

For the Little Sheep program, the target escapement for Little Sheep Creek is 250 adults. Unharvested hatchery-origin fish returning to Little Sheep Creek beyond those needed to reach the escapement goal and for broodstock will be captured and removed at the Little Sheep Creek weir. Removed fish may be given to the tribes and/or be used by local food banks upon agreement with co-managers. If not suitable for consumption, removed fish may be used for nutrient enhancement.

For the Tucannon program, proposed management above the weir is to allow passage of up to 375 hatchery fish minus those needed for broodstock. Hatchery-origin returns from the conservation component of the program are prioritized for passage above the weir, but will be supplemented with mitigation component fish as needed to meet the goal. Surplus hatchery-origin fish will be given to the Nez Perce and Umatilla Tribes for ceremonial and subsistence purposes if desired, outplanted to the lower river for fisheries if the fisheries are still open, or placed downstream of the weir for natural spawning. Recreational non-Indian fisheries targeting hatchery-origin steelhead downstream of the weir help reduce numbers of hatchery-origin adults reaching the weir.

1.3.4. Proposed research, monitoring, and evaluation

In addition to the research, monitoring and evaluation (RM&E) described in Table 5, the applicants propose developing and participating on a workgroup to evaluate the ecological and genetic effects of steelhead straying in the Snake River Basin. The goals of the workgroup are to (1) improve estimation of hatchery-origin steelhead spawning naturally with ESA-listed steelhead populations, and (2) develop biologically acceptable limits for hatchery-origin steelhead that spawn naturally with non-target ESA-listed steelhead populations. Members of the workgroup have already been assigned and the first meeting of the group occurred on March 28, 2017. The results from workgroup-generated efforts is intended to enhance program assessments/evaluations for the next permitting period unless adaptive management of current programs can be accomplished with new information.

Table 5. Research, monitoring and evaluation associated with the four steelhead hatchery programs and any existing ESA coverage.

Activity	Associated Program	ESA Coverage
Monitor adult collection, numbers, origin, length, age, genetic samples, marks/tags, and return timing at weirs, traps, and hatchery facilities	All	This Opinion

Determine density of residual smolts and fingerlings in key natural production areas	Grande Ronde and Little Sheep	Spring Chinook permits 18030, 18033, 18034, 18035, 18036
Monitor proportion of hatchery- and natural-origin fish in natural production areas and collect basic life history information (i.e., length, maturity, migration status, marks/tags, sex, aging, (via scale samples and/or otoliths), genetic identity, and condition)	All	ISEMP permit; Spring Chinook permits 18024, 18030, 18033, 18034, 18035, 18036; Tucannon will be covered in this Opinion
Develop genetic profiles for hatchery and natural steelhead populations in the Grande Ronde and Imnaha Subbasins and conduct regular monitoring	Grande Ronde and Little Sheep	Spring Chinook permits 18030, 18033, 18034, 18035, 18036
Operate rotary screw traps to estimate the abundance, timing, and age composition of naturally produced steelhead migrants, and to collect tissue samples for pedigree analysis to determine parentage of migrants in Little Sheep	All	NMFS research permit (13822-2R); Spring Chinook permits 18024, 18030, 18033, 18034, 18035, 18036; Snake River Fall Chinook permit 16607; Tucannon and Little Sheep smolt traps will be covered in this Opinion
Adult trapping on the Penewawa, Deadman, Alkali Flat, Petaha, and Meadow Creeks	Tucannon	This Opinion
Smolt-to-adult survival, outmigration timing, and in season run forecasts using PIT tag detections	All	This Opinion
Evaluate use of early brood	Grande Ronde	This Opinion
Evaluate use of a chemical attractant as a way to sort and remove precociously mature hatchery smolts prior to release from acclimation sites	Grande Ronde and Little Sheep	This Opinion
Evaluate the ODFW-WDFW study for Wallowa stock fish to determine the effects of different rearing and release strategies on survival and straying	Grande Ronde and Lyons Ferry	This Opinion
Within hatchery monitoring of fish health and survival	All	This Opinion

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

All programs return water to the diverted creek or river (minus any leakage and evaporation) along with any groundwater discharge. Water at all facilities is withdrawn in accordance with state-issued water rights. All facilities that rear over 20,000 pounds of fish operate under National Pollutant Discharge Elimination System (NPDES) through a general permit (Permit number 300J) issued by the Oregon Department of Environmental Quality or Washington

Department of Ecology (Table 6). The facilities addressed in this opinion are covered by existing NPDES permits where applicable.

The LSRCP is in the process of reviewing all of its facilities for compliance with the most recent NMFS screening criteria (NMFS 2011a); reports have been drafted for most facilities. Following the assessment of all facilities, the LSRCP will initiate discussions with NMFS, facility operators, and co-managers to determine relative risks to listed species and the various hatchery programs based on compliance concerns. Using this information as a backdrop, a strategy to prioritize and schedule facility upgrades will be developed and implemented contingent upon the availability of funding. Because these upgrades may adversely affect the local environment, and have short-term implications for the management of hatchery programs, upgrades will undergo separate section 7 consultations to ensure ESA compliance.

Routine Maintenance

Several routine and semi-routine maintenance activities occur in or near water that could impact fish in the area including: sediment/gravel removal/relocation from intake and/or outfall structures, pond cleaning, pump maintenance, debris removal from intake and outfall structures, and maintenance and stabilization of existing bank protection and at the intake diversions, fish ladders, and effluent outfall. All in-water maintenance activities considered “routine” (occurring on an annual basis) or “semi-routine” (occurring with regularity, but not necessarily on an annual basis) for the purposes of this action will occur within existing structures or the footprint of areas that have already been impacted. When maintenance activities occur within water, they will comply with the following guidance:

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

Table 6. Facility details for those facilities that divert water for hatchery operations.

Facilities	Program(s)	Surface Water (cfs)	Ground Water (cfs)	Water Diversion Distance (km)	Surface water source	Discharge Location	Instream Structures	NPDES Permit?
Wallowa Hatchery	Grand Ronde, Little Sheep	10	0.13 of 2.5	0.2	Spring Creek	Spring Creek	4: Intake, outfall, ladder, weir	Yes
Irrigon Hatchery	Grand Ronde, Little Sheep	0	5 of 46.6	0	Wallowa River	Columbia River	1: outfall	Yes
Big Canyon Satellite	Grand Ronde	10	0	0.2	Deer Creek	Deer Creek	4: Intake, outfall, ladder, weir	Not applicable
Little Sheep Acclimation Site	Little Sheep	10	0	0.2	Little Sheep Creek	Little Sheep Creek	4: Intake, outfall, ladder, weir	Not applicable
Lyons Ferry Hatchery	Lyons Ferry, Tucannon	Not applicable	119	Not applicable	Not applicable	Snake River	2: outfall, fish ladder	Yes
Cottonwood Acclimation Site	Lyons Ferry	6	0	0.1	Cottonwood Creek	Grande Ronde River	4: Intake, outfall, ladder, weir	Yes
Tucannon Fish Hatchery	Tucannon	16	7.3	1.3	Tucannon River	Tucannon River	3: Intake, discharge outfall, fish ladder	Yes
Dayton Acclimation Facility	Lyons Ferry	6	0	0.1	Touchet River	Touchet River	4: Intake, outfall, ladder, weir	Not applicable

1.4. Action Area

The "action area" means all areas to be affected directly or indirectly by the Proposed Action, in which the effects of the action can be meaningfully detected measured, and evaluated (50 CFR 402.02). The action area resulting from this analysis includes the Snake River from its confluence with the Imnaha River downstream to McNary Dam on the Columbia River. Within this reach and included in the action area are four major tributaries to the Snake and Columbia Rivers: (1) the Imnaha Subbasin, (2) the Grande Ronde Subbasin, (3) the Tucannon Subbasin, and (4) the Walla Walla Basin. The action area includes locations where fish are captured, reared, and released, as well as areas where they may be monitored, or stray. In addition, Irrigon Hatchery is used to incubate eggs and rear juveniles and the area immediately surrounding this facility is included in the action area.

1.5. Interrelated and Interdependent Actions

Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration. NMFS has not identified any interdependent or interrelated activities associated with the proposed action.

Fisheries are not part of this Proposed Action. Although tributary fisheries target hatchery-origin returns from these programs, harvest frameworks are managed separately from hatchery production, and are not solely tied to production numbers. Additionally, production and fishery implementation are subject to different legal mandates and agreements. Because of the complexities in annual management of the production and fishery plans, fisheries in these areas or impacting fish produced by these programs are considered as separate actions.

There are also existing mainstem Columbia River and ocean fisheries that may catch fish from these programs. However, these mixed fisheries would exist with or without these programs, and have previously been evaluated in a separate biological opinion (NMFS 2008b). The impacts of fisheries in the action area on these programs and, in particular, on ESA-listed salmonids returning to the action area for this opinion are included in the environmental baseline.

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

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. Section 7(a)(2) of the ESA requires Federal agencies to consult with the FWS, NMFS, or both, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. 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 and their critical habitat. If incidental take is expected, section 7(b)(4) requires the consulting agency to provide an ITS that specifies the impact of any incidental taking and includes reasonable and prudent measures to minimize such impacts.

2.1. Analytical Approach

Section 7(a)(2) of the ESA requires Federal agencies, in consultation with NMFS, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. The jeopardy analysis considers both survival and recovery of the species. “To jeopardize the continued existence of a listed species” means to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of the species in the wild by reducing the reproduction, numbers, or distribution of that species or reduce the value of designated or proposed critical habitat (50 CFR 402.02).

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

The designations of critical habitat for the species considered in this opinion use the terms primary constituent element (PCE) or essential features. The new critical habitat regulations (81 Fed. Reg. 7414, February 11, 2016) replace this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a “destruction or adverse modification” analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

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

Range-wide status of the species and critical habitat

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

Describing the environmental baseline
The environmental baseline includes the past and present impacts of Federal, state, or private actions and other human activities *in the action area* on ESA-listed species. It includes the anticipated impacts of proposed Federal projects that have already undergone formal or early section 7 consultation and the impacts of state or private actions that are contemporaneous with the consultation in process. The environmental baseline is discussed in Section 2.3 of this opinion.

Cumulative effects
Cumulative effects, as defined in NMFS' implementing regulations (50 CFR 402.02), are the effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area. Future Federal actions that are unrelated to the proposed action are not considered because they require separate section 7 consultation. Cumulative effects are considered in Section 2.5 of this opinion.

Integration and synthesis
Integration and synthesis occurs in Section 2.6 of this opinion. In this step, NMFS adds the effects of the Proposed Action (Section 2.4) to the status of ESA protected populations in the Action Area under the environmental baseline (Section 2.3) and to cumulative effects (Section 2.5). Impacts on individuals within the affected populations are analyzed to determine their effects on the VSP parameters for the affected populations. These impacts are combined with the overall status of the MGP to determine the effects on the ESA-listed species (ESU/DPS), which will be used to formulate the agency's opinion as to whether the hatchery action is likely to: (1) result in appreciable reductions in the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat.

Jeopardy and adverse modification
Based on the Integration and Synthesis analysis in section 2.6, the opinion determines whether the proposed action is likely to jeopardize ESA protected species or destroy or adversely modify designated critical habitat in Section 2.7.

Reasonable and prudent alternative(s) to the proposed action
If NMFS determines that the action under consultation is likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat, NMFS must identify a RPA or RPAs to the proposed action.

2.2. Range-wide Status of the Species and Critical Habitat

This opinion examines the status of each species and designated critical habitat that would be affected by the Proposed Action described in Table 7[2]. Status of the species is the level of risk

[2] ESA-listed bull trout (*Salvelinus confluentus*) are administered by the FWS and the proposed hatchery program is currently covered under a separate FWS section 7 consultation (FWS ref # 01E0FW00-2015-F-0154). Take associated with hatchery monitoring and evaluation activities is covered under USFWS TE-702631, sub-permit MCFRO-13.

that the listed species face based on parameters considered in documents such as recovery plans, status reviews, and ESA listing determinations. The species status section helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The opinion also examines the status and conservation value of critical habitat in the action area and discusses the current function of the essential physical and biological features that help to form that conservation value.

Table 7. Federal Register notices for the final rules that list species, designate critical habitat, or apply protective regulations to ESA-listed species considered in this consultation.

Species	Listing Status	Critical Habitat	Protective Regulations
Chinook salmon *(Oncorhynchus tshawytscha)*			
Snake River spring/summer-run	Threatened, 79 FR 20802,[3] April 14, 2014	64 FR 57399, October 25, 1999	70 FR 37160, June 28, 2005
Snake River fall-run	Threatened, 79 FR 20802, April 14, 2014	58 FR 68543, December 28, 1993	70 FR 37160, June 28, 2005
Sockeye salmon *(O. nerka)*			
Snake River	Endangered, 79 FR 20802, April 14, 2014	70 FR 52630, September 2, 2005	ESA Section 9
Steelhead *(O. mykiss)*			
Snake River	Threatened, 79 FR 20802, April 14, 2014	70 FR 52769, September 2, 2005	70 FR 37160, June 28, 2005
Middle Columbia River	Threatened, 79 FR 20802, April 14, 2014	70 FR 52808, September 2, 2005	70 FR 47160, June 28, 2005

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

2.2.1. Status of Listed Species

For Pacific salmon and steelhead, NMFS commonly uses four parameters to assess the viability of the populations that, together, constitute the species: abundance, productivity, spatial

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

structure, and diversity (McElhany et al. 2000). These “viable salmonid population” (VSP) criteria therefore encompass the species’ “reproduction, numbers, or distribution” as described in 50 CFR 402.02. When these parameters are collectively at appropriate levels, they maintain a population’s capacity to adapt to various environmental conditions and allow it to sustain itself in the natural environment. These parameters or attributes are substantially influenced by habitat and other environmental conditions.

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

“Productivity,” as applied to viability factors, refers to the entire life cycle; i.e., the number of naturally-spawning adults (i.e., progeny) produced per naturally spawning parental pair. When progeny replace or exceed the number of parents, a population is stable or increasing. When progeny fail to replace the number of parents, the population is declining. McElhany et al. (2000) use the terms “population growth rate” and “productivity” interchangeably when referring to production over the entire life cycle. They also refer to “trend in abundance,” which is the manifestation of long-term population growth rate.

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

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

In describing the range-wide status of listed species, we rely on viability assessments and criteria in TRT documents and recovery plans, when available, that describe VSP parameters at the population, major population group (MPG), and species scales (i.e., salmon ESUs and steelhead DPSs). For species with multiple populations, once the biological status of a species’ populations and MPGs have been determined, NMFS assesses the status of the entire species. Considerations for species viability include having multiple populations that are viable, ensuring that populations with unique life histories and phenotypes are viable, and that some viable populations are both widespread to avoid concurrent extinctions from mass catastrophes and spatially close to allow functioning as meta-populations (McElhany et al. 2000).

2.2.1.1. Snake River Spring/summer Chinook Salmon ESU

Spring/summer-run Chinook salmon from the Snake River basin exhibit stream-type life history characteristics. Chinook salmon return to the Columbia River from the ocean in early spring through August. Returning fish hold in deep mainstem and tributary pools until late summer, when they emigrate up into tributary areas and spawn from mid- through late August. The eggs incubate over the following winter, and hatch in late winter and early spring of the following year. Juveniles rear through the summer, overwinter, and typically migrate to sea in the spring of their second year of life, although some juveniles may spend an additional year in fresh water. Snake River spring/summer-run Chinook salmon spend two or three years in the ocean before returning to tributary spawning grounds primarily as 4- and 5-year-old fish. A small fraction of the fish return as 3-year-old “jacks,” heavily predominated by males.

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

There are two independent populations within the Lower Snake River MPG: Tucannon River and Asotin Creek. The ESA Recovery Plan for SEWA (SRSRB 2011) requires that the Tucannon River population be at low risk (no more than a 1 percent risk of extinction in 100 years). The Tucannon River population is required to meet highly viable status for delisting of the ESU because the Asotin Creek population is extirpated. The most recent status review by NMFS (NWFSC 2015) maintains that the Tucannon population remains at high risk (Table 9).

There are six extant independent populations of spring/summer Chinook salmon within the Grande Ronde/Imnaha MPG: Wenaha River, Lostine River, Minam River, Catherine Creek, Upper Grande Ronde River, and the Imnaha River. The remaining two populations, Lookingglass and Big Sheep Creeks, are functionally extirpated. The ICTRT criteria call for a minimum of four populations at viable or highly viable status. The potential scenario identified by the ICTRT (2007) would include viable populations in the Imnaha River (run timing), the Lostine/Wallowa River (large size) and at least one from each of the following pairs: Catherine Creek or Upper Grande Ronde (large size); and Minam or Wenaha Rivers. The most recent status review by NMFS (NWFSC 2015) maintains that all extant populations remain at high risk of extinction (Table 8).

Table 8. Risk levels and viability ratings for Snake River spring/summer Chinook salmon populations (NWFSC 2015); ICTRT = Interior Columbia Technical Recovery Team. Data are from 2005-2014.

Population	ICTRT minimum threshold	Geometric mean natural spawning abundance (standard error)	Proportion natural-origin spawners	Geometric mean productivity (standard error)	Abundance and productivity risk	Spatial structure and diversity risk	Overall viability risk rating
Tucannon	750	267 (0.19)	0.67	0.69 (0.23)	High	Moderate	High
Asotin Creek	Extirpated						
Wenaha	750	399 (0.12)	0.76	0.93 (0.21)	High	Moderate	High
Lostine/Wallowa	1000	332 (0.24)	0.45	0.98 (0.12)	High	Moderate	High
Minam	750	475 (0.12)	0.89	0.94 (0.18)	High	Moderate	High
Catherine Creek	1000	110 (0.31)	0.45	0.95 (0.15)	High	Moderate	High
Up. Grande Ronde	1000	43 (0.26)	0.18	0.59 (0.28)	High	High	High
Imnaha River	750	328 (0.21)	0.35	1.2 (0.09)	High	Moderate	High
Lookingglass Creek	500	Extirpated					
Big Sheep Creek	Extirpated						

2.2.1.2. Snake River Steelhead DPS

O. mykiss exhibit perhaps the most complex suite of life-history traits of any species of Pacific salmonid. They can be anadromous or freshwater resident, and under some circumstances, yield offspring of the opposite form. Steelhead are the anadromous form. A non-anadromous form of *O. mykiss* (redband trout) co-occurs with the anadromous form in this DPS, and juvenile life stages of the two forms can be very difficult to differentiate. Steelhead can spend up to 7 years in fresh water prior to smoltification, and then spend up to 3 years in salt water prior to first spawning. This species can also spawn more than once (iteroparous), whereas all other species of *Oncorhynchus*, except *O. clarkii*, spawn once and then die (semelparous). Snake River steelhead are classified as summer-run because they enter the Columbia River from late June to October. After holding over the winter, summer steelhead spawn the following spring (March to May).

Factors that limit the DPS's survival and recovery include: juvenile and adult migration through the FCRPS; the degradation and loss of estuarine areas that help fish transition between fresh and marine waters; spawning and rearing areas that have lost deep pools, cover, side-channel refuge areas, high quality spawning gravels, and; interbreeding and competition with hatchery fish that outnumber natural-origin fish. A more detailed description of the populations that are the focus of this consultation follows.

There are two independent populations within the Lower Snake River MPG: Tucannon River and Asotin Creek. The ESA Recovery Plan for southeast Washington (SRSRB 2011) requires that the Tucannon River population be at moderate risk and for the Asotin Creek population to be at low risk of extinction. The most recent status review (NWFSC 2015) found that the Tucannon River population remains at high risk, and the Asotin Creek population is maintained (Table 9). However, both populations have insufficient data on abundance and productivity to assess accurately these metrics.

There are four independent populations of steelhead within the Grand Ronde MPG: Joseph Creek, Lower Grand Ronde River, Upper Grand Ronde River, and Wallowa River. The Draft ESA Recovery Plan for northeast Oregon (NMFS 2012a) requires that the Upper Grand Ronde and Wallowa River populations have a minimum of moderate risk, the Joseph Creek population maintain its current low risk status, and the Lower Grand Ronde population achieve low or moderate risk. Although these populations are close to achieving recovery requirements, there is a large amount of uncertainty in the data.

There is one independent population of steelhead within the Imnaha MPG, the Imnaha River population. The Draft ESA Recovery Plan for northeast Oregon (NMFS 2012a) requires that the Imnaha River population achieve low risk. NMFS' status review (NWFSC 2015) found that information for this population is insufficient to be able to assess risk reliably, but estimates the population is most likely at moderate risk of extinction (Table 9).

Table 9. Risk levels and viability ratings for Snake River steelhead populations (NWFSC 2015). Parentheses indicate range. Data are from 2004-2015. ID = insufficient data; ICTRT = Interior Columbia Technical Recovery Team.

Population	ICTRT minimum threshold	Natural spawning abundance	Productivity	Abundance and productivity risk	Spatial structure and diversity risk	Overall risk viability rating
Tucannon River	1000	ID	ID	High[1]	Moderate	High[1]
Asotin Creek	500	ID[2]	ID	Moderate[1]	Moderate	Moderate[1]
Lo. Grande Ronde	1000	ID	ID	[1]	Moderate	Moderate[1]
Joseph Creek	500	1839	1.86	Very low	Low	Low
Up. Grande Ronde	1500	1649 (0.21)	3.15 (0.4)	Moderate	Moderate	Moderate
Wallowa River	1000	ID	ID	High[1]	Moderate	High[1]
Imnaha River	1000	ID	ID	Moderate[1]	Moderate	Moderate[1]

[1]Uncertain due to lack of data, only a few years of data, or large gaps in data series.
2Monitoring beginning in 2005 suggests that the average annual natural-origin population seems is ~900-1100 (J. Bumgarner, WDFW, personal communication, April 6, 2017).

2.2.1.3. Snake River Fall Chinook Salmon ESU

Before alteration of the Snake River Basin by dams, Snake River fall-run Chinook salmon exhibited a largely ocean-type life history, where they migrated downstream during their first-year. Today, fall-run Chinook salmon in the Snake River Basin exhibit one of two life histories; 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 (mainly from fish that spawned in the Clearwater River), which prevents juveniles from reaching a suitable size to migrate out of the Snake River and on to the ocean.

The Snake River Fall-run Chinook Salmon ESU includes naturally spawned fish in the lower mainstem of the Snake River and the lower reaches of several of the associated major tributaries including the Tucannon, the Grande Ronde, Clearwater, Salmon, and Imnaha Rivers, along with 4 artificial propagation programs (Jones Jr. 2015; NWFSC 2015). All of the hatchery programs are included in the ESU along with a single natural-origin population that is currently viable, with a low risk for abundance/productivity and a moderate risk for spatial structure and diversity.

The Snake River Fall-run Chinook Salmon ESU remains at threatened status (NWFSC 2015). Factors that limit the ESU's survival and recovery include: hydropower projects, predation, harvest, degraded estuary habitat, and degraded mainstem and tributary habitat (Ford 2011). Ocean conditions have also affected the status of this ESU. Ocean conditions affecting the survival of Snake River fall-run Chinook salmon were generally poor during the early part of the last 20 years (NMFS 2012c).

2.2.1.4. Snake River Sockeye Salmon ESU

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

The ESU includes naturally spawned anadromous and residual sockeye salmon originating from the Snake River Basin in Idaho, as well as artificially propagated sockeye salmon from the Redfish Lake captive propagation program (Jones Jr. 2015). At this stage of the recovery efforts, there is only one extant population, and the ESU remains endangered with a high risk for spatial structure, diversity, abundance, and productivity (NWFSC 2015). At present, anadromous returns are dominated by production from the captive spawning component. The ongoing reintroduction program is still in the phase of building sufficient returns to allow for large scale reintroduction into Redfish Lake, the initial target for restoring natural program (NMFS 2015).

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

2.2.1.5. Mid-Columbia River Steelhead DPS

Most fish in this DPS smolt at two years and spend one to two years in salt water before re-entering fresh water, where they may remain up to a year before spawning (Howell et al. 1985; BPA 1992). Summer steelhead typically enter freshwater from June through October with peak entry occurring in July (Busby et al. 1996). Juvenile life stages (i.e., eggs, alevins, fry, and parr) inhabit freshwater/riverine areas throughout the range of the DPS. A non-anadromous form of *O. mykiss* (redband trout) co-occurs with the anadromous form in this DPS, and juvenile life stages of the two forms can be very difficult to differentiate.

Factors that limit the DPS's survival and recovery include low water flow during certain times of the year, increased peak flows, elevated temperatures, sedimentation, a lack of pool habitat and lack of habitat diversity. A more detailed description of the populations that are the focus of this consultation follows.

There are three independent summer steelhead populations within the Umatilla/Walla Walla River MPG: Touchet River, Walla Walla River, and Umatilla River. To meet recovery goals, two of the three populations are required to obtain viable status and one population must be highly viable. Currently, none of the populations are considered viable, but compared to the previous status review (Ford 2011), the proportion of out-of-basin spawners has decreased in both the Touchet and Umatilla populations (Table 10). In the Touchet population, the composition of hatchery spawners has shifted towards fish returning from the endemic hatchery program (NWFSC 2015).

Table 10. Risk levels and viability ratings for mid-Columbia steelhead populations (NWFSC 2015); ICTRT = Interior Columbia Technical Recovery Team. Data are from 2005-2014.

Population	ICTRT minimum threshold	Geometric mean of natural spawning abundance	Proportion natural-origin spawners	Productivity	Abundance and productivity risk	Spatial structure and diversity risk	Overall risk viability rating
Touchet River	1000	382 (0.12)	0.8	1.25 (0.11)	High	Moderate	High

Walla Walla River	1000	877 (0.13)	0.97	1.65 (0.11)	Moderate	Moderate	Moderate
Umatilla River	1500	2379 (0.11)	0.82	1.2 (0.32)	Moderate	Moderate	Moderate

2.2.2. Range-wide Status of Critical Habitat

NMFS determines the range-wide status of critical habitat by examining the condition of its PBFs that were identified when critical habitat was designated. These features are essential to the conservation of the listed species because they support one or more of the species' life stages. An example of some PBFs are listed below. These are often similar among listed salmon and steelhead; specific differences can be found in the critical habitat designation for each species (Table 7).

(1) Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development;

(2) Freshwater rearing sites with: (i) Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; (ii) Water quality and forage supporting juvenile development; and (iii) Natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks;

(3) Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival;

(4) Estuarine areas free of obstruction and excessive predation with: (i) Water quality, water quantity, salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; (ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels; and (iii) Juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation;

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

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

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

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

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

The Mid-Columbia River Steelhead DPS's range includes 111 watersheds. The CHART assigned low, medium, and high conservation value ratings to 9, 24, and 78 watersheds, respectively (NMFS 2005a). They also identified 1 watershed with an unknown conservation value. The following are the major factors limiting the conservation value of critical habitat for Mid-Columbia River steelhead:

- Agriculture
- Channel modifications/diking
- Dams,
- Forestry
- Fire activity and disturbance
- Grazing
- Irrigation impoundments and withdrawals,
- Urbanization

- Road building/maintenance

2.3. Environmental Baseline

Under the Environmental Baseline, NMFS describes what is affecting listed species and designated critical habitat before including any effects resulting from the Proposed Action. The 'Environmental Baseline' includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area and the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation (50 CFR 402.02).

We decided to limit our action area to the Imnaha Subbasin and the mainstem Snake River down to McNary Dam on the Columbia River. We did not extend the action area to the estuary/plume for several reasons. The first was that all of the programs in the Proposed Action combined release fewer than 1.5 million steelhead, a small proportion of the ~150 million hatchery fish released into the Columbia and Snake River Basins annually. Second, steelhead move relatively quickly through the migratory corridor and estuary to the ocean, and therefore would be expected to have a low potential for interacting meaningfully with fish migrating through the mainstem or utilizing the estuary for rearing. Third, the NMFS (2017) Opinion on Mitchell Act funding considered the effects of hatchery fish downstream of McNary Dam in the estuary and ocean, and found that subyearling Chinook salmon and coho salmon are the most likely hatchery fish to have effects in these areas due to their long residence times and relatively high predation rates, respectively. Together these reasons suggest that the likelihood of detecting effects from the releases of hatchery steelhead considered in this Opinion on natural-origin fish below McNary Dam have already been examined to the best of our ability.

2.3.1. Habitat and Hydropower (NMFS 2012a)

A discussion of the baseline condition of habitat and hydropower throughout the Columbia River Basin occurs in our Biological Opinion on the Mitchell Act Hatchery programs (NMFS 2017). The baseline includes all federally-authorized hydropower projects, including projects with licenses issued by the Federal Energy Regulatory Commission, the Federal Columbia River Power System, and other developments which have undergone ESA §7 consultation. Here we summarize some of the key impacts on salmon and steelhead habitat in the Snake River Basin.

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

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

- Total dissolved gas (water quality and safe passage in the migration corridor)
- Food webs, including both predators and prey (food/prey and safe passage in the migration corridor)

Many floodplains in the Middle and lower Snake River watersheds have been altered by channelization to reduce flooding and by conversion of land to agricultural and residential uses. Flood control structures (i.e. dikes) have been constructed on a number of streams and rivers, including the Touchet, Tucannon, and Walla Walla Rivers and Asotin Creek. These have accelerated surface water runoff and decreased groundwater recharge, contributing to lower summer stream flows. Natural groundwater recharge and discharge patterns have also been modified by groundwater pumpage and surface water diversion for irrigation. Most irrigation water withdrawals occur during the summer dry months when precipitation is lowest and demand for water is the greatest. Irrigation withdrawals have reduced flows in the Walla Walla, Touchet, Grande Ronde, and to a much lesser extent, the Tucannon River, and Asotin, Pataha, Steptoe, Wawawai, Almota, Little Almota, Penewawa, and Alkali Flat Creeks. Road construction, overgrazing, and removal of vegetation in floodplain areas have also caused bank erosion, resulting in wide channels that increase the severity of low summer flows. Primary water quality concerns for salmonids in Snake River tributaries include high water temperatures, which can cause direct mortality or thermal passage barriers, and high sediment loads, which can cause siltation of spawning beds.

While harmful land-use practices continue in some areas, many land management activities, including forestry practices, now have fewer impacts on salmonid habitat due to raised awareness and less invasive techniques. For example, timber harvest on public land has declined drastically since the 1980s and current harvest techniques (e.g., the use of mechanical harvesters and forwarders) and silvicultural prescriptions (i.e., thinning and cleaning) require little, if any, road construction and produce much less sediment. In addition, the Federal Conservation Reserve and Enhancement Program (CREP) began in the 1990's nearly 80 percent of all salmonid bearing streams in the area have been re-vegetated with native species and protected from impacts. Under the CREP, highly erodible and other environmentally sensitive lands that have produced crops are converted to a long-term resource-conserving vegetative cover. Participants in the CREP are required to seed native or introduced perennial grasses or a combination of shrubs and trees with native forbs and grasses. For example, some of the streams in the action area (e.g. Tucannon), have seen an effort to increase channel complexity and reconnect natural floodplains by the addition of large wood to the streams. In the Tucannon River, through these and other land use actions, there has been an overall increase in summer base flows over the last 10 years.

2.3.2. Climate Change

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

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

Recently, researchers examining data from 1990-2009 found that temperatures in the Snake Basin region are increasing, while average streamflows are slightly decreasing (Dittmer 2013). However, basins in northeast Oregon saw an increase in summer flows, despite an average overall annual decrease (Dittmer 2013). Warming winter temperature and decreasing snowpack have been observed in the Blue Mountains and the Pacific Northwest in general (Mote et al. 2005), which has an impact on the snowmelt-driven basins in northeast Oregon and southeast Washington. This is problematic because snowpack rather than man-made reservoirs are the primary form of water storage in the region.

Climate change is also predicted to cause a variety of impacts on Pacific salmon as well as their ecosystems (Crozier et al. 2008a; Martins et al. 2012; Mote et al. 2003; Wainwright and Weitkamp 2013). While all habitats used by Pacific salmon will be affected, the impacts and certainty of the change vary by habitat type. Some impacts (e.g., increasing temperature) affect salmon at all life stages in all habitats, while others are habitat-specific (e.g., stream flow variation in freshwater). The complex life cycles of anadromous fishes including salmon rely on productive freshwater, estuarine, and marine habitats for growth and survival, making them particularly vulnerable to environmental variation (Morrison et al. 2016). Ultimately, the effect of climate change on salmon and steelhead across the Pacific Northwest will be determined by the specific nature, level, and rate of change and the synergy between interconnected terrestrial/freshwater, estuarine, nearshore, and ocean environments. The primary effects of climate change on Pacific Northwest salmon and steelhead are:

- Direct effects of increased water temperatures on fish physiology
- Temperature-induced changes to stream flow patterns
- Alterations to freshwater, estuarine, and marine food webs

How climate change will affect each stock or population of salmon also varies widely depending on the level or extent of change and the rate of change and the unique life history characteristics of different natural populations (Crozier et al. 2008b). Dittmer (2013) suggests that juveniles may outmigrate earlier if they are faced with less tributary water. Lower and warmer summer flows may be challenging for returning adults. In addition, the warmer water temperatures in the summer months may persist for longer periods and more frequently reach and exceed thermal tolerance thresholds for salmon and steelhead (Mantua et al. 2009). Larger winter streamflows may increase redd scouring for those adults that do reach spawning areas and successfully spawn. Climate change may also have long-term effects that include accelerated embryo development, premature emergence of fry, and increased competition among species (ISAB

2007). The uncertainty associated with these potential outcomes of climate change do provide some justification for hatchery programs as reservoirs for some salmon stocks. For more detail on climate change effects, please see NMFS (2017).

2.3.3. Hatcheries

A more comprehensive discussion of hatchery programs in the Snake River Basin can be found in our opinion on Mitchell Act funded programs (NMFS 2017). In summary, because most programs are ongoing, the effects of each are reflected in the most recent status of the species, (NWFSC 2015) and was summarized in Section 2.2.1 of this Opinion. In the past, hatcheries have been used to compensate for factors that limit anadromous salmonid viability (e.g., harvest, human development) by maintaining fishable returns of adult salmon and steelhead. A new role for hatcheries emerged during the 1980s and 1990s as a tool to conserve the genetic resources of depressed natural populations and to reduce short-term extinction risk (e.g., Snake River sockeye salmon). Hatchery programs also can be used to help improve viability by supplementing natural population abundance and expanding spatial distribution. However, the long-term benefits and risks of hatchery supplementation remain untested (Christie et al. 2014). Therefore, fixing the factors limiting viability is essential for long-term viability.

Below we have included more detail on the history and purpose of the steelhead hatchery programs included in our proposed action: Little Sheep Creek, Grande Ronde Basin, LFH, and Tucannon. All are currently ongoing, and were initiated under the LSRCP to mitigate for the construction and operation of the lower four Snake River dams on salmon and steelhead in the Snake River basin.

Initial natural-origin adult collection for the integrated Little Sheep Creek Summer Steelhead Program in the Imnaha Subbasin occurred in 1982. Since the program began, a minimum of five percent of the brood has consisted of natural-origin fish. Resulting smolt releases of 330,000 fish began in 1983 into Big and Little Sheep Creeks. After brood year 2007, releases were reduced to 215,000 smolts for supplementation and harvest purposes.

The Grande Ronde Subbasin segregated hatchery program utilizes the Wallowa stock derived from Snake River Basin adults collected at Ice Harbor and Little Goose dams between 1976 and 1979. Collected fish were hauled and spawned at Wallowa Hatchery in Oregon and termed the "Wallowa" stock. The original production program consisted of 1.35 million smolts released for harvest. Program releases included both direct stream smolt releases and adult outplants at several locations. The program has been modified in recent years based on the results of rearing and release studies (Clarke et al. 2014; Clarke et al. 2011; Clarke et al. 2010) in an effort to address concerns regarding impacts on wild steelhead and Chinook salmon populations in the basin while maintaining harvest benefits. These changes include: (1) shifting all smolt releases to existing acclimation facilities and eliminating direct stream releases, (2) utilizing volitional smolt releases, (3) elimination of adult outplants, (4) rearing smolts to a larger release size, and (5) reduction of program size by 35 percent (current smolt releases – 800,000).

The LFH segregated summer steelhead program has been operated since 1983 and originally released fish at several locations for harvest: Cottonwood acclimation facility in the Grande Ronde Subbasin (using Wallowa stock obtained from ODFW), the Tucannon, Touchet and Walla

Walla Rivers, on–station at LFH in the Snake River, the Snake River above Little Goose Dam, at Texas Rapids, at Central Ferry, and above Ice Harbor, Asotin Creek, Wildcat Creek (Oregon), and Mill Creek (Walla Walla basin). Some of these releases occurred only a couple of times. Prior to 2001, all hatchery steelhead production came from the use of LFH stock steelhead (Schuck et al. 1998) which was primarily derived from Wells stock in the upper Columbia River, but also had some Wallowa stock influence, which WDFW replaced in 2013 with Wallowa stock. Returns of primarily Wells stock fish to Lyons Ferry Hatchery were used for broodstock in the early 1980's and eventually were termed the "Lyons Ferry" stock. Data indicate that there is no strong evidence for introgression between the LFH stock and natural-origin steelhead in the Walla Walla Subbasin (Bumgarner and Dedloff 2007).

A steelhead program has been operated in the Tucannon River since 1983 to allow for harvest. The program used either Wells or Wallowa stocks in the early 1980's, but since the late 1980s the LFH stock was used. The 1999 Biological Opinion by NOAA Fisheries on the LSRCP-produced hatchery steelhead concluded that the continued use of LFH stock jeopardized the continued existence and recovery of wild steelhead populations within the Snake River. In response, WDFW initiated testing an endemic stock from the Tucannon River in 2000, which led to an integrated program adopted in 2010 used to supplement the natural population as well as supply fish for harvest. The LFH stock fish were last released in the Tucannon in 2010. Genetic data indicated introgression between the LFH and Tucannon stocks had occurred (Bumgarner and Dedloff 2007).

2.3.4. Harvest

Spring Chinook Salmon

Fisheries also occur within the Columbia River tributary subbasins in northeast Oregon. These fisheries typically take place from May to July. Management of these fisheries limits catch of natural-origin fish to a certain percentage of the natural-origin abundance (i.e., a sliding scale). The effects of the fisheries' operation on the ESA-listed Snake River Spring/summer Chinook Salmon ESU and the Snake River Steelhead DPS were previously analyzed by NMFS. NMFS also found, as with ocean and mainstem Columbia River fisheries, above, that the action did not appreciable reduce the likelihood of survival and recovery of the listed species (NMFS 2013). Based on recent natural-origin abundances, the percentage of natural-origin Chinook salmon caught in tributary fisheries ranges from 1 to 9 percent across all subbasins. Steelhead are rarely encountered (1 fish reported from 2001 to 2009) in tributary fisheries for spring Chinook salmon because they spawn from April to early June, which overlaps with the spring Chinook fishery from June through July for only a short time (NMFS 2013).

There is a small tribal spring Chinook salmon fishery in the Tucannon River that operates intermittently. From 2007-2009, this fishery did not occur. (https://www.fws.gov/lsnakecomplan/Reports/NPTreports.html).

Steelhead

Sport harvest in the action area is restricted to adipose clipped, hatchery-origin fish. Estimates of maximum incidental mortality rates for listed populations associated with steelhead and trout fisheries are based on estimates of hooking rates and hooking-related mortality estimated at 5 percent for adult steelhead caught and released in steelhead fisheries (Hooton 1987), and 10 percent for spring chinook adults caught and released during trout fisheries (Lindsay et al. 2001). For the individual populations where fisheries occur to selectively harvest hatchery fish in terminal areas, incidental mortality of natural steelhead is usually less than 5 percent of the population (Tables 11-12; Table 14). Catch-and-release mortality of steelhead is likely to be higher if the fishery occurs during warm water conditions (Mongillo 1984). However, most of the steelhead harvest occurs between October and March when average water temperature in the Snake River is around 8-9°C, (WDOE – River and Stream Water Quality Monitoring Program – Station#35A150). In the Snake River mainstem, where effects are likely distributed among populations, mortality is less than one percent across the DPS (Table 13).

Table 11. Population run sizes and incidental mortality of natural steelhead in four populations above Lower Granite Dam. Incidental mortality was estimated using two methods—before the slash is from run reconstructions and after the slash is from creel surveys and angler catch cards.

Run Year	Lower Grande Ronde		Upper Grande Ronde		Imnaha		Wallowa	
	Natural run size	Incidental natural mortality	Natural run size	Incidental natural mortality	Natural run Size	Incidental natural mortality	Natural run Size	Incidental natural mortality
2010-2011	1014	44/89	2434	0/43	2387	0/75	2021	0/43
2011-2012	1137	329/123	2731	0/34	2306	207/12	2267	0/34
2012-2013	957	239/55	2297	0/17	2128	12/10	1905	39/17
2013-2014	1167	162/39	2799	0/NA	2336	233/14	2325	0/NA
Average natural loss (%)		18/7		0/1.2		4.9/1.1		0.5/1.5

Source: (Clarke 2016; Copeland et al. 2015; Copeland et al. 2013; Copeland et al. 2014; Stark et al. 2016)

Table 12. Population run size and incidental mortality of natural steelhead in the Tucannon population.

Run Year	Tucannon Natural	Estimated Unmarked Steelhead Caught[1]	Estimated Unmarked Steelhead Mortality[2]	Total Unmarked Steelhead[3]	% Tucannon Natural	Tucannon Natural Mortality (%)
2007	123	100	5	686	18	1
2008	102	307	15	789	13	2
2009	509	0	0	1671	30	0
2010	346	1300	65	867	40	26
2011	175	883	44	929	19	8
2012	205	1400	70	806	25	18
2013	203	344	17	600	34	6
2014	267	150	7	713	37	3
2015	202	14	1	956	21	0
Average	**237**	**500**	**25**	**891**	**26**	**7**

Source: Bumgarner (2016)

[1]These comprise natural fish from the Tucannon and other various rivers and streams as well as unmarked hatchery fish from the Tucannon and Touchet conservation programs based on catch record card reports. The same fish may be caught more than once.
[2]Estimated number of unmarked steelhead hooking mortalities based on a 5% mortality rate of those caught.
[3]Non-Tucannon-origin natural steelhead were estimated using a 5% expansion rate of PIT Tags, which is an assumption about tagging rates of non-Tucannon natural-origin steelhead.

Table 13. Run size and incidental mortality of natural steelhead[1] from mainstem Snake River fisheries.

Year	Ice Harbor run size	Incidental mortality: Lower Snake	Lower Granite Dam run size	Incidental mortality: Upper Snake	Incidental mortality: Lower Granite Pool
2010-2011	44261	222	44455	729	126
2011-2012	44160	230	37433	138	187
2012-2013	26095	245	24396	138	91
2013-2014	28170	260	25858	195	242
Average natural loss (%)		**0.7**		**0.9**	**0.5**

Source: (Copeland et al. 2015; Copeland et al. 2013; Copeland et al. 2014; Stark et al. 2016)
[1]Because all populations are mixed in the mainstem, incidental mortality can be from any of the 24 designated extant populations in the Snake River Basin.

Table 14. Population run size and incidental mortality of natural steelhead in the Walla Walla Subbasin.

Run Year	Walla Walla Subbasin Natural	Estimated Unmarked Steelhead Caught[1]	Estimated Unmarked Steelhead Mortality[2]	Total Unmarked Steelhead	% Walla Walla Subbasin Natural	Walla Walla Subbasin Natural Mortality (%)
2000	1190	1,209	60	1190	100	5.0
2001	2246	2,608	130	2246	100	5.8
2002	1271	1,117	56	1275	99	4.4
2003	818	636	32	856	95	3.7
2004	1313	998	50	1366	96	3.7
2005	1115	606	30	1177	94	2.5
2006	846	955	48	959	88	5.0
2011	1504	1,050	53	1580	95	3.3
2012	1242	1,348	67	1426	87	4.7
Average	**1283**	**1170**	**58**	**1342**	**95**	**4.2**

[1]These are composed of natural fish from the Walla Walla Subbasin as well as unmarked hatchery fish from the Touchet conservation program based on catch record card reports. The same fish may be caught more than once.
[2]Estimated number of unmarked steelhead hooking mortalities based on a 5% mortality rate of those caught.

Creel survey data and incidental reports indicate an occasional fall Chinook salmon is hooked and landed in the steelhead fishery. Based on creel data from Idaho’s 2008 fall Chinook/steelhead fishery random angler checks, ODFW estimated Oregon angler incidental impact on Snake River fall Chinook was less than one natural-origin adult in 2008. WDFW generally estimates <1 percent incidental mortality to the natural-origin fall Chinook salmon return (J. Bumgarner, WDFW, personal communication, December 22, 2016).

Creel survey data also indicates that very few spring/summer Chinook salmon are incidentally caught in steelhead fisheries. From 2006 to 2015, an average of 4, 2, and 1 spring/summer Chinook salmon were caught in the Grande Ronde Oregon, Grande Ronde, Washington and Imnaha River fisheries (ODFW 2016 data). No spring/summer Chinook salmon were encountered in the Tucannon fishery (J. Bumgarner, WDFW, personal communication, December 22, 2016), and spring Chinook salmon are not listed in the Walla Walla Subbasin.

We see no opportunity for steelhead fisheries to intercept sockeye. Adult sockeye move through the reach of the Snake River between the mouth of the Salmon River and the Oregon/Washington border prior to steelhead angling activity.

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

This section describes the effects of the Proposed Action, independent of the Environmental Baseline and Cumulative Effects. The methodology and best scientific information NMFS follows for analyzing hatchery effects is summarized in Appendix A and application of the methodology and analysis of the Proposed Action is in Section 2.4.2. The "effects of the action" means the direct and indirect effects of the action on the species and on designated critical habitat, together with the effects of other activities that are interrelated or interdependent, 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. Effects of the Proposed Action that are expected to occur later in time (i.e., after the 10-year timeframe of the Proposed Action) are included in the analysis in this opinion to the extent they can be meaningfully evaluated. The Proposed Action, the status of ESA-protected species and designated critical habitat, the Environmental Baseline, and the Cumulative Effects are considered together to determine whether the Proposed Action is likely to appreciably reduce the likelihood of survival and recovery of ESA protected species or result in the destruction or adverse modification of their designated critical habitat.

2.4.1. Factors That Are Considered When Analyzing Hatchery Effects

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

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

NMFS' analysis of the Proposed Action is in terms of effects it would be expected to have on ESA-listed species and on designated critical habitat, based on the best scientific information available. This allows for quantification (wherever possible) of the effects of the seven factors of hatchery operation on each listed species at the population level (in Section 2.4.2), which in turn allows the combination of all such effects with other effects accruing to the species to determine the likelihood of posing jeopardy to the species as a whole (Section 2.7).

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

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

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

2.4.2. Effects of the Proposed Action

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

Two of the proposed hatchery programs (Little Sheep and Tucannon) remove fish from the local natural population for broodstock leading to a negative effect for steelhead. However, the removal of natural-origin broodstock is limited by abundance-based sliding scales, which are explained and analyzed in detail below (2.4.2.2.1), to reduce risk to the naturally spawning population. At most, 41 fish would be removed from the Tucannon population for broodstock, and 126 from the Imnaha population. This would result in an adverse effect on each population by reducing the natural spawning population and increasing pHOS. However, fish are spawned and their progeny are intended to supplement each natural population. Thus, the genetic contribution of these natural-origin fish used for broodstock to the population is not lost. Moreover, the sliding scale approach to adult management would minimize the impacts by reducing take in low-return years.

There is no effect on spring/summer Chinook, fall Chinook, or sockeye salmon because none of these species are propagated by these programs.

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

The proposed hatchery programs pose both genetic and ecological risks, and although there is some benefit to the species from the integrated programs designed to supplement the natural populations, the net effect on steelhead is negative, as discussed below.

Only ecological and adult collection effects are relevant for spring Chinook, fall Chinook, and sockeye salmon because these proposed programs do not propagate these species. The overall effect of this factor on these species is negligible, as discussed below.

2.4.2.2.1. Genetic Effects

Evaluation of Proposed Adult Management

For each of the four steelhead programs, NMFS considers three major areas of genetic effects: within-population diversity, outbreeding effects, and hatchery-influenced selection. For all four programs, all three areas of genetic effects could occur. Rarely is it possible to measure the three types of effects separately, however. Until such time as more direct genetic tools are available, our metrics for inferring the magnitude of these effects are pHOS, pNOB, and, in the case of integrated programs, PNI.

NMFS has not strictly adopted HSRG gene flow (i.e., pHOS, pNOB, PNI) standards. However, at present the HSRG standards and the 5% stray standard from Grant (1997) are the only widely acknowledged quantitative standards available, so NMFS considers them a useful screening tool[4]. Programs must be evaluated individually. For a particular program, NMFS may, based on specifics of the program, broodstock, and environment, consider a pHOS or PNI level to be a lower risk than the HSRG would but, generally, if a program meets HSRG standards, NMFS will consider the risk it poses to be acceptable.

Segregated programs

Because supplementation of the natural population is not an objective for this type of program, the number/proportion of hatchery-origin spawners should be limited, and ideally be as close as possible to zero. Because fish stray into areas that are under different management authorities and that may have different approaches to monitoring naturally-spawning fish, it is difficult to assess pHOS for all populations where fish from these two programs may occur. Spawning surveys to recover spent carcasses may not be the best approach to monitoring steelhead spawning naturally, because flows are high when steelhead spawn making conditions for surveyors unsafe at times, and make it difficult to collect carcasses, a necessary step for recovering coded-wire tags and/or genetic tissue samples for parental-based tagging analyses.

Over the past five years, the co-managers in the Snake Basin have been working on reconstructing the steelhead run, which may provide estimates of the number of steelhead harvested, returning to the hatchery, and spawning naturally for each steelhead population (Copeland et al. 2015; Copeland et al. 2013; Copeland et al. 2014; Stark et al. 2016). This is a huge step in trying to tackle the very difficult question of where returning adult steelhead end up. However, there are a number of assumptions/critical uncertainties in the model calculations that require improvement—namely, the number of steelhead harvested from each population in the Snake River mainstem fisheries and the genetic classification of fish to the population level or even MPG level for the Grande Ronde and Lower Snake MPGs (Copeland et al. 2015; NWFSC 2015). Because of these critical uncertainties, we will not use the estimates derived from this modeling effort to inform our analysis of genetic effects at this time. However, NMFS will remain engaged with this run reconstruction effort and will consider the modeled outcomes when all parties agree the model functions well enough to be used to inform the management of steelhead programs in the Grande Ronde, Imnaha, and Lower Snake MPGs, although we acknowledge that this agreement may not occur at the same time for all management areas.

While an analysis based on recipient population is what is really needed to assess pHOS attributable to these hatchery programs, for reasons described above, the best available method for understanding straying from these steelhead programs is to summarize straying by program. To do this, CWT recoveries and PIT detections were summarized by program of origin in a prescribed area, including all recoveries/detections that occurred in areas (spawning ground, hatchery trap, or harvest) where the fish should not appear had they homed properly. We chose to consider recoveries/detections above Ice Harbor Dam, the lowest dam on the Snake River, and after translating these to fish numbers compared them to the estimated number of natural-origin fish crossing the dam, and then expressed the result as stray rate within the Snake Basin (Table 15). Note that stray rate estimates based on PIT detections are typically much higher than those

[4] In addition, HSRG standards have been incorporated into policy by Washington's Fish and Wildlife Commission Washington Fish and Wildlife Commission. 2009. Policy POL-C3619: Hatchery reform. Olympia, Washington.

based on CWT recoveries, because returning fish can be detected at PIT tag arrays, which do not require any handling.

These data suggest that steelhead straying from these programs comprise a small proportion—1 to 3 percent depending on the tagging method—of the natural-origin steelhead above Ice Harbor Dam. The average returns of natural-origin steelhead to Ice Harbor from 2002-2015 (which corresponds with the brood years in Table 15) was 42,953 and ranged from 27,530 to 76,434. For our analysis, we have only considered steelhead that were harvested and/or were encountered at the hatchery rack after March 1st, and those encountered during spawning ground surveys. Prior to March 1st, steelhead may have been encountered in other areas, but still had time to migrate back to their natal stream or hatchery prior to spawning; steelhead typically spawn from March through June. It is likely that the populations with the greatest number of fish from segregated programs are those that are in close geographic proximity (e.g., fish released in the Grande Ronde are most likely to spawn naturally with the Grande Ronde populations). This is a natural phenomenon, can be highly variable, and it is important to remember that straying is often an overestimate for the number of fish that are able to spawn successfully because some are harvested, some return to the hatchery rack and others may spawn in unsuitable habitat. Additional discussion of specific programs follows.

Table 15. Number of fish detected as strays from each steelhead program (2000-2012) and the number of natural-origin steelhead entering the Snake Basin (2002-2015). Values are derived from coded-wire tag recoveries, and PIT tag detections when available (shown in parentheses).

Program	Mean number strays	% strays in run of natural-origin steelhead over Ice Harbor Dam	Mean release number	Expected percent change from past releases to proposed releases[1]	Expected future number stray	Expected future % stray
Grande Ronde	152	0.4%	791,072	1.011	154	0.4%
Little Sheep	15	0.03%	194,224	1	15	0.03%
LFH-On-station	17 (302)	0.04 (0.7)%	81,648	0.27	12 (220)	0.03 (0.5)%
LFH-Touchet	15 (153)	0.03 (0.4)%	91,860	1.09	16 (167)	0.04 (0.4)%
LFH-Cottonwood	15 (148)	0.03 (0.3)%	180,151	1.11	17 (164)	0.04 (0.4)%
LFH-Walla Walla	23 (77)	0.05 (0.2)%	100,942	Terminated	0	0%
Tucannon	34 (203)	0.08 (0.5)%	56,849	2.64	89 (536)	0.2 (1.2)%
Total	271 (883)	0.66 (2.1)%	1,496,766	1.04	314 (1087)	0.77 (2.9)%

[1]This is the maximum percent change in release number for the short-term goal; since the LFH Touchet, and LFH on-station releases may\will be terminated for the long-term goal and the LFH Cottonwood release is only increasing by 25,000, the total number of potential strays will decrease.

Wallowa stock fish used for both segregated programs are also known to stray into the Deschutes River. A relative reproductive success study has been ongoing in two streams in the Deschutes River since 2011 (Wilson et al. 2016), so detailed pHOS information is available. From the two streams surveyed in this study researchers estimate that about five percent of the out-of-basin strays are Wallowa stock (Faber 2016). The pHOS in the Eastside and Westside Deschutes steelhead populations has averaged about 0.15 and 0.06 percent respectively from 2010 to 2014 (http://www.odfwrecoverytracker.org., accessed February 24, 2017). Thus, fish from these segregated programs are likely to equate to less than one percent of the total proportion of hatchery-origin spawners in the Deschutes Basin, and much less than one percent for the mid-Columbia steelhead DPS.

Wallowa stock fish also stray into the Imnaha Basin, but this appears to be a rare occurrence. Over the last six years, only 7 out-of-basin hatchery strays have been detected in the Imnaha Basin. Of these, three were Wallowa stock and two of these three were detected in the fall and may not have stayed to spawn in the Imnaha Basin. Thus, straying of segregated program fish into the Imnaha Basin is likely small (only seven out-of-basin strays were detected in the last six years) (Harbeck 2017).

Within the Grande Ronde Basin, the operators conduct intensive redd surveys for the Upper Grande Ronde and Joseph Creek populations. For these two populations, pHOS is low, with estimates ranging from 2 to 5.7 percent for the Joseph Creek population and from 2 to 11.7 percent for the Upper Grande Ronde (NWFSC 2015) (Lance Clarke, ODFW, personal communication February 17, 2017). However, the higher estimates are based on a relatively small number of carcasses (< 80) collected during surveys from 2008 to 2016, and the origin of hatchery fish is unable to de determined for some fish due to carcass degradation, and/or lack of a CWT/PIT tag. There has also been some work conducted to assess the amount of genetic influence from Wallowa stock steelhead into the Upper Grande Ronde population (including Lookingglass and Catherine Creeks) using microsatellites. Narum et al. (2006) found that the Wallowa hatchery stock had minimal influence on the Upper Grande Ronde population, although there may be a potential hatchery influence detectable in Catherine Creek. This suggests that hatchery effects on natural-origin steelhead genetics may be concentrated in particular subareas of a single population.

The Wallowa population is not surveyed as intensively as the Upper Grande Ronde and Joseph Creek population, but estimates of pHOS are also low (zero for the last 10 years) for this population (Clarke 2017). However, these estimates are based on redd surveys, which are limited in their ability to detect spawner composition. Recent work with PIT tag detection is occurring, but is not yet available for this population. No information exists for the Lower Grande Ronde population, but this population is not required for recovery of the Grande Ronde MPG; only two of the four populations are needed for recovery (ICTRT 2007a), with the Grande Ronde and Joseph Creek populations targeted. Thus, pHOS limits as a proxy for genetic effects, could be higher for the Wallowa and Lower Grande Ronde populations. For now, a target pHOS in the Joseph Creek and Upper Grande populations of less than five percent, calculated as a five-year running average using any of the available estimation methods (i.e., intensive spawning ground surveys, redd surveys), will be used as a proxy for genetic effects of straying into the MPG.

Even though Wallowa stock fish are released into the Touchet River (which is part of the Mid-Columbia Steelhead DPS) from the Lyons Ferry program, recovery of coded-wire tags from stray steelhead from this release predominantly occurs in the lower Snake River Basin, with only a few recoveries outside the Touchet River in the mid-Columbia (Bumgarner 2017a). In the Touchet River, the estimated average pHOS estimate attributable to steelhead returns from the

LFH program was 1.6 percent from 2009 to 2013 and ranged from 0.3 to 3.4 percent (Bumgarner 2017a)[5].

Interestingly, releases of steelhead from the Lyons Ferry program, especially the Touchet, Walla Walla, and on-station releases at LFH, have been returning to the Tucannon River (Figure 2) and represent a large proportion of the pHOS in that population. This high rate of straying and overshoot of these fish past their intended location into this particular population is a concern and was the impetus behind the elimination of the Walla Walla River release site by WDFW, and the reduction in the on-station release size at LFH proposed by the cooperators. Our analysis for PNI in the Tucannon population occurs later in this subsection, but we anticipate that pHOS attributable to the Walla Walla and Lyons Ferry on-station releases should decrease from about 39 percent to 18 percent with the realization of the short-term goal by 2021 (Table 18).

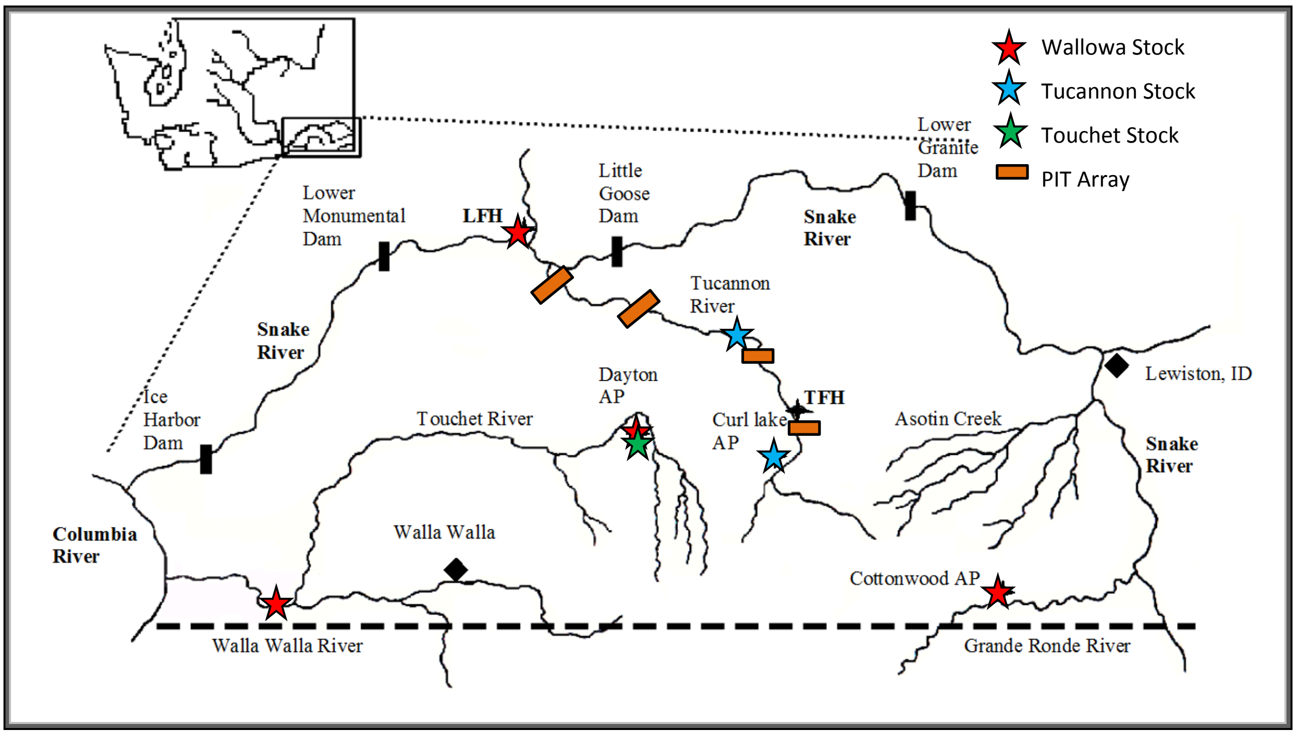


Figure 2. Map of Lyons Ferry Hatchery and Tucannon Steelhead Program releases (WDFW 2011a). Locations of PIT Tag Arrays in the Tucannon River are also shown. Walla Walla River releases are shown, but will be eliminated following the 2017 release.

We have used the currently best available science to analyze the potential genetic effects of fish that stray from each of the programs included in the proposed action and it is our opinion that straying is unlikely to result in a high level of genetic risk in the short term. However, in the long-term, more work is needed to ensure that segregated hatchery fish spawning naturally will not cause long-term genetic effects. To address this issue, the co-managers have proposed the

[5] Data for Touchet Index Area, Coppei Creek, Whiskey Creek, and Patit Creek based on redd counts and adult trap information. Does not represent all areas of the Touchet – mainstem Touchet from Dayton to Prescott is not included here because surveys are typically not possible in this river reach.

formation of a workgroup to determine: (1) appropriate methodologies for assessing hatchery-origin steelhead composition in receiving populations throughout the action area, and (2) target levels at which hatchery program modifications will be discussed and possibly implemented.

Integrated programs

The Little Sheep and Tucannon program evaluations are necessarily different from evaluation of the segregated programs because of their use of natural-origin broodstock. To perform our analysis, we will use models that consider the best available information for the target populations to determine the likely PNI of the population based on the applicants' proposed proportion of natural-origin broodstock (pNOB) and the pHOS in the target populations' natural spawning areas. A PNI of > 0.5 indicates that natural selection outweighs hatchery-influenced selection and is the target for primary and contributing populations according to the HSRG (e.g., HSRG 2009), but the timeline associated with achieving a PNI > 0.5 is unique to each program.

We found in evaluating this program that the simple well-known equation in which PNI is approximated as a simple function of pNOB and pHOS did not adequately model the genetic relationship between the hatchery programs and the natural spawning populations. As in the case of a recent biological opinion on Methow spring Chinook (NMFS 2016), we applied an expanded multi-population model for estimation of PNI (Busack 2015) that explicitly considers these linkages.

Little Sheep

Our analysis for the Little Sheep program demonstrates that under the current management regime, obtaining a PNI of > 0.5 on an annual basis is likely to occur. We used data from 2011 to 2015 provided by the co-managers (Harbeck and Hurst 2017) to provide estimates of each parameter in our model, expanded to four population components based on Busack (2015), with weights applied to each natural-origin component. Weighting of each of the three natural-origin components is necessary to ensure accurate representation in the model. For the Imnaha Subbasin, the three natural-origin components, Little Sheep, Big Sheep, and Imnaha remainder, (Figure 2) had weights of 6, 23, and 71 percent respectively, based on the proportion of the total natural-origin population returning to each area. Although current and future operation of the program targets a 215,000 smolt release, smolt releases from 2006-2012 (the years for which we have data) averaged 228,105 smolts annually. We believe that the data from 2011 to 2015 are a good basis for estimating future program genetic effects provided natural- and hatchery-origin returns to the Imnaha Subbasin are within the range of returns we have seen over the last five years.

We also assumed that all estimates of hatchery-origin spawners were within-basin, because the number of identifiable out-of basin strays detected is low (7 in the last six years). Many other PIT tagged hatchery fish have been detected in the Imnaha River over the course of six years, but their origin could not be determined. It is very likely the majority are Little Sheep Creek hatchery fish that were not tagged as juveniles (J. Harbeck, NPT, personal communication, January 23, 2017).

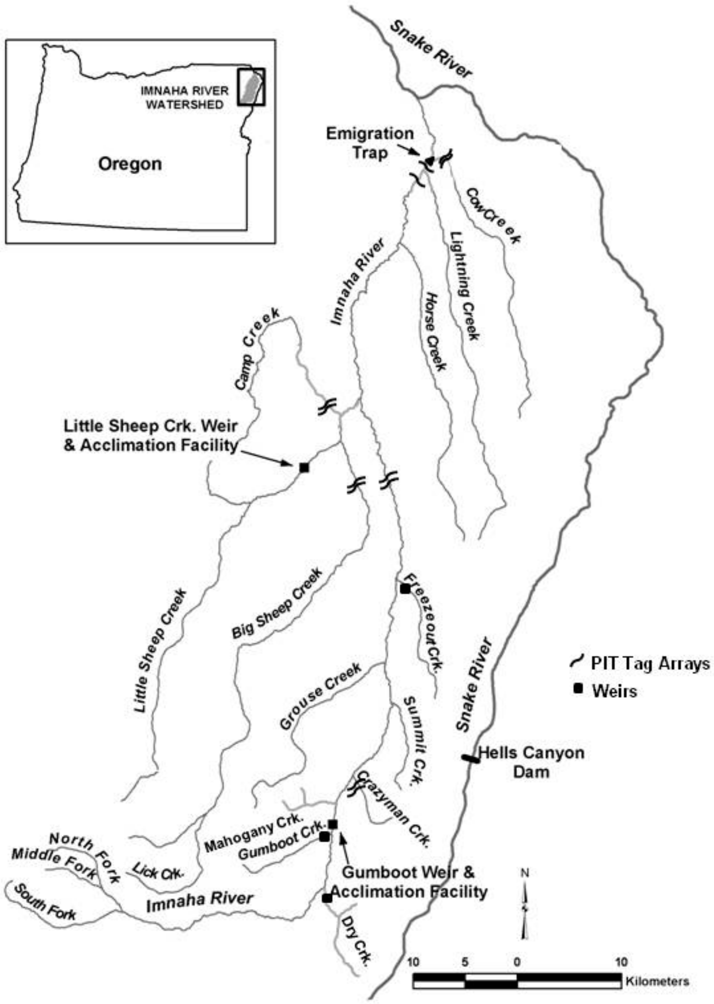


Figure 3. Study area for the Imnaha adult steelhead monitoring project with adult weir, juvenile emigration trap and instream array locations (courtesy of the Nez Perce Tribe).

There are two additional factors we considered in our analysis. The first is that live-spawned males released to potentially spawn upstream of the Little Sheep Creek weir have been shown to successfully produce progeny from their upstream matings (Berntson et al. 2011). Thus, we included these fish twice in our calculations, once in the pNOB value and once for pNOS. Second, the relative reproductive success of hatchery steelhead from this program ranged from 30-60 percent of their natural-origin counterparts (Berntson et al. 2011). Although we did not modify our parameter values in any way to account for this because it is unclear at this time how to do so and how broadly to apply this finding, it is important to remember that pHOS values are only a proxy for genetic effects and are likely to be an overestimate of the actual genetic effects.

However, the consolidation of the releases from Big Sheep Creek and Little Sheep Creek only into Little Sheep Creek necessitated some changes in the parameter values for Big Sheep Creek.

We assumed this change will cause a decrease in the hatchery-origin spawners in Big Sheep Creek to 10 percent of the estimated hatchery-origin spawners (HOS; Table 16). We believe that reducing the number of hatchery-origin spawners in Big Sheep Creek to 10 percent is a valid approach to estimating HOS after the proposed changes in stocking Big Sheep Creek take effect because it is likely that some hatchery-origin fish from the Little Sheep Program will continue to return to nearby Big Sheep Creek.

Our modeling results indicate that the current program is well above a PNI of 0.5 and in most years meets or exceeds the HSRG PNI recommendation of 0.67 for an integrated program operating on a primary population (HSRG 2009). After incorporation of the proposed changes to the current program PNI projections improve to an average value of 0.74 for the Imnaha population. The cooperators agree that there are unlikely to be any spawners in the three miles below the weir on Little Sheep Creek. However, if there are data in the future to suggest that steelhead do spawn in this reach, we will need to revise the model to account for this new information.

A final consideration in our analysis is that, in some years, pHOS estimates for the Little Sheep aggregate can exceed the HSRG recommended value of 0.3 for an integrated program operating on a primary population. However, this is only for a portion of the population and estimating pHOS for the entire Imnaha population would result in a value that is much lower (Table 16), and well within the HSRG recommendation. In addition, pHOS within a population is typically measured as an average over a period of five years to have a value that best represents a generation of fish, and provides perspective on values that may be really high or low

Similar to segregated programs, we must also consider the effects of fish that stray from this program into non-target ESA-listed populations. The same difficulties and assumptions for the two segregated programs discussed above apply here as well. As shown in Table 15, an average of 15 fish from the Little Sheep Program stray into other populations, which represents less than one percent of the natural-origin steelhead entering the Snake Basin; thus the potential effects of straying as assessed here are likely negligible for this program.

Table 16. Natural-origin spawner (NOS), hatchery-origin spawner (HOS) and the proportion of each (pNOS and PHOS), as well as natural- and hatchery-origin broodstock composition (pNOB and pHOB) for the Imnaha Subbasin and Little Sheep Program from 2011-2015. Results of the PNI population model are depicted in the PNI column. Text shown in red indicate changes to the original data as discussed in the text above.

Current program

Return Year	Little Sheep Creek				Little Sheep Hatchery				Big Sheep Creek				Imnaha River remainder					Total
	NOS	HOS	pNOS	pHOS	NOB	HOB	pNOB	pHOB	NOS	HOS	pNOS	pHOS	NOS	HOS	pNOS	pHOS	PNI	pHOS
2011	226	93	0.71	0.29	48	79	0.38	0.62	682	674	0.50	0.50	2088	19	0.99	0.01	0.78	0.21
2012	129	112	0.54	0.46	26	109	0.19	0.81	846	672	0.56	0.44	1894	47	0.98	0.02	0.68	0.22
2013	92	152	0.38	0.62	15	114	0.12	0.88	307	120	0.72	0.28	926	19	0.98	0.02	0.61	0.18
2014	114	156	0.42	0.58	21	111	0.16	0.84	494	269	0.65	0.35	1814	75	0.96	0.04	0.56	0.17
2015	76	71	0.52	0.48	36	96	0.27	0.73	479	589	0.45	0.55	1769	44	0.98	0.02	0.67	0.23
Average	**127**	**117**	**0.51**	**0.49**	**29**	**102**	**0.22**	**0.78**	**562**	**465**	**0.58**	**0.42**	**1698**	**41**	**0.98**	**0.02**	**0.65**	0.20

Future program

Return Year	Little Sheep Creek				Little Sheep Hatchery				Big Sheep Creek				Imnaha River remainder					Total
	NOS	HOS	pNOS	pHOS	NOB	HOB	pNOB	pHOB	NOS	HOS	pNOS	pHOS	NOS	HOS	pNOS	pHOS	PNI	pHOS
2011	226	93	0.71	0.29	48	79	0.38	0.62	682	67	0.91	0.09	2088	19	0.99	0.01	0.84	0.06
2012	129	112	0.54	0.46	26	109	0.19	0.81	846	67	0.93	0.07	1894	47	0.98	0.02	0.73	0.08
2013	92	152	0.38	0.62	15	114	0.12	0.88	307	12	0.96	0.04	926	19	0.98	0.02	0.72	0.12
2014	114	156	0.42	0.58	21	111	0.16	0.84	494	27	0.95	0.05	1814	75	0.96	0.04	0.66	0.10
2015	76	71	0.52	0.48	36	96	0.27	0.73	479	59	0.89	0.11	1769	44	0.98	0.02	0.76	0.07
Average	**127**	**117**	**0.51**	**0.49**	**29**	**102**	**0.22**	**0.78**	**562**	**46**	**0.93**	**0.07**	**1698**	**41**	**0.98**	**0.02**	**0.74**	0.09

Tucannon

Our analysis of the Tucannon steelhead population PNI includes both the effects of this action as well as the effects of other hatchery actions that affect the same population.[6] The status of the Tucannon steelhead population is complicated by the large amount of fish (both natural and hatchery origin) that stray into the Tucannon River from a variety of natural populations and hatchery programs, some of which are included in this proposed action and others that are not. In addition, there are a number of small tributaries to the Snake River Basin that are included as part of the Tucannon population that we needed to consider in our analysis (ICTRT 2003). Thus, we expanded our PNI model (Busack 2015) to consider five components to the population: (1) naturally spawning steelhead in the Tucannon (including strays from other natural populations), (2) naturally-spawning fish in Penewawa, Alkali Flat, and Deadman Creeks, (3) the Tucannon Hatchery program conservation component, (4) the Tucannon Hatchery program mitigation component, (5) and other hatchery fish straying into the Tucannon population.

The Tucannon Hatchery program was designed to genetically link the conservation and mitigation program components, where fish returning from the integrated conservation component are used as broodstock for the mitigation component. This approach reduces genetic risk by more closely linking fish intended for mitigation with fish intended for conservation. A hatchery program in the Tucannon is essential for aiding in the recovery of the species because of the low natural-origin returns compared to the ICTRT minimum population abundance threshold and because it is one of only two populations in the Lower Snake steelhead MPG, both of which must achieve viability for recovery of the DPS.

Similar to the Little Sheep analysis above, we weighted the natural-origin fish spawning in each naturally-spawning fish population component by the natural-origin fish returns. This meant that 83 percent of the natural-origin returns spawned in the Tucannon and 17 percent spawned in the small tributaries to the Snake River that are included in the Tucannon population. We also considered the fish straying into the Tucannon in two ways. The first was with all strays included and the second was to include only those strays that are from programs that are a part of this proposed action. The former analysis addresses some baseline genetic effects, providing a more realistic picture of what is currently occurring in the Tucannon population, and the latter allows us to see how modification to the programs considered in this proposed action through the short-term and long term goals could improve PNI over time. Any modifications to programs outside of the Proposed Action (Mid-Columbia or upper Snake hatchery programs) to reduce straying into the Tucannon River would be addressed in future consultations.

To better understand our analysis, we provided a summary of the short- and long-term goals here. In brief, the short-term release goals are to eliminate the release of Wallowa stock fish into the Walla Walla River, reduce the size of the on-station LFH releases of Wallowa stock from

[6] NMFS' species-level determinations consider the effects of the proposed action, combined with the effects of other programs through our consideration of both the species status (which reflects the past effects of various human activities), the environmental baseline (which reflects past, present and future federal actions that have undergone ESA consultation), and the cumulative effects (which reflects ongoing and future non-federal actions). In this case, it may not be possible to separate which incidences of straying are from baseline activities, cumulative effects, or the proposed action, but the description and analysis of the population makeup and the projected effects are intended to give NMFS the complete picture of effects regardless of their origin.

60,000 to 160,000 (per the previous US v Oregon Agreement) to a flat 50,000, increase the size of the Tucannon program from 100,000 to 150,000, and increase the releases in the Touchet River by 15,000. In the long-term, the operators have proposed to eliminate the releases of Wallowa stock fish from the LFH program from the Touchet and on-station sites, increase the release of fish at Cottonwood by 25,000, and potentially increase the size of the integrated program in the Touchet River (150,000 smolts). Over time, the result would be a decrease in the release of fish from the segregated hatchery program in favor of the integrated program in the Tucannon, and potentially the Touchet.

Under current management conditions, and assuming the selective steelhead fishery removes 20 percent of the adipose-clipped hatchery-origin fish, PNI in the Tucannon population is approximately 0.17. Removing hatchery-origin fish that stray into the Tucannon River from programs not included in our proposed action from our analysis does not substantially increase the PNI, and leads to a PHOS of LFH steelhead of 39 percent (Table 17). For analysis of the short-term proposal (Table 4), we assumed that natural-origin returns stayed the same, but returns were adjusted by the proportion of change in the release numbers for each program. For example, LFH on-station releases are proposed to decrease 40 percent compared to what they release currently (~150,000 from 2010-2012), which should result in a pHOS of 18 percent from the LFH steelhead (Table 18). This is a decrease of over 50 percent from the current pHOS level attributable to the LFH program, and is a vast improvement over current conditions, which include the factors discussed below that limit the natural-origin Tucannon population. We also applied the new sliding scale for adult management to the data we currently have for 2013-2015. Using these values, PNI increased to 0.21 (Table 18).

Implementing the long-term goal the co-managers provided is contingent on space usage amongst various programs at Lyons Ferry Hatchery (Snake River fall Chinook, Tucannon River spring Chinook, and potentially other spring Chinook programs), which have yet to be discussed and agreed upon. However, we included analysis of this goal here to demonstrate how much improvement could be expected in the PNI value of the Tucannon population from modifications to the hatchery programs included in the Proposed Action. By eliminating all releases from the LFH program except for those into Cottonwood, the PNI value increases to 0.32 (Table 19). With the removal of fish straying from programs not included in the proposed action, the long-term PNI is substantially increased to 0.42, a vast improvement over the current PNI of 0.18.

There are a few other things to consider when calculating PNI for the Tucannon population. First is that NMFS recently evaluated the potential for extending the time frame for the steelhead fishery in the Tucannon River from the end of February to mid-April (Jones 2017). This would increase the opportunity for anglers to catch and retain hatchery-origin fish marked with an adipose clip, and is likely to result in fewer hatchery-origin fish on the spawning grounds.

Second, although our calculations assume that natural-origin returns over the course of the proposed action will remain similar to what they have been from 2013-2015, any increase in natural-origin returns is likely to result in more natural-origin fish on the spawning grounds and higher proportions of natural-origin fish in the broodstock, which would increase the population PNI.

Third, our calculation indicates that, despite termination of some releases, including three of the four LFH releases associated with the long-term goal, the associated change in PNI is still below the HSRG recommendation of 0.67 for a primary population (Table 19). Achieving a higher PNI value may require additional modifications to the harvest and hatchery programs as well as changes in habitat and hydropower operations because of the location of the Tucannon River between two of the four major dams on the Snake River. The need for improvements in habitat/hydropower operation is highlighted by the fact that natural-origin fish from the Tucannon River overshoot and stray at rates similar to Tucannon hatchery-origin fish. This same phenomenon has also been noted for natural-origin fish from the Walla Walla Basin (Bumgarner 2017a). From 2002-2013, an average of 135 natural-origin fish from the Tucannon returned to areas other than the Tucannon River, nearly ½ of the estimated returns of those fish that passed over Ice Harbor Dam. From 2003-2012 (excepting 2008), an average of 203 LFH hatchery-origin fish returned to areas other than the Tucannon River, again nearly ½ of the estimated returns of those fish that passed over Ice Harbor Dam. Nearly all of these fish migrate above Lower Granite Dam; this is likely due to habitat and hydropower effects (e.g., inundation at the Tucannon River mouth, temperature), because this behavior is observed in both hatchery and natural-origin fish. Further investigation into this phenomenon and any subsequent solutions could lead to actions resulting in a higher number of natural-origin returns to the Tucannon River. These changes would also likely result in an increase in hatchery-origin returns, but improved homing for all returning fish would allow for more effective adult management. For now, NMFS would like to see the results of the short-term modifications proposed by the co-managers (with changes realized fully for the short-term modifications by 2021) before making further changes to the hatchery programs included in the Proposed Action.

Table 17. The proportion of natural- and hatchery-origin spawners (pNOS and PHOS, respectively), natural- and hatchery-origin broodstock composition (pNOB and pHOB), and proportionate natural influence (PNI) for the Tucannon steelhead population based on data from 2013-2015.

Current Conditions (fishery efficiency of 20%)

	Tucannon River			Penewawa, Alkali and Deadman Creeks		Tucannon Conservation		Tucannon Mitigation			
Return Year	pNOS	pHOS-Tucannon	pHOS-other hatchery	pNOS	pHOS-Tucannon	pNOB	pHOB	pNOB	pHOB-Tucannon Conservation	pHOB-Tucannon Mitigation	PNI
2013	0.35	0.31	0.34	0.83	0.17	0.7	0.3	Not applicable			0.16
2014	0.36	0.15	0.49	0.97	0.03	0.7	0.3				0.16
2015	0.39	0.15	0.46	0.99	0.01	0.7	0.3				0.18
Average	**0.37**	**0.2**	**0.43**	**0.93**	**0.07**	**0.7**	**0.3**				**0.17**

Current Conditions-other hatchery fish not included in proposed action removed

	Tucannon River			Penewawa, Alkali and Deadman Creeks		Tucannon Conservation		Tucannon Mitigation			
Return Year	pNOS	pHOS-Tucannon	pHOS-other hatchery	pNOS	pHOS-Tucannon	pNOB	pHOB	pNOB	pHOB-Tucannon Conservation	pHOB-Tucannon Mitigation	PNI
2013	0.37	0.32	0.31	0.83	0.17	0.7	0.3	Not applicable			0.17
2014	0.39	0.15	0.46	0.97	0.03	0.7	0.3				0.17
2015	0.43	0.16	0.41	0.99	0.01	0.7	0.3				0.19
Average	**0.39**	**0.21**	**0.39**	**0.93**	**0.07**	**0.7**	**0.3**				**0.18**

Table 18. The proportion of natural- and hatchery-origin spawners (pNOS and PHOS, respectively), natural- and hatchery-origin broodstock composition (pNOB and pHOB), and proportionate natural influence (PNI) for the Tucannon steelhead population based on data from 2013-2015 modified (see text above) to reflect proposed short-term changes in Proposed Action.

Short-term proposal with fishery efficiency of 20%

	Tucannon River			Penewawa, Alkali and Deadman Creeks		Tucannon Conservation		Tucannon Mitigation			
Return Year	pNOS	pHOS-Tucannon [1]	pHOS-other hatchery	pNOS	pHOS-Tucannon	pNOB	pHOB	pNOB	pHOB-Tucannon Conservation	pHOB-Tucannon Mitigation	PNI
2013	0.26	0.58	0.16	0.83	0.17	0.69	0.31	0	1	0	0.21
2014	0.35	0.35	0.30	0.97	0.03	0.81	0.19	0	1	0	0.19
2015	0.40	0.38	0.22	0.99	0.01	0.81	0.19	0	1	0	0.24
Average	**0.34**	**0.44**	**0.23**	**0.93**	**0.07**	**0.77**	**0.23**	**0**	**1**	**0**	**0.21**

Same as above, but other hatchery fish not included in proposed action are removed

	Tucannon River			Penewawa, Alkali and Deadman Creeks		Tucannon Conservation		Tucannon Mitigation			
Return Year	pNOS	pHOS-Tucannon	pHOS-other hatchery	pNOS	pHOS-Tucannon	pNOB	pHOB	pNOB	pHOB-Tucannon Conservation	pHOB-Tucannon Mitigation	PNI
2013	0.27	0.60	0.14	0.83	0.17	0.69	0.31	0	1	0	0.22
2014	0.37	0.37	0.26	0.97	0.03	0.81	0.19	0	1	0	0.21
2015	0.44	0.41	0.15	0.99	0.01	0.81	0.19	0	1	0	0.27
Average	**0.36**	**0.46**	**0.18**	**0.93**	**0.07**	**0.77**	**0.23**	0	1	0	**0.23**

[1]We assumed 5 percent of this was from returning mitigation component adults.

Table 19. The proportion of natural- and hatchery-origin spawners (pNOS and PHOS, respectively), natural- and hatchery-origin broodstock composition (pNOB and pHOB), and proportionate natural influence (PNI) for the Tucannon steelhead population based on data from 2013-2015 modified (see text above) to reflect long-term changes likely only to be realized after LFH usage amongst multiple programs is decided.

Long-term goal with fishery efficiency of 20%

	Tucannon River			Penewawa, Alkali and Deadman Creeks		Tucannon Conservation		Tucannon Mitigation			
Return Year	pNOS	pHOS-Tucannon	pHOS-other hatchery	pNOS	pHOS-Tucannon	pNOB	pHOB	pNOB	pHOB-Tucannon Conservation	pHOB-Tucannon Mitigation	PNI
2013	0.30	0.67	0.03	0.83	0.17	0.69	0.31	0	1	0	0.33
2014	0.46	0.47	0.07	0.97	0.03	0.81	0.19	0	1	0	0.33
2015	0.45	0.42	0.13	0.99	0.01	0.81	0.19	0	1	0	0.29
Average	**0.4**	**0.52**	**0.08**	**0.93**	**0.07**	**0.77**	**0.23**	**0**	**1**	**0**	**0.32**

Same as above, but other hatchery fish not included in proposed action are removed

	Tucannon River			Penewawa, Alkali and Deadman Creeks		Tucannon Conservation		Tucannon Mitigation			
Return Year	pNOS	pHOS-Tucannon	pHOS-other hatchery	pNOS	pHOS-Tucannon	pNOB	pHOB	pNOB	pHOB-Tucannon Conservation	pHOB-Tucannon Mitigation	PNI
2013	0.31	0.69	0	0.83	0.17	0.69	0.31	0	1	0	0.39
2014	0.50	0.50	0	0.97	0.03	0.81	0.19	0	1	0	0.47
2015	0.49	0.47	0.04	0.99	0.01	0.81	0.19	0	1	0	0.39
Average	**0.43**	**0.55**	**0.01**	**0.93**	**0.07**	**0.77**	**0.23**	0	1	0	**0.42**

Similar to segregated programs, we must also consider the effects of fish that stray from this program into non-target ESA-listed populations. The same difficulties and assumptions for the two segregated programs discussed above apply here as well. Table 15 suggests that less than two percent of all natural-origin steelhead entering the Snake Basin are strays from the Tucannon program. In addition, the next closest population to the Tucannon River is Asotin Creek, but any Tucannon hatchery-origin fish that stray into the Asotin Creek population streams are removed at the weirs currently operated there (with the exception of Almota Creek since the trap is not operated every year at this time). In addition, only three Tucannon hatchery-origin fish have been detected in the Imnaha Basin over the past six years (J. Harbeck, NPT, personal communication, January 23, 2017). Thus, the potential effects of straying as assessed here are likely unsubstantial for this program.

2.4.2.2.2. Ecological Effects

Adult Nutrient Contribution

The return of hatchery fish likely contributes nutrients to the action area. Table 20 shows that adult hatchery steelhead, if all estimated returning fish spawn naturally, would contribute an estimated 587 kg of phosphorous to the action area annually. With the use of mark-selective fisheries and fish collected for broodstock, the true contribution is likely less than this value, around 50 percent less or 294 kg. Regardless, hatchery-origin steelhead increase phosphorous concentrations, which likely compensates for some marine-derived nutrients lost from declining numbers of natural-origin fish.

Table 20. Total phosphorous imported by adult returns from the proposed hatchery steelhead programs based on the equation (Imports= hatchery adults*mass*phosphorous concentration) in Scheuerell et al. (2005).

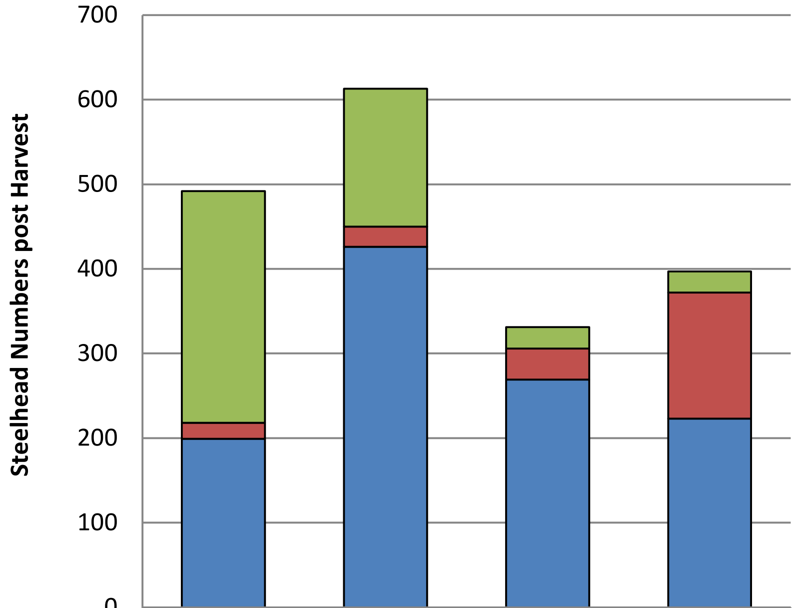
Program	Release number	SAS[1]	Estimated number of hatchery-origin adults[2]	Adult mass (kg)	Phosphorous concentration (kg/adult)	Phosphorous imported (kg/year)
Grande Ronde	800,000	0.0153	12,240	5.5	0.0038	256
Lyons Ferry-Cottonwood	225,000	0.0221	4,973	5.5	0.0038	104
Lyons Ferry-on-station	60,000	0.0181	1,086	5.5	0.0038	23
Lyons Ferry-Touchet	100,000	0.0160	1,600	5.5	0.0038	33
Little Sheep	330,000	0.0159	5,247	5.5	0.0038	110
Tucannon	150,000	0.0196	2,940	5.5	0.0038	61

[1] Smolt-to-adult survival rate. Data from 2000-2009 (Bumgarner 2015; ODFW data). Values from the LFH program are with the discontinued Lyons Ferry Hatchery stock because estimates are not available for the Wallowa stock released from these locations.
[2] Calculated by multiplying the release number by the smolt to adult survival (SAS) values.

Competition with Natural-origin Steelhead for Spawning Sites

Natural and naturally-spawning hatchery steelhead are likely to overlap in their selection of spawning sites due to similar niche requirements. This is a desired result of the two supplementation programs to ensure sufficient gene flow. However, a consequence of having any hatchery fish on the spawning grounds is the potential for spawning site competition and redd superimposition. Although these are difficult effects to assess, especially for steelhead, which tend to spawn when flows are highest during the spring, some work conducted in the Tucannon and measurements of pHOS allow some qualitative analyses:

In contrast to many other river systems, the Tucannon River is unique in that four PIT tag arrays are in place to be able to assess the relative spatial distribution of returning hatchery and natural origin steelhead (Figure 2). Figure 4 shows that hatchery fish from outside the Tucannon primarily utilize the middle to lower reaches of the river, while the majority of Tucannon Hatchery fish primarily use the upper reaches. Wild fish tend to spawn evenly throughout the Subbasin, which is likely a result of where these fish reared as juveniles originally. With the proposed changes to program production, we anticipate that any potential competition occurring between hatchery and natural fish in the lower portions of the river are likely to decrease when the returns resulting from decreased production from the Lyons Ferry Program are realized. Conversely, pHOS attributed to the Tucannon program is likely to increase unless the returns of natural fish also increase. Thus, given the likely reductions in “other hatchery fish” and because natural fish spawn throughout the entire Subbasin, we believe there is unlikely to be a measureable effect from spawning site competition and redd superimposition on natural-origin steelhead from hatchery-origin steelhead produced under the proposed action.



	LTR-MTR	MTR-UTR	UTR-TFH	+TFH
Other Hatchery	274	163	25	25
Tuc Hatchery	19	24	37	149
Total Wild	199	426	269	223

Figure 4. Estimated number of steelhead in each zone (lower, middle upper Tucannon River, and above Tucannon Fish Hatchery) based on PIT Tag estimates from 2013-2015.

Competition and redd superimposition with natural steelhead by steelhead from the three remaining programs is also likely to have no measurable effect for three reasons. The first is that the releases of hatchery-origin juveniles from the LFH program into the Walla Walla Subbasin will be reduced under the proposed action by 46 percent, leading to a decrease in adults returning to that Subbasin. The second is that straying from these programs is estimated to be low (see section above). The third is that the Little Sheep Creek program is the only steelhead program in the Imnaha Subbasin and, because Little Sheep Creek represents a small portion of available spawning habitat, we believe the potential for competition and redd superimposition is low. Continuing to assess pHOS as a surrogate for genetic effects and managing adults to minimize pHOS is also likely to ensure that ecological effects of hatchery-origin fish spawning naturally are minimized.

Competition with Listed Salmon for Spawning Sites

Competition between adult hatchery-origin spring/summer Chinook salmon and summer steelhead is likely negligible due to differences in run-timing, holding, and spawn timing. Steelhead begin their entry into freshwater during the last portion of the Chinook salmon migration and reach the action area after spring/summer Chinook salmon have held over the summer and spawned (Table 16). Although sockeye and fall Chinook salmon overlap with the steelhead run, Snake River sockeye salmon only spawn in lakes in the Salmon River Basin in

Idaho, and both complete their spawning before steelhead spawning begins (Table 16). Thus, there is unlikely to be any competition effect between steelhead and other listed salmon species.

Table 21. Run-timing, holding, and spawn timing of spring/summer Chinook salmon and summer steelhead (ODFW 2011a).

Species	Run Timing	Holding	Spawning
Spring/Summer Chinook Salmon	March-May	April-July	Early August-mid September
Summer Steelhead	May-August	September-April	March-early June
Fall Chinook Salmon	July-October	August to October	Late October-early December
Sockeye Salmon	June-September	August to October	September to November

2.4.2.2.3. Adult Collection

The operation of weirs and traps for steelhead broodstock collection would result in the capture and handling of both natural- and hatchery-origin fish of several species. There is no effect of collection of steelhead at weirs and traps on listed Chinook and sockeye salmon because none have been encountered during weir and/or trap operation specifically for steelhead. The effects on fall and spring/summer Chinook salmon captured and handled at weirs and or traps associated with these programs (i.e., Lyons Ferry Hatchery trap, Tucannon Hatchery trap and weir) are currently permitted separately under section 10 permit number 18024 (2,200 natural-origin adults captured, handled and sampled) for Tucannon, and Section 10 permit number 16607 (4,100 natural-origin adults captured, handled and sampled) for Lyons Ferry. Therefore, the handling effects associated with these programs is in the environmental baseline.

Other effects of weir operation are the potential for delayed migration and changes in spatial distribution of listed species. Though adult passage may be delayed slightly, weir operation guidelines and monitoring of weirs by the managers and co-managers (Section 1.3.1) minimize the delays to and impacts on fish. For the four steelhead programs, the weir will be operated to assure that fish would be delayed for no more than three days throughout the trapping season. In addition, the spatial distribution of juvenile and adult listed species is not expected to be affected by weir operation in these areas because the weirs are designed to allow juvenile passage and natural-origin adults are passed upstream when not required for broodstock. In addition, in the Tucannon, where spawning distribution data exists on a fine enough scale to assess this effect, natural fish spawn both above and below the weir (Figure 4).

Table 22. Number of steelhead handled by origin. Mortalities, if any, are shown in parentheses and exclude those used as broodstock or treated as surplus; these mortalities are attributed only to the act of handling and collecting adults.

Facility	Program Association(s)	Fish origin	2009	2010	2011	2012	2013

Wallowa Hatchery	Grande Ronde	Hatchery	3227 (41)	4875 (15)	3473 (3)	1765 (1)	1225 (4)
		Natural	24	30	26	10	24
Big Canyon	Grande Ronde	Hatchery	1790 (39)	3275	2852	1425	1271
		Natural	80	136	133	69	63
Little Sheep	Little Sheep	Hatchery	1087 (2)	3450 (3)	1315	1261	357
		Natural	172	274 (2)	241	139	99
Lyons Ferry Hatchery	WDFW Wallowa	Hatchery	1656	1665	2114	1605 (12)	Not used
		Natural	1	0	0	3	Not used
Cottonwood Creek Adult Trap	WDFW Wallowa	Hatchery	Not used	502	1070	916	881
		Natural	Not used	10	10	26	~10
Tucannon Adult Trap	Tucannon	Hatchery	330	129	211	213	253
		Natural	323	202	186	87	181

Sources: (Bumgarner and Dedloff 2011; Bumgarner and Dedloff 2013b; Bumgarner and Dedloff 2015; ODFW 2016)

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

We have drawn our action area for this action down to McNary Dam on the Columbia River and thus only consider effects of juvenile hatchery fish in juvenile rearing areas and the migratory corridor down to McNary Dam. The effects of this factor on all listed species considered in this Opinion is negative.

2.4.2.3.1. Hatchery release competition and predation effects

Pearsons and Busack (2012) developed a model that quantifies the potential number of natural-origin salmon and steelhead juveniles lost to competition and predation from the release of hatchery-origin juveniles. Since the publication of the paper, bugs have been identified by model users that prevented completion of model runs. To use this model for the current analysis, we modified some model code, and shut off some aspects of the model, specifically parameters related to disease, and the ability to obtain probabilistic (as opposed to deterministic) results. The remaining parameters and their values considered in the model are shown in Tables 23-25.

For our model runs, we assumed a 100 percent population overlap between hatchery steelhead and all natural-origin species present. Hatchery steelhead are released from mid-March to May, and may overlap with natural-origin Chinook and sockeye salmon, and steelhead. However, our analysis is focused on assessing effects on listed species, and this limits overlap of those species in certain areas. To address this, we modified residence times for hatchery steelhead if they did not overlap completely with certain listed natural-origin species by adjusting the total distance traveled. For example, Snake River sockeye juveniles do not inhabit the Grande Ronde, Imnaha, Tucannon, or Walla Walla Subbasins and thus effects on sockeye salmon from hatchery steelhead released as part of the proposed action would not occur until they comingled in the mainstem Snake and Columbia Rivers (more detailed calculations can be found in Hurst (2017)).

In addition, Chinook salmon in the Walla Walla Subbasin are not listed and thus residence time was adjusted to only account for overlap with listed Chinook salmon after entry into the Columbia River. We believed it was better to address overlap by adjusting residence time than by adjusting population overlap, because the population overlap parameter represents microhabitat overlap not basinwide-scale overlap, and a 100 percent population overlap in microhabitats is likely an overestimation.

In addition, our model does not consider ecological effects on age-0 steelhead because steelhead spawn from March to June with a peak from April to May in the action area (Busby et al. 1996). Thus, it is unlikely that any age-0 steelhead would have emerged in time to interact with the hatchery steelhead smolts as they migrate downstream. In addition, both Chinook salmon and steelhead have an earlier fall-to-early-winter migration, but there is unlikely to be any overlap with juvenile hatchery fish during this period because they are all released in the spring and the majority of hatchery fish (> 50 percent) migrate past McNary Dam within a month of release when traveling at a rate of 4-10 miles per day (Table 25).

Table 23. Parameters in the PCDrisk model that are the same across all programs. All values from HETT (2014) unless otherwise noted.

Parameter	Value
Habitat complexity	0.1
Population overlap	1.0
Habitat segregation	0.3 for steelhead, 0.6 for all other species
Dominance mode	3
Piscivory	0.0023
Maximum encounters per day	3
Predator:prey length ratio for predation	0.25[1]
Average temperature across release sites	7.4°C[2]

[1]Daly et al. (2009)
[2]PTAGIS accessed on December 16, 2016.

Table 24. Age and size of listed natural-origin salmon and steelhead encountered by juvenile hatchery fish after release.

Species	Age Class	Size in mm (SD)

Chinook salmon	0	62 (10)
	1	89 (10)
Steelhead	1	71 (10)
	2	134 (21)
Sockeye Salmon	1	86 (7)
	2	128 (8)

Sources: (Clarke et al. 2015; Jonasson 2016; Jonasson et al. 2015; Olsen et al. 2015).

Table 25. Hatchery fish parameter values for the PCDRisk model.

Program	Proposed Release #	Size in mm (SD)	Survival to McNary Dam	Travel Rate (river miles/day)	Residence Time[1] Chinook	Steelhead	Sockeye
Grande Ronde-Wallowa	580,000	207 (21)	0.53	10	32	32	20
Grande Ronde-Big Canyon	320,000	207 (21)	0.53	10	23	23	20
Little Sheep	215,000	200 (20)	0.53	5	46	46	45
LFH-cottonwood	225,000	207 (21)	0.53	11	21	21	18
LFH-mainstem	60,000	207 (21)	0.65	8	11	11	11
LFH-Touchet	100,000	207 (21)	0.8	4	17	17	17
Tucannon	150,000	207 (21)	0.65	4	32	32	24

Sources: PTAGIS database; (Hurst 2016; NMFS 2016a)

[1]This value has been altered to reflect when natural-origin fish of each species are likely to be encountered.

Based on the data above, our model results show that hatchery steelhead are likely to have the largest effect on natural-origin steelhead, followed by effects on Chinook salmon, and then sockeye salmon. We assumed 500,000 natural-origin fish were present within our action area in our calculations, to obtain the percentages, but the maximum numbers of fish lost are also shown in Table 26 and would not change if more natural-origin fish were present throughout the action area because this is the value where all possible hatchery fish interactions with natural-origin fish are exhausted at the end of each day (i.e., larger hatchery releases require more natural-origin fish to be included in the model to ensure all possible interactions are exhausted). This equates to about 131 Chinook salmon, 600 steelhead, and 52 sockeye salmon adult equivalents calculated using average smolt-to-adult survival rates from the six spring Chinook programs (0.006; Feldhaus et al. 2016) and four steelhead programs in the lower Snake River (0.018;Table 20), as well as the sockeye program in Idaho (0.005; IDFG 2012). Using the number of wild steelhead that pass McNary Dam (55,201 from 2012-2016; www.fpc.org), this would equate to about a 1.2 percent reduction in surviving juveniles from competition and predation during the juvenile life stage. Although the number of wild Chinook and sockeye salmon at McNary Dam is unavailable, the adult equivalents are also much smaller than those for steelhead. In addition, these negative effects are spread out over the various populations that comprise the Snake River ESUs/DPSs and the Mid-Columbia Steelhead DPS.

Table 26. Maximum numbers and percent of natural-origin salmon and steelhead lost to competition and predation with hatchery-origin steelhead smolts released from the Proposed Action.

Program	Chinook salmon		Steelhead		Sockeye salmon	
	Pred.	Comp.[1]	Pred.	Comp.	Pred.	Comp.
Grande Ronde-Wallowa	1508	7238	1680	11886	0	4223
Grande Ronde-Big Canyon	538	2903	246	4663	0	1461
Little Sheep	515	3907	272	6137	0	2233
LFH-Cottonwood	325	1873	160	3001	0	928
LFH-Mainstem	49	290	22	462	0	166
LFH-Touchet	43	242	53	1280	0	465
Tucannon	332	2073	149	3295	0	895
Total Number	**21836**		**33306**		**10371**	
Adult Equivalents[2]	**131**		**600**		**52**	

[1] Competition as used here is the number of natural-origin fish lost to competitive interactions assuming that all competitive interactions that result in body weight loss are applied to each fish until death occurs (i.e., when a fish loses 50% of its body weight). This is not reality, but does provide a maximum mortality estimate using these parameter values.
[2]This was calculated by using the smolt-to-adult survival rates for hatchery fish of each species (see above text) and multiplying by the total number of fish lost. However, this calculation does not account for compensatory survival. If this occurs, then the adult equivalents calculated here are likely an overestimate.

It is more difficult to assess the ecological effects of outplanting of eyed-eggs/fry, because the numbers may vary when outplanting occurs due to availability. However, it is unlikely that predation would occur because these fish would be the same size as the natural-origin juveniles. In addition, only a small proportion would be expected to survive to the smolt stage (7 percent of eggs/fry to smolt (Bradford 1995)). NMFS also anticipates egg/fry outplanting to be a rare event for the Tucannon program; the last fry releases took place in 2011. Thus, NMFS does not expect this relatively small number of smolts to result in a measureable effect on the natural-origin fish.

Residual hatchery steelhead are not explicitly accounted for in our model at this time. However, assessment of residualism is conducted for all four hatchery programs. ODFW conducts surveys of residual natural and hatchery-origin steelhead in 359 m^2 of Deer Creek and 529 m^2 in Little Sheep Creek. These locations were selected because these are the sites of release for both the Grande Ronde and Little Sheep hatchery programs and are the most likely locations to find residual hatchery fish. Residual hatchery steelhead number from a couple to a few dozen per 100 m^2 in both survey locations (Table 20). The number of hatchery residuals identified is often less than wild juvenile steelhead identified in Deer Creek, but juvenile wild steelhead in Little Sheep

Creek are outnumbered by residual hatchery fish. However, Little Sheep Creek represents only a minor portion (i.e., 6 percent) of natural spawning area in the Imnaha Subbasin and the proposed action represents the only steelhead program present in the subbasin. Because residual hatchery steelhead numbers are similar to natural steelhead, only a small portion of natural habitat is surveyed, and the survey locations contain hatchery release sites making them the most likely to have residual hatchery fish, it is unlikely that residual steelhead from these programs are having a measurable negative effect on natural-origin fish. For now, we do not believe these densities pose a risk to the natural-origin population, as long as they remain below 20 fish/100m^2 measured as a running average over five years.

For the Tucannon and Lyons Ferry programs, residualism is measured differently: through a visual examination of the percentage of precocial males at the hatchery before smolts are released. We only considered data from the Cottonwood release because this is the only site that has used Wallowa stock for a long time series. The other release sites used LFH stock until it was replaced with Wallowa stock in 2013. Data available does indicate this is a small percentage of the hatchery program (Table 28). Although precocial males may be more likely to residualize because they are closer to being ready to spawn, residualism is not guaranteed. Precocial maturation rates similar to what has been observed in the past could equal a few thousand fish residualizing from steelhead released in each location. However, because data from the Grande Ronde and Imnaha Subbasins suggest that many fewer fish actually residualize, NMFS believes residualism of a few thousand fish would likely be the highest rates expected. Continued monitoring of these rates is needed to ensure that once the model can incorporate residualism, data is available. For now, we do not believe these rates pose a risk to the natural-origin population, as long as they remain below two percent measured as a running average over five years.

Table 27. Juvenile steelhead density (fish/100m^2).

Index Location	Fish Origin	2010	2011	2012	2013	2014	Average
Deer Creek-Grande Ronde Subbasin	Hatchery	11	4	3	5	2	5
	Wild	31	16	11	16	10	17
Little Sheep-Imnaha Subbasin	Hatchery	28	17	9	17	13	17
	Wild	4	ND	1	0	1	2

Sources: (ODFW 2016)

Table 28. Percent of release comprising precocial male steelhead using visual examination.

Release Location	2009	2010	2011	2012	2013	Average
Tucannon	1.5	3.25	1.2	0	0	1.2
LFH-Cottonwood	1.85	0.3	0.4	0.3	0.8	0.7

Sources: (Bumgarner and Dedloff 2011; Bumgarner and Dedloff 2013a; Bumgarner and Dedloff 2015)

2.4.2.3.2. Naturally-produced progeny competition

Naturally spawning hatchery-origin steelhead are likely to be less efficient at reproduction than their natural-origin counterparts (Christie et al. 2014), but the progeny of such hatchery-origin spawners are likely to make up a sizable portion of the juvenile fish population. This is actually a desired result of the integrated recovery programs. There is no reason to expect offspring of naturally spawning hatchery-origin adults to behave differently from the offspring of natural-origin parents. Therefore, the only expected effect of this added production is a density-dependent response of decreasing growth and potential exceedance of habitat capacity.

Because spring/summer Chinook salmon historically coexisted in substantial numbers with steelhead, it follows that there must have been adequate passage and habitat to allow both species to be productive and abundant. It does not follow automatically, however, that the historical situation can be restored under present-day conditions. Habitat and passage conditions have changed considerably over time to the point that both species are so depleted that they are listed under the ESA. However, ecological impacts may increase in the future if the steelhead populations grow. Should the situation arise where steelhead natural production is limiting spring/summer Chinook salmon natural production, recovery planners would have to prioritize one species over another. NMFS expects that the monitoring efforts would detect negative impacts before they reach problematic levels, and we include language in the ITS (Section 2.8.4) to ensure that appropriate monitoring takes place.

2.4.2.3.3. Disease

The risk of pathogen transmission to natural-origin salmon and steelhead is negligible for these steelhead programs. This is because juvenile rearing for all four programs takes place at either Irrigon or Lyons Ferry hatcheries, which rear fish only on well water with minimal, if any, exposure to pathogens through the water source. Over the last twenty years, steelhead from the Grande Ronde program (ODFW 2011b) have been infected with *Flavobacterium psychrophilum* (causes coldwater disease), *Yersenia ruckeri* (causes enteric redmouth septicemia), and *Aeromonas salmonicida* (causes furunculosis). Over the last 10 years, fish for the Little Sheep program have been infected with *F. psychrophilum* and *Aeromonas/Pseudomonas spp* (ODFW 2011c) as well as some external fungi and the parasite *Ichthyobodo sp.* Outbreaks at Lyons Ferry and Tucannon hatcheries with steelhead have been due to *F. psychrophilum* over the last five years (Bumgarner and Dedloff 2011; Bumgarner and Dedloff 2013b). Despite these detections/outbreaks with pathogens that could be transmitted to natural-origin salmon and steelhead, all are treatable and are endemic to the Columbia Basin.

Furthermore, to prevent outbreaks and reduce the amplification of IHNV in natural environments, hatchery staff drain the coelomic fluid from females during spawning and treat eggs with an iodophor solution, controlling, to some extent, the transmission of IHNV (IHOT 1995; NWIFC and WDFW 2006; ODFW 2003; Pacific Northwest Fish Health Protection Committee (PNFHPC) 1989). Because of these preventative measures, no epidemics of IHNV associated with these four programs have occurred in recent years.

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

The monitoring and evaluation activities directly related to the proposed hatchery programs are part of a larger effort to determine the overall status of the Snake River steelhead DPS. Because the intent is to improve our understanding of listed population status, the information gained outweighs the risks to the populations based on the small proportion of fish encountered, resulting in an overall negligible effect of RM&E on steelhead. Effects on fall Chinook and spring/summer Chinook salmon and sockeye are negligible.

The proposed RM&E directly related to fish culture uses well-established (e.g., AHSWG 2008) methods and protocols. For the integrated programs included in this proposed action, the egg-to-smolt survival was 69 and 74 percent, respectively, for the Little Sheep and Tucannon programs (Bumgarner and Dedloff 2015; ODFW 2011b). These rates are anticipated prior to egg takes, and generally pose little to no risk to the population because these survival rates greatly exceed survival expectations of egg-to-smolt survival in the wild (e.g., egg-to-smolt survival was 7 percent for Chinook salmon (Bradford 1995)).

The effects of surveying for redds and adults to estimate abundance for steelhead in both the Imnaha and Grande Ronde Subbasins was previously analyzed and authorized in NMFS (2016). Surveys were also used to determine abundance in the Tucannon Subbasin and Asotin Creek in the past, but no longer occur except in the upper Tucannon above the adult trap. This was because redd surveys in the Tucannon were sporadic between years due to environmental conditions and did not provide useful information for the managers, so were stopped in favor of PIT tag estimates. In Asotin Creek, surveys were eliminated because estimates from the adult weir on the main creek and in Almota Creek, in combination with PIT tag arrays in the upper Asotin Creek watershed have proven more reliable and consistent than redd surveys. The effects of these surveys are limited to the observation of listed steelhead. Because the typical response of fish to this activity is within the range of normal behaviors (i.e., startling response to a predator), we do not believe take occurs as a result of this pathway. However, up to 100 natural-origin fish are likely encountered and handled at the Almota Creek weir. Similar numbers of ESA-listed hatchery-origin fish are likely to be encountered and handled. This take was covered under NMFS' Federal Columbia River Power System (NMFS 2014(NMFS 2014)).

There are also temporary weirs operated intermittently in Penewawa, Alkali Flat, Deadman, and Pataha Creeks to assess adult steelhead abundance and composition from February through May for the Tucannon population. In addition, these weirs may also be used to collect broodstock for the Tucannon program in the future if returns to the Tucannon River weir are low. Future weir trapping in Meadow Creek, which is also included in the Tucannon population, may also occur in the future to better inform natural-origin steelhead abundance and composition. From data collected from 2013 to 2015 (Table 29), a high of 277 natural-origin steelhead were encountered across 4 of the 5 creeks sampled. (Bumgarner 2017b; Trump and Gembala 2015; Trump and Gembala 2016; Trump et al. 2014). NMFS believe it is possible that around 400 natural-origin steelhead, and the same number of ESA-listed hatchery-origin steelhead could be encountered and handled at the weirs across all five creeks annually for the life of the permit. This number seems reasonable because some creeks have not been assessed, and this number also provides for an increase in encounter and handling due to an increase in natural-origin returns. It is unlikely any listed salmon will be present in these creeks during this time, resulting in no effect on salmon.

Table 29. Numbers of natural-origin steelhead encountered and handled in small creeks associated with the Tucannon steelhead populations over the most recent 1-3 years.

Creek	Natural Average (High)	Handling numbers Requested
Penewawa	70 (154)	175
Deadman	9 (10)	50
Meadow	Not available[1]	50
Alkali Flat	0[2]	25
Pataha	30 (40)	100
Total	**159 (277)**	**400**

Sources: (Bumgarner 2017b)
[1]Not sampled, but is thought to be similar to Deadman.
[2]Only sampled once and habitat is conducive for spawning.
[3]Thought to be at least 50 spawners due to prior redd surveys.

The effects of sampling for steelhead juveniles for RM&E in both the Imnaha and Grande Ronde Subbasins was previously analyzed and authorized in NMFS' permit 18030, and NMFS' permits 18035, 18034, and 18033 with one exception. That exception is screw trapping in Little Sheep Creek; data on past handling of steelhead for this activity is included in Table 29. The highest number of juveniles encountered during screw trap operations was 7,648 and 2,340 natural- and hatchery-origin steelhead, respectively. With an assumed two percent unintentional mortality this would equate to the mortality of ~ 2 natural-origin adults on average annually. The previously authorized activities resulted in a small level of incidental mortality of less than 2 percent of the spring Chinook salmon and steelhead juveniles encountered in the trap. No effect of this activity on sockeye or fall Chinook salmon is expected because they are separated spatially and/or temporally from this activity, and have not been encountered previously.

Sampling of juveniles occurs in the Tucannon Subbasin using a screw trap to assess juvenile outmigration and abundance. Although the highest number of natural-origin steelhead juveniles encountered was 3,247 (Table 29), the applicants are requesting authorization for encountering up to 5,000 natural-origin and 7,500 hatchery-origin steelhead juveniles with a two percent unintentional mortality (~ 2 natural-origin adult equivalents). This low level of mortality likely has a negligible effect on the steelhead population and is outweighed by the benefits of collecting the information needed to assess the hatchery program, and natural origin returns to the basin based on PIT tags, which are applied at the screw trap. In addition, WDFW (2011b) does mention that a few kelts are incidentally encountered during screw trap operation. Encounter of spring/summer Chinook salmon was covered in the consultation for Chinook salmon (NMFS 2016b), and the associated permit, number 18024. Encounter of fall Chinook salmon has also been covered under Permit 16607. No effect of this activity on sockeye salmon is expected because they are separated spatially and/or temporally from this activity, and have not been encountered previously.

Table 30. Number of juvenile steelhead encountered during juvenile steelhead rotary screw trapping.

Program	Fish origin	2009	2010	2011	2012	2013	Average Adult Equivalents[1]
Tucannon	Natural	1314	2657	3247	2341	3022	1 fish
	Hatchery	Not available	1327	Not available	Not available	Not available	3 fish
Little Sheep	Natural	4132	7648	3079	6713	4821	2 fish
	Hatchery	1557	2340	1098	2014	1766	1 fish

Sources: (Bumgarner and Dedloff 2013a; Bumgarner and Dedloff 2015; Clarke 2016; WDFW 2011b)

[1]This is calculated by taking the five-year average by a 2 percent incidental mortality rate to find the number of juveniles intentionally killed and then multiplying that number by the steelhead hatchery program SAR of 0.018 (Table 20).

There are three research studies designed to better assess the effectiveness of these hatchery programs. ODFW has been conducting a study to evaluate the performance of early brood for the Wallowa program by assessing survival of hatchery-origin fish at various life stages. The co-managers are also conducting a study to rear Wallowa-stock fish at Irrigon Hatchery and release them from the Cottonwood site (normally these fish would be released at Wallowa hatchery) and to rear Wallowa-stock fish at LFH and release them from Wallowa Hatchery (normally these would be released at Cottonwood). The study purpose is to determine if survival and straying into the Deschutes River Basin differences between the ODFW and WDFW programs are influenced by rearing and release locations. Neither study will have effects on listed species because they use non-listed hatchery fish and do not encounter listed species except during migration to the ocean.

A third study involves the use of a chemical attractant placed within a trap in acclimation sites to attract precociously mature males prior to smolt release. If this technique works, these fish will be removed by ODFW and placed in lakes or reservoirs with no access to anadromous waters. Of the three acclimation sites where this work could take place, only the Little Sheep Creek acclimation site rears ESA-listed hatchery-origin fish. If successful, it is estimated that about 2,000 hatchery-origin fish (likely males), could be attracted to the chemical and removed prior to release downstream.

2.4.2.5. Factor 5. Construction, operation, and maintenance of facilities that exist because of the hatchery program

Operation and maintenance of the facilities associated with the hatchery programs included in the Proposed Action would have a negligible effect on ESA-listed spring Chinook salmon and Snake River steelhead or their designated critical habitat. No construction is included as part of the Proposed Action.

Table 31. Program water source and use.

Facility	Program	Maximum Surface Water Use (cfs)	Maximum Ground or Spring Water Use (cfs)	Surface Water Source/ Discharge Location	Diversion Distance (km)	Mean Monthly Surface Water Flow During Operation (cfs)	Maximum Percent Surface Water Diverted
Wallowa Hatchery	Grande Ronde, Little Sheep	10	0.1	Spring Creek	0.2	12 (January-May)	80-90
Irrigon Hatchery	Grande Ronde, Little Sheep	0	5	Columbia River	0	Not applicable	0
Big Canyon Satellite	Grande Ronde	10	0	Deer Creek	0.2	12	83
Little Sheep Acclimation Site	Little Sheep	10	0	Little Sheep Creek	0.2	16	63
Cottonwood Acclimation Site	WDFW Wallowa	6	0	Cottonwood Creek/Grand Ronde River	0.1	Not available	Not available
Lyons Ferry Hatchery	WDFW Wallowa, Tucannon	0	119	Not applicable/Snake River	0	Not applicable	0
Tucannon Fish Hatchery	Tucannon	16	7.3	Tucannon River	1.3	47.5 (August)	34
Dayton Acclimation Facility	WDFW Wallowa, Touchet	6	0	Touchet River	0.1	57 (February-April)	11

Ron Harrod, ODFW, personal communication, August 23, 2016; Ace Trump, WDFW, personal communication, August 23, 2016) Tucannon USGS gauge-13331500 years 2006-2016.

Under the Proposed Action, because there is no change in water withdrawals from current operation, water withdrawals are expected to have similar effects into the future. For Lyons Ferry and Irrigon Hatcheries, no surface water is used, and thus the facilities will not cause a change in habitat use or decrease availability (Table 23). Tucannon hatchery could use a maximum of about 34 percent of the river water available from the Tucannon River. Some of the acclimation sites and Wallowa Hatchery's use of Spring Creek can lead to a large proportion of water diversion from a particular water body, because some of the water feeding these water bodies is still reserved as snow. However, dewatering of redds or prevention of natural-origin fish movement has not been observed when water flow could be limited by hatchery operation during the summer. Also, with the exception of Wallowa and Tucannon Hatcheries, the acclimation sites are only used for a short time in the spring (three to four months), and thus would not be operating during juvenile rearing in the summer. In addition, during the summer months (when flows are lowest), it is unlikely that many adults, and as a result redds, would be present in these river systems. Juvenile fish that did not migrate in the spring may be present, but are mobile and would likely be able to move to another area relatively close by if water flow became an issue because water at all facilities is diverted over a relatively short distance and is non-consumptive. Note that, because climate change trends indicate that juveniles may outmigrate earlier, the risk of dewatering juvenile rearing habitat during the summer months, when flows are at their lowest, under likely changes in climate conditions is reduced even further (Dittmer 2013).

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

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

In addition, the LSRCP team is reviewing all facilities they own for compliance with the most recent NMFS' 2011 screening criteria and prioritizing repairs/upgrades (see section 1.3). These improvements should further reduce any effects on listed fish associated with facility operation.

Hatchery maintenance activities may displace juvenile fish through noise and instream activity or expose them to brief pulses of sediment as activities occur instream. The Proposed Action includes best management practices that limit the type, timing, and magnitude of allowable instream activities. The measures would limit any potential short-term effects that are within the normal range of fish behaviors in response to noise or a periodic habitat disturbance.

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

There are no fisheries that exist because of the Proposed Action. The effects of fisheries that may impact fish produced by these programs are described in Section 2.3.4.

2.4.2.7. Effects of the Action on Critical Habitat

This consultation analyzed the Proposed Action for its effects on designated critical habitat. NMFS has determined that operation of the hatchery programs would have a minor effect on designated critical habitat PBFs in the action area.

The existing hatchery facilities have not led to altered channel morphology and stability, reduced and degraded floodplain connectivity, excessive sediment input, or the loss of habitat diversity. In addition, no new facilities are proposed. Hatchery maintenance activities are expected to retain existing conditions, and would have minimal adverse effects on designated critical habitat.

Most facilities that use surface water diversions return that water to the river a short distance from the diversion point and use only a small proportion of the total surface water volume (Table 30). Because the uses are non-consumptive, these withdrawals would not affect adult spawning and juvenile rearing critical habitat of ESA-listed Chinook salmon, sockeye salmon, or steelhead.

Another potential effect on critical habitat is the use of chemicals for cleaning or treating pathogens that are present in the hatchery effluent at Wallowa, Irrigon, Lyons Ferry, and Tucannon Hatcheries. At this time, no information exists to suggest the use of the chemicals and their subsequent dilution to manufacturer's instructions would cause adverse effects on ESA-listed fish. Furthermore, the use of abatement ponds at hatcheries to allow chemical degradation into less toxic components, and the mixing of effluent with the remaining water in the creek or river, is not likely to lead to a detectable change in water quality. Thus, the effects on water quality in spawning and rearing critical habitat are negligible.

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). For the purpose of this analysis, the action area is that part of the Columbia River Basin described in Section 1.4. To the extent ongoing activities have occurred in the past and are currently occurring, their effects are included in the baseline (whether they are Federal, state, tribal or private). To the extent those same activities are reasonably certain to occur in the future (and are tribal, state or private), their future effects are included in the cumulative effects analysis. This is the case even if the ongoing tribal, state or private activities may become the subject of section 10(a)(1)(B) incidental take permits in the future until an opinion for the take permit has been issued.

State, tribal, and local governments have developed plans and initiatives to benefit listed species and these plans must be implemented and sustained in a comprehensive manner for NMFS to consider them "reasonably foreseeable" in its analysis of cumulative effects. It is acknowledged, however, that such future state, tribal, and local government actions would likely be in the form of legislation, administrative rules, or policy initiatives, and land-use and other types of permits, and that government actions are subject to political, legislative, and fiscal uncertainties.

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

More detailed discussion of Cumulative effects for the Columbia River basin can be found in our biological opinion on the funding of Mitchell Act hatchery programs (NMFS 2017). It should be noted that the action in the Mitchell Act biological opinion – the operation of Columbia River hatchery programs -- is included in the baseline for this opinion.

2.6. Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the Proposed Action. In this section, NMFS adds the effects of the Proposed Action (Section 2.4.2) to the environmental baseline (2.3) and to cumulative effects (2.5) to formulate the agency's opinion as to whether the Proposed Action is likely to: (1) result in appreciable reductions in the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat. This assessment is made in full consideration of the status of the species and critical habitat and the status and role of the affected population(s) in recovery (Sections 2.2.1, 2.2.2, and 2.2.3).

In assessing the overall risk of the Proposed Action on each species, NMFS considers the risks of each factor discussed in Section 2.4.2., above, in combination, considering their potential additive effects with each other and with other actions in the area (environmental baseline and cumulative effects). This combination serves to translate the positive and negative effects posed by the Proposed Action into a determination as to whether the Proposed Action as a whole would appreciable reduce the likelihood of survival and recovery of the listed species and their designated critical habitat.

2.6.1. Snake River Steelhead DPS

Best available information indicates that the Snake River Steelhead DPS is at high risk and remains at threatened status (Ford 2011). Ford (2011) determined that all populations remain below minimum natural-origin abundance thresholds. In addition, the biological review team identified the lack of direct data on spawning escapements and pHOS in the individual population tributaries as a key uncertainty, rendering quantitative assessment of viability for the DPS difficult (Ford 2011). Still, after taking into account the current viability status of these species, the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the effects of the Proposed Action will not appreciably reduce the likelihood of survival and recovery of these ESA-listed ESUs in the wild, as discussed below.

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

The majority of the effects of the Proposed Action on this ESU are genetic and ecological in nature. Effects of facility operation and broodstock collection are small and localized, and, while RM&E requires handling of a substantial portion of the juvenile population, less than two percent are expected to die as a result of handling. In addition, the information gained from conducting the work is essential for understanding the effects of the hatchery program on natural-origin steelhead populations.

The ecological and genetic effects on the adult life stage are limited by the proportion of hatchery-origin fish spawning naturally. For these four programs, this is managed through removal of adults at adult trapping locations and via fisheries in the area. Three of the four programs contribute relatively few fish to natural-origin spawning populations. Although the pHOS levels in the Tucannon are high, the co-managers have taken steps in the past to reduce pHOS levels in the Tucannon (eliminate releases of LFH stock into the Tucannon). For this proposed action, co-managers have eliminated direct releases into the Walla Walla River and have reduced the size of the release that occurs at LFH. These actions should further reduce pHOS in the Tucannon, resulting in a decreased potential for spawning site competition and redd superimposition between hatchery- and natural-origin fish. Genetic effects are also limited by the use of natural-origin broodstock for the Little Sheep and Tucannon programs, which have expected PNI values of > 0.67 and ~0.23, respectively. Although the relatively low PNI for the Tucannon is a concern, we believe the co-managers are taking steps to modify the hatchery programs in this Proposed Action to address this concern, both in the long- and short-term. These actions should contribute to an increase in abundance and productivity for this population in the long-term.

Ecological effects on natural-origin juvenile steelhead associated with releases from the hatchery program equates to a loss of less than 1.2 percent of the adult natural-origin steelhead in the DPS. It is likely that this percentage is even smaller because the analysis also includes a portion of fish from the mid-Columbia Steelhead DPS. However, this relatively small loss is unlikely to have an effect on the abundance and productivity of the DPS

Added to the Species' Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area. The recovery plan for this DPS describes the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed steelhead. Such actions are improving habitat conditions and hatchery and harvest practices to protect ESA-listed steelhead DPSs, and NMFS expects this trend to continue, ultimately improving the abundance and productivity of natural populations.

2.6.2. Mid-Columbia River Steelhead DPS

Best available information indicates that the Mid-Columbia River Steelhead DPS is at high risk and remains at threatened status (Ford 2011). After taking into account the current viability status of these species, the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the effects of the Proposed Action will not appreciably reduce the likelihood of survival and recovery of these ESA-listed ESUs in the wild, as discussed below.

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

The majority of the effects of our Proposed Action on this ESU are genetic and ecological in nature because the effects from facility operation and broodstock collection are small and localized. The ecological and genetic effects on the adult life stage are limited by the proportion of hatchery-origin fish spawning naturally. For these four programs, this is managed through removal of adults at adult trapping locations and via fisheries in the area. The main contributors to pHOS in this DPS are fish from the LFH program released in the Touchet River and stray Wallowa stock fish into the Deschutes River. Our analysis demonstrates that pHOS from the LFH program represents less than 5 percent of the natural-origin steelhead in the Touchet River. Wallowa stock fish also comprise less than 5 percent of the spawners in the Deschutes River. Thus, abundance and productivity are unlikely to be affected by the proposed action.

Ecological effects on natural-origin juvenile steelhead associated with releases from the hatchery program equates to a loss of less than 1.2 percent of the adult natural-origin steelhead in the DPS. It is likely that this percentage is even smaller because the analysis also includes the Snake River Steelhead DPS. However, we would expect effects on the mid-Columbia River DPS to be smaller than Snake River steelhead because there is greater opportunity for overlap with Snake River steelhead than Mid-Columbia Steelhead. Thus, this relatively small loss is unlikely to have an effect on the abundance and productivity of the DPS

Added to the Species' Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area. The recovery plan for this DPS describes the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to the DPS. Such actions are improving habitat conditions, and hatchery and harvest practices to protect listed steelhead DPSs, and NMFS expects this trend to continue, leading to an increase in the abundance and productivity of the DPS.

2.6.3. Snake River Salmon ESUs

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

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

The effects of our proposed action on these ESUs is limited to ecological effects, broodstock collection, and RM&E. Adverse ecological effects on adults are small because of the differences in spatial and temporal overlap of these three species with steelhead. However, juveniles may potentially undergo larger effects because of the overlap in outmigration timing. Our analysis showed that the impacts of these programs on sockeye salmon equates to a loss of 52 sockeye salmon adults and 131 Chinook salmon. The loss of this small number of adults is unlikely to affect the productivity of the Chinook salmon and sockeye ESUs.

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

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

2.6.4. Critical Habitat

The hatchery water diversion and the discharge pose a negligible effect on designated critical habitat in the action area (Section 2.4.2.5). Existing hatchery facilities have not contributed to altered channel morphology and stability, reduced and degraded floodplain connectivity, excessive sediment input, or the loss of habitat diversity. The operation of the weirs and other hatchery facilities may impact migration PBFs due to delay at these structures and possible rejection. However, the number of natural-origin adults delayed is expected to be small and the delay would be for only a short period. Thus, the impact on the spawning, rearing, and migration PBFs will be small in scale, and will not appreciably diminish the capability of the critical habitat to satisfy the essential requirements of the species.

Climate change may have some effects on critical habitat as discussed in Section 2.3.2. With continued losses in snowpack and increasing water temperatures, it is possible that increases in the density and residence time of fish using cold-water refugia could result in increases in ecological interactions between hatchery and natural-origin fish of all life stages, with unknown but likely small effects. The continued restoration of habitat may also provide additional refugia for fish. . After reviewing the Proposed Action and conducting the effects analysis, NMFS has determined that the Proposed Action will not impair PBFs designated as essential for spawning, rearing, juvenile migration, and adult migration purposes.

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, including effects of the Proposed Action that are likely to persist following expiration of the Proposed Action, and cumulative effects, it is NMFS' biological opinion that the Proposed Action is not likely to jeopardize the continued existence or recovery of any of the ESUs and DPSs listed in the Columbia River Basin (Table 6), or destroy or adversely modify 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[7], harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by regulation to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering (50 CFR 17.3). Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not prohibited under the ESA, if that action is performed in compliance with the terms and conditions of the ITS.

2.8.1. Amount or Extent of Take

The primary form of take of ESA-listed summer steelhead is direct take, authorized in the permits for the Little Sheep and Tucannon programs. However, NMFS also expects incidental take of ESA-listed steelhead will occur as a result of the proposed action for the following factors.

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

Effects of hatchery fish on the genetics of natural-origin fish can occur through a reduction in genetic diversity, outbreeding depression, and hatchery-influenced selection. Take due to these genetic effects cannot be directly measured because it is not possible to observe gene flow or interbreeding between hatchery and wild fish in a reliable way. NMFS will therefore rely on a surrogate take indicator that relates to the type of take identified: the number of hatchery-origin fish on the spawning grounds for each program as defined here:

- An annual maximum of 250 hatchery-origin steelhead passed above the weir on Little Sheep Creek
- An annual maximum of 338 hatchery-origin steelhead passed above the Tucannon weir
- Less than 20 percent of the hatchery-origin spawners in the Tucannon steelhead population will be comprised of fish from the Lyons Ferry Hatchery Program calculated

[7] NMFS recognizes the benefit of providing guidance on the interpretation of the term "harass". As a first step, for use on an interim basis, NMFS will interpret harass in a manner similar to the USFWS regulatory definition for non-captive wildlife: "Create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering. " NMFS interprets the phrase "significantly disrupt normal behavioral patterns" to mean a change in the animal's behavior (breeding, feeding, sheltering, resting, migrating, etc.) that could reasonably be expected, alone or in concert with other factors, to create or increase the risk of injury to an [ESA-listed] animal when added to the condition of the exposed animal before the disruption occurred. See Weiting (2016) for more information on the interim definition of "harass."

as a five-year average[8] beginning in 2021 after the short-term goal is realized (including all three releases: on-station, Cottonwood Acclimation Facility, and Touchet River). From now until 2021, the five-year running average of the Tucannon population pHOS attributable to the Lyons Ferry Hatchery program will be less than 40 percent.
- Less than five percent of the hatchery-origin spawners in the Upper Grande Ronde and Joseph Creek steelhead populations can be returning adults from the Grande Ronde Wallowa Steelhead program (including releases at Wallowa Hatchery and Big Canyon), measured as a five-year running average beginning in 2017.[9]

This last two bullets related to hatchery adult composition may not capture every location where straying of hatchery fish occur as a result of the proposed action, but it does capture the locations where straying occurs in detectable numbers, and can be reliably measured. To the extent fish may stray elsewhere as a result of the proposed action that additional straying is expected to correlate to the limits identified here. For example if straying remains below the five percent limit for the Joseph Creek population then it is also acceptably low in other steelhead populations. Therefore, these thresholds are surrogates for placing a limit on all genetic effects resulting from the proposed action, not just any such effects in the named river basins.

Limiting the number of hatchery-origin fish on the spawning grounds also limits the opportunity for spawning with natural-origin fish, which can lead to incorporation of genes that have undergone hatchery-influenced selection into the natural population. Therefore, the take surrogate is logically related to the take pathway. Moreover, through weir collections and controlled passage upstream, the take surrogate can be reliably measured and monitored.

Table 32. Permissible annual incidental take of listed adipose-present and natural-origin steelhead associated with broodstock collection. Incidental mortality is one percent of handling.

Program	Collection Site	Maximum listed hatchery-origin captured and handled (and estimated mortality)	Maximum natural-origin captured and handled (and estimated mortality)
Grande Ronde	Wallowa Hatchery	50 (1)	50 (1)
	Big Canyon	50 (1)	150 (2)
LFH	Cottonwood Weir	50 (1)	30 (1)
	LFH	50 (1)	10 (1)
Little Sheep	Little Sheep Weir	Covered in permit (35)	Covered in permit (3)
Tucannon	Tucannon Weir	Covered in permit (4)	Covered in permit (3)

[8] However, if it is apparent, from numbers observed in years prior to the fifth year, that the average is certain to exceed 20 or 40 percent (depending on pre- or post-2021), NMFS will consider the take estimate to have been exceeded at that time rather than waiting for the full five years to elapse.
[9] However, if it is apparent, from numbers observed in years prior to the fifth year, that the average is certain to exceed one percent after five years, NMFS will consider the take estimate to have been exceeded at that time rather than waiting for the full five years to elapse.

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

Competition with and predation by residual hatchery-origin steelhead could result in take of natural-origin Chinook and sockeye salmon and steelhead. However, it is difficult to quantify this take because ecological interactions cannot be observed. Thus, NMFS will rely on two surrogate take variables.

The first surrogate take variable for this take pathway can be measured either as the percentage of steelhead that are precociously mature prior to release (LFH, Tucannon programs), or the number of steelhead that residualize per $100m^2$ (Grande Ronde and Little Sheep programs). This standard has a rational connection to the amount of take expected from ecological interactions because precocious steelhead are more likely to residualize after release from the hatchery. NMFS considers, for the purpose of this take surrogate, that no more than 2 percent of program fish should be precociously mature (based on visual observation at pre-release sampling), using a five-year average beginning with the 2017 release[10] for the Tucannon and LFH programs. NMFS considers, for the purpose of this take surrogate, that no more than 20 fish/$100m^2$ in the areas surveyed should residualize, described as a five-year average beginning with the 2017 release[11] for the Grande Ronde and Little Sheep programs. The take surrogate can be reliably measured and monitored through assessment of precocious maturation rates prior to release, and through index surveys in Deer and Little Sheep Creeks.

Predation, competition, or pathogen transmission, collectively referred to as ecological interactions between natural-origin juvenile Chinook and sockeye salmon and steelhead and hatchery steelhead smolts released from the acclimation ponds, can also occur. The take of juvenile natural-origin salmon and steelhead through ecological interactions with juvenile hatchery fish cannot be directly or reliably measured. For this factor, NMFS applies a second surrogate take variable that relates to the median travel time for hatchery steelhead to reach McNary Dam after release. Specifically, the extent of take from interactions between hatchery and natural-origin juvenile salmonids above McNary Dam will be the take that occurs when the travel rate[12] for emigrating juvenile hatchery steelhead is greater than 3 river miles per day following hatchery release and/or the last day of the volitional release period, measured as a five-year running average[13]. This is a reasonable, reliable, and measurable surrogate for incidental take because if travel rate falls below 3 river miles per day, it is a sign that fish are not exiting the action area as quickly as expected, and therefore the expected take from interactions has likely been exceeded as a result of greater overlap between hatchery and natural-origin fish. This threshold will be monitored using emigration estimates from PIT tags, screw traps, or other juvenile monitoring techniques developed by the operators and approved by NMFS.

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[10]However, if it is apparent, from numbers observed in years prior to the fifth year, that the average is certain to exceed 2 percent after five years, operators will contact NMFS in the year the likely exceedance is discovered.
[11]However, if it is apparent, from numbers observed in years prior to the fifth year, that the average is certain to exceed 20 steelhead/$100m^2$ after five years, operators will contact NMFS in the year the likely exceedance is discovered.
[12] NMFS recognizes that this metric can be influenced by factors other than hatchery operation (i.e., environmental variables, hydrosystem operation).
[13] However, if it is apparent, from numbers observed in years prior to the fifth year, that the average is certain to fall below 3 river miles per day after five years, operators will contact NMFS in the year the average will not be met.

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

Table 33. Incidental mortality of steelhead resulting from RM&E activities (e.g., screw traps). Capture, handling, and sampling is considered direct take and is included in the permit.

Program	Lifestage	Maximum incidental mortality number
Little Sheep	Adult	2 hatchery and/or natural
	Juvenile	160 natural, 50 hatchery
Tucannon	Adult	5 hatchery and/or natural
	Juvenile	100 natural, 150 hatchery

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 jeopardize the continued existence of the Snake River Spring/summer Chinook Salmon ESU, Snake River Fall Chinook Salmon ESU, Snake River Sockeye Salmon ESU, and Snake River Basin Steelhead DPS or result in the destruction or adverse modification of their designated critical habitat.

2.8.3. 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 incidental take. The NMFS and the USFWS (i.e., LSRCP) shall ensure that:

1. The applicants implement the hatchery programs and operate the hatchery facilities as described in the Proposed Action (Section 1.3) and in the submitted HGMPs.
2. The applicants provide reports to SFD annually for all hatchery programs, and associated RM&E.

2.8.4. Terms and Conditions

The terms and conditions described below are non-discretionary, and NMFS must comply with them in order to implement the reasonable and prudent measures (50 CFR 402.14). Action Agencies 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 entity to whom a term and condition is directed does not comply, protective coverage for the proposed action would likely lapse.

The LSRCP shall ensure for all programs that:

1. The applicants implement the hatchery programs as described in the Proposed Action (Section 1.3) and the submitted HGMPs, including:
    a. Providing advance notice to NMFS of any change in hatchery program operation (including early releases) that potentially increases the amount or extent of take, or results in an effect of take not previously considered.
    b. Providing notice if monitoring reveals an increase in the amount or extent of take, or discovers an effect of the Proposed Action not considered in this opinion.
    c. NMFS will be allowed to accompany any employee or representative field personnel while they conduct activities covered by their biological opinion.
    d. By December 31, 2018, initiate discussions of infrastructure needs (e.g., additional rearing vessels) at LFH to improve management and evaluation opportunities for steelhead hatchery programs (relative to concerns regarding wild steelhead populations). It is understood that management of multiple programs (species and stocks) occurs at LFH, and that these programs need to be accommodated.
    e. Continue discussions with partners (e.g., NMFS, WDFW, and BPA) to determine responsible party (or parties) for funding and implementation of a small stream monitoring program associated with the Tucannon steelhead population in the lower Snake River mainstem; monitoring would focus on adult escapement, by origin into select Snake River tributaries. A decision or strategy for long-term monitoring will be coordinated with entities associated with the Federal Columbia River Power System consultation effort by the end of 2018.
2. The applicants provide reports to NMFS SFD annually for all hatchery programs, and associated RM&E.
    a. All reports/notifications be submitted electronically to the NMFS SFD point of contact for this opinion: Charlene Hurst (503) 230-5409, charlene.n.hurst@noaa.gov
    b. Reports shall be submitted to NMFS SFD by March 31st of the year following release (e.g., brood year 2016, release year 2017, report due March 2018).
    c. Applicants will notify NMFS SFD within 48 hours after exceeding any authorized take, and shall submit a written report detailing why the authorized take was exceeded within two weeks of the event. This will trigger a discussion of the circumstances surrounding the exceeded take with the appropriate NMFS staff.
    d. Annual reports to NMFS SFD for the LFH and Grande Ronde steelhead programs should include:
        i. A calculation of quantifiable encounter and mortality take for each species across all activities included in the Proposed Action
        ii. *Hatchery Environment Monitoring Reporting*
            - Number and composition of broodstock, and dates of collection
            - Numbers, pounds, dates, locations, and tag/mark information of released fish
            - Average size of released juveniles and standard deviation
            - Egg-to-smolt survival rate

- Disease occurrence, duration and proportion of production lost at hatcheries and the acclimation sites
- Precocial maturation rate prior to release (visual; LFH and Tucannon programs)
- Residualism rates (Grande Ronde program)
- Any unforeseen effects on ESA-listed fish

iii. *Natural Environment Monitoring Reporting*

- Distribution of hatchery- and natural-origin spawners in all populations in which releases occur (i.e., Touchet population for Touchet release)
- The contribution of fish from these programs into ESA-listed populations (i.e., pHOS)
- Smolt-to-adult survival rate as calculated by the operators in previous program evaluation reports
- Post-release out-of-basin migration timing, and travel speed of juvenile hatchery-origin fish to McNary Dam
- Mean size and standard deviation, number, outmigration timing, and age structure of natural-origin juveniles
- Number of any natural-origin ESA-listed sockeye salmon and steelhead encountered and the number that die annually during RM&E and broodstock collection activities. Refer to fall Chinook and spring/summer Chinook salmon reports for capture of those species

NMFS shall include in the permits a condition that:

1. The applicants implement the Tucannon and Little Sheep Hatchery Programs as described in the Proposed Action (Section 1.3) and the submitted HGMPs, including:
    a. Providing advance notice to NMFS of any change in hatchery program operation that potentially increases the amount or extent of take, or results in an effect of take not previously considered.
    b. Providing notice if monitoring reveals an increase in the amount or extent of take, or discovers an effect of the Proposed Action not considered in this opinion.
    c. Allowing NMFS to accompany any employee or representative field personnel while they conduct activities covered by their biological opinion.
2. The applicants provide reports to NMFS SFD annually for all hatchery programs, and associated RM&E.
    a. All reports/notifications be submitted electronically to the NMFS SFD point of contact for this opinion: Charlene Hurst (503) 230-5409, charlene.n.hurst@noaa.gov
    b. Reports shall be submitted to NMFS SFD by March 31st of the year following release (e.g., brood year 2016, release year 2017, report due March 2018).
    c. Applicants will notify NMFS SFD within 48 hours after exceeding any authorized take, and shall submit a written report detailing why the authorized take was exceeded within two weeks of the event. This will trigger a discussion of the circumstances surrounding the exceeded take with the appropriate NMFS staff.

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 (50 CFR 402.02). NMFS has identified three conservation recommendations appropriate to the Proposed Action:

1. Obtain/improve estimates of natural-origin juvenile population abundance for listed species in the Snake Basin.
2. Continue, in coordination with other entities, modifying the Tucannon and Lyons Ferry Hatchery programs in concert with other actions to possibly modify harvest, hydropower, and habitat actions to work towards a target PNI of 0.67 for the Tucannon population.
3. Increase frequency of the adult sampling monitoring program on Penewawa, Deadman, and Meadow Creeks, which is currently funded by BPA for natural steelhead monitoring on a rotating frequency, to better inform the Tucannon population model that estimates PNI.
4. Consider how to normalize hatchery-origin stray rates with natural-origin steelhead stray rates for both.

2.10. Re-initiation of Consultation

As provided in 50 CFR 402.16, re-initiation 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, including outcomes of the Steelhead Straying Effects Workgroup, reveals effects of the agency action on listed species or critical habitat not considered in this opinion
3. The agency action is modified in a manner that causes an effect on the listed species or critical habitat that was not considered in this opinion
4. A new species is listed or critical habitat designated that may be affected by the action

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

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

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

3.1. Essential Fish Habitat Affected by the Project

The Proposed Action is the implementation of four steelhead hatchery programs, as described in Section 1.3. The action area (Figure 1) of the Proposed Action includes habitat described as EFH for Chinook and coho salmon (PFMC 2003) within the Snake River Basin. Because EFH has not been described for steelhead, the analysis is restricted to the effects of the Proposed Action on EFH for Chinook and coho salmon.

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

3.2. Adverse Effects on Essential Fish Habitat

The Proposed Action has small effects on the major components of EFH. As described in Section 2.4.2, water withdrawal for hatchery operations can adversely affect salmon by reducing streamflow, impeding migration, or reducing other stream-dwelling organisms that could serve as prey for juvenile salmonids. Water withdrawals can also kill or injure juvenile salmonids through impingement upon inadequately designed intake screens or by entrainment of juvenile fish into the water diversion structures. The proposed hatchery programs include designs to minimize each of these effects. In general, water withdrawals are small enough in scale that changes in flow would be undetectable, and impacts would not occur.

The PFMC (2003) recognized concerns regarding the “genetic and ecological interactions of hatchery and wild fish… [which have] been identified as risk factors for wild populations.” The biological opinion describes in considerable detail the impacts hatchery programs might have on natural populations of Chinook salmon (Appendix A); the effects on coho salmon are typically much smaller, due to the species-specific nature of many of the interactions and relatively small overlap in habitat usage by the two species. Ecological effects of juvenile and adult hatchery-origin fish on natural-origin fish are discussed in Sections 2.4.2.2 and 2.4.2.3. Hatchery fish returning to the Lower Snake River Subbasin are expected to largely spawn and rear near the hatchery and not compete for space with spring Chinook or coho salmon. Some steelhead from the programs would stray into other rivers but not in numbers that would exceed the carrying capacities of natural production areas, or that would result in increased incidence of disease or predators. Predation by adult hatchery steelhead on juvenile natural-origin Chinook or coho salmon is unlikely due to timing differences and because adult salmon typically stop feeding by the time they reach spawning areas. Predation and competition by juvenile hatchery steelhead on juvenile natural-origin Chinook or coho salmon is small because these fish outmigrate relatively quickly and at sizes that limit these types of interactions.

3.3. Essential Fish Habitat Conservation Recommendations

For each of the potential adverse effects by the Proposed Action on EFH for Chinook and coho salmon, NMFS believes that the Proposed Action, as described in the HGMPs and the ITS (Section 2.8) includes the best approaches to avoid or minimize those adverse effects. Thus, NMFS has no conservation recommendations specifically for Chinook and coho salmon EFH. However, the Reasonable and Prudent Measures and Terms and Conditions included in the ITS sufficiently address potential EFH effects.

3.4. Supplemental Consultation

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

4. Data Quality Act Documentation and Pre-Dissemination Review

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

4.1. Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. NMFS has determined, through this ESA section 7 consultation, that operation of the six spring/summer Chinook salmon hatchery programs as proposed will not jeopardize ESA-listed species and will not destroy or adversely modify designated critical habitat. Therefore, NMFS can issue an ITS. The intended users of this opinion are the NMFS (permitting entity), and the USFWS LSRCP Office (funding entity). The scientific community, resource managers, and stakeholders benefit from the consultation through the anticipated increase in returns of salmonids to the Grande Ronde, Imnaha, and Tucannon Rivers, and through the collection of data indicating the potential effects of the operation on the viability of natural populations of Snake River steelhead. This information will improve scientific understanding of hatchery-origin Chinook salmon effects that can be applied broadly within the Pacific Northwest area for managing benefits and risks associated with hatchery operations. This opinion will be posted on NMFS' West Coast Region web site (http://www.westcoast.fisheries. noaa.gov). The format and naming adheres to conventional standards for style.

4.2. Integrity

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

4.3. Objectivity

Information Product Category: Natural Resource Plan

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

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

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

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

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6. APPENDIX A-FACTORS CONSIDERED WHEN ANALYZING HATCHERY EFFECTS

NMFS' analysis of the Proposed Action is in terms of effects the Proposed Action would be expected to have on ESA-listed species and on designated critical habitat, based on the best scientific information available. The effects, positive and negative, for the two categories of hatchery programs are summarized in Table 1. Generally speaking, effects range from beneficial to negative when programs use local fish[14] for hatchery broodstock, and from negligible to negative when programs do not use local fish for broodstock[15]. Hatchery programs can benefit population viability, but only if they use genetic resources that represent the ecological and genetic diversity of the target or affected natural population(s). When hatchery programs use genetic resources that do not represent the ecological and genetic diversity of the target or affected natural population(s), NMFS is particularly interested in how effective the program will be at isolating hatchery fish and at avoiding co-occurrence and effects that potentially disadvantage fish from natural populations. NMFS applies available scientific information, identifies the types of circumstances and conditions that are unique to individual hatchery programs, then refines the range in effects for a specific hatchery program. Analysis of a Proposed Action for its effects on ESA-listed species and on designated critical habitat depends on six factors. These factors are:

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

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

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

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

[14] The term "local fish" is defined to mean fish with a level of genetic divergence relative to the local natural population(s) that is no more than what occurs within the ESU or steelhead DPS (70 FR 37215, June 28, 2005).
[15] Exceptions include restoring extirpated populations and gene banks.

steelhead DPS recovery, the target viability for the affected natural population(s), and the environmental baseline including the factors currently limiting population viability.

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

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

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

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

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

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

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

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

However, NMFS recognizes that beneficial effects exist as well, and that the risks just mentioned may be outweighed under circumstances where demographic or short-term extinction risk to the population is greater than risks to population diversity and productivity. Conservation hatchery programs may accelerate recovery of a target population by increasing abundance faster than may occur naturally (Waples 1999). Hatchery programs can also be used to create genetic reserves for a population to prevent the loss of its unique traits due to catastrophes (Ford 2011).

NMFS also recognizes there is considerable debate regarding genetic risk. The extent and duration of genetic change and fitness loss and the short- and long-term implications and consequences for different species (i.e., for species with multiple life-history types and species subjected to different hatchery practices and protocols) remain unclear and should be the subject of further scientific investigation. As a result, NMFS believes that hatchery intervention is a legitimate and useful tool to alleviate short-term extinction risk, but otherwise managers should seek to limit interactions between hatchery and natural-origin fish and implement hatchery practices that harmonize conservation with the implementation of treaty Indian fishing rights and other applicable laws and policies (NMFS 2011d).

6.2.1. Genetic effects

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

First, within-population genetic diversity is a general term for the quantity, variety, and combinations of genetic material in a population (Busack and Currens 1995). Within-population diversity is gained through mutations or gene flow from other populations (described below under outbreeding effects) and is lost primarily due to genetic drift, a random loss of diversity due to population size. The rate of loss is determined by the population's effective population size (N_e), which can be considerably smaller than its census size. For a population to maintain genetic diversity reasonably well, the effective size should be in the hundreds (e.g., Lande 1987), and diversity loss can be severe if N_e drops to a few dozen.

Hatchery programs, simply by virtue of creating more fish, can increase N_e. In very small populations, this increase can be a benefit, making selection more effective and reducing other small-population risks (e.g., (e.g., Lacy 1987; Whitlock 2000; Willi et al. 2006). Conservation hatchery programs can thus serve to protect genetic diversity; several programs, such as the Snake River sockeye salmon program, are important genetic reserves. However, hatchery programs can also directly depress N_e by two principal methods. One is by the simple removal of fish from the population so that they can be used in the hatchery broodstock. If a substantial portion of the population is taken into a hatchery, the hatchery becomes responsible for that portion of the effective size, and if the operation fails, the effective size of the population will be reduced (Waples and Do 1994). Two is when N_e is reduced considerably below the census number of broodstock by using a skewed sex ratio, spawning males multiple times (Busack 2007), and by pooling gametes. Pooling semen is especially problematic because when semen of several males is mixed and applied to eggs, a large portion of the eggs may be fertilized by a single male (Gharrett and Shirley 1985; Withler 1988). An extreme form of N_e reduction is the Ryman-Laikre effect (Ryman et al. 1995; Ryman and Laikre 1991), when N_e is reduced through the return to the spawning grounds of large numbers of hatchery fish from very few parents. On the other hand, factorial mating schemes, in which fish are systematically mated multiple times, can be used to increase N_e (Busack and Knudsen 2007; Fiumera et al. 2004).

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

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

Gene flow from other populations can have two effects. It can increase genetic diversity (e.g., Ayllon et al. 2006), which can be a benefit in small populations, but it can also alter established allele frequencies (and co-adapted gene complexes) and reduce the population's level of adaptation, a phenomenon called outbreeding depression (Edmands 2007; McClelland and Naish 2007). In general, the greater the geographic separation between the source or origin of hatchery fish and the recipient natural population, the greater the genetic difference between the two populations (ICTRT 2007b), and the greater potential for outbreeding depression. For this reason, NMFS advises hatchery action agencies to develop locally derived hatchery broodstock. Additionally, unusual rates of straying into other populations within or beyond the population's MPG, salmon ESU, or a steelhead DPS can have an homogenizing effect, decreasing intra-population genetic variability (e.g.(Vasemagi et al. 2005), and increasing risk to population diversity, one of the four attributes measured to determine population viability. Reduction of within-population and among-population diversity can reduce adaptive potential.

The proportion of hatchery fish (pHOS)[16] among natural spawners is often used as a surrogate measure of gene flow. Appropriate cautions and qualifications should be considered when using this proportion to analyze outbreeding effects. Adult salmon may wander on their return migration, entering and then leaving tributary streams before spawning (Pastor 2004). These "dip-in" fish may be detected and counted as strays, but may eventually spawn in other areas, resulting in an overestimate of the number of strays that potentially interbreed with the natural population (Keefer et al. 2008). Caution must also be taken in assuming that strays contribute genetically in proportion to their abundance. Several studies demonstrate little genetic impact from straying despite a considerable presence of strays in the spawning population (Blankenship et al. 2007; Saisa et al. 2003). The causative factors for poorer breeding success of strays are likely similar to those identified as responsible for reduced productivity of hatchery-origin fish in general, e.g., differences in run and spawn timing, spawning in less productive habitats, and

[16] It is important to reiterate that as NMFS analyzes them, outbreeding effects are a risk only when the hatchery fish are from a different population than the naturally produced fish. If they are from the same population, then the risk is from hatchery-influenced selection.

reduced survival of their progeny (Leider et al. 1990; Reisenbichler and McIntyre 1977; Williamson et al. 2010).

Hatchery-influenced selection (often called domestication), the third major area of genetic effects of hatchery programs, occurs when selection pressures imposed by hatchery spawning and rearing differ greatly from those imposed by the natural environment and causes genetic change that is passed on to natural populations through interbreeding with hatchery-origin fish. These differing selection pressures can be a result of differences in environments or a consequence of protocols and practices used by a hatchery program. Hatchery-influenced selection can range from relaxation of selection that would normally occur in nature, to selection for different characteristics in the hatchery and natural environments, to intentional selection for desired characteristics (Waples 1999).

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

Most of the empirical evidence of fitness depression due to hatchery-influenced selection comes from studies of species that are reared in the hatchery environment for an extended period – one to two years – prior to release (Berejikian and Ford 2004). Exposure time in the hatchery for fall and summer Chinook salmon and Chum salmon is much shorter, just a few months. One especially well-publicized steelhead study (Araki et al. 2007; Araki et al. 2008), showed dramatic fitness declines in the progeny of naturally spawning Hood River hatchery steelhead. Researchers and managers alike have wondered if these results could be considered a potential outcome applicable to all salmonid species, life-history types, and hatchery rearing strategies, but researchers have not reached a definitive conclusion.

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

Critical information for analysis of hatchery-induced selection includes the number, location, and timing of naturally spawning hatchery fish, the estimated level of gene flow between hatchery-origin and natural-origin fish, the origin of the hatchery stock (the more distant the origin compared to the affected natural population, the greater the threat), the level and intensity of hatchery selection and the number of years the operation has been run in this way. Efforts to control and evaluate the risk of hatchery-influenced selection are currently largely focused on gene flow between natural-origin and hatchery-origin fish[17]. The Interior Columbia Technical Recovery Team (ICTRT) developed guidelines based on the proportion of spawners in the wild consisting of hatchery-origin fish (pHOS) (Figure 13).

More recently, the Hatchery Scientific Review Group (HSRG) developed gene-flow guidelines based on mathematical models developed by (Ford 2002) and by(Lynch and O'Hely 2001). Guidelines for isolated programs are based on pHOS, but guidelines for integrated programs are based also on a metric called proportionate natural influence (PNI), which is a function of pHOS and the proportion of natural-origin fish in the broodstock (pNOB)[18]. PNI is, in theory, a reflection of the relative strength of selection in the hatchery and natural environments; a PNI value greater than 0.5 indicates dominance of natural selective forces. The HSRG guidelines vary according to type of program and conservation importance of the population. When the underlying natural population is of high conservation importance, the guidelines are a pHOS of no greater than 5 percent for isolated programs. For integrated programs, the guidelines are a pHOS no greater than 30 percent and PNI of at least 67 percent for integrated programs (HSRG 2009). Higher levels of hatchery influence are acceptable, however, when a population is at high risk or very high risk of extinction due to low abundance and the hatchery program is being used to conserve the population and reduce extinction risk in the short-term. (HSRG 2004)offered additional guidance regarding isolated programs, stating that risk increases dramatically as the level of divergence increases, especially if the hatchery stock has been selected directly or indirectly for characteristics that differ from the natural population. The HSRG recently produced an update report (HSRG 2014) that stated that the guidelines for isolated programs may not provide as much protection from fitness loss as the corresponding guidelines for integrated programs.

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[17] Gene flow between natural-origin and hatchery-origin fish is often interpreted as meaning actual matings between natural-origin and hatchery-origin fish. In some contexts, it can mean that. However, in this document, unless otherwise specified, gene flow means contributing to the same progeny population. For example, hatchery-origin spawners in the wild will either spawn with other hatchery-origin fish or with natural-origin fish. Natural-origin spawners in the wild will either spawn with other natural-origin fish or with hatchery-origin fish. But all these matings, to the extent they are successful, will generate the next generation of natural-origin fish. In other words, all will contribute to the natural-origin gene pool.

[18] PNI is computed as pNOB/(pNOB+pHOS). This statistic is really an approximation of the true proportionate natural influence, but operationally the distinction is unimportant.

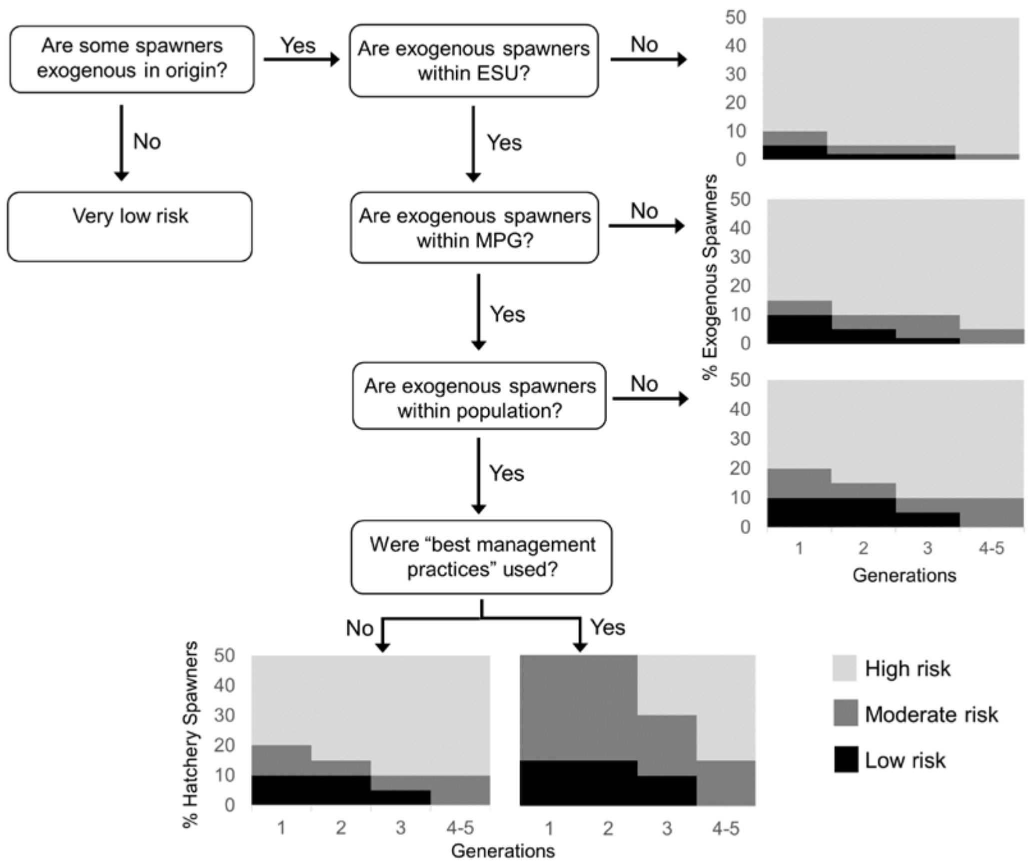

Figure 5. ICTRT (2007b) risk criteria associated with spawner composition for viability assessment of exogenous spawners on maintaining natural patterns of gene flow. Exogenous fish are considered to be all fish hatchery origin, and non-normative strays of natural origin.

Another HSRG team recently reviewed California hatchery programs and developed guidelines that differed considerably from those developed by the earlier group (California HSRG 2012). The California HSRG felt that truly isolated programs in which no hatchery-origin returnees interact genetically with natural populations were impossible in California, and was "generally unsupportive" of the concept. However, if programs were to be managed as isolated, they recommend a pHOS of less than 5 percent. They rejected development of overall pHOS guidelines for integrated programs because the optimal pHOS will depend upon multiple factors, such as "the amount of spawning by natural-origin fish in areas integrated with the hatchery, the value of pNOB, the importance of the integrated population to the larger stock, the fitness differences between hatchery- and natural-origin fish, and societal values, such as angling opportunity." They recommended that program-specific plans be developed with corresponding population-specific targets and thresholds for pHOS, pNOB, and PNI that reflect these factors. However, they did state that PNI should exceed 50 percent in most cases, although in supplementation or reintroduction programs the acceptable pHOS could be much higher than 5 percent, even approaching 100 percent at times. They also recommended for conservation programs that pNOB approach 100 percent, but pNOB levels should not be so high they pose demographic risk to the natural population.

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

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

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

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

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

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

In some cases, adjusting pHOS downward may be appropriate, however, particularly if there is strong evidence of a non-genetic component to RRS. Wenatchee spring Chinook salmon (Williamson et al. 2010) is an example case with potentially justified adjustment by RRS, where the spatial distribution of natural-origin and hatchery-origin spawners differs, and the hatchery-origin fish tend to spawn in poorer habitat. However, even in a situation like the Wenatchee spring Chinook salmon, it is unclear how much of an adjustment would be appropriate. By the same logic, it might also be appropriate to adjust pNOB in some circumstances. For example, if hatchery juveniles produced from natural-origin broodstock tend to mature early and residualize (due to non-genetic effects of rearing), as has been documented in some spring Chinook salmon and steelhead programs, the "effective" pNOB might be much lower than the census pNOB.

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

Additional perspective on pHOS that is independent of HSRG modelling is provided by a simple analysis of the expected proportions of mating types. Figure 14 shows the expected proportion of mating types in a mixed population of natural-origin (N) and hatchery-origin (H) fish as a function of the census pHOS, assuming that N and H adults mate randomly[19]. For example, at a census pHOS level of 10 percent, 81 percent of the matings will be NxN, 18 percent will be NxH, and 1 percent will be HxH. This diagram can also be interpreted as probability of parentage of naturally produced progeny, assuming random mating and equal reproductive success of all mating types. Under this interpretation, progeny produced by a parental group with a pHOS level of 10 percent will have an 81 percent chance of having two natural-origin parents, etc.

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

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[19] These computations are purely theoretical, based on a simple mathematical binomial expansion ($(a+b)^2=a^2 + 2ab + b^2$).

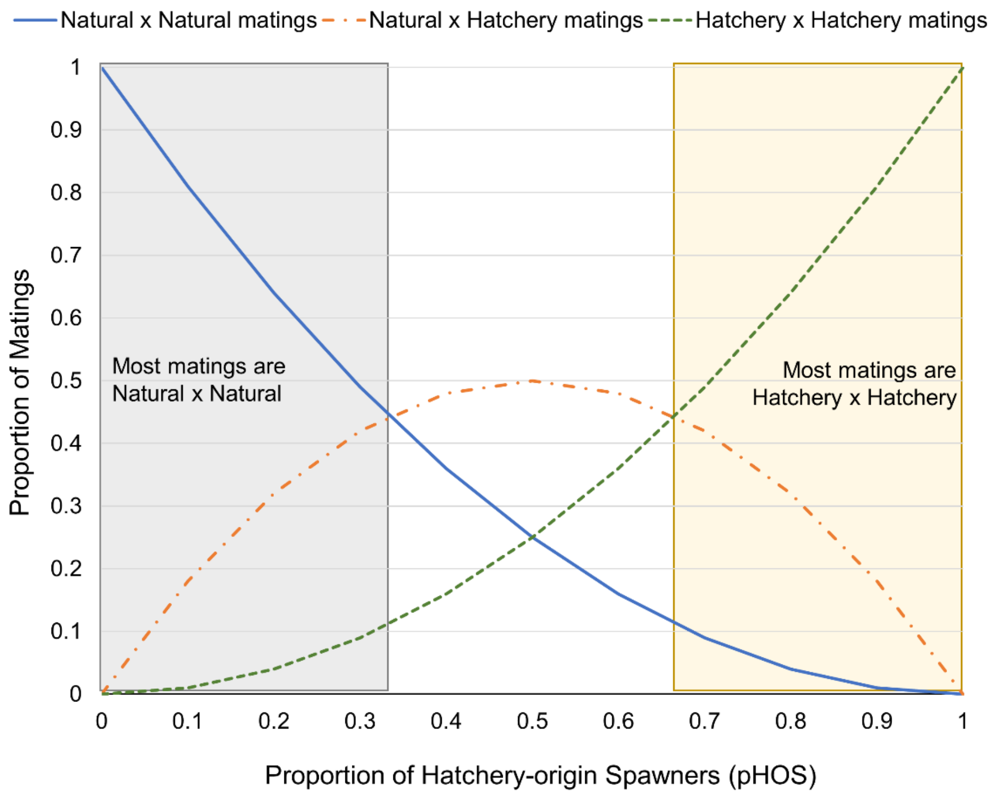

Figure 6. Relative proportions of types of matings as a function of proportion of hatchery-origin fish on the spawning grounds (pHOS).

6.2.2. Ecological effects

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

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

The added spawner density resulting from hatchery-origin fish spawning in the wild can have negative consequences at times. In particular, the potential exists for hatchery-derived fish to superimpose or destroy the eggs and embryos of ESA-listed species when there is spatial overlap between hatchery and natural spawners. Redd superimposition has been shown to be a cause of egg loss in pink salmon and other species (e.g., Fukushima et al. 1998).

6.2.3. Adult Collection Facilities

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

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

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

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

6.3.1. Competition

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

Specific hazards associated with competitive impacts of hatchery salmonids on listed natural-origin salmonids may include competition for food and rearing sites (NMFS 2012b). In an assessment of the potential ecological impacts of hatchery fish production on naturally produced salmonids, the Species Interaction Work Group (Rensel et al. 1984) concluded that naturally produced coho and Chinook salmon and steelhead are all potentially at "high risk" due to competition (both interspecific and intraspecific) from hatchery fish of any of these three species. In contrast, the risk to naturally produced pink, chum, and sockeye salmon due to competition from hatchery salmon and steelhead was judged to be low.

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

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

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

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

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

Critical to analyzing competition risk is information on the quality and quantity of spawning and rearing habitat in the action area,[20] including the distribution of spawning and rearing habitat by quality and best estimates for spawning and rearing habitat capacity. Additional important information includes the abundance, distribution, and timing for naturally spawning hatchery fish and natural-origin fish; the timing of emergence; the distribution and estimated abundance for progeny from both hatchery and natural-origin natural spawners; the abundance, size, distribution, and timing for juvenile hatchery fish in the action area; and the size of hatchery fish relative to co-occurring natural-origin fish.

6.3.2. Predation

Another potential ecological effect of hatchery releases is predation. Salmon and steelhead are piscivorous and can prey on other salmon and steelhead. Predation, either direct (consumption by hatchery fish) or indirect (increases in predation by other predator species due to enhanced attraction), can result from hatchery fish released into the wild. Considered here is predation by hatchery-origin fish, the progeny of naturally spawning hatchery fish, and avian and other predators attracted to the area by an abundance of hatchery fish. Hatchery fish originating from egg boxes and fish planted as non-migrant fry or fingerlings can prey upon fish from the local natural population during juvenile rearing. Hatchery fish released at a later stage, so they are more likely to emigrate quickly to the ocean, can prey on fry and fingerlings that are encountered during the downstream migration. Some of these hatchery fish do not emigrate and instead take up residence in the stream (residuals) where they can prey on stream-rearing juveniles over a more prolonged period, as discussed above. The progeny of naturally spawning hatchery fish also can prey on fish from a natural population and pose a threat. In general, the threat from

[20] "Action area" means all areas to be affected directly or indirectly by the action in which the effects of the action can be meaningfully detected and evaluated.

predation is greatest when natural populations of salmon and steelhead are at low abundance, when spatial structure is already reduced, when habitat, particularly refuge habitat, is limited, and when environmental conditions favor high visibility.

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

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

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

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

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

limiting the duration of interaction between hatchery fish and naturally produced fish present within, and downstream of, release areas.

- Releasing hatchery smolts in lower river areas near river mouths and below upstream areas used for stream-rearing young-of-the-year naturally produced salmon fry, thereby reducing the likelihood for interaction between the hatchery and naturally produced fish.
- Operating hatchery programs and releases to minimize the potential for residualism.

6.3.3. Disease

The release of hatchery fish and hatchery effluent into juvenile rearing areas can lead to transmission of pathogens, contact with chemicals or altering of environmental parameters (e.g., dissolved oxygen) that can result in disease outbreaks. Fish diseases can be subdivided into two main categories: infectious and non-infectious. Infectious diseases are those caused by pathogens such as viruses, bacteria, and parasites. Noninfectious diseases are those that cannot be transmitted between fish and are typically caused by genetic or environmental factors (e.g., low dissolved oxygen). Pathogens can also be categorized as exotic or endemic. For our purposes, exotic pathogens are those that have no history of occurrence within state boundaries. For example, *Oncorhynchus masou virus* (OMV) would be considered an exotic pathogen if identified anywhere in Washington state. Endemic pathogens are native to a state, but may not be present in all watersheds.

In natural fish populations, the risk of disease associated with hatchery programs may increase through a variety of mechanisms (Naish et al. 2008), including:

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

The transmission of pathogens between hatchery and natural fish can occur indirectly through hatchery water influent/effluent or directly via contact with infected fish. Within a hatchery, the likelihood of transmission leading to an epizootic (i.e., disease outbreak) is increased compared to the natural environment because hatchery fish are reared at higher densities and closer proximity than would naturally occur. During an epizootic, hatchery fish can shed relatively large amounts of pathogen into the hatchery effluent and ultimately, the environment, amplifying pathogen numbers. However, few, if any, examples of hatcheries contributing to an increase in disease in natural populations have been reported (Naish et al. 2008; Steward and Bjornn 1990). This lack of reporting is because both hatchery and natural-origin salmon and trout are susceptible to the same pathogens (Noakes et al. 2000), which are often endemic and ubiquitous (e.g., *Renibacterium salmoninarum,* the cause of Bacterial Kidney Disease).

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

In addition to the state, federal and tribal fish health policies, disease risks can be further minimized by preventing pathogens from entering the hatchery facility through the treatment of incoming water (e.g., by using ozone) or by leaving the hatchery through hatchery effluent (Naish et al. 2008). Although preventing the exposure of fish to any pathogens prior to their release into the natural environment may make the hatchery fish more susceptible to infection after release into the natural environment, reduced fish densities in the natural environment compared to hatcheries likely reduces the risk of fish encountering pathogens at infectious levels (Naish et al. 2008). Treating the hatchery effluent would also minimize amplification, but would not reduce disease outbreaks within the hatchery itself caused by pathogens present in the incoming water supply. Another challenge with treating hatchery effluent is the lack of reliable, standardized guidelines for testing or a consistent practice of controlling pathogens in effluent (LaPatra 2003). However, hatchery facilities located near marine waters likely limit freshwater pathogen amplification downstream of the hatchery without human intervention because the pathogens are killed before transmission to fish when the effluent mixes with saltwater.

Noninfectious diseases are those that cannot be transmitted between fish and are typically caused by genetic or environmental factors (e.g., low dissolved oxygen). Hatchery facilities routinely use a variety of chemicals for treatment and sanitation purposes. Chlorine levels in the hatchery effluent, specifically, are monitored with a National Pollutant Discharge Elimination System (NPDES) permit administered by the Environmental Protection Agency. Other chemicals are discharged in accordance with manufacturer instructions. The NPDES permit also requires monitoring of settleable and unsettleable solids, temperature, and dissolved oxygen in the hatchery effluent on a regular basis to ensure compliance with environmental standards and to prevent fish mortality. In contrast to infectious diseases, which typically are manifest by a limited number of life stages and over a protracted time period, non-infectious diseases caused by environmental factors typically affect all life stages of fish indiscriminately and over a relatively short period of time. One group of non-infectious diseases that are expected to occur rarely in current hatchery operations are those caused by nutritional deficiencies because of the vast literature available on successful rearing of salmon and trout in aquaculture.

6.3.4. Acclimation

One factor the can affect hatchery fish distribution and the potential to spatially overlap with natural-origin spawners, and thus the potential for genetic and ecological impacts, is the acclimation (the process of allowing fish to adjust to the environment in which they will be released) of hatchery juveniles before release. Acclimation of hatchery juvenile before release increases the probability that hatchery adults will home back to the release location, reducing their potential to stray into natural spawning areas. Acclimating fish for a period of time also allows them to recover from the stress caused by the transportation of the fish to the release location and by handling. (Dittman and Quinn 2008) provide an extensive literature review and introduction to homing of Pacific salmon. They note that, as early as the 19th century, marking studies had shown that salmonids would home to the stream, or even the specific reach, where they originated. The ability to home to their home or "natal" stream is thought to be due to odors to which the juvenile salmonids were exposed while living in the stream (olfactory imprinting) and migrating from it years earlier (Dittman and Quinn 2008; Keefer and Caudill 2013). Fisheries managers use this innate ability of salmon and steelhead to home to specific streams by using acclimation ponds to support the reintroduction of species into newly accessible habitat or into areas where they have been extirpated (Dunnigan 2000; Quinn 1997; YKFP 2008).

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

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

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

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

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

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

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

6.4.1. Observing/Harassing

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

6.4.2. Capturing/handling

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

6.4.3. Fin clipping and tagging

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

In addition to fin clipping, PIT tags and CWTs are included in the Proposed Action. PIT tags are inserted into the body cavity of the fish just in front of the pelvic girdle. The tagging procedure requires that the fish be captured and extensively handled, so it is critical that researchers ensure that the operations take place in the safest possible manner. Tagging needs to take place where there is cold water of high quality, a carefully controlled environment for administering anesthesia, sanitary conditions, quality control checking, and a recovery holding tank.

Most studies have concluded that PIT tags generally have very little effect on growth, mortality, or behavior. Early studies of PIT tags showed no long-term effect on growth or survival (Prentice et al. 1987; Prentice and Park 1984; Rondorf and Miller 1994). In a study between the tailraces of Lower Granite and McNary Dams (225 km), (Hockersmith et al. 2000) concluded that the performance of yearling Chinook salmon was not adversely affected by orally or surgically implanted sham radio tags or PIT tags. However, (Knudsen et al. 2009) found that, over several brood years, PIT tag induced smolt-adult mortality in Yakima River spring Chinook salmon averaged 10.3 percent and was at times as high as 33.3 percent.

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

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

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

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

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

6.5. Factor 5. Construction, operation, and maintenance, of facilities that exist because of the hatchery program

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

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

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

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

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