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

Nine Snake River Steelhead Hatchery Programs and one Kelt Reconditioning Program in Idaho
Reinitiation 2020

NMFS Consultation Number: WCRO-2020-00624 (previously WCRO-2017-7286)

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

Affected Species and Determinations:

ESA-Listed Species	**Status**	**Is Action Likely to Adversely Affect Species?**	**Is Action Likely to Jeopardize the Species?**	**Is 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
Snake River	Threatened	Yes	No	No

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

Issued By:

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Date: July 22, 2020

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1. INTRODUCTION

This introduction section provides information relevant to the other sections of this document and is incorporated by reference into Sections 2 and 3 below. The underlying activities that drive the Proposed Actions are the operation and maintenance of ten hatchery programs rearing and releasing Snake River steelhead in the Snake River basin. The hatchery programs are operated by Federal, state, and/or tribal agencies as described in Table 1. Each program is described in detail in a Hatchery and Genetic Management Plan (HGMP) or proposed actions, which were submitted to the National Marine Fisheries Service (NMFS) for review, as well as the most recent Annual Operating Plans and Standard Operating Procedures available on the US Fish and Wildlife Service, Lower Snake River Compensation Plan Office (LSRCP) website.

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

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

Program	HGMP Receipt	Program Operator[1]	Funding Source	Program Type and Purpose	ESA Pathway
Steelhead Streamside Incubator (SSI) Project	June 2010	SBT	TBD[2]	Segregated Supplementation	4(d) Tribal rule
Dworshak National Fish Hatchery B-Run Steelhead	April 2010	NPT and USFWS	ACOE, USFWS, and LSRCP[3]	Segregated Harvest	Section 7
East Fork Salmon Natural A-run Steelhead	December 2009	IDFG	LSRCP	Integrated Recovery	4(d) Limit 6
Hells Canyon Snake River A-run Summer Steelhead	September 2011	IDFG	IPC	Segregated Harvest	4(d) Limit 6
Little Salmon River A-run Summer Steelhead	September 2011	IDFG	IPC and LSRCP	Segregated Harvest	4(d) Limit 6
Pahsimeroi A-run Summer Steelhead	September 2011	IDFG	IPC	Segregated Harvest	4(d) Limit 5
South Fork Clearwater (Clearwater Hatchery) B-Run Steelhead	November 2011	IDFG	LSRCP	Segregated Harvest	4(d) Limit 6
Upper Salmon River A-Run Steelhead	November 2011	IDFG	LSRCP	Segregated Harvest	Section 7
Salmon River B-Run Steelhead	November 2011	IDFG and SBT	LSRCP	Segregated Harvest	4(d) Limit 5
Snake River Kelt Reconditioning	Not Applicable	NPT	CRITFC and BPA	Kelt Reconditioning	4(d) Tribal rule

[1] Primary operators are listed, but all programs are coordinated between Idaho, Tribes, and Federal agencies collectively. Operators and funders are: U.S. Fish and Wildlife Service (USFWS), USFWS Lower Snake River Compensation Plan Office (LSRCP), Idaho Power Company (IPC), U.S. Army Corps of Engineers (ACOE), Idaho Fish and Game (IDFG), Nez Perce Tribe (NPT), Shoshone-Bannock Tribes (SBT), Bonneville Power Administration (BPA), and the Columbia River Inter-Tribal Fish Commission (CRITFC); TBD = To be decided.

[2] Future funding sources for the SSI program are under consideration. Past funders include: Bureau of Indian Affairs (638 Grant program); BPA; LSRCP; Pacific Coastal Salmon Recovery Fund.

[3] FWS shares in facility operation costs at DNFH, and LSRCP shares in infrastructure repair/replacement costs at DNFH; these costs support both the COE steelhead and LSRCP spring Chinook programs at this facility.

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 USC 1531, et seq.), and implementing regulations at 50 CFR 402, as amended. The opinion documents consultation on the action proposed by NMFS, the U.S. Fish and Wildlife Service (USFWS), the USFWS Lower Snake River Compensation Plan (LSRCP), the U.S. Army Corps of Engineers (ACOE), and the Bonneville Power Administration (BPA).

We also completed an essential fish habitat (EFH) consultation on the proposed action, in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 USC 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 within two weeks at the NOAA Library Institutional Repository. 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 River Basin followed the first listings of Columbia River Basin salmon under the ESA. Snake River sockeye salmon were listed as an endangered species on November 20, 1991, Snake River spring/summer Chinook salmon and Snake River fall Chinook salmon were listed as threatened species on April 22, 1992, and the first hatchery consultation and opinion was completed on April 7, 1994 (NMFS 1994). The 1994 opinion was superseded by "Endangered Species Act Section 7 Biological Opinion on 1995-1998 Hatchery Operations in the Columbia River Basin, Consultation Number 383" completed on April 5, 1995 (NMFS 1995). This opinion determined that hatchery actions jeopardize listed Snake River salmon and required implementation of reasonable and prudent alternatives (RPAs) to avoid jeopardy.

A new opinion was completed on March 29, 1999, after 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 2002). HGMPs were submitted to NMFS under RPA 169; however, many were incomplete and, therefore, were not found to be ready for ESA review.

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 7 consultation, the effects of future operations cannot be included in the baseline. In some instances, effects are ongoing (e.g., returning adults from past hatchery practices) and included in this analysis despite the fact that future operations cannot be included in the baseline. The Proposed Action does not encompass hatchery operations per se, and therefore no incidental take coverage is offered through this biological opinion to hatcheries operating in the region. Instead, we expect the operators of each hatchery to address its obligations under the ESA in separate consultations, as required" (see NMFS 2008d, p. 5-40).

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

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

The previous opinion (NMFS 2017g) on the operation of nine steelhead hatchery programs and a kelt reconditioning program was based on a series of documents submitted to NMFS by the co-managers and the funding agencies. Because 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 between 2002 and 2011 (Table 1). In March of 2017, NMFS used these draft HGMPs as well as the most recent Annual Operating Plan for each program to draft a Proposed Action. The applicants then edited the Proposed Action for accuracy, and submitted the Proposed Action for all nine programs along with their HGMPs to NMFS to serve as the official request for formal consultation (Chandler 2017; Delarosa 2017; Hebdon 2017; Kennedy 2017; Largo 2017; Schaller 2017; Small 2017). NMFS then drafted sufficiency letters (Purcell 2017a; Purcell 2017b; Purcell 2017c; Purcell 2017d; Purcell 2017e; Purcell 2017f).

This opinion was reinitiated to evaluate the effects of some requested changes to the Proposed Action (Section 1.3), to incorporate new information about tributary harvest management (Section 2.4.4) and monitoring data related to Passive Integrated Transponder (PIT) tag arrays throughout the action area (Section 2.5.2.2.1). We also simplified the data in Table 14 (Table 16 in the previous opinion) so that it reflected hatchery and wild detections, and did not conflate this with an attempt to elucidate straying because straying was best represented by the subsequent two tables. This consultation evaluates the effects of the hatchery programs on all ESU and DPSs of salmon and steelhead in the Snake River Basin under the ESA, and their designated critical habitat. It also evaluates the effects of the programs on Essential Fish Habitat (EFH) under the Magnuson-Stevens Fishery and Conservation Management Act.

1.3. Proposed Federal Action

Under the ESA, "action," means all activities, of any kind, authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR 402.02). Under MSA, Federal action means any authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken by a Federal Agency (50 CFR 600.910). Because the actions of the Federal agencies are subsumed within the effects of the hatchery program, and any associated research, monitoring and evaluation, the details of each hatchery program are summarized in this section.

The objective of this Proposed Action is to document the determination of likely effects on ESA-listed salmon and steelhead and their designated critical habitat resulting from operation and maintenance of the nine steelhead hatchery programs, and one steelhead kelt reconditioning program. This document evaluates whether the Proposed Actions comply with the provisions of Section 7(a)(2) of the ESA, and, as pertinent, ESA Section 4(d) (Limit 5 for artificial propagation and Limit 6 for resource management plans developed jointly by states and tribes within the *U.S. v. Oregon* or *U.S. v. Washington* constructs) or the Tribal 4(d) rule. The duration of the Proposed Action is intended to be ongoing.

There are four Proposed Actions we consider in this Opinion:

- The Proposed Action for the U.S. Fish and Wildlife Service (USFWS) is its funding of the operation, maintenance, monitoring, and evaluation of the Little Salmon River A-run and), East Fork Salmon natural A-run, South Fork Clearwater (Clearwater Hatchery) B-run, Upper Salmon A-Run, and Salmon River B-run steelhead hatchery programs. Funding is provided through the Lower Snake River Compensation Plan (LSRCP), which is approved by the Water Resources Development Act of 1976, (Public Law 94-587, Section 102, 94th Congress).
- The Proposed Action for the Bonneville Power Administration (BPA) is the funding of the Kelt Reconditioning Program and associated monitoring and evaluation under the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (Northwest Power Act) (16 U.S.C. sections 839 et seq.) to protect, mitigate, and enhance anadromous salmon affected by the Federal Columbia River Power System dams.
- The Proposed Action for the ACOE is the funding of the operations, maintenance, fish health monitoring, and monitoring and evaluation of the Dworshak National Fish Hatchery (DNFH) North Fork B-run Steelhead Program. The majority of DNFH smolts are released at the hatchery. In collaboration with regional partners, some DNFH steelhead are outplanted to Lolo Creek, Clear Creek, and the South Fork Clearwater River. Any additional actions associated with such outplants may require specific Congressional authority and will require further coordination between the ACOE and regional fish managers.
- The Proposed Action for NMFS is a proposed approval of hatchery programs under

section 4(d) limit 5, or a determination under section 4(d) limit 6 or the Tribal 4(d) rule, for a subset of programs as defined in Table 1.

NMFS has considered, under the ESA, whether or not the proposed action would cause any other activities and determined that it would not. Specifically, fisheries are not caused by 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 are considered a separate action.

There are also existing mainstem Columbia River and ocean fisheries that may catch fish from these programs. However, these mixed fisheries would exist with or without these programs, and have previously been evaluated in a separate biological opinion (NMFS 2008b). Finally, this Opinion does account broadly for the effects of fisheries, as part of the species status, baseline and cumulative effects discussions.

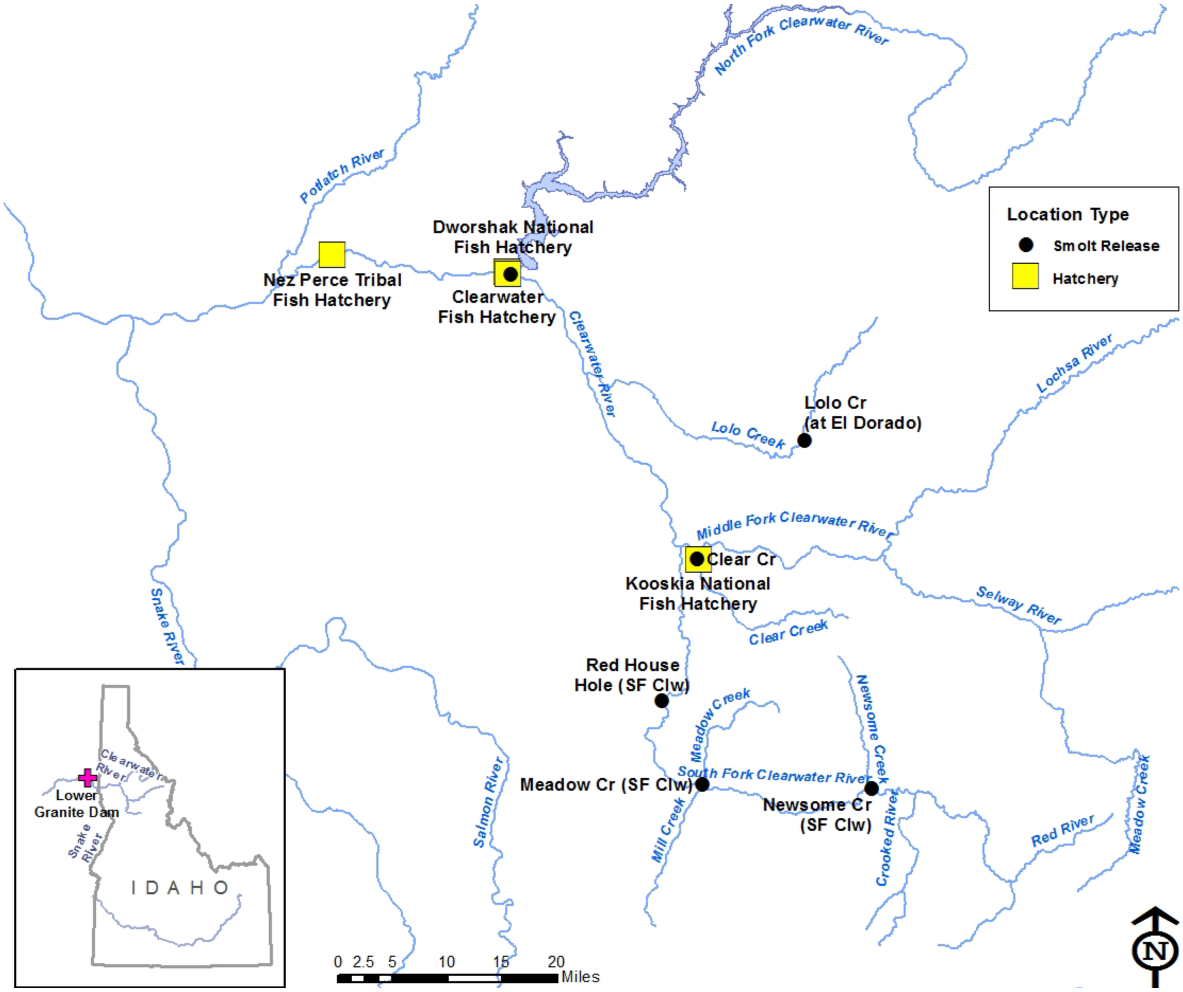

Figure 1. Location of facilities in the Clearwater River Basin used in the Proposed Action.

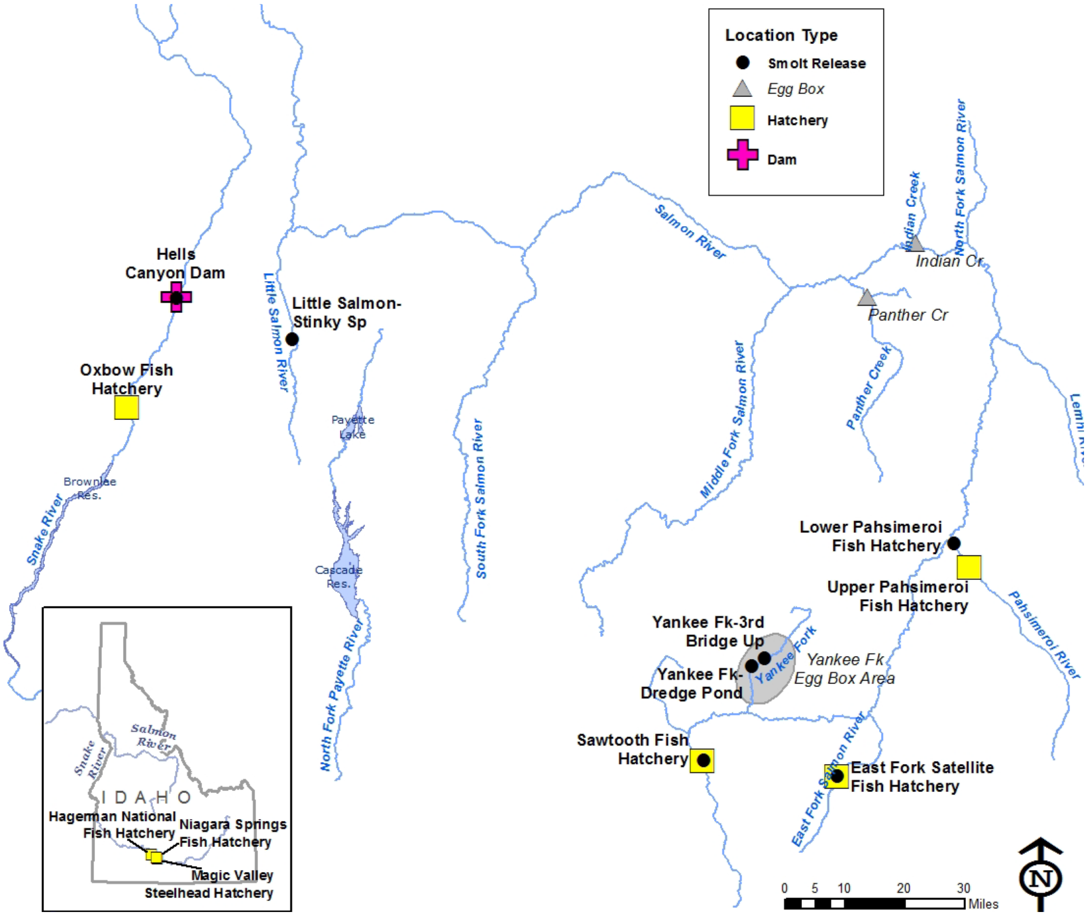

Figure 2. Location of facilities in the Salmon and Snake river basins used in the Proposed Action. Eggboxes in this figure indicate locations of steelhead streamside incubators.

1.3.1. Proposed hatchery broodstock collection

Broodstock collection occurs as depicted in Table 2. For the three segregated A-run programs in the Salmon and Snake river basins that collect broodstock (Upper Salmon, Pahsimeroi, Hells Canyon), the 2nd choice broodstock collection options are intended to function as contingency brood collection locations in the event that brood needs are unlikely to be met using the primary collection site. For this purpose, brood will be collected at the 2nd choice collection site, but fish will be spawned, fertilized, and incubated to the egg/juvenile stage before moving to the primary facility.

Broodstock collection for the B-run program in the Salmon Basin currently occurs primarily at Pahsimeroi Fish Hatchery (PFH) with a portion provided by DNFH, and with some collection in Yankee Fork. In the event that not enough B-run steelhead return to the Snake River Basin for hatchery broodstock, the Salmon River B-run program may use A-run steelhead from either Pahsimeroi, Oxbow, or Sawtooth Hatcheries to backfill to ensure the production goals are met.

However, operators will ensure that mating of the two run types is kept separate using differential marks and tags.

The Oxbow trap (at Hells Canyon Dam) is typically operated three days per week, up to eight hours per day, during the fall and spring periods until target brood numbers are reached; fish are processed each day. Pahsimeroi and Sawtooth traps are operated 24 hours per day, seven days per week. Fish are processed up to five times per week. The East Fork trap is operated 24 hours per day, seven days per week, and fish are processed daily. With the exception of the East Fork Salmon River, and Hells Canyon steelhead program, all natural-origin steelhead are passed upstream of the weirs (on the East Fork Salmon River, some natural-origin steelhead are retained for broodstock). The Yankee Fork picket weirs are operated and checked daily during the broodstock collection period.

Table 2. Broodstock collection details. SFH = Sawtooth Fish Hatchery; PFH = Pahsimeroi Fish Hatchery; DNFH = Dworshak National Fish Hatchery; HC = Hells Canyon; SF = South Fork; NF = North Fork; EF = East Fork; KNFH = Kooskia National Fish Hatchery; SSI = Steelhead streamside incubator; LGD = Lower Granite Dam Trap.

Program	Source	Collection Location(s)	Collection Method	Collection Target (females only)[1]	Collection Duration	pNOB
East Fork Salmon Natural A-run	Local hatchery- and natural-origin	EF Salmon River Satellite	Weir and trap	~14	March-May	up to 100%
Upper Salmon River A-run	Hatchery fish in Snake and Salmon Rivers	SFH 1st; lower PFH 2nd	Weir and trap	~447	March-April	0
Hells Canyon A-run	Hatchery fish in Snake River	Hells Canyon1st; lower PFH and SFH 2nd	Ladder and trap	~375	October-Nov, March-April	0
Pahsimeroi A-Run	Hatchery fish in Pahsimeroi River	Lower PFH 1st, SFH 2nd	Weir and trap	~456	February-May	0
Little Salmon River A-run	Receives juveniles from the Pahsimeroi and Hells Canyon A-run programs and does not collect additional brood					
SSI A-run	Receives eggs from the Pahsimeroi A-run program and does not collect additional brood					
Dworshak B-run	NF Clearwater River B-run	DNFH, KNFH, LGD, SF Clearwater	Ladder and trap; Angling[2]	~ 600	October-April (DNFH, LGD); March-May (KNFH); Angling mid Feb-early April	0
SF Clearwater B-run	NF Clearwater River B-run	SF Clearwater River, DNFH, KNFH, LGD	Ladder and trap; Angling[2]	~193		0

Salmon River B-run	DNFH[3]	PFH, Yankee Fork, DNFH, LGD, SFCW	Weir and trap	~347	October-April (LGD); February-April (PFH); April-May (Yankee Fork)	0
SSI B-run	Receives eggs from the Salmon River B-run program and does not collect additional brood					

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[1] Similar number of males will also be collected.
[2] The effects of angling are subsumed in the larger fishery action, which is not a part of this Proposed Action, though angling effects are considered generally as part of the baseline and cumulative effects.
[3] Although this was the original donor source, current broodstock is primarily fish trapped in the Upper Salmon River.

1.3.2. **Proposed hatchery rearing and juvenile release**

The details of hatchery juvenile rearing and release, including release numbers, marking/tagging, rearing and release locations, and release timing can be found in Table 3. A few programs have contingency plans in place for backfilling programs in the event of a broodstock shortfall. Priority backfill for the Salmon River B-run program is DNFH and/or Clearwater Hatchery. If no B-run backfill broodstock are available, the co-managers may increase the A-run program in the Little Salmon River to fill the shortfall; no A-run releases are to occur in the Yankee Fork.

If a broodstock shortfall occurs for the Hells Canyon A-run program, production will be backfilled with A-run juveniles/eyed-eggs from either Pahsimeroi or Sawtooth Hatchery. The Pahsimeroi Hatchery A-run program would only be backfilled with steelhead from Sawtooth Hatchery and vice versa.

Some additional detail on fish health protocols follows. Prior to hatching, dead eggs are picked on a regular schedule (approximately two times per week) to discourage the spread of fungus. During rearing, regular fish health inspections are conducted. If disease agents are suspected or identified, more frequent inspections will be conducted. Recommendations for treating specific disease agents comes from the Idaho Department of Fish and Game Fish Health Laboratory in Eagle, Idaho, or from the USFWS Pacific Region Fish Health Program Office in Orofino, Idaho. Prior to release, final pre-release fish health inspections are conducted by these offices for their respective programs. All fish production is conducted according to the USFWS - National Fish Health Policy (USFWS 2004), PNFHPC (1989), Integrated Hatchery Operations Team (IHOT) policies and guidelines (IHOT 1995), and as described in the most recent Annual Operating Plan.

Table 3. Proposed annual release protocols for each program. AD = adipose fin clip; CWT = coded-wire tag; PIT = passive integrated transponder tag; PBT =Parentage-Based Tagging; SSI = Steelhead Streamside Incubator; HNFH = Hagerman National Fish Hatchery; NSFH = Niagara Springs Fish Hatchery; MVFH = Magic Valley Fish Hatchery.

Program	Number, life stage, and size (fpp)	Marking and Tagging[1]	Rearing Location	Acclimation Site; Duration	Volitional Release?	Release Location	Release Time
East Fork Salmon Natural A	60,000 yearling; 4.5	100% CWT and PBT; ~15% PIT	HNFH	None	No	East Fork Salmon River	Early May
Pahsimeroi A	800,000 yearling; 4.5	100% ad and PBT; ~1% PIT	NSFH	None	No	PFH	April
Upper Salmon River A	1,779,000 yearling; 4.5	100% ad and PBT; ~2% PIT	HNFH/MVFH	None	No	Sawtooth Fish Hatchery Weir	March -April
SSI Project A	400,000 eyed-egg	100% PBT	Panther Creek	Panther Creek	Yes	Panther Creek	May-July
	100,000 eyed-egg		Indian Creek	Indian Creek	Yes	Indian Creek	
Hells Canyon A	550,000 yearling; 4.5	100% ad and PBT; ~2% PIT	NSFH	None	No	Snake River below Hells Canyon Dam	March-April
Little Salmon River A	250,000 yearling ; 4.5	100% ad and PBT; ~1% PIT	NSFH	None	No	Little Salmon River-Stinky Springs	April
	186,000 yearling; 4.5		MVFH	None	No		
	200,000 yearling; 4.5		NSFH	None	No		
Dworshak B	1,200,000 yearling; 6	100% ad and PBT; ~10% CWT; ~2% PIT	DNFH	DNFH	No	Clearwater River	Mid-April
	400,000 yearling; 6	100% ad and PBT; ~10% CWT; ~2% PIT	DNFH	DNFH	No	SF Clearwater-Red House Hole	
	300,000 yearling; 6	100% ad and PBT; ~7% CWT; ~2% PIT	DNFH	DNFH	No	Clear Creek	
	200,000 yearling; 6	100% PBT; ~2% PIT	DNFH	DNFH	No	Lolo Creek	
SF Clearwater (Clearwater Hatchery) B	501,000 yearling; 4.5	100% PBT; ~58% ad; 42% CWT; ~2% PIT	CFH	None	No	SF Clearwater-Meadow Creek	April
	219,000 yearling; 4.5	100% ad and PBT; ~2% PIT				SF Clearwater-Red House Hole	

	123,000 yearling; 4.5	100% CWT and PBT; ~1% PIT				SF Clearwater-Newsome Creek	
Salmon River B	344,000 yearling; 4.5	100% CWT and PBT; 3% PIT	MVFH	None	No	Pahsimeroi Weir[2]	April
	524,000 yearling; 4.5	100% PBT; 77% ad; 23% CWT; ~3% PIT	MVFH	None and/or Yankee Fork; hours-few days	No	Yankee Fork	April-May
	217,000 yearling; 4.5	100% ad and PBT; 1% PIT	MVFH	None	No	Little salmon River	April
SSI Project B	500,000 eyed-egg	100% PBT	Yankee Fork	Yankee Fork	Yes	Yankee Fork	April

[1] Funding for PIT tags come from multiple sources.

[2] To be released in Yankee Fork in the future.

1.3.3. **Proposed disposition of excess juvenile and adult hatchery fish, broodstock and post-spawned carcasses**

All programs strive to meet and not exceed production goals. However, given that in-hatchery survival metrics change from year to year at all life stages, and because accidental losses can occur, managers desire some flexibility to ensure the highest probability of meeting release goals, without creating significant excesses. Programs currently use the most recent 5-year average of in-hatchery performance data to determine how many adults need to be trapped to accurately meet their goals.

To ensure goals are met for each program, hatchery managers have agreed to target the release number as specified in the Proposed Action. However, because of the variability in within-hatchery survival in any given year caused by; low adult holding survival, unexpected drops in trapping success, low egg fecundity in spawned females, poor juvenile survival, fish pathogen impacts, diminished water quality, human error, power outages, etc., some flexibility is needed. Therefore, the proposed action includes juvenile release targets that include a cushion, not to exceed an additional 10 percent of each program's, or in the case of the Clearwater, Subbasin's, release target, annually, which must be approved by the co-managers as part of the AOP process.

Table 4. Proposed disposition protocols for steelhead in excess of hatchery program requirements.

Program(s)	Lifestage	Disposition
Hells Canyon, Little Salmon A	Adults	● given to tribes, the public, or food banks ● trap and haul to non-anadromous waters for fisheries ● nutrient enhancement in local watersheds
	Juveniles	● culled ● outplanted in local reservoirs not conducive to anadromy
Pahsimeroi A	Adults	● trap and haul to non-anadromous waters for fishery, or given to tribes, the public, or food banks ● given to rendering plants or landfills for disposal ● nutrient enhancement in local watersheds
	Juveniles	● outplanted in local reservoirs not conducive to anadromy
Upper Salmon A, Salmon River B	Adults	● given to tribes, the public, or food banks ● given to rendering plants or landfills for disposal ● outplanted upstream for tribal fishery (Yankee Fork) ● nutrient enhancement (Yankee Fork; Salmon River)
	Juveniles	● outplanted in local reservoirs not conducive to anadromy
East Fork Salmon Natural and SSI A and B	Adults	● released upstream for natural production ● nutrient enhancement (strays only)
Dworshak B	Adults	● outplanted for natural production ● sampled for CWTs ● released into South Fork Clearwater River for harvest ● given to tribes, the public, or food banks

		● used to feed captive bears and eagles ● used for research ● nutrient enhancement
	Juveniles	● used as food for the kelt reconditioning program or sturgeon projects ● outplanting of eggs into the North Fork and/or South Fork Clearwater[1] not to exceed 20 percent of the juvenile target release number in any given year
SF Clearwater (Clearwater Hatchery) B	Adults	● released into South Fork Clearwater River for harvest ● sampled for CWTs ● given to tribes, the public, or food banks ● used to feed captive bears and eagles ● used for research ● given to rendering plants or landfills for disposal
	Juveniles	● used as food for the kelt reconditioning program or sturgeon projects ● outplanting of eggs into the North Fork and/or South Fork Clearwater[1] not to exceed 20 percent of the juvenile target release number in any given year

[1] The location of outplanted eggs is dependent on their parentage; eggs from North Fork parents will be outplanted in the North Fork Clearwater, and eggs from South Fork parents will be outplanted in the South Fork Clearwater.

1.3.4. **Proposed research, monitoring, and evaluation (RM&E)**

Table 5. Proposed research, monitoring, and evaluation associated with hatchery programs; DNFH = Dworshak National Fish Hatchery.

Activity	Purpose	Associated Program
Adult trapping and tissue sampling at hatchery traps/weirs for recording: date, sex, length, origin (hatchery or natural), marks/tags, and disposition	Identify and track returns to all trapping facilities; maintain PBT genetic identification; identify potential straying of steelhead released at other locations	All programs
PIT tagging of adipose-clipped hatchery-origin steelhead at Lower Granite Dam	To improve detection of hatchery-origin fish from the proposed programs on the spawning grounds	All programs
Monitoring of survival metrics for all life stages in the hatchery from spawning to release.	Track program performance and identify limiting factors	All programs
PIT tagging representative groups of hatchery juvenile steelhead	Estimate migration timing, outmigration survival rate, and adult returns	All programs
Direct stream versus acclimated fish releases	Evaluate homing efficiency between release strategies	Salmon River B-run
Monitor and document numbers of non-DNFH fish present in DNFH's water	To monitor effects of the DNFH facility on listed natural-origin fish.	DNFH

system throughout the year. Collect a portion, and sample for genetics, species, run, and origin		
Electrofishing for juvenile steelhead in the Yankee Fork and Panther Creek	Determine distribution, age structure, origin, abundance, and productivity	Salmon River B-run
Using rotary screw traps to insert PIT tags into hatchery and natural-origin juveniles	Evaluate juvenile emigration timing, survival from release to Lower Granite Dam, natural-origin abundance/productivity, and parentage	SSI

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 meetings have taken place regularly since March 2017. The results from workgroup-generated efforts are intended to enhance program assessments/evaluations to allow for adaptive management of ongoing steelhead programs throughout the Snake Basin.

1.3.5. **Proposed operation and maintenance of hatchery facilities**

Water at all facilities is withdrawn in accordance with state-issued water rights (Table 6) except for DNFH where water withdrawals are pursuant to federally reserved water rights (Winters Doctrine). All facilities that rear over 20,000 pounds of fish and feed more than 5,000 pounds of feed at any one time operate under a National Pollutant Discharge Elimination System (NPDES) permit issued by the Environmental Protection Agency (Table 6).

Routine Maintenance

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

- In-water work will:
    - Be done during the allowable freshwater work times established for each location, or comply with an approved variance of the allowable freshwater work times with the appropriate state 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. Details for those facilities that divert water for hatchery operations; SSI = steelhead streamside incubator; NA = not applicable; UD = undetermined.

Facilities	Surface Water (cfs)	Ground /Spring Water (cfs)	Water Diversion Distance (km)	Water source	Discharge Location	Instream Structures	Meet NMFS Screening Criteria?	NPDES Permit #	Water Right Permit #
Magic Valley Fish Hatchery	NA	87.2	NA	Crystal Springs	NA	NA	NA	IDG130016	36-07033
Niagara Springs Fish Hatchery	NA	120	NA	Niagara Springs	NA	NA	NA	IDG130013	36-02704
Hagerman National Fish Hatchery	NA	84.6	NA	Springs	NA	NA	NA	IDG13004	36-00128; 36-00130; 36-00132; 36-15444; 36-15446; 36-15448A; 36-15448B; 36-15449; 36-15450; 36-15451
East Fork Salmon River Satellite	15	NA	200	East Fork Salmon River	East Fork Salmon River	2: Intake, outfall	LSRCP currently evaluating[1]	NA	72-07185
Dworshak National Fish Hatchery	182[2]	NA	0.0, 3.0[3]	North Fork Clearwater River	North and Middle Fork Clearwater River	3: Intake; Outfalls (2); Ladder	No	IDG131003	NA[4]
SSI: Panther Creek, Beaver Creek 2	0.021	NA	0.015	Beaver Creek	Panther Creek	1: Diversion	UD[5]	NA	NA
SSI: Panther Creek, Beaver Creek 3	0.021	NA	0.015	Beaver Creek	Panther Creek	1: Diversion	UD[5]	NA	NA
SSI: Panther Creek, Beaver Creek 4	0.021	NA	0.015	Beaver Creek	Panther Creek	1: Diversion	UD[5]	NA	NA
SSI: Indian Creek 1	NA	0.021	0.015	Indian Creek	Indian Creek	1: Diversion	UD[5]	NA	NA
SSI: Indian Creek 2	NA	0.021	0.1	Indian Creek	Indian Creek	2: Diversion, Headbox	UD[5]	NA	NA

SSI: Yankee Fork, Cearly Creek	0.021	NA	0.1	Cearly Creek	Cearly Creek	2: Diversion, Headbox	UD[5]	NA	NA
SSI: Yankee Fork, Swift Gulch	0.021	NA	0.1	Swift Gulch	Swift Gulch	2: Diversion, Headbox	UD[5]	NA	NA
SSI: Yankee Fork, Ramey Creek	0.021	NA	0.1	Ramey Creek	Ramey Creek	2: Diversion, Headbox	UD[5]	NA	NA
SSI: Yankee Fork, Greylock Creek	0.021	NA	0.1	Greylock Creek	Greylock Creek	2: Diversion, Headbox	UD[5]	NA	NA
SSI: Yankee Fork, Jordan Creek	0.021	NA	0.1	Jordan Creek	Jordan Creek	2: Diversion, Headbox	UD[5]	NA	NA

[1] The existing facility and any subsequent structures (as applicable) were built to design specifications at the time of construction. Structures are currently being evaluated relative to compliance with NMFS's 2011 Screening/Passage criteria. When final assessments for LSRCP facilities are completed, the LSRCP and facility managers/cooperators will coordinate with NMFS to determine compliance levels (e.g., in compliance, in compliance with minor variances, or out of compliance) and develop a strategy to prioritize appropriate/necessary modifications contingent on funding availability, program need, and biological impacts on listed and native fish.

[2] Up to 154 cfs is from the North Fork River. The remainder of up to 28 cfs is sourced from the Dworshak Reservoir. The intake is located in the reservoir on the dam wall, and provides water by gravity fed pipeline.

[3] The surface water intake is adjacent to hatchery in North Fork Clearwater River. Dworshak Reservoir is located on the north wall of the Dworshak Dam approximately 3 km from the hatchery.

[4] Water withdrawals to support DNFH operations are pursuant to federally reserved water rights (Winters Doctrine).

[5] The Shoshone-Bannock Tribes are actively working on meeting with a NMFS engineer to evaluate compliance of their streamside incubators.

The Oxbow Fish Hatchery, Pahsimeroi Fish Hatchery, Sawtooth Fish Hatchery, Clearwater Fish Hatchery, Nez Perce Tribal Hatchery, Clear Creek Acclimation Site, and Newsome Acclimation Site were analyzed in three other Opinions covering the Chinook salmon and coho programs in Idaho. None of these facilities were found to jeopardize the listed species or cause adverse modification of listed species' critical habitat (NMFS 2017a; NMFS 2017e; NMFS 2017f).

1.3.6. Kelt Reconditioning Program

A kelt is the term used for an adult steelhead that has spawned successfully and is returning to the ocean, with the chance to return upstream to spawn at a later time. Typically, shortly after spawning, a kelt is in fairly poor condition, and its chances of surviving the downstream migration may be low. The objective of kelt reconditioning is to improve the condition of kelts by feeding and disease treatment in a hatchery environment, so that the kelts can be returned to the river in a healthier state, when ready to spawn again (Hatch et al. 2017).

The kelt reconditioning program currently being proposed consists of the collection of up to 700 post-spawned steelhead greater than 60 cm (see Table 7), and the administration of disease-preventative medications and feed for the purpose of improving survival over what would be expected in the wild. Upon release, these fish are intended to return to natal populations, thereby increasing spawner escapement and productivity if reconditioned individuals successfully spawn.

Table 7. Kelt collection details.

Collection Location[1]	Collection Method	Expected Number Collected	Collection Duration
Lower Granite Dam	Juvenile Bypass System and collection facility	450-700	Mid-March to July, peak in May
Little Goose Dam	Juvenile Bypass System and collection facility	200[2]	Mid-March to July, peak in May
Snake River Basin	Angling, Weirs	200[2]	Mid-February to June
Dworshak National Fish Hatchery[2]	Ladder and trap	100[3]	Late February to mid-April

[1] From highest to lowest collection location priority order.
[2] Collection at these locations would only occur if the goal of up to 700 is not achieved at Lower Granite Dam.
[3] Mature females from this broodstock would first be air-spawned to collect eggs for production at DNFH. Air spawning is a non-lethal method of egg collection from adult fish; a needle is inserted into the female and air is gently pumped in, which expels the eggs as it compresses.

The adult fish separator of the juvenile bypass system at Lower Granite and Little Goose Dams is staffed 24 hours per day throughout the spring juvenile salmonid emigration season. At the tributary weirs, trap boxes are examined several times each day. Trapped kelts are netted, anesthetized, measured, examined, have genetic samples taken, are PIT-tagged, and receive an antibiotic injection. Rejected fish are released into the river downstream.

In addition to kelts, on occasion, pre-spawn steelhead (fallbacks) also find their way into the juvenile bypass system at Lower Granite and Little Goose dams. These fish may be sampled, and released below the dam. The co-managers estimate this to be a maximum of up to 200 fish per year. A piece of tissue is collected to for genetic stock identification and fish are PIT tagged to track their movement.

To minimize fish holding time, fish selected for reconditioning are transferred from the temporary holding tank at the dams every one or two days. Steelhead from offsite traps will be transferred within 24 hours to the reconditioning facilities at the Nez Perce Tribal Hatchery or at Dworshak Hatchery. At the hatchery, reconditioning of kelts includes the provision of prophylactics and feed for the purpose of improving survival relative to the untreated condition[1]. They are treated for infection, fungus, parasites, and disease and fed a specially formulated diet. Staff monitor the feeding behaviors of the kelt and modify feeding practices as needed to improve survival. Select mortalities will be necropsied and sampled for disease by fish health staff.

The kelts will be held at the hatchery until their release that same year (consecutive spawners) or the following year (skip spawners). Approximately 33% of the surviving[2] fish are held for up to seven months then released, while 66% may be held for up to 20 months before release. Reconditioned kelts are released from October through November when the steelhead run at large is returning from the ocean. Prior to release all steelhead kelts are scanned for PIT tags, and sampled for biological information. Kelts are released in the Snake River near Lower Granite Dam. These reconditioned fish generally mix with the run at large and proceed to over-winter locations and then to spawning grounds in the spring.

Monitoring and Evaluation

Monitoring and evaluation activities for the kelt reconditioning program are summarized in Table 8.

Table 8. Research, monitoring, and evaluation of steelhead kelts during reconditioning and after release.

Activity	Purpose
Monitoring of survival, feeding, water quality, and prophylactic treatments during reconditioning	To refine reconditioning strategies
PIT tagging of released kelts	Monitor post-release survival and run-timing, homing and straying, contribution to population escapement
Genotyping of released kelts	Allows for monitoring the relative reproductive success of released kelts

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[1] The mortality of kelts migrating to the ocean is very high and consequently only a small number of kelts return to repeat spawn. In the Yakima River, repeat spawners make up about 3% of the steelhead run, yet over half of the run is seen moving downstream as kelts. In the Snake River, kelts make up about 1% of the steelhead run (Lothrop 2016).

[2] The survival rate during reconditioning was found to be about 47% for consecutive spawners, and 24% for skip spawners.

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

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

2.1. Analytical Approach

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

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

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

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

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

- Evaluate the rangewide status of the species and critical habitat expected to be adversely affected by the proposed action.
- Evaluate the environmental baseline of the species and critical habitat.

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

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

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

Table 9. 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	Threatened, 79 FR 20802, April 14, 2014	64 FR 57399, October 25, 1999	70 FR 37160, June 28, 2005
Snake River fall	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	Issued under 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

"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.

(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 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" 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.

The Snake River Spring/Summer Chinook Salmon ESU remains listed as threatened (NWFSC 2015). 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, cover, side-channel refuge areas, high quality spawning gravels, and interbreeding and competition with hatchery fish that may outnumber natural-origin fish (Ford et al. 2011). The most serious risk factor is low natural productivity (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.

The Snake River Spring/summer-run Chinook Salmon ESU includes all naturally spawned populations of spring/summer-run Chinook salmon in the mainstem Snake River and the Tucannon River, Grande Ronde River, Imnaha River, and Salmon River subbasins, as well as 11 artificial propagation programs (Jones 2015; NWFSC 2015). However, inside the geographic range of the ESU, there are a total of 19 hatchery spring/summer-run Chinook salmon programs currently operational (Jones 2015). A more detailed description of the populations that are the focus of this consultation follows.

There are four independent populations within the South Fork MPG, nine independent populations in the Middle Fork MPG, and nine independent populations in the Upper Salmon River MPG. Only the Panther Creek population is extirpated (Table 10). The most recent status review by NMFS (NWFSC 2015) maintains that all but the Chamberlain Creek population remain at high risk (Table 10).

Table 10. Productivity (10-year geomean (standard error) from 2005-2014), risk levels and viability ratings for Snake River spring/summer Chinook salmon populations (NWFSC 2015). Abundance estimates are five-year geomeans from 2014-2018. ICTRT = Interior Columbia Technical Recovery Team; MPG = Major Population Group.

MPG	Population	ICTRT minimum threshold	Natural spawning abundance[1]	Productivity	Overall viability risk rating
South Fork (SF)	SF Mainstem	1000	271	1.21 (0.2)	High
	Secesh River	750	472[2]	1.25 (0.2)	High
	East Fork/ Johnson Creek	1000	208[2]	1.15 (0.2)	High
	Little Salmon River	750	Not available	Not available	High
Middle Fork (MF)	Chamberlain Creek	750	718	2.26 (0.45)	Maintained
	Big Creek	1000	138	1.1 (0.21)	High
	Loon Creek	500	46	0.98 (0.4)	High
	Camas Creek	500	59	0.8 (0.29)	High
	Lower mainstem MF	500	5	Not available	High
	Upper mainstem MF	750	79	0.5 (0.72)	High
	Sulphur Creek	500	54	0.92 (0.26)	High
	Marsh Creek	500	320	1.21 (0.24)	High
	Bear Valley Creek	750	381	1.37 (0.17)	High
Upper Salmon River	Salmon Lower main	2000	68	1.18 (0.17)	High
	Salmon upper main	1000	236	1.22 (0.19)	High
	Pahsimeroi River	1000	210	1.37 (0.2)	High
	Lemhi River	2000	287	1.3 (0.23)	High
	Valley Creek	500	141	1.45 (0.15)	High
	Salmon East Fork	1000	305	1.08 (0.28)	High
	Yankee Fork	500	57	0.72 (0.39)	High
	North Fork	500	57	Not available	High
	Panther Creek	750	Extirpated		
Grande Ronde/Imnaha	Wenaha River	750	420	0.93 (0.21)	High
	Lostine/Wallowa River	1000	471	0.98 (0.12)	High
	Lookingglass Creek	500	Extirpated		
	Minam River	750	460	0.94 (0.18)	High
	Catherine Creek	1000	125	0.95 (0.15)	High
	Upper Grande Ronde River	1000	82	0.59 (0.28)	High
	Imnaha River	750	406	1.2 (0.09)	High
Lower Snake	Tucannon River	750	90	0.69 (0.23)	High
	Asotin Creek	500	Extirpated		

[1] Interior Columbia Steelhead and Chinook Natural Origin Spawner Abundance Dataset (1949-2018). Accessed Feb 13 2020 10:00PM by Mari Williams, NOAA NWFSC/OAI.

[2] Updated abundance data for this population is not yet available. The value in this cell is from the NWFSC 2015 status review.

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. 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. However, summer run steelhead can be divided into two sub-types; A-run steelhead, which return to spawning areas beginning in the summer, and B-run steelhead, which exhibit a larger body size and begin their migration in the fall (NMFS 2011a). After holding over the winter, summer steelhead spawn the following spring (March to May).

The Snake River Steelhead DPS remains threatened (NWFSC 2015). Factors that limit the DPS's survival and recovery include: 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. Factors affecting habitat conditions are likely to affect most if not all populations within the DPS. Hatchery effects are likely more pronounced when the program occurs on a listed population. Those populations within the DPS with hatchery fractions > 50 percent are the Tucannon, Asotin Creek, Lolo Creek, South Fork Clearwater, Little Salmon River, Pahsimeroi, Lemhi, East Fork Salmon and Upper Salmon River based on a preliminary run reconstruction model (see Table 29; NWFSC 2015). Those in the Clearwater and Salmon River Basins are most likely to be affected by the programs in this Proposed Action.

The Snake River Basin Steelhead DPS includes all naturally spawned anadromous *O. mykiss* originating below natural and manmade impassable barriers in streams in the Snake River Basin of southeast Washington, northeast Oregon, and Idaho (NWFSC 2015). Twenty-four extant populations within five MGPs comprise the Snake River Basin Steelhead DPS. In addition, a number of populations may have existed above Hells Canyon Dam, constituting a sixth MPG. Four out of the five extant MPGs are not meeting the specific objectives in the draft Snake River Recovery Plan, and the status of many individual populations remains uncertain. Within the geographic range of the DPS, 19 steelhead hatchery programs are currently operational. Six of these artificial programs are included in the DPS. A great deal of uncertainty still remains regarding the relative proportion of hatchery-origin fish in natural spawning areas near major hatchery release sites within individual populations (NWFSC 2015). A more detailed description of the populations that are the focus of this consultation follows.

There are five independent populations within the Clearwater River MPG, and twelve independent populations in the Salmon River MPG. Abundance and productivity estimates for most of these populations individually are unknown, but multiple popualtions can be grouped into larger stock groups based on Genetic Stock Identification (Table 11). Information on the distribution of natural returns among stock groups and populations indicates that differences in abundance/productivity status among populations may be more related to geography or elevation rather than the morphological forms of A-run versus B-run (NWFSC 2015).

Table 11. Productivity (10 year geomean (standard error), 2004-2015),risk levels and viability ratings for Snake River steelhead Major Population Groups (MPGs) (NWFSC 2015). Abundance data (5-year geomeans) are from 2015-2019 (Lawry et al. 2020). ICTRT = Interior Columbia Technical Recovery Team.

MPG	Population	ICTRT minimum threshold	Natural spawning abundance	Productivity	Overall risk viability rating
Clearwater River	Lower Main	1500	1366	2.36 (0.16)	Maintained
	South Fork	1000	1011	Not available	Maintained/High
	Lolo Creek	500	Insufficient data		Maintained
	Selway River	1000	1796	2.33 (0.18)	Maintained
	Lochsa River	1000			Maintained
Salmon River	Little Salmon River	500	401	Not available	Maintained
	South Fork	1000	605	1.8 (0.15)	Maintained
	Secesh River	500			Maintained
	Chamberlain Creek	500	1245	2.38 (0.10)	Maintained
	Lower Middle Fork	1000			Maintained
	Upper Middle Fork	1000			Maintained
	Panther Creek	500	Insufficient data		High
	North Fork	500	2109	Not available	Maintained
	Pahsimeroi River	1000			Maintained
	East Fork	1000			Maintained
	Upper Main	1000			Maintained
	Lemhi	1000			Maintained
Imnaha	Imnaha River	1000	Insufficient data		Maintained
Grande Ronde River	Lower Grande Ronde	1000	Insufficient data		Maintained
	Joseph Creek	500	1839[1]	1.86	Low
	Upper Grande Ronde	1500	1786	3.15	Low
	Wallowa River	1000	Insufficient data		Maintained
Lower Snake River	Tucannon River	1000	264	Not available	High
	Asotin Creek	500	424	Not available	High

[1] Updated abundance data for this population is not yet available. The value in this cell is from the NWFSC 2015 status review.

[2] Uncertain due to lack of data, only a few years of data, or large gaps in data series.

2.2.1.3.Snake River Fall Chinook Salmon

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, 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 2015; NWFSC 2015). All of the hatchery programs are included in the ESU along with a single natural-origin population that is currently viable, but at moderate risk, with a low risk for abundance/productivity and a moderate risk for spatial structure and diversity.

The moderate risk rating was driven by changes in major life history patterns, shifts in phenotypic traits, and high levels of genetic homogeneity in natural-origin returns. In addition, risk associated with indirect factors (e.g., the high levels of hatchery spawners in natural spawning areas, the potential for selective pressure imposed by current hydropower operations, and cumulative harvest impacts) contribute to the current rating level. However, the overall adult abundance has been increasing from the mid-1990s, with substantial growth since the year 2000 (NMFS 2012b). The most recent natural-origin five-year geomean is 8,809 fall Chinook salmon[3], which is slightly less than the previous five-year geomean of 8,985.

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 et al. 2011). Hatcheries mitigating for losses caused by the dams have played a major role in the production of Snake River fall-run Chinook salmon since the 1980s (NMFS 2012b). Since the species were originally listed in 1992, fishery impacts have been reduced in both ocean and river fisheries. Total exploitation rate has been relatively stable in the range of 40% to 50% since the mid-1990s (NWFSC 2015). Poor ocean conditions over the last 20 years have also negatively affected the survival of Snake River fall-run Chinook salmon (NMFS 2012b).

Overall, the status of Snake River fall Chinook salmon has clearly improved compared to the time of listing and since the time of prior status reviews. Although the single extant population in the ESU is considered viable, the ESU as a whole is not meeting the recovery goals described in

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[3] East Fork South Fork Salmon River summer Chinook, Secesh River summer Chinook, and Snake River Lower Mainstem fall Chinook Natural Origin Spawner Abundance Dataset (1957-2018). Spawner abundance data. Nez Perce Tribe. Protocol and methods available at https://www.cbfish.org/Document.mvc/Viewer/P165414; https://www.cbfish.org/Document.mvc/Viewer/P164600. Personal communication with Mari Williams, NOAAF NWFSC/OAI Dec 2019.

the draft recovery plan for the species, which require the single population to be "highly viable with high certainty" and/or will require reintroduction of a viable population above the Hells Canyon Dam complex (NWFSC 2015).

2.2.1.4.Snake River Sockeye Salmon

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 2015). The ICTRT treats Sawtooth Valley sockeye salmon as the single MPG within the Snake River Sockeye Salmon ESU. The MPG contains one extant population (Redfish Lake) and two to four historical populations (Alturas, Pettit, Stanley, and Yellowbelly Lakes). Since ESA-listing, progeny of the Redfish Lake sockeye salmon population have been outplanted to Pettit and Alturas Lakes within the Sawtooth Valley for recolonization purposes (NMFS 2011a). At this stage of the recovery efforts, 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). The most recent five-year geomean of sockeye salmon was 923 spawners[4], which is slightly less than the previous five-year geomean of 977.

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, reduced tributary stream flows, and high temperatures. The decline in abundance itself has become a major limiting factor, making the remaining population vulnerable to catastrophic loss and posing significant risks to genetic diversity (NMFS 2015; NWFSC 2015). However, some

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[4] Interior Columbia Steelhead and Chinook Natural Origin Spawner Abundance Dataset (1949-2018). Spawner abundance data. Confederated Tribes and Bands of the Yakama Indian Nation, Idaho Department of Fish and Game, Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife, and Confederated Tribes of the Colville Reservation. Protocol and Methods available at https://fortress.wa.gov/dfw/score/score/; http://odfwrecoverytracker.org/metadata/; https://www.monitoringmethods.org/Protocol/Details/159; https://www.cbfish.org/Document.mvc/Viewer/P148516; https://www.monitoringmethods.org/Protocol/Details/235. Accessed from www.cax.streamnet.org vers Feb 13 2020 10:00PM by Mari Williams, NOAAF NWFSC/OAI.

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).

2.2.2. **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 (This opinion examines the status of each species that would be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the function of the PBFs that are essential for the conservation of the species.
Table 9).

(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 steelhead DPS. 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.

Of these, 26 watersheds occur in the Upper Salmon River where the majority of Salmon River steelhead releases occur. 19 of the 26 are ranked as high, with 6 and 1 ranked as medium and low respectively. The Pahsimeroi had no watersheds with a conservation value ranking. The Little Salmon River was divided into 5 watersheds, with 3 ranked as high and 2 ranked as low. In the Clearwater Subbasin, the one watershed in the Lower Clearwater was ranked as low, but the three in Lolo Creek were considered high. The lower North Fork Clearwater River watershed did not have any PBF's to support steelhead (NMFS 2005a) 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

2.3. Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). The action area resulting from this analysis includes the entire Clearwater and Salmon River Basins downstream to its confluence with the Snake River, and the mainstem Snake River down to Ice Harbor Dam. The action area includes locations where fish are captured, reared, and released, as well as areas where they may be monitored, or stray.

We decided to limit our action area to the Snake River Basin down to Ice Harbor Dam. We did not extend the action area to the estuary/plume for two reasons. The first was that 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. Second, the NMFS (2017) opinion on Mitchell Act funding considered the effects of hatchery fish in the estuary and ocean, and found that subyearling Chinook salmon and coho salmon are the most likely hatchery fish to have effects in these areas due to their long residence times and relatively high predation rates, respectively. Together these reasons suggest that the likelihood of detecting effects from the releases of hatchery steelhead on natural-origin fish below Ice Harbor Dam have already been examined to the best of our ability.

2.4. Environmental Baseline

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

2.4.1. **Habitat and Hydropower**

A discussion of the baseline condition of habitat and hydropower throughout the Columbia River Basin occurs in our Biological Opinion on the Mitchell Act Hatchery programs (NMFS 2017c). Here we summarize some of the key impacts on salmon and steelhead habitat, primarily in the Snake River Basin because it encompasses the Action Area for this Opinion.

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

Currently, salmon and steelhead occupy only a portion of their former range in the Snake Basin. Starting in the 1800s, dams blocking anadromous fish from their historical habitat were constructed for irrigation, mining, milling, and hydropower. Construction of the Hells Canyon Complex of impassable dams along the Idaho-Oregon border in the 1960s completed the extirpation of anadromous species in the upper Snake River and its tributaries above Hells Canyon Dam. Major tributaries upstream from Hells Canyon Dam that once supported anadromous fish include the Wildhorse, Powder, Burnt, Weiser, Payette, Malheur, Owyhee, Boise, Bruneau, and Jarbidge Rivers, and Salmon Falls Creek. These tributaries supported most of the sockeye salmon and fall Chinook salmon populations in the basin and an estimated 15 steelhead populations and 25 spring/summer-run Chinook salmon populations (McClure et al. 2005).

Other dams besides the Hells Canyon complex have significantly reduced access to salmon and steelhead habitat. Dworshak Dam, completed in 1971, caused the extirpation of Chinook salmon and steelhead runs in the North Fork Clearwater River drainage. Lewiston Dam, built in 1927 and removed in 1973, is believed to have caused the extirpation of native Chinook salmon, but not steelhead, in the Clearwater drainage above the dam site. Harpster Dam, located on the South Fork Clearwater River at approximately river mile (RM) 15, completely blocked both steelhead and Chinook salmon from reaching spawning habitat from 1949 to 1963. The dam was removed in 1963 and fish passage was restored to approximately 500 miles of suitable spawning and rearing habitat.

Spawning, rearing, and migration habitat quality in tributary streams in Idaho occupied by salmon and steelhead varies from excellent in wilderness and roadless areas to poor in areas subject to intensive human land uses. Mining, agricultural practices, alteration of stream morphology, riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, and urbanization have degraded stream habitat throughout much of the Snake River Basin. Reduced summer stream flows, impaired water quality, and loss of habitat complexity are common problems for stream habitat in nonwilderness areas. Human land-use practices throughout the Snake River Basin have modified streams, reducing rearing habitat and increasing water temperature fluctuations.

In many stream reaches occupied by anadromous fish in Idaho, water diversions substantially reduce stream flows during summer months. Withdrawal of water, particularly during low flow periods, increases summer stream temperatures, blocks fish migration, strands fish, and alters sediment transport. Reduced tributary streamflow is considered a major limiting factor for Snake River spring/summer-run Chinook salmon and Snake River Basin steelhead (NMFS 2011c).

Many streams occupied by salmon and steelhead are listed on the State of Idaho's Clean Water Act section 303(d) list for impaired water quality, such as impairment for elevated water temperature (IDEQ 2014). High summer stream temperatures may currently restrict salmonid use of some historically suitable habitat areas, particularly rearing and migration habitat. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water all contribute to elevated stream temperatures. Water quality in spawning, rearing, and migration habitat has also been impaired by high levels of sedimentation, and by other pollutants such as heavy metal contamination from mine waste (e.g., IDEQ (2001); IDEQ (2003)).

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.

2.4.2. **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 in air temperatures of 0.1 ºC to 0.6 ºC per decade over the next century, and a ~0.17 °C per decade increase in stream temperatures (Isaak et al. 2017 in Crozier and Siegel 2018). According to the Independent Scientific Advisory Board (ISAB), these changes pose the following impacts over the next 40 years:

- Warmer air temperatures will result in diminished snowpacks and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season
- With a smaller snowpack, watersheds will see their runoff diminished earlier in the season, resulting in lower streamflows from June through September
- 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, including the action area, are increasing, while average streamflows are slightly decreasing (Dittmer 2013). However, basins in northeast Oregon saw an increase in summer flows, despite an average 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. Specifically in southern Idaho, Ahmadalipour and Moradkhani (2017 in Crozier and Siegel 2018) identified a decline of 3% annual snowpack per decade. This is problematic because snowpack rather than man-made reservoirs are the primary form of water storage in the region. Thus, peak flows in the Snake Basin could occur earlier in the year, and would likely lead to even lower flows during the summer months.

Climate change is also predicted to cause a variety of impacts on Pacific salmon and steelhead (Crozier et al. 2008a; Martins et al. 2012; Mote et al. 2003; Wainwright and Weitkamp 2013). While all habitats used by Pacific salmon and steelhead will be affected, the impacts and certainty of the change vary by habitat type. Some effects (e.g., increasing temperature) affect salmon at all life stages in all habitats, while others are habitat specific (e.g., stream flow variation in freshwater). These effects can also be indirect; for example, a common pathogen (*Tetracapsuloides bryosalmonae*) in salmonids was found to increase in infection prevalence and pathogen load when water temperatures were warmer (Bailey et al. 2017 in Crozier and Siegel 2018). This could result in increases in disease severity as temperatures warm, although it may also decrease severity for pathogens that prefer colder temperatures. The complex life cycles of anadromous fish 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.

How climate change will affect each stock or population of salmon also varies widely depending on the extent and rate of change, and the unique life history characteristics of different natural populations (Crozier et al. 2008b). For many populations, the effects of climate change are expected to be more severe at the southern end of the species' range, but may provide potential colonization opportunities at the northern end (Crozier and Siegel 2018). Dittmer (2013) suggests that juveniles may out-migrate earlier with less tributary water, while returning adults may be challenged by lower and warmer summer flows. Larger winter stream flows 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).

In addition, the warmer water temperatures in the summer months may persist for longer and more frequently reach and exceed thermal tolerance thresholds for salmon and steelhead (Mantua et al. 2009). Despite these potential pressures due to climate change, salmon and steelhead are known to have plastic life history types, and have to the ability to evolve in response to selection. For example, steelhead migrate after summer temperatures decrease. Compared to migration timing in the 1950's their migration timing has shifted to later in the year. This allows steelhead to avoid peak temperatures in the mainstem Columbia River during the summer (Crozier and McClure 2018). Furthermore, steelhead specifically appear to use cool water refugia more than other Pacific salmon species, which may help as waters warm. However, increased time spent in these cool water refugia can have adverse effects on survival by potentially making them more vulnerable to harvest (Crozier and McClure 2015). Thus, the uncertainty associated with the potential outcomes of climate change provides some justification for hatchery programs as reservoirs for some salmon stocks.

Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the degree and rate of change. However, the life history types that will be successful in the future are neither static nor predictable. Therefore, maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is likely a wise strategy for continued existence of populations.

2.4.3. **Hatcheries**

Included in the Environmental Baseline are the ongoing effects of hatchery programs or facilities which have undergone Federal review under the ESA, as well as the past effects of programs which have not yet undergone such review, including those found in the proposed action. A more comprehensive discussion of hatchery programs in the Columbia 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. 2014a). Therefore, fixing the factors limiting viability is essential for long-term viability.

Below we have included more detail here on the history of the steelhead hatchery programs included in our proposed action. All are currently ongoing, and were initiated under the LSRCP, Hells Canyon Settlement Agreement or the BPAs Fish and Wildlife Program to mitigate for the construction and operation of the four lower Snake River dams, the Hells Canyon Complex, and Dworshak Dam, on salmon and steelhead in the Snake River basin.

Salmon River Basin

The Streamside Incubator Supplementation Program began outplanting eyed-eggs in 1995. Eggs are provided to the SBT from spawning of excess A-run steelhead adults returning to the Sawtooth and Pahsimeroi Hatcheries. Steelhead A-run eyed-eggs are then outplanted in Indian and Panther Creeks. However, recently the 500,000 eggs outplanted into Yankee Fork were changed from A-run to a local B-run stock. From 1995-2009, about 82.3 percent of the eggs outplanted into Yankee Fork have survived to the fry stage (SSI HGMP). This program continues to be a part of the *U.S. v. Oregon* Management Agreement.

Smolts produced from eggs collected at Dworshak National Fish Hatchery (DNFH) have been released into the Upper Salmon River since the 1970s to increase the number of large two-ocean B-run fish returning to the upper Salmon River. The program to develop a locally adapted steelhead release started in 1980s. These releases first occurred in the Pahsimeroi River, but then shifted to the East Fork of the Salmon River. From the mid-1980s though the late-1990s, large B-run adults were collected at the East Fork Satellite Facility. The offspring of these fish were released at the satellite facility to perpetuate the locally adapted East Fork B-run stock. However, adults did not readily return to this location, and, in 1998, IDFG started releasing B-run smolts into Squaw Creek to improve broodstock collection. Squaw Creek has also not proven effective for broodstock collection. Thus, managers have implemented a phased transition to a local broodstock. The first phase of this transition involves releasing unclipped B-run juveniles at Pahsimeroi Fish Hatchery, and clipped and unclipped juveniles in Yankee Fork. Adult returns from these releases will be used to establish the local broodstock. An additional release of B-run fish also occurs in the Little Salmon River using local Salmon B-run when available. The longer-term goal includes phasing out the use of Pahsimeroi for Yankee Fork when infrastructure in Yankee Fork becomes available. A portion of this program continues to be a part of the *U.S. v. Oregon* Management Agreement.

The Upper Salmon A-run program began in 1985 to mitigate for the four lower Snake River Dams. Broodstock for this program originated from fish returning to the Snake and Salmon Rivers, and are collected at Sawtooth Fish Hatchery. Historically, fish from this program were released at five mainstem Salmon River sites in addition to releases at Sawtooth Fish Hatchery. The current proposal consolidates all the release locations to just Sawtooth Fish Hatchery. A portion of this program continues to be a part of the *U.S. v. Oregon* Management Agreement.

The Pahsimeroi and Hells Canyon A-run steelhead programs began in 1966. The Hells Canyon Settlement Agreement calls for the production of 400,000 pounds of summer steelhead smolts (1.8 million smolts at 4.5 fish per pound). This represents the combined production for the Pahsimeroi A-run, and Hells Canyon Steelhead A-run programs, along with releases beginning in 1983 of A-run fish into the Little Salmon River. Recently, the smolt release at Pahsimeroi Hatchery has decreased from 830,000 to 800,000, while the Hells Canyon component has increased from 525,000 to 550,000.

The East Fork steelhead program is the only integrated steelhead program in Idaho, and began in 2000. The purpose of the program is to increase the abundance of the natural population. It is part of the Lower Snake River Compensation Plan, a federally mandated program to mitigate for fish losses caused by the construction and operation of the four lower Snake River federal dams. The need for the conservation program was also identified in the 2008 Federal Columbia River Power System Biological Opinion (RPA 42). Production from this program continues to be a part of the *U.S. v. Oregon* Management Agreement. As of 2013, smolt production was decreased from 170,000 to 60,000, largely to increase the proportion of natural-origin fish used in the broodstock.

Clearwater River Basin

The DNFH steelhead program began in 1970 to replace adult steelhead and rainbow trout lost by construction and operation of Dworshak Dam and reservoir on the North Fork Clearwater River in Idaho. This hatchery program is part of the U.S. Army Corps of Engineer's Dworshak Dam and Reservoir Fish and Wildlife Mitigation Program. A total of 2.1 million smolts are released at four locations in the Clearwater Basin: 1.2 million directly from Dworshak Hatchery, 200,000 to Lolo Creek, 300,000 to Clear Creek (Kooskia Hatchery) and 400,000 in the South Fork Clearwater. Production from this program continues to be a part of the *U.S. v. Oregon* Management Agreement.

The South Fork Clearwater program began in 1991. The purpose of the South Fork Clearwater summer steelhead hatchery program is to mitigate for fish losses caused by the construction and operation of the four lower Snake River federal dams. In addition to harvest mitigation, approximately 40 percent of the steelhead production at Clearwater Fish Hatchery is dedicated to producing steelhead intended to supplement natural spawners in the upper South Fork Clearwater River. Fish that are part of the supplementation effort are released with adipose fins intact and are not intended for harvest in mark-selective fisheries.

Historically, broodstock for all hatchery steelhead production in the Clearwater was collected at the Dworshak National Fish Hatchery. However, since 2010, managers have implemented a transition to a local segregated broodstock collected in the South Fork Clearwater River. A total of 840,000 steelhead smolts were released at five locations in the South Fork Clearwater drainage: Crooked River (83,000 smolts), Red River (150,000 smolts), Red House Hole in the mainstem South Fork Clearwater (260,000 smolts), Peasley Creek (250,000 smolts) and Newsome Creek (100,000 smolts) each year. Currently there are now three release sites in Meadow Creek, Red House Hole and Newsome Creek for the 843,000 proposed total smolt release. Hatchery production associated with this program continues to be included in the *U.S. v. Oregon* Management Agreement.

2.4.4. **Harvest**

The Snake River Basin is a terminal harvest area, but harvest on the DPSs and ESUs considered here does occur in other fisheries outside of the Snake River Basin, such as the mainstem Columbia River (NMFS 2018). Although fish from the Snake River are not specifically targeted because of the mixed-stock nature of mainstem fisheries, they are impacted. However, the effects of these mainstem Columbia River fisheries are realized before the remainder of each ESU and DPS passes dams in the Snake River. Thus harvest management in the Snake River is responsive to information derived from estimates at the dams, before, and also during harvest in the Snake River Basin.

The NPT's treaty-reserved fishing rights and fisheries in the Snake Basin continue to be critically important to the Tribe in maintaining and practicing its culture and ways of life and fishing-based economy. It is customary practice for the Tribe to shape tributary fishing regimes to be sensitive to the biological and conservation needs of the fish. The NPT uses its Tribal Code to help administer the treaty-reserved rights and natural resources of the Tribe. The Tribe governs its fishing and hunting activities to the fullest extent of tribal jurisdiction in order to properly regulate, manage and protect all of the fish and game resources available to the tribe and its members. Key elements of this include, for example: properly regulating, managing and protecting all of the fish and game resources available to the tribe and its members; taking such action necessary to protect, manage and enhance fish and wildlife; and providing for the conservation, enhancement and management of the tribe's fish and wildlife resources.

Spring/Summer Chinook Salmon Fisheries

The spring/summer Chinook fisheries in the Snake basin typically occur from late April through July. The non-tribal fisheries selectively target hatchery fish with a clipped adipose fin. Tribal fisheries target both hatchery and natural-origin fish regardless of external marking, meaning there is no incidental take of the target species for their fisheries. Table 12 below shows that an average of ~ 5% of the Snake River Spring/summer Chinook Salmon ESU is killed by fisheries. This may be an overestimate of the percentage impact because the Lower Granite Dam natural-origin return estimate does not include those fish that return to tributaries of the Snake River below Lower Granite Dam (e.g., Tucannon River).

Table 12. Number of ESA-listed natural-origin spring/summer Chinook salmon encountered and incidentally killed (catch and release mortality is estimated at 10 percent of those caught) in fisheries from 2011-2016.

Fishery Manager	Average Incidental Mortality take Authorization	Average Encounter	Average Mortality	Average natural-origin estimated escapement above LGD	% Average natural-origin incidental mortality above LGD
IDFG	774	2,260	260	19,788	1.3
SBT[1]	Not Applicable	407	407	19,788	2.1
NPT	Not Applicable	326	326	19,788	1.6

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

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

There are no incidental encounters or mortality of Snake River steelhead, fall Chinook salmon, or sockeye salmon during spring/summer Chinook salmon fisheries. The fishery does not open until after the steelhead run, and the fishery closes prior to the arrival of fall Chinook salmon in the Snake Basin. Sockeye salmon are not encountered because they typically do not strike at lures used by recreational anglers fishing for Chinook salmon.

Steelhead

Steelhead fisheries above Lower Granite Dam typically occur from July through May of the following year. Although steelhead bound for Idaho enter the Columbia River from about June 1 through October 1 each year, a portion of the run spends the winter in the Columbia and Snake rivers downstream of Lower Granite Dam, and migrates into Idaho in the spring of the following year. Recently, NMFS completed a biological opinion on the recreational and steelhead fisheries throughout the Snake River Basin. Along with the fishery managers we established a framework that limits impacts to natural-origin steelhead by Major Population Group (MPG), with no more than 5% mortality of the natural-origin abundance in the Lower Snake and Imnaha MPGs, and no more than 10% mortality in the Grande Ronde, Clearwater, and Salmon River MPGs. NMFS and the co-managers, working together, established low abundance thresholds for each MPG that would dictate when further management action was needed beyond the fixed MPG impacts. NMFS determined that the basin-wide steelhead fishery framework was not likely to result in jeopardy of any ESA-listed species (NMFS 2019c).

Similar to spring/summer Chinook salmon fisheries, the non-tribal fisheries selectively target hatchery fish with a clipped adipose fin. All mortality of natural-origin fish is incidental (catch and release mortality), and is estimated at 5 percent of those caught. Tribal fisheries target both hatchery and natural-origin fish regardless of external marking, meaning there is no incidental take of the target species for their fisheries. Table 13 below shows that an average of ~ 4.1 % of the Snake River steelhead DPS is killed annually in fisheries.

Table 13. Number of ESA-listed natural-origin steelhead mortalities in fisheries from 2011-2016; ICH= Ice Harbor Dam.

MPG	Average Mortality	Average natural-origin estimated escapement above ICH	% Average natural-origin mortality above ICH
Lower Snake	114	8,018	1.4
Grande Ronde	308	8,230	3.7
Imnaha	108	2,121	5.1
Clearwater	338	8,402	4.0
Salmon	387	12,203	3.2

Sources: (Hurst 2018; Stark 2018)

Fall Chinook Salmon Fisheries

The fall Chinook salmon fishery typically takes place from August through November. As of fall 2019, the non-tribal fisheries may selectively target hatchery fish with a clipped adipose fin if abundance is low, but otherwise can harvest unclipped hatchery and natural-origin fall Chinook salmon according to a basin-wide harvest framework that allows for increased impacts as natural-origin abundance increases. Prior to 2019 and back to the early 2000s, the non-tribal fall Chinook salmon fisheries were managed to only allow for selective harvest of adipose fin-clipped fish. Tribal treaty fisheries target both hatchery and natural-origin fish regardless of natural-origin abundance, although these fisheries are still limited to the impact rates that correspond with natural-origin abundance. We determined that the basin-wide steelhead fishery framework was not likely to result in jeopardy of the listed species' (NMFS 2019b).

Data from 2011 to 2016 shows that of the 12,535 natural-origin fall Chinook salmon estimated to escape above Lower Granite Dam, on average 4.3% (542 fish) are estimated to have died in the fishery (Oatman 2017a)(Kozfkay 2018) (Jeremy Trump, WDFW, Personal Communication, August 31, 2018). When state fisheries are managed selectively, a 10% catch-and-release mortality rate is used to calculate impacts to natural-origin fall Chinook salmon.

Other Fisheries

In some years, Idaho opens a kokanee salmon fishery in Redfish Lake to help offset intra-specific competition in Redfish Lake between resident kokanee and sockeye salmon. From 2014 to 2016, an average of 0.7 percent of the *O. nerka* population in Redfish Lake was harvested in this fishery (IDFG 2014; IDFG 2016; IDFG 2017). Therefore, an estimated 0.7% of the residual sockeye salmon population in Redfish Lake was incidentally harvested in this fishery each year. This estimate assumes that residual sockeye salmon and kokanee are equally vulnerable to harvest (kokanee and sockeye salmon are phenotypically indistinguishable).

2.5. Effects of the Action on ESA Protected Species and on Designated Critical Habitat

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

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.

2.5.1. **Factors That Are 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. Our analysis is based on the best scientific information available. 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), and do not depress fitness or erode diversity. 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. Our analysis of a Proposed Action addresses six factors:

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

For this Opinion, we also are evaluating the effects of a kelt reconditioning program as a separate factor, Factor 7.

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 severity of an effect 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/ DPS recovery, the target viability for the affected natural population(s), and the environmental baseline including the factors currently limiting population viability.

For more information on how NMFS evaluates each factor, please see Appendix A.

2.5.2. **Effects of the Proposed Action**

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

Only the East Fork Steelhead Hatchery Program removes fish from the local natural population for broodstock, leading to a negative effect for steelhead return numbers. However, the removal of natural-origin broodstock is limited by abundance-based sliding scales to reduce risk to the naturally spawning population, which are explained and analyzed in detail below (2.5.2.2.1). At most, 28 natural-origin fish will be removed from the naturally-spawning population. At this time, NMFS most recent status review found that there was insufficient data to provide an estimate of natural-origin population abundance for the East Fork Salmon River population

(Table 11). However, data from IDFG for our genetic analyses in the following section suggest that between 52 and 151 natural-origin steelhead returned to the East Fork River from 2013 to 2016 (Table 17).

Although 28 fish of 52 would lead to a large proportion of natural-origin fish used for broodstock, the weir is about 18 river miles from the mouth, and more fish may naturally spawn below the weir than above. Thus, fewer than half of the natural-origin steelhead returning are likely to make it to the weir and be available for broodstock collection. In addition, all of the fish used for broodstock are spawned in the hatchery, leading to higher egg-to-smolt survival rates than they would have in the wild, and, when their progeny return as adults, the intent is to pass them above the weir to spawn naturally, increasing the abundance of naturally-spawning steelhead in the East Fork population. The net effect is anticipated to be an increase in abundance—potential adverse effects of naturally spawning hatchery fish are discussed in the following subsection.

There is no effect of factor 1 on spring/summer Chinook, fall Chinook, or sockeye salmon because none of these species are propagated by these programs.

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

The proposed hatchery programs pose both genetic and ecological risks, and, although there is some benefit to the species from the integrated program designed to supplement the East Fork population, the net effect on steelhead is negative. Ecological and adult collection effects are relevant only for spring Chinook, fall Chinook, and sockeye salmon because these programs do not propagate these species. The overall effect of this factor on these species is negligible.

2.5.2.2.1. Genetic effects

For each program, NMFS considers three major areas of genetic effects: within-population diversity, outbreeding effects, and hatchery-influenced selection.

Assessment of genetic effects typically occurs using the PNI, pNOB, and pHOS metrics (see appendix for details). We also consider information on heterozygosity and effective population size when available. The Hatchery Scientific Review Group (HSRG) has developed guidelines for allowable pHOS levels in populations, scaled by the population's conservation importance, recommending a maximum of 5% in "primary" populations, 10% for "contributing" populations, and at a level required to maintain "sustaining" populations (e.g., HSRG 2014). Listed salmonid populations in the Snake are classified by recovery expectation (ICTRT 2007a) rather than by the HSRG classification scheme, but "viable" and "highly viable" equate to "primary", and "maintain" equates to "contributing" and "sustaining."

The use of the word "maintained" to characterize an ESA-listed population comes from the work conducted by the Interior Columbia Technical Recovery Team (ICTRT 2007b). The ICTRT states, "Our criteria focus efforts at recovering a minimum number of populations within each MPG to viable levels. In many cases there will be one or more additional extant populations within an MPG". The ICTRT established the maintained criterion for application to these populations. The primary intent is to avoid situations where one or more of these populations serve as an overall 'sink' for production across an MPG. In addition, meeting the maintained criterion for these populations contributes to connectivity within and among MPGs and promotes the preservation of genetic and life history diversity. More information on the maintained criterion can be found in ICTRT (2007b). How we then apply this in the current recovery scenario for each steelhead population can be found in (NMFS 2017d).

Another aspect of pHOS to consider is that total pHOS may be comprised of fish from a variety of hatchery programs, and these programs can be from within or outside of a particular watershed, we call this straying[5]. Because fish stray into areas that are under different management authorities and may have different approaches to monitoring naturally-spawning fish, it is difficult to assess the proportion of total pHOS attributable to the Idaho steelhead programs for all populations where fish from these programs may occur. Spawning surveys to recover spent carcasses are not the best approach to monitoring steelhead spawning naturally because flows are high when steelhead spawn, making conditions for surveyors unsafe at times. Additionally, many steelhead attempt to return to the ocean as kelts, making it difficult to collect carcasses, a necessary step for recovering coded-wire tags and/or genetic tissue samples for parentage-based tagging analyses.

Snake River Steelhead Run Reconstruction

Over the past five years, a multiagency workgroup in the Snake Basin has been developing a data analysis framework with the primary goal of estimating the abundance of hatchery and wild steelhead returning to the Snake Basin, the spatial distribution of spawners, and the fates of these fish (Copeland et al. 2013). Efforts from this workgroup began with the 2010-2011 steelhead return and refinements to the model have been incorporated annually through the 2014-2015 return. The model utilizes direct estimates of stock specific hatchery and wild adults returns to Lower Granite Dam based on the fish ladder window counts and systematic sampling of adults as they pass upstream of the dam. Fates of these fish are based on harvest sampling programs, and hatchery trap and weir counts and incorporate movement and survival probabilities as fish transition upstream to the natal or hatchery release locations for wild and hatchery fish respectively.

One output from the model is an estimate of the number of hatchery and wild fish available for spawning in each of the six Snake River Major Population Groups. A comparison of run reconstruction model outputs to independent estimates for wild fish escapements in a subset of populations over the five years of this effort has been variable but generally results in similar numbers of populations being either overestimated or underestimated relative to the independent estimates (Copeland et al. 2015; Copeland et al. 2013; Copeland et al. 2014; Stark et al. 2016).

However, there are a number of assumptions/critical uncertainties in the model calculations that require improvement. For example, the number of hatchery steelhead harvested in the Snake

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[5] For this analysis, a stray means a fish that returns to a location that is geographically distinct from that of its population of origin. We use straying as a way to understand the composition of pHOS, but straying is really only of concern when fish actually spawn in those areas because of potential genetic and ecological effects.

River mainstem fisheries, and the genetic classification of fish to the population or even MPG level (Copeland et al. 2015; NWFSC 2015). Thus, the model continues to undergo refinement, with one proposed change being the use of Parentage Based Tagging assignments from hatchery fish sampled in the fisheries to estimate the stock and release site specific harvest numbers, instead of assuming that all hatchery stocks are harvested in proportion to their abundance in each river reach throughout their return to the release site. Other possible improvements to the model include refinements to the GSI baseline to improve resolution of population assignments of wild fish, use of telemetry results to improve movement rates, and incorporation of PIT array and weir estimates. Because of these critical uncertainties and potential refinements, we will not use the estimates derived from this modeling effort to inform our analysis of pHOS at this time. 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 inform the management of steelhead programs in Idaho.

Assessing hatchery-origin steelhead detection rates

Although we do not have estimates of pHOS for the various steelhead populations, for many of the populations we have PIT tag detections of hatchery- and natural-origin fish that provide some relative values of those areas/populations that have a relatively high level of hatchery influence (Table 14).We removed any detections of fish of unknown hatchery/natural origin from our analysis. We also did not include hatchery fish detections at weirs associated with programs where no hatchery-origin fish are passed upstream (i.e., Upper Salmon, Wallowa). If fish were detected at multiple arrays, they were only counted in the area of their last detection. Some of these PIT tag detections are likely to include fish from programs outside of our Proposed Action, because the origin of hatchery fish tagged at mainstem dams/traps is not always known and some level of straying may exist from programs external to the proposed action. In addition, hatchery steelhead detections do not necessarily mean that these fish spawned because fish are still vulnerable to harvest after detection, may be removed at various traps and weirs upstream of an array, or may have wandered into an area prior to spawning (especially if detected prior to March), and were undetected as they moved back out before spawning

Table 14 indicates that based on PIT tag detections, the populations/areas with the highest percentages of hatchery-origin steelhead detections are those where hatchery programs operate within them (e.g., Upper Salmon). Conversely, South Fork Salmon River, Secesh River, Middle Fork Salmon River (represented by Big Creek), Lemhi River, NF Salmon River Lochsa River, Selway River, Joseph Creek, Lower Grande Ronde River, Upper Grande Ronde River, and Asotin Creek, do not have steelhead hatchery programs, and have low (≤ 5%) detections of hatchery-origin steelhead.

The co-managers' hatchery strategy in the Clearwater and Salmon River Subbasins is to concentrate steelhead hatchery programs and releases within areas where populations are designated as maintained in the current recovery scenario, meaning the natural-origin population exists at levels providing ecological and evolutionary function to the DPS as a whole (ICTRT 2007b; NWFSC 2015). The concept is that this will encourage hatchery-origin steelhead to home to populations designated as maintained, and not go into populations targeted for viable or highly viable status. There are a few exceptions to this general approach identified in Table 14. The first is Panther Creek, which is targeted for viability in the current recovery scenario, but

> does have a steelhead streamside incubator for hatchery-origin steelhead. The second is the Lower mainstem Clearwater River, which is also targeted for viability, but where hatchery fish are released into Clear Creek near the upstream boundary of this population with the South Fork Clearwater. Data suggests that hatchery fish detections in the Lower Mainstem Clearwater population are 8%, but over half of those (57%) are fish of unknown hatchery-origin. Of the 29 hatchery steelhead detections of known hatchery origin, 48% are from programs not included in the Proposed Action, 45% are from the Clear Creek releases, and 7% are from the two hatchery programs in the Clearwater Subbasin (Albee 2020).

Based on the data to date, the co-managers' strategy generally appears to be working as intended, as evidenced by the low levels of hatchery-origin fish detections in populations listed above that are targeted for viable or highly viable status in the current recovery scenario to minimize hatchery influence to the steelhead DPS. We have not extrapolated the detections to estimate numbers of fish here, but how to do this is an ongoing topic of discussion for the Snake River Steelhead Workgroup. The Workgroup is investigating the possibility of PIT tagging adipose-clipped hatchery-origin steelhead at Lower Granite Dam to increase the sample size and hence precision around the PIT tagging results. However, there are many factors that would influence this course of action; human health concerns over inserting PIT tags into fish that may be consumed, available resources and logistical limitations for tagging at the Lower Granite Dam Trap, and the number of fish required to be tagged to have at least a standard error of less than 25% (See et al. 2020).

Table 14. Summed detections at PIT tag arrays (including arrays at weirs and hatcheries if hatchery fish are passed upstream) of hatchery- and natural-origin steelhead into various rivers/creeks above Lower Granite Dam, based on data from 2011 to 2019 (unless a different start year is noted). Only populations/areas within each major population Group (MPG) with active PIT tag arrays are included. Releases of hatchery steelhead occur in Populations/Areas in bold. The recovery scenario proposed target status are from Table 4-2 in (NMFS 2017d).

Population/Area	Number of arrays	Major population group	Hatchery detections	Total detections	% Detections that are hatchery-origin Fish	Recovery scenario proposed target status
SF Salmon River	2	Salmon	9	1,002	1	Viable
Secesh River	1		1	194	1	Maintained
Big Creek	1		8	391	2	Highly viable
Upper Salmon (2013)[1]	4		275	688	40	Maintained
NF Salmon River (2016 only)	1		1	22	5	Maintained
Lemhi River	18		20	476	4	Viable
Panther Creek (2018)	1		1	50	2	Viable
Imnaha River[2]	10	Imnaha	1,065	3,888	27	Highly viable
Lower Grande Ronde (2017)	2	Grande Ronde	1	95	1	Viable or highly viable
Joseph Creek	1		102	4,015	3	Highly viable
Wallowa River (2014)	5		106	636	15	Viable or highly viable[3]
Upper Grande Ronde (2013)	5		18	1,116	2	Viable or highly viable
SF Clearwater River (2012)	2	Clearwater	2,086	4,223	49	Maintained
Lower Mainstem Clearwater River	8		67	883	8	Viable
Lolo Creek (2012)	2		99	665	15	Maintained
Lochsa River (2017)	1		4	378	1	Highly viable
Selway River (2017)	1		1	140	1	Viable
Asotin Creek	4	Lower Snake	54	1,229	4	Viable or highly viable

Source: (Albee 2020).

[1] This excludes the Sawtooth weir because any hatchery-origin steelhead encountered at the weir are removed and prevented from spawning naturally.

[2] The Imnaha River detections also include fish handled at the Little Sheep weir. This could overestimate hatchery fish detections on the spawning grounds if hatchery fish are removed at the weir. Removals are variable annually based on broodstock sliding scales; see the Lower Snake River Steelhead Biological opinion for more details (NMFS 2017b).

[3] Targeted for viable or highly viable, but for MPG viability, only 2 of the four populations are required to achieve viability, with the other two achieving at least maintained status.

Stray Hatchery-origin Steelhead

To inform our analysis on hatchery-origin steelhead strays from programs included in the Proposed Action we used two methods. The first method uses the final detection location of the returning adults with a PIT tag initially detected at Lower Granite Dam to infer straying. For example, if we detect 100 adults originating from Pahsimeroi Hatchery at Lower Granite Dam, and 60 of them are detected at the Pahsimeroi Hatchery, two are detected in Big Creek, and 38 are never detected again, then we would assume that 2 out of 100 strayed into Big Creek and 38 were likely harvested in terminal area fisheries. Table 15 indicates those fish that were detected at Lower Granite Dam and then stray out of a total sample size of 8,462 hatchery-origin steelhead over 10 years (spawn years 2010-2019); the remainders likely either returned to the hatchery, succumbed to natural mortality, or were intercepted in fisheries. For all programs, less than 2% of the adults detected at Lower Granite Dam were detected outside their watershed of origin.

There are a few caveats for interpreting this result associated with this second method. First, although many PIT tag arrays exist throughout the Snake River Basin, there are some places where a potential stray may not be detected for lack of infrastructure (e.g., Middle Fork Salmon River where only one PIT tag array exists). Second, even when an array exists, the detection efficiency is less than 100%, but does typically exceed 80%. Third, there are many adults returning to Lower Granite Dam that are identified as hatchery fish, but do not have a PIT tag, which limits sample size for this estimation method and may lead to an underestimate of straying. However, our analysis spans a decade, and includes ~8,500 detections with relatively consistent numbers of detections among years. Lastly, because the co-managers discontinued off-station releases for steelhead programs in the Salmon River Subbasin around 2015 (e.g., McNabb Point), we did not include detections of these returns in our results for this straying estimation method or for our analyses above.

A second method uses returns of hatchery fish to adult collection facilities to determine what proportion of program broodstock is composed of non-program fish. Similar to the method above, we did not include hatchery-origin steelhead released at discontinued off-station sites in our results. This assessment was based on parentage-based tagging of all broodstock summed from 2012-2019 after fish used for broodstock are spawned. Table 16 demonstrates that for those programs where data is available, fish used for broodstock are predominately fish from the target program. For example, no fish from any of the Clearwater River Subbasin programs were detected in the Salmon River Subbasin. Similar to our findings for the first method, detections of stray hatchery-origin steelhead are low.

Together, these two analyses suggest that very few fish from Idaho Steelhead programs return to a place from which they were not released, leading us to conclude there are low levels of steelhead straying from these programs.

Table 15. Number of PIT tag detections at Lower Granite Dam and the number of those detected as strays from spawn years 2010-2019.

Juvenile Release Location	Unique PIT tags detected at LGD	Total number of PITs in non-natal areas	PIT tags detected at a non-target hatchery	PIT tags detected in non-natal tributary arrays	% PIT tags detected in non-natal tributary arrays
South Fork Clearwater River	1,275	31	30	1	0.1
Dworshak National Fish Hatchery	1,270	4	0	4	0.3
East Fork Salmon River	312	2	0	2	0.6
Hells Canyon	768	0	0	0	0.0
Little Salmon River	1,422	4	0	4	0.3
Pahsimeroi Hatchery	1,440	11	0	11	0.8
Sawtooth Hatchery	1,578	8	0	8	0.5
Yankee Fork	397	6	0	6	1.5
Total	**8,462**	**66**	**30**	**36**	**0.4**

Source: (Leth 2020a)

Table 16. The hatchery of origin for steelhead returning to adult collection locations and used for broodstock compared to their program assignment via Parentage-based tagging, summed for spawn years 2012-2019.

Adult Collection Location	Program origin-based on collection location	Program origin based on PBT assignment						Total
		Dworshak/SF Clearwater	East Fork Natural	Hells Canyon	Pahsimeroi A	Upper Salmon A	Salmon River B	
Dworshak National Fish Hatchery	Dworshak/SF Clearwater	11,934	0	0	3	0	1	11,938
East Fork Salmon River Weir	East Fork Natural	0	93	0	0	0	0	93
Hells Canyon Weir	Hells Canyon	0	0	2,972	2	1	1	2,976
Pahsimeroi Hatchery	Pahsimeroi A	0	30	3	8,369	16	0	8,418
Sawtooth Hatchery	Upper Salmon A	0	0	0	2	5,925	0	5,927
Pahsimeroi Hatchery	Salmon River B	0	0	0	0	0	1,726	1,726
Total		11,934	123	2,975	8,376	5,942	1,728	31,078

Source: (Leth 2020b)

Despite the data indicating that hatchery-origin steelhead detections in populations targeted for viable/highly viable are low, and that detections of stray steelhead are also low, we still have some concerns when analyzing this type of data. The first is that the proportion of juveniles PIT tagged at release is small, typically between 1 and 5 percent. Thus, there are likely many fish returning that do not have a PIT tag, making their ultimate destination impossible to determine. Second, and related to the first, is that, in many years, detections of hatchery fish in the different areas can be zero. This could be an indicator of very little straying, or it could mean that tagging/detection rates are not robust enough to reliably detect the low levels of hatchery fish straying in some years.

The continuation of the work by the steelhead workgroup is necessary for addressing these uncertainties in the future, and will inform the broader workgroup objectives of determining (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 changes may be triggered. At this time, the data indicates that straying of fish from the programs included in the proposed action is low; the percentage of PIT tags from segregated hatchery programs included in the Proposed Action detected as adults at non-natal tributary arrays is expected to be no more than three percent (based on data from Table 15) measured as a 5-year rolling sum of all the PIT tags from a particular program detected at Lower Granite Dam beginning in 2020. If new information indicates straying is higher than considered in this opinion, we will revisit this opinion.

It is possible that with the contingency plans for certain programs to meet production goals, adult steelhead distribution could change. For example, if the Hells Canyon A-run program does not meet production and is backfilled with fish from the Pahsimeroi program, it is possible that some of the adults could return to Pahsimeroi Hatchery, which could increase the number of hatchery fish on the spawning grounds in the Pahsimeroi River. However, we anticipate this to occur at very low levels on an infrequent basis without substantially altering the overall effects of the action for three reasons. The first is that we anticipate backfilling to be a rare event. For example, even with the low steelhead returns in 2019-2020, backfilling was only required at Sawtooth Hatchery at a low level of 20 females. Second, no new release sites are being added to accommodate the backfilling contingency plans beyond those already utilized for the steelhead programs in the Salmon River. Third, transfers are made at the eyed-egg stage to one of the three out-of-basin hatcheries that are used for all program production in the Salmon River Basin. This practice has been in place since the inception of the steelhead programs, and the results above suggest that where juveniles are released into the Salmon River is the main determinant to where they return as adults. Thus, it is more likely that backfilled fish will imprint to their new release location versus the location they were incubated/reared.

Assessing Steelhead Diversity in the Snake River Basin

Nielsen et al. (2009) investigated the genetic diversity of natural-origin steelhead populations and hatchery stocks in the Snake Basin at multiple spatial scales. The authors analyzed 11 microsatellite loci in 74 collections of natural-origin fish and 5 collections of hatchery-origin fish collected in the summer of 2000. Recent work (Kinzer et al. 2020) summarized in a series of memorandums (Hargrove and Campbell 2020a; Hargrove and Campbell 2020b; Hargrove and

Campbell 2020c) analyzed 176 SNP loci in steelhead samples from spawn years 2010 to 2019 and builds upon the work conducted by Nielsen et al. (2009).

A few things need to be considered when comparing and contrasting these two studies:

- The scale of the analyses differ. Although Nielsen et al. (2009) presented results both at "population" and "watershed" scales, we will focus on their results at the watershed scale, as these are most similar to the ICTRT designated populations (ICTRT 2003) that NMFS considers in recovery plans and status reviews. Even then, the watersheds in the Nielsen et al. (2009) study are not exactly equivalent to the ICTRT populations used in the recent study (Kinzer et al. 2020).
- Nielsen et al. (2009) used the linkage disequilibrium (LDNE) method (Waples and Do 2008) for estimating effective size, whereas Hargrove and Campbell (2020a) used both the LDNE method and one based on kinship (Jones and Wang 2010), reporting the harmonic mean of the two estimates.
- The earlier study used microsatellites, while the latter used SNPs, but this is likely a minor factor, as there is good agreement between the two studies in determining relationships between populations using neighbor-joining trees.
- Likely the most important difference is that the Nielsen et al. (2009) study used samples collected in a single year, 2000, while Hargrove and Campbell (2020a), used samples collected over a period of 10 years. Population size fluctuations could easily cause significant year-to-year variability in measures of diversity and effective size.
- Lastly, hatchery influence has possibly changed over time due to adaptive management of the hatchery programs. For example, in the Upper Salmon River, the use of mainstem release sites was discontinued in 2015-2016.

Nielsen et al. (2009) found that effective sizes in watersheds managed for wild populations (e.g., Lochsa River, Selway River, MF Salmon, and SF Salmon), were significantly higher than those in watersheds managed for hatchery production (mean of 367 vs 144). However, allelic richness, a measure of within population genetic variability, was significantly higher for hatchery-influenced watersheds compared to wild watersheds, perhaps indicative of different alleles contributed by the hatchery and natural components. Of over 3,000 pairwise tests for genetic differences between samples using the F_{ST} statistic, a measure of genetic differentiation between populations, fewer than 10% were not statistically significant, which indicates statistically significant differentiation between the majority of populations. Of the few insignificant tests of natural-hatchery sample pairs, almost all were between the Oxbow, Pahsimeroi, and Sawtooth hatchery stocks and natural populations in the Upper Salmon and Lower Snake regions. Neighbor-joining trees at both spatial scale displayed groupings that seemed geographically logical at the watershed level. However, many nodes in the trees were not well supported by resampling.

In the more recent study (Hargrove and Campbell 2020a; Kinzer et al. 2020), the mean heterozygosity, a measure of within population genetic variability, in ICTRT-defined populations with hatchery additions was slightly higher than wild populations (0.303 vs 0.291), and while statistically significant the differences in heterozygosity among management strategies was small. The mean number of effective breeders (N_b) was also higher in populations with hatchery additions (276) than for wild populations (244), although the difference was also not significant.

Thus, this more recent work suggests that the two types of populations have similar levels of genetic diversity. Importantly, the implied correlations of hatchery management on within-population diversity and effective size noted by Nielsen et al. (2009) were not seen in the more recent work.

The findings of lower effective size yet higher diversity in populations managed for hatchery production relative to those managed for wild production are plausible, however. Berntson et al. (2011) found that the reproductive success of hatchery-origin steelhead in Little Sheep Creek in the Imnaha basin was 30-60% that of natural-origin steelhead, and that the magnitude of the reproductive deficit was linked to density. It is possible for N_b to be reduced if hatchery-origin fish with reduced reproductive capacity displace rather than augment natural spawning. The higher diversity finding would be evident if the hatchery-origin fish contributing to a natural population came from a stock with higher or different levels of diversity than the natural population, and the Pahsimeroi, Sawtooth, and Oxbow stocks displayed higher levels of allelic richness than many natural populations (Nielsen et al. 2009). is that absent hatchery influence,

Average effective size and diversity in populations would be similar without hatchery influence. This could easily not be the case. For example, one of the reasons for initiating hatchery programs in the upper Salmon drainage was that natural steelhead production was historically low in that area. Therefore, it is possible the effective sizes were low in the upper Salmon natural populations prior to hatchery influence.

Another approach to assessing hatchery impacts is to evaluate patterns of genetic differentiation among natural and hatchery populations. As previously mentioned, there is good agreement between Nielsen et al. (2009) and the new analyses of Kinzer et al. (2020). Both found patterns that were logical from a geographical perspective, with better support for some areas of the Snake Basin than others, and both showed areas where hatchery stocks seemed genetically similar to natural populations with which they could be expected to influence.

Figure 3. Presents a neighbor-joining tree (NJT) from the recent analysis (Busack 2020b; Hargrove and Campbell 2020b). Salmon River and Clearwater River groupings, including local hatchery stocks, are well supported by bootstrap resampling. Groupings in the lower basin are less well supported, but still seem logical: Imnaha is separate from Grande Ronde, Grande Ronde populations form a cluster, and Asotin and Tucannon form a group.

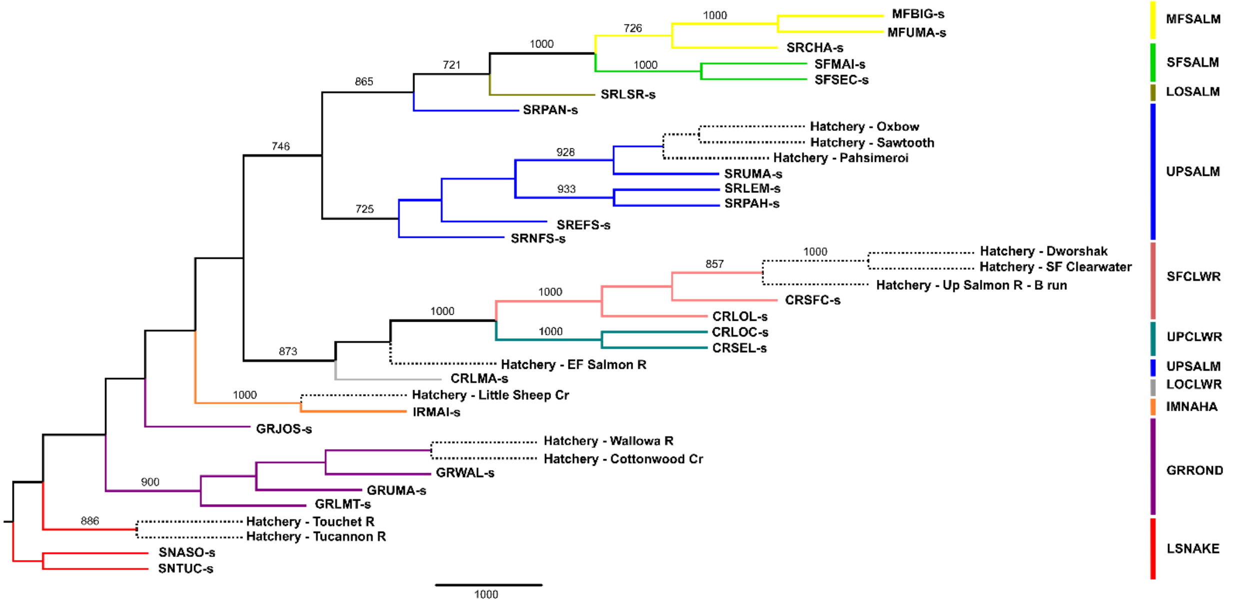

Figure 3. Neighbor-joining tree of Snake Basin natural and hatchery steelhead populations, based on allele frequencies at 176 SNP loci. Numbers on diagram indicate number of times a node appeared in 1000 bootstrap resamplings (Busack 2020b; Hargrove and Campbell 2020b).

To explore the groupings with less bootstrap support, Hargrove (Busack 2020a) evaluated the same data by principal component analysis (PCA; Figure 4). Relationships in this diagram are not nearly as clear as in the NJT, demonstrating how misleading groupings with low bootstrap support can be. Three major clusters are apparent: Salmon (exclusive of upper Salmon), Clearwater (except for lower Clearwater, and a large cluster consisting of upper Salmon, lower Clearwater, Grande Ronde, Imnaha, Tucannon and Asotin. The Clearwater grouping has two obvious subclusters: 1) Lolo Creek, South Fork, and the B-run hatchery programs, and 2) the Selway and Lochsa rivers. A final PCA was done to resolve the "everything else" cluster, using only the populations in that group (Figure 4).

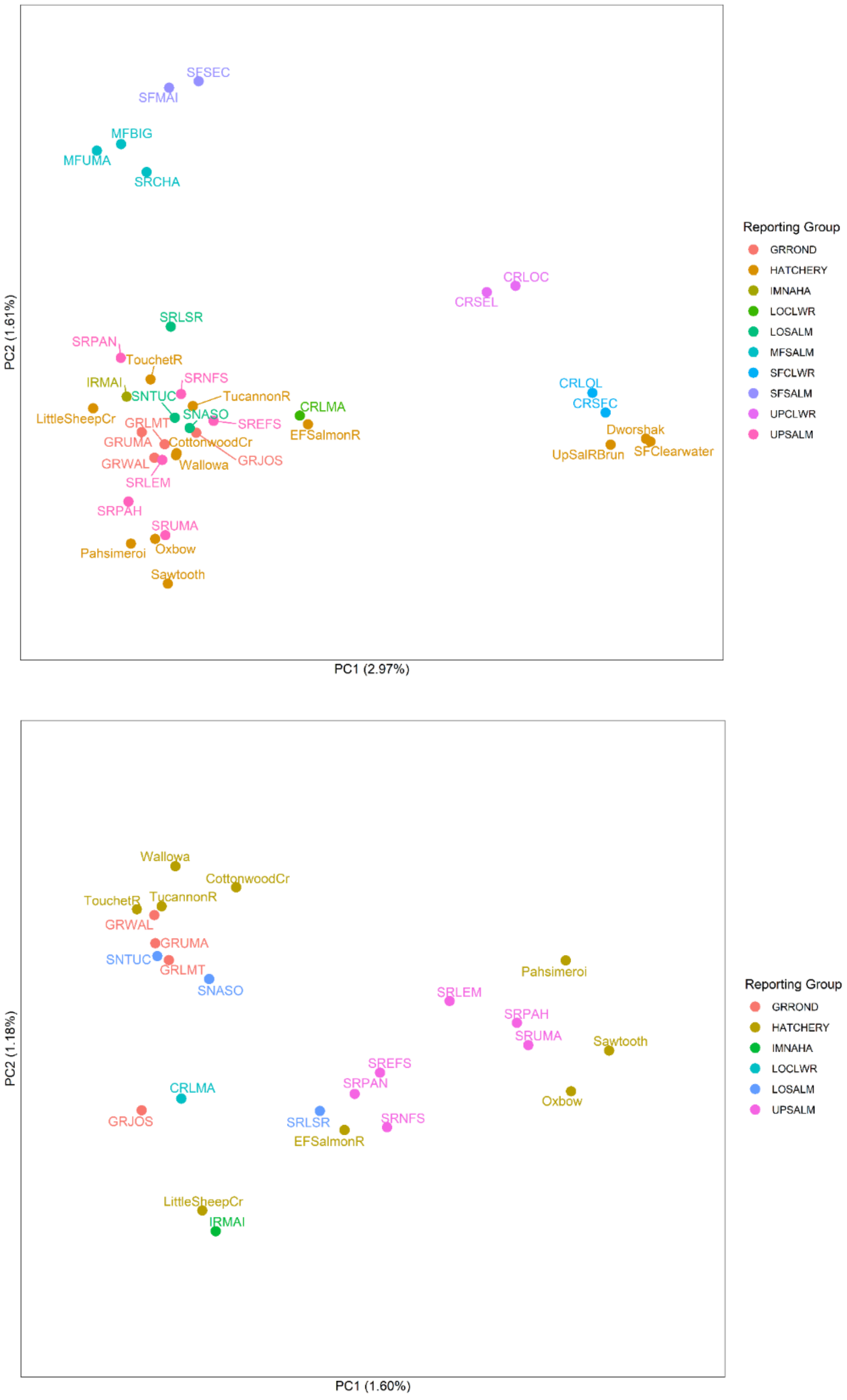

Figure 4. Top: Principal component analysis of Snake Basin natural and hatchery steelhead populations, based on allele frequencies at 176 loci. Bottom: Principal component analysis of selected Snake Basin natural and hatchery steelhead populations (those in lower left group in top figure; Busack 2020a).

This second PCA does a better job than the first of conveying relationships in the “everything else cluster”. Specifically, the upper Salmon River wild populations form a cluster, which includes upper Salmon hatchery stocks and the EF Salmon River/Little Salmon River. The Little Salmon River clustering with upper Salmon stocks is not surprising given that steelhead from the Hells Canyon program (also a source for the Sawtooth and Pahsimeroi hatcheries) have been stocked there for some time. Here and in the past, the Imnaha River is genetically distinct from other populations - in this case, it is somewhat separated from nearby populations. A final cluster in this PCA is Grande Ronde/Asotin/Tucannon populations.

In general, based on the analyses presented, the South Fork Salmon, Middle Fork Salmon, Upper Clearwater, and South Fork Clearwater Rivers are all genetically distinct, with many of the remaining populations exhibiting varying levels of genetic overlap. Gene flow/mixing among populations in the lower sections of the major rivers (Salmon, Clearwater, Snake) has confounded efforts to assign fish from these populations into different genetic stocks (Busack 2020a). In addition, patterns of genetic differentiation among Snake Basin steelhead populations show evidence of the influence of hatchery management. For example, hatchery programs in the Clearwater River (Dworshak, SF Clearwater) influence a subset of populations in the drainage (Lolo Creek, SF Clearwater, but not Upper Clearwater/Lower Clearwater). The positioning of the upper Salmon River populations in Figure 4 also makes sense given the history of fish transfers in the basin. However, these patterns demonstrate that management efforts to minimize hatchery influence in certain areas, typically those targeted for viability or high viability within the current recovery scenario (e.g., Middle Fork Salmon River, Lochsa and Selway Rivers), have been successful.

Gene Flow Assessment for the East Fork Salmon River Population

The East Fork Salmon River Natural Steelhead Program's evaluation is necessarily different from evaluation of the segregated programs because of the use of natural-origin broodstock. The potential negative genetic effects from this program are considered along with the demographic benefit of increasing abundance. To perform our analysis, we will use models that consider the best available information for the target population to determine the likely PNI of the population based on the applicants' proposed proportion of natural-origin broodstock (pNOB) and the pHOS in natural spawning areas. A PNI of > 0.5 indicates that natural selection outweighs hatchery-influenced selection. More background on PNI is provided in Section 5, Appendix A.

Best available data suggests that the East Fork Salmon River Natural program is likely to obtain a PNI of > 0.5. For example, data from 2013-2016 indicates that PNI ranged from 0.39 to 0.52 based on the multi-population model analysis tool developed by Busack (2015), despite very low natural-origin returns (Table 17). In addition, smolt releases were reduced in 2013 from a goal of 170,000 to 60,000 steelhead. Therefore, 2016 would have been the first year where returns from this reduction were realized. Because of this, we calculated the proportional decrease in smolt numbers from those released in 2010 through 2012, which corresponded with return years 2013-2015, to 60,000 and applied this proportional decrease to the returning adult East Fork Natural hatchery-origin steelhead. This allowed us to estimate what pHOS and pNOS would have been for years 2013-2015 if only 60,000 smolts were released, under the assumption that natural-origin return numbers are the same. With this approach, PNI would range from 0.44 to 0.52, and we anticipate that this will increase in the future as long as returns of natural-origin fish increase.

Table 17. Proportionate Natural Influence (PNI) for the East Fork Salmon River Natural Population; pHOS = proportion of hatchery-origin spawners, pNOS = proportion of natural-origin spawners, pNOB = proportion of natural-origin broodstock.

	Natural-origin	Below Weir		Above Weir			
Return Year	Returns	pHOS	pNOS	pHOS	pNOS	pNOB	PNI
Current Conditions							
2013	52	0.95	0.05	0.98	0.02	0.68	0.39
2014	151	0.88	0.12	0.93	0.07	0.63	0.43
2015	102	0.95	0.05	0.98	0.02	0.76	0.45
2016	129	0.84	0.16	0.9	0.1	0.97	0.52
Proposed Action Applied to Current Conditions (releases reduced from 170,000-60,000)							
2013	52	0.89	0.11	0.94	0.06	0.68	0.44
2014	151	0.69	0.31	0.93	0.07	0.63	0.44
2015	102	0.89	0.11	0.95	0.05	0.76	0.46
2016	129	0.84	0.16	0.9	0.1	0.97	0.52

Source: (Leth et al. 2017)

However, because estimated natural-origin returns for this population are so low, we believe at this time that demographic concerns outweigh genetic concerns for the population. This is because the minimum abundance threshold for the East Fork Salmon River population is 500 natural-origin spawners (NWFSC 2015); abundance over the last five years has ranged from about 10-30 percent of this value (Table 17). In addition, in the current recovery scenario, this population is not targeted for viability or high viability, but for maintained status; maintained is synonymous with the HSRG's stabilizing population. These populations are recommended to maintain current conditions (HSRG 2014). Thus, NMFS believes a PNI of 0.5 is adequate for maintaining the population, but a PNI < 0.5 for this population is tolerable to the species at the MPG level when natural-origin abundance is low (i.e. < 250 fish), because the main priority is to ensure enough fish are available to spawn regardless of fish origin.

2.5.2.2.2. Ecological effects

Adult nutrient contribution

The return of hatchery fish likely contributes nutrients to the action area. Table 18 shows that adult hatchery fish, if all estimated returning fish spawn naturally, contribute an estimated 913 kg of phosphorous to the action area annually. Such transport by anadromous fish of nutrients from the marine environment to freshwater is important because temperate freshwater environments like that of the action area are typically low in available nutrients and relatively unproductive (Cederholm et al. 2000). Because some fish are removed from the environment in mark-selective fisheries and for broodstock, and because the iteroparous life history of steelhead means that some adults may return more than once before dying and contributing nutrients, the true contribution is likely less than this value, perhaps ~30 percent less or 274 kg. Regardless, hatchery-origin fish increase phosphorous concentrations, which likely compensates for some marine-derived nutrients lost from declining numbers of natural-origin fish.

Table 18. Total phosphorous imported by adult returns from the proposed hatchery programs based on the equation (Imports= hatchery adults*mass*phosphorous concentration) in Scheuerell et al. (2005).

Program	Release number	SAR (years of data)	Estimated number of hatchery-origin adults[3]	Adult mass (kg)	Phosphorous concentration (kg/adult)	Phosphorous imported (kg/year)
East Fork Salmon A-run	60,000	0.0084[1]	504	4	0.0038	7.7
Upper Salmon River A-run	1,779,000	0.0084 (1995-2005)	14,944			227.1
Hells Canyon	550,000	0.0059 (1995-2005)	3,245			49.3
Pahsimeroi A-Run	800,000	0.0092 (1994-2005)	7,360			111.9
Little Salmon River A-run	636,000	0.0084[1]	5,342			81.2
SSI A-run	500,000 eggs	0.0084[1]	8			0.1
Dworshak	2,100,000	0.0098 (1995-2002)	20,580			312.8
South Fork Clearwater	843,000	0.0043 (1994-2003)	3,625			55.1
Salmon River B-run	1,065,000	0.0042 (1999-2004)	4,473			68.0
SSI B-run	500,000 eggs	0.0042[2]	4			0.1

[1] We used the Upper Salmon A-run values as a surrogate for SARs from these programs.
[2] We used the Salmon River B-run SAR as a surrogate for this program.
[3] Calculated by multiplying the release number by the smolt-to-adult survival rate (SAR) values. For the SSI A-run and B-run programs, we multiplied the number of eggs by the egg-to-smolt survival rate (0.002; HGMP), and then multiplied this by the Upper Salmon River A-run SAR, or Salmon River B-run SARs, respectively.

Competition with natural-origin steelhead for spawning sites

Natural-origin and naturally spawning hatchery-origin steelhead are likely to overlap in their selection of spawning sites due to similar niche requirements. This is a desired result of the supplementation program 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, making sampling difficult and at times unsafe—the analysis on straying above (2.5.2.2.1, Genetic Effects) suggests that straying is low. While some hatchery fish may spawn naturally, this spawning primarily occurs within populations that are not targeted for viability of the DPS. Thus, competition with natural-origin steelhead may occur, but is likely to have a low effect assuming PIT tag detections approximate the extent of possible competition.

Competition with ESA-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 19). 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 19). Chinook salmon and steelhead are also likely to have different spawning site preferences because of the larger size of Chinook salmon. Thus, there is unlikely to be any competition effect between steelhead and other listed salmon species.

Table 19. Run-timing, holding, and spawn timing of adult salmon and steelhead (ODFW 2011).

Species	Run Timing	Holding	Spawning
Spring/Summer Chinook Salmon	March-May	April-July	Early August-mid September
Summer Steelhead	May-August	October-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

Disease

Over the last three years, a variety of pathogens endemic to the Snake Basin have been detected in adult steelhead intended for broodstock, but none of these detections have resulted in a disease outbreak. Although all three pathogens listed in Table 20 have no known treatment, fish health protocols are designed to prevent and control outbreaks with these pathogens. For example, to prevent outbreaks and reduce amplification in natural environments, hatchery staff may decide to cull individuals with high infection loads (IHOT 1995; ODFW 2003; PNFHPC 1989; WWTIT and WDFW 2006). These control measures have proven effective in controlling pathogens as demonstrated by the lack of outbreaks in the broodstock population for the various programs. NMFS believes the risk of hatchery-origin adults transmitting pathogens to listed salmon and steelhead or amplifying pathogen levels in the natural environment is negligible.

Table 20. Pathogen detections in steelhead program adults that are part of the proposed action; IHNV = infectious hematopoietic necrosis virus.

Facility	Program	Pathogen Detected		
		2014	2015	2016
Pahsimeroi Hatchery	Pahsimeroi A	None	IHNV	*Myxobolus cerebralis*
	Salmon River B	IHNV*;* *Renibacterium salmoninarum*	*R. salmoninarum*	*R. salmoninarum; M. cerebralis*
Sawtooth Hatchery	Upper Salmon A	*Renibacterium salmoninarum*	*R. salmoninarum*	*R. salmoninarum; M. cerebralis*
	EF natural	*R. salmoninarum*	None	*R. salmoninarum; M. cerebralis*
Oxbow	Hells Canyon	None	IHNV	None
DNFH	DNFH	IHNV	IHNV	IHNV

2.5.2.2.3. Adult collection

The operation of weirs and traps for broodstock collection may result in the capture and handling of both natural- and hatchery-origin steelhead (Table 23). Samples for parentage-based tagging and relative reproductive success analyses may also be taken from all steelhead regardless of origin at the time of collection. Handling and sampling of hatchery-origin steelhead for B-run hatchery programs at Lower Granite collected at Lower Granite Dam was previously covered as part of the Lower Granite Dam trap operations considered in the opinion on the Columbia River System Operations Biological Opinion (NMFS 2019a). Fish selected for broodstock based on size and timing indicative of B-run steelhead are transported to DNFH where they are held and ultimately spawned. These are very reliable indicators of B-run steelhead from programs in the Snake River. For example, of the 318 steelhead collected for B-run broodstock in 2019, and assigned to the PBT baseline, 317 originated from the three B-run programs, and 300 originated from the two B-run programs in the Clearwater Subbasin (Brian Leth, IDFG, personal communication, December 12, 2019).

There is likely to be a small negative effect of collection on listed salmon because a relatively small number are handled at these facilities when used for steelhead (Table 22). Encounters with sockeye salmon during the operation of these weirs and traps for steelhead broodstock collection is a rare occurrence; the effects of such capture and handling on sockeye salmon was evaluated in the opinion on issuance of ESA section 10 permits 1450 and 1455 (NMFS 2013) and determined to not result in jeopardy of the species or adverse modification of critical habitat.

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 co-managers (Section 1.3) minimize the delays to and affects fish; fish generally are not delayed for more than 24 hours 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.

Table 21. Number of ESA-listed steelhead handled by origin. Mortalities, if any, are shown in parentheses and exclude those used as broodstock; these mortalities are attributed only to the act of collecting, handling and holding adults.

Facility	Origin	Average Actual Handling; min and max (mortalities)	Proposed Handling (incidental mortality)[1]
Pahsimeroi Hatchery Weir	Natural	125; 22-378 (0)	400 (4)
	Hatchery	283; 110-567 (0)	900 (5)
Sawtooth Hatchery Weir	Natural	48; 15-115 (0)	200 (2)
	Hatchery	0	10 (1)
East Fork Weir	Natural	30; 2-94 (0)	200 (2)
	Hatchery	285; 3-1115 (2)	1200 (12)
Yankee Fork Hook-and-Line Angling[2]	Natural	Not available	142 (8)
	Hatchery	Not available	220 (11)
Yankee Fork Weir[3]	Natural	17 (0)	60 (1)
	Hatchery	35 (0)	2000 (20)
Hells Canyon Weir	Natural	63; 2-186 (1)	200 (2)
	Hatchery	0	10 (1)
Dworshak Hatchery[4]	Natural	31; 1-4 (2)	75 (8)
	Hatchery	3463: 3255-3723 (104)	3900 (200)
Kooskia Hatchery[5]	Natural	8: 0-22	25 (2)
	Hatchery	Not available	300 (30)
SF Clearwater (Clearwater Hatchery)[6]	Natural	Not available	10 (1)
	Hatchery	Not available	400 (4)

Sources: (Izbicki 2017; Leth 2017b)

[1] Up to 100% of the fish returning to the weir will be handled.

[2] Angling is conducted by SBT staff to supplement brood collections at the weir. Based on brood need, PIT tag detections of hatchery- and natural-origin fish in Yankee Fork and an estimated catch and release mortality of 5 percent (Ebel 2017).

[3] Because the SBT has only operated a temporary side-channel weir on Yankee Fork in 2017, and that was only for 17 out of the 60 days they are likely to operate the weir in the future, we have scaled up these values to reflect this longer use period. Hatchery numbers are based on an SAR of 0.003 for a 620,000 smolt release.

[4] Average handling, and min and max mortalities information for DNFH based on actual values for the most recent three years (2015-2017). Values only pertain to volunteers to DNFH, SF adults collected are not included.

[5] Because this is a back-up collection location for DNFH that is rarely needed, actual data on the number of hatchery steelhead collected annually was not available. Natural fish data is for years 2001-2009 from USFWS and NPT (2010).

[6] Fish are provided to the hatchery by anglers.

Table 22. Number of fall Chinook and spring/summer Chinook salmon handled during steelhead broodstock collection by origin. Mortalities, if any, are shown in parentheses these mortalities are attributed only to the act of handling adults intended for re-release.

Facility	Origin	Fall Chinook salmon	Spring/summer Chinook Salmon

		Average Actual Handling; min and max (mortalities)	Proposed Handling (mortalities)	Average Actual Handling; min and max (mortalities)	Proposed Handling (mortalities)
Pahsimeroi Hatchery Weir	Natural	0	0	0	0
	Hatchery	0	0	0	0
Sawtooth Hatchery Weir	Natural	0	0	0	0
	Hatchery	0	0	0	0
East Fork Weir	Natural	0	0	0	10 (1)
	Hatchery	0	0	0	10 (1)
Yankee Fork Weir	Natural	0	0	0	0
	Hatchery	0	0	0	0
Hells Canyon Trap	Natural	14; 1-42	50 (1)	0	0
	Hatchery	100; 10-239	300 (3)	0	0
Dworshak Hatchery Ladder[1]	Natural	0; 0 (0)	10 (2)	Not applicable	
	Hatchery	27; 0-81 (0)	100 (5)		

Sources: (Izbicki 2017; Leth 2017b)

[1]Average handling, minimum and maximum handling, and mortality information for Dworshak Hatchery based on actual values for the most recent three years (2015-2017).

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

The effects of this factor on all four listed species is negative, as discussed in greater detail below.

2.5.2.3.1. Hatchery release competition and predation effects

We used the PCDRisk model of Pearsons and Busack (2012) PCDRisk, to quantify the potential number of natural-origin salmon and steelhead juveniles lost to competition and predation from the release of hatchery-origin juveniles. The original version of the model suffered from operating system conflicts that prevented completion of model runs and was suspected of also having coding errors. As a result, Busack modified the program in 2017 into a considerably simpler version to increase supportability and reliability. At present, the program does not include disease effects and probabilistic output. Parameter values used in the model runs are shown in Tables 25-27.

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, sockeye salmon, and steelhead in the action area. However, our analysis is limited to 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 natural-origin species, by adjusting the total distance traveled. For example, Snake River sockeye juveniles do not inhabit the Clearwater Subbasin 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 River (more detailed calculations can be found in Hurst (2017b)). 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 basin wide-scale overlap. We acknowledge that a 100-percent population overlap in microhabitats is likely an overestimation.

In addition, our model does not include age-0 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. A lack of spatial overlap with age-0 sockeye salmon rearing in Redfish, Petit and Alturas Lakes, provide the basis for our decision to also not include this age-class in our model. In addition, we did not analyze the effects of hatchery steelhead on age-1 steelhead below Lower Granite Dam because these fish are not yet smolted and migrating downstream. Including them in our analyses all the way to Lower Granite Dam is also probably an overestimate of effects, as this steelhead age class is unlikely to move out of tributary rearing areas until the following year. We also excluded age-1 natural-origin Chinook salmon from our model runs in the Clearwater Basin because spring/summer Chinook salmon are unlisted there, and listed fall Chinook outmigrate as age-0 fish.

In contrast to how we have used the model in other areas (e.g., Upper Columbia River), we considered the proportion of fish being barged downstream in this model. We used barging proportions from 2008 and 2015 (Table 25) to represent the range of possible barging proportions, but we do not anticipate these proportions to vary more than they have in the past despite a new flex spill regime at the dams (Jay Hesse, NPT, personal communication, May 26, 2020). To do this we estimated survival and travel times from each release site down to Lower Granite Dam. We then estimated the number of hatchery steelhead that arrived at Lower Granite Dam from each program, removed those that are barged, and routed the remainder through the model with new inputs for survival and travel time from Lower Granite Dam to Ice Harbor Dam (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
Hatchery fish size (mm)	200
Piscivory	0.0023
Maximum encounters per day	3

Predator: prey length ratio for predation	0.25[1]
Average temperature across release sites	10.5°C[2]

[1] Daly et al. (2014)
[2] DART, accessed on May 15, 2017.

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	55 (10)
	1	91 (11)
Steelhead	1	71 (10)
	2	128 (30)
Sockeye Salmon	1	86 (7)
	2	128 (8)

Sources: HETT (2014; for sockeye salmon); (Rabe 2017; Young 2017)

Table 25. Hatchery fish parameter values for the PCDRisk model; SSI = steelhead streamside incubator.

Program	Release Site	Release #	Survival to LG Dam	Residence/Travel Time to LG Dam (days; from 2010-2016)[1]	Proportion Barged in 2008	Proportion Barged in 2015	Survival from LG to ICH Dam	Travel Time from LG to ICH Dams (days)
East Fork Salmon A	East Fork River	60,000	0.7	18	0.485	0.135	0.86	3
Pahsimeroi A	Pahsimeroi Hatchery	800,000	0.85	26				
Upper Salmon River A	Sawtooth Hatchery	1,779,000	0.77	18				
SSI Project A	Panther Creek	800	0.77	12				
	Indian Creek	200	0.77	12				
Hells Canyon A	Hells Canyon Dam	550,000	0.72	35				
Little Salmon River A	Little Salmon River: Stinky Springs	636,000	0.95	19				
Salmon River B	Little Salmon River: Stinky Springs	217,000	0.91	20	0.557	0.214		
	Pahsimeroi Hatchery	248,000	0.82	18				
	Yankee Fork	620,000	0.69	21				
SSI Project B	Yankee Fork	1,000	0.69	21				
Dworshak B	Dworshak Hatchery	1,200,000	0.81	15 (3)	0.304	0.078		
	Clear Creek	300,000	0.73	14 (4)				
	Lolo Creek	200,000	0.66	10 (3)				
	Red House Hole	400,000	0.84	12 (4)				
SF Clearwater (Clearwater Hatchery) B	Meadow Creek	501,000	0.79	17 (4)				
	Red House Hole	219,000	0.84	12 (3)				
	Newsome Creek	123,000	0.8	28 (6)				

Sources: (Griffith 2017; Leth 2017a; McCann 2017)

[1] This value has been altered for sockeye salmon (shown in parentheses) to reflect when natural-origin sockeye salmon are likely to be encountered (i.e., only once Clearwater fish reach the mainstem Snake River). For the streamside incubator programs, we used the travel rate for the egg source program to estimate travel time.

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 Chinook salmon, and sockeye salmon. The maximum numbers of fish lost are shown in Table 26, and would not change if more natural-origin fish were present throughout the action area because we used natural-origin fish numbers to the point where all possible hatchery fish interactions are exhausted at the end of each day. The exception to this is for sockeye salmon because we have data for natural-origin abundance for the one population that composes the entire ESU that demonstrates that, from 2006-2016; the maximum number of natural-origin sockeye salmon produced was ~61,000. Thus, we used this value in the model along with the actual proportions of each age-class (87 percent age-1, and 13 percent age-2) available (Kozfkay 2017).

We used the average number from 2011-2016 of each species that passed over Lower Granite Dam from 2011-2016 to estimate the percentage adult equivalents lost from competition and predation during the juvenile life stage. These values were 30,607 for natural-origin Chinook salmon (both fall and spring/summer runs combined; section 2.4.4, Harvest baseline), 25,991 for steelhead (Table 13 in Harvest baseline section), and 1,115 for both hatchery and natural sockeye salmon (DART, 10-year average from 2007-2016 accessed August 2, 2017). Therefore, we anticipate a maximum potential loss of ~ 1.8, 4.6, and 2.6 percent of the potential adult return for Chinook salmon, steelhead, and sockeye salmon respectively, from competition and predation with hatchery smolts as juveniles. In addition, these negative effects are spread out over the various populations that comprise the Snake River ESUs/DPSs, and include the unlisted spring/summer Chinook salmon originating from the Clearwater Subbasin.

Travel time of juvenile hatchery fish can have a substantial effect on the outcome of the model. This is because the slower fish travel, the more time available for preying and competing on the natural-origin juveniles in the area. Thus, in the future, NMFS recommends monitoring of this input parameter to identify any potential increase in ecological effects. Specifically, we anticipate the 5-year running median of the travel time to Lower Granite Dam to slow by no more than three days beyond the median travel time identified in Table 25.

We do not anticipate a notable change in our analysis associated with backfilling of program fish with another program to help meet mitigation goals for a couple of reasons. The first is that backfilling is a contingency plan for a production shortage, and is likely to occur only in years of low steelhead abundance. For example, fish from either the Upper Salmon or Pahsimeroi programs were used to backfill a production shortage at Hells Canyon only four times in the last 30 years (IDFG 2020). Second, travel times to Lower Granite Dam across the various release groups and programs in the Salmon River Basin and Hells Canyon are within ~two weeks of each other (Table 25). Furthermore, we are monitoring travel time as described above. Third, there is no increase in program releases because of the backfilling contingency plan.

Table 26. Maximum numbers and percent of juvenile natural-origin salmon and steelhead lost annually to predation (P) by and competition (C) with hatchery-origin steelhead smolts released under the Proposed Action.

Program	Chinook		Steelhead		Sockeye	
	P	C[1]	P	C[1]	P	C[1]
Release to Lower Granite Dam						

East Fork Salmon Natural A-run	184	650	26	1036	0	368
Pahsimeroi A-run	4314	13510	690	21712	0	536
Upper Salmon River A-run	7328	19590	1932	31673	0	371
SSI Project A-run	2	7	1	12	0	5
Hells Canyon A-run	3548	11619	559	18661	0	722
Little Salmon River A-run	2554	8308	415	13375	0	391
Salmon River B-run	4278	13374	631	21353	0	1053
SSI Project B-run	5	13	1	20	0	8
Dworshak B-run	6735	11318	977	29669	0	97
SF Clearwater B-run	4814	9053	429	14418	0	69
Lower Granite Dam to Ice Harbor Dam						
Aggregate-large barged proportion	2495	6699	214	9399	0	62
Aggregate-small barged proportion	4447	10085	702	13022	0	62
Total Juveniles Lost	130398-135736		167203-171314		5847	
SAR[2]	0.004		0.007		0.005	
Adult Equivalents	522-543		1170-1199		29	

[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 for each competitive interaction, but does provide a maximum mortality estimate using these parameter values.

[2] Smolt-to-adult survival rate for Chinook salmon averaged across all spring/summer Chinook salmon programs in Idaho (NMFS 2017a; NMFS 2017e; NMFS 2017f), steelhead (Table 18), and sockeye salmon (IDFG 2012).

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

Residual hatchery steelhead are those fish that do not emigrate to the ocean after release from the hatchery. These fish have the potential to compete with and prey on natural-origin fish for a longer period relative to fish actively outmigrating, and could impart some genetic effects when they spawn naturally. Although residualism is a natural life history, hatchery programs have the potential to increase residualism rates through hatchery rearing. The SSI project is an exception in that we do not anticipate any effects from residuals beyond naturally occurring residualism levels. This is because these fish are placed into the natural environment as eggs and are allowed a more natural feeding and growth regime as opposed to fish reared in a hatchery.

Residuals are not explicitly accounted for in our model at this time, but NMFS recommends the applicants monitor this phenomenon through visual assessment of juvenile fish prior to release. Supporting methods of estimating residual rates, such as comparing survival values between volitional migrant and forced-out releases and assessment of sexual development via gonadosomatic index (GSI), may be conducted to provide reliable estimates for some release groups. We anticipate the number of residual fish to be no more than 5 percent based on a 5-year running average of the number of fish within each release group, leading to a small negative effect on listed natural-origin salmon and steelhead. This threshold is based on a study conducted by IDFG (2003) that demonstrated that of three hatcheries rearing steelhead (Hagerman NFH, Niagara Springs, and Magic Valley), a maximum of ~5 percent of the males sampled were precocially mature. Females were sampled, but few, if any, were found to be precocially mature. NMFS recommends expanding this metric to include both parr and precocially mature fish, which are more likely to residualize, and to include female samples in the calculation. Additionally, similar to the discussion of straying above, populations most at risk of negative effects attributable to residualism have high productivity and increasing abundance. This information supports the conclusion that maintaining residualism potential similar to the 2003 study is unlikely to inhibit the growth of listed steelhead populations.

2.5.2.3.2. 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. 2014a), but the progeny of such hatchery-origin spawners are likely to make up a sizable portion of the juvenile fish population for those areas where hatchery-origin steelhead are allowed to spawn naturally. This is actually a desired result of the integrated recovery programs. Therefore, the only expected effect of this added production is a density-dependent response of decreasing growth and increased competition/predation when habitat capacity is being approached. However, ecological impacts on both listed Chinook salmon and steelhead may increase in the future if the steelhead populations grow.

Because spring/summer and fall Chinook salmon and sockeye salmon historically coexisted in substantial numbers with steelhead, it follows that there must have been adequate passage and habitat to allow all 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 all four species are so depleted that they are listed under the ESA. Should the situation arise where steelhead natural production is limiting natural production of listed salmon species, 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 and reporting requirements (Section 2.9) to ensure that appropriate monitoring takes place.

2.5.2.3.3. Disease

The risk of pathogen transmission to natural-origin salmon and steelhead is negligible for these steelhead programs. This is because juvenile rearing for all steelhead programs in the Salmon Basin occurs on spring or well water, with minimal, if any, exposure to pathogens through the water source. In addition, none of the rearing facilities for steelhead released in the Salmon Basin are in anadromous areas. Thus, even though detections and outbreaks with endemic pathogens do occur (Table 27 and Table 28), it would be very unlikely that any listed salmon or steelhead could be exposed to pathogens shed from hatchery fish during rearing. In addition, treatments for the pathogens responsible for outbreaks in Table 28 below usually are effective within 3-10 days after treatment begins. Thus, the amount of time available over which shedding of pathogens could occur is limited.

There are a few pathogens in the tables below for which there is no known treatment; *Renibacterium salmoninarum* (causes bacterial kidney disease), *Myxobolus cerebralis* (causes whirling disease), and infectious hematopoietic necrosis virus (IHNV; causes infectious hematopoietic necrosis). However, fish health protocols are designed to prevent and control outbreaks with these pathogens. For example, 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, control the transmission of IHNV (IHOT 1995; ODFW 2003; PNFHPC 1989; WWTIT and WDFW 2006). Culling of fish with *R. salmoninarum* and *M. cerebralis* infections is also an option. These control measures have proven effective in controlling pathogens as indicated by the outbreak of IHNV twice at one facility over the past three years, in association with another bacterial pathogen. Given this information, NMFS believes the risk of hatchery-origin adults transmitting pathogens to listed salmon and steelhead or amplifying pathogen levels in the natural environment is negligible.

Table 27. Pathogen detections in hatchery steelhead juveniles that are part of the proposed action; IHNV = infectious hematopoietic necrosis virus.

Facility	Program	Pathogen Detected		
		2014	2015	2016
Magic Valley Hatchery	Pahsimeroi A	None	None	*Flavobacterium psychrophilum (x2)*
	Salmon River B	*F. psychrophilum*	None	*F. psychrophilum (x2)*
Niagara Springs Hatchery	Hells Canyon	None	IHNV, *F. psychrophilum*	*Aeromonas hydrophila; Flavobacterium sp.*
	Pahsimeroi A	None	None	*A. hydrophila*
Hagerman NFH	Upper salmon A	*Nucleospora salmonis; F. psychrophilum; A. hydrophila; Gyrodactylus spp.*	*N. salmonis; F. psychrophilum, Ichthopthorius multifiliis; A. hydrophila; Gyrodactylus spp.; Chilodonella spp.; Pseudomonas fluorescens; Ichthyobodo sp.*	*N. salmonis; F. psychrophilum; A. hydrophila; Gyrodactylus spp.*
	East Fork Natural	*N. salmonis; R. salmoninarum; Ambiphyra spp.; Gyrodactylus spp.*	*N. salmonis; F. psychrophilum, I. multifiliis*	*N. salmonis; R. salmoninarum; Ambiphyra spp.; Gyrodactylus spp.*
DNFH	DNFH	IHNV, *F. psychrophilum*	IHNV, *F. psychrophilum*	IHNV

Sources: (Blair 2017; Eaton 2017; Munson 2017a; Munson 2017b; Munson 2017c)

Table 28. Disease outbreaks in steelhead program juveniles that are part of the proposed action; IHNV = infectious hematopoietic necrosis virus.

Facility	Program	Pathogen	Date(s)	Treatment/ Control Regime
Clearwater Hatchery	SF Clearwater	*Flavobacterium psychrophilum*	September 2015	Medicated feed

Magic Valley Hatchery	Salmon River B-run	*F. psychrophilum*	June 2015	Medicated feed
Niagara Springs Hatchery	Hells Canyon	*F. psychrophilum*	July-August 2014; July 2015; August 2015	Medicated feed
	Hells Canyon	*Aeromonas hydrophila*	August-September 2014	Medicated feed
	Hells Canyon	IHNV, *F. psychrophilum*	November 2014; February 2015	Medicated feed
	Pahsimeroi A-run	*A. hydrophila*	August-September 2014	Medicated feed
	Pahsimeroi A-run	*F. psychrophilum*	June 2015; September 2015	Medicated feed
	Hells Canyon	*F. branchiophilum*	July 2016	Chloramine-T
Hagerman National Fish Hatchery	Upper Salmon A and East Fork Natural	*Icthyopthirius multifiliis*	October – December 2016	Potassium permanganate
		F. columnare	March 2015	Potassium permanganate/chlormaine T
		I. multifiliis	December 2015-January 2016	Formalin
		I. multifiliis	August-December 2014	Formalin

Sources: (Blair 2017; Eaton 2017; Munson 2017a; Munson 2017b; Munson 2017c)

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

RM&E actions included in the proposed action are described in Table 5 above. Although there is a great deal of additional RM&E that takes place in the action area to assess the effects of these programs on listed species, the effects of this RM&E on listed species is largely included in the Environmental Baseline. For example, run size, PBT sampling, and PIT tagging of unclipped adults all takes place at the Lower Granite Dam Trap, which is covered in the NMFS' Opinion on the Federal Columbia River Power System and the associated Reasonable and Prudent Alternative (NMFS 2014). As part of our proposed action, we also intend to insert PIT tags into adipose-clipped hatchery-origin adults (potentially up to 5,000) to improve our understanding of hatchery-origin steelhead distribution in natural-spawning areas.

There is also a variety of section 10 permits and 4(d) authorizations currently in place to allow the operators to assess natural-origin juvenile abundance, productivity and migration timing with screw traps and electrofishing and to conduct spawning ground/redd surveys for estimating escapement to individual populations. These include the 4(d) "IDFG Salmon Basin VSP monitoring for spring/summer Chinook and steelhead" project (APPS #20863), the 4(d) "IDFG Region 2 Fish Management" project (APPS #20868), Section 10(a)(1)(A) # 16615-2R "Operation, monitoring and evaluation of the Nez Perce Tribal Hatchery (NPTH) fall Chinook salmon program, and Section 10 permit numbers 1341-5R, 19391, 1339-5M, 1334-7R, 1127-4R, 16298-3R, and 1454. The expected impacts of each of the RM&E activities were previously analyzed by NMFS in the Biological Opinions associated with these 4(d) authorizations and Section 10 permits. None of these analyses resulted in jeopardy, and RM&E activities have both beneficial (e.g., more accurate estimates of out-migrant timing) and negative effects (e.g., small proportion of incidental mortality).

Some of the take associated with screw trap operation and electrofishing in the Snake Basin was previously covered by Section 10 permits, but the continued effects associated with ongoing operation is included as part of the proposed action here. The effects of the Yankee Fork, and Panther Creek screw traps are detailed in Table 29. The effects of electrofishing on steelhead in Yankee Fork and Panther Creek are detailed in Table 30. In addition, a few spring/summer Chinook salmon adults (10 hatchery, 5 natural) may be incidentally encountered at each screw trap during operation annually, resulting in mortality of up to two adults of each origin. The total number of natural steelhead adult equivalents potentially handled and incidentally killed by these activities is 113 and 6, respectively, a small negative effect.

The proposed RM&E directly related to fish culture uses well established (e.g., AHSWG 2008) methods and protocols. Listed fish are cultured in the East Fork Salmon River Natural, South Fork Clearwater (Clearwater Hatchery) B-run, DNFH B-run, and Salmon River B-run programs. Green egg-to smolt survival rates have been about 55 percent from 2002-2008 (IDFG 2009; IDFG 2011a; IDFG 2011b; USFWS and NPT 2010). 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)).

For each program, a proportion of the juvenile releases (Table 3) are PIT-tagged to assess outmigration survival and travel time. These tags also aid in estimating adult distribution upon return. For the Salmon River B-run program, operators are conducting a study to assess which release strategy, direct or acclimated, results in better adult homing to Yankee Fork with PIT tags and PBT. Because the intent of RM&E 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 beneficial effect of RM&E on steelhead. Incidental effects resulting from tagging such as injury, on fall and spring/summer Chinook salmon and sockeye salmon are negligible.

Table 29. Number of juvenile steelhead handled/tagged and that incidentally die due to handling/tagging and trap operation during juvenile rotary screw trapping.

Trap Site	Fish Species	Fish origin	Average, minimum, and maximum of observed handling/tagging (incidental mortality)	Proposed handling/tagging (incidental mortality)	Adult Equivalents handled (incidental mortality)
Yankee Fork[1]	Steelhead	Natural	1099; 858-1448 (25; 18-32)	5000 (100)	36 (2)
		Hatchery	206; 41-442 (0)	2000 (20)	14 (0)
Panther Creek[2]	Steelhead	Natural	Not applicable	2500 (50)	18 (1)
		Hatchery	Not applicable	1000 (10)	7 (0)

[1] Based on trapping from 2014-2016, was previously covered in permit 1127-4R. The proposed values were derived from past data and based on a potential trap efficiency doubling from 5-10 percent due to use of a bigger trap and a new trap location in the near future (Jonathan Ebel, SBT, personal communication).

[2] Was previously covered in permit 19391, but no actual take was available in the Apps database.

Table 30. Number of juvenile steelhead handled/tagged and that incidentally die from handling/tagging during electrofishing.

Electrofishing Site	Fish origin	Actual handling/tagging (incidental mortality)	Proposed handling/tagging (incidental mortality)	Adult Equivalents handled (incidental mortality)
Yankee Fork[1]	Natural	1663; 377-2560 (101; 33-148)	4000 (200)	28 (2)
	Hatchery	0 (0)	100 (2)	1 (0)
Panther Creek[2]	Natural	Not applicable	4000 (200)	28 (2)
	Hatchery	Not applicable	100 (2)	1 (0)

[1] Based on trapping from 2014-2016, was previously covered in permit 1127-4R.

[2] Was previously covered in permit 19391, but no actual take was available in the Apps database.

2.5.2.5. 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; NA = not applicable; SSI = steelhead streamside incubator

Facility	Maximum Surface Water Use (cfs)	Maximum Ground or Spring Water Use (cfs)	Surface Water Source/ Discharge Location	Diversion Distance (km)	Minimum Mean Monthly Surface Water Flow During Operation (cfs)	Maximu Percent Surface Wa Diverte
Magic Valley Fish Hatchery	NA	87.2	Crystal Springs	NA	NA	NA
Niagara Springs Fish Hatchery	NA	120	Niagara Springs	NA	NA	NA
Hagerman National Fish Hatchery	NA	84.6	Springs	NA	NA	NA
East Fork Salmon River Satellite	15	NA	East Fork Salmon River	0.06	143.1 (March)[1]	10.5
Dworshak National Fish Hatchery	182	NA	Clearwater River	3.0	1,938 (October)[2]	9
SSI: Panther Creek, Beaver Creek 2	0.021	NA	Beaver Creek	0.015	74 (July)[3]	< 1
SSI: Panther Creek, Beaver Creek 3	0.021	NA	Beaver Creek	0.015		< 1
SSI: Panther Creek, Beaver Creek 4	0.021	NA	Beaver Creek	0.015		< 1
SSI: Indian Creek 1	NA	0.021	Indian Creek	0.015	NA	NA
SSI: Indian Creek 2	NA	0.021	Indian Creek	0.1	NA	NA
SSI: Yankee Fork, Cearly Creek	0.021	NA	Cearly Creek	0.1	155 (July)[4]	< 1
SSI: Yankee Fork, Swift Gulch	0.021	NA	Swift Gulch	0.1		< 1
SSI: Yankee Fork, Ramey Creek	0.021	NA	Ramey Creek	0.1		< 1
SSI: Yankee Fork, Greylock Creek	0.021	NA	Greylock Creek	0.1		< 1
SSI: Yankee Fork, Jordan Creek	0.021	NA	Jordan Creek	0.1		< 1

[1] Idaho Power Company Gauge 13298050 flow data from 2014-2017, accessed July 25, 2017.

[2] Data from HDR and USFWS (2017).

[3] United States Geological Survey (USGS) gauge 13306370 flow data from 2012-2016, accessed July 25, 2017.

[4] USGS gauge 13296000 flow data from 2012-2016, accessed July 25, 2017.

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 Niagara Springs, Magic Valley, and Hagerman, all three hatcheries are out of anadromous waters and no surface water is used, thus the facilities will not cause a change in habitat use or decrease availability of water in rearing or spawning areas (Table 31). Of those facilities included in the Proposed Action and considered in this Opinion, surface water usage is estimated to be less than 15 percent of the total surface water available at each location, even during the month of operation with the lowest surface water flow (Table 31). In addition, water at all facilities is diverted over a relatively short distance, the degree of reduced flow over that distance is not enough to interfere with passage or rearing through that reach, and the water usage is ultimately non-consumptive.

Low flows during the summer months may affect juvenile rearing. Only the steelhead streamside incubators use surface water and are operated during the summer months (May through July). However, these facilities use less than one percent of the water available in either Yankee Fork or Panther Creek. In addition, few juveniles are present during the summer, as most spring Chinook and steelhead smolts would have emigrated in the late spring to early summer. Juveniles may also choose to move to deeper pools for holding during periods of low flow. Because climate change trends indicate that juveniles may outmigrate earlier with less tributary water available, the risk of dewatering juvenile rearing habitat during the summer months under likely changes in climate conditions is non-existent (Dittmer 2013).

A concern at DNFH is the potential for listed steelhead and fall Chinook salmon juveniles to enter the hatchery system via the hatchery North Fork Clearwater River water intake. Because the intake screen was installed in 1968, it does not adhere to the most recent NMFS screening criteria (NMFS 2011b). While this alone may not be a problem, there is a recent incidence of natural-origin juveniles, largely fry, within the hatchery water system.

In 2013, fish were discovered in the head boxes of Chinook raceways (on the other side of the Chinook raceway screens). Twenty-eight were captured and a fin sample was taken to determine if they were offspring from DNFH parents. Thirteen of the samples were *O. mykiss* and the remaining samples were Chinook salmon (the race was not identified). None of the samples were from fish spawned at DNFH hatchery (Nemeth 2017), although assignment is not 100%. Thus, these fish could have been DNFH Chinook salmon that did not assign correctly, un-listed natural-origin spring Chinook salmon, listed fall Chinook salmon, or listed natural-origin steelhead.

If a natural-origin fish passes the intake screen and enters the hatchery water system, it may:

- Return to the river volitionally
- Rear in the water system until all rearing containers are evacuated during spring smolt releases,
- Be flushed out with hatchery discharge water while production fish are still being reared, or
- Become entrained and perish/be injured anywhere in the water system.

Natural-origin fish entering and rearing in the hatchery system can be difficult to identify because hatchery production fish can also escape past raceway or burrow’s pond screens and continue to rear in the system. Once the fish are swimming freely in the water system, they can be difficult or impossible to capture depending upon where they are located.

Fish found dead are usually newly emerged fry, but occasionally larger fish are found. Until 2017, the hatchery did not keep a record of mortalities found in the hatchery water system. Anecdotally, prior to 2017 and corroborated by monitoring since 2017, this has happened infrequently. Species identification can be hampered by the small size and deteriorated condition of the specimens. Since 2017, only one fish mortality has been documented within the hatchery water system, on the fire maintenance intake screen where entrained fish can be readily recovered. It was an adipose-clipped Chinook salmon collected on May 4, 2017 and was smolt-sized. Employees suspect it was likely a DNFH released fish that swam back into the DNFH water system.

Beginning in 2020, personnel will monitor and document the numbers of non-hatchery production fish present outside of rearing containers in the hatchery water system throughout the year. A portion of these fish may be collected and genetically analyzed to determine if they originated from the DNFH program or elsewhere. Other information such as species, race, origin, and final disposition will be collected when possible, and reported annually to NMFS.

The facilities discharge proportionally small volumes of water with waste (predominantly biological waste) into a larger water body, which results in temporary and very low or undetectable levels of contaminants. General effects of various biological waste in hatchery effluent are summarized in (NMFS 2004), 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.

In addition to monitoring, data collection, and reporting, modifications to the intake screen could provide a beneficial effect by preventing entry of natural-origin fish from the North Fork River into the DNFH. A recent evaluation (USACE 2018) of the intake screens at DNFH was completed by the ACOE in coordination with NMFS' engineering staff for compliance with NMFS' most recent screening criteria (NMFS 2011). NMFS engineers have since reviewed that report, and the report confirms the intake is not in compliance. The ACOE will coordinate with USFWS, NPT, and NMFS Environmental Services Branch to bring the structure into compliance with current passage and screening criteria. The ACOE intends to solicit funds for re-design to meet NMFS design criteria in 2023. Once the design is completed, the ACOE will have an estimate for the construction cost and the necessary funding request to support construction will be initiated.

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).

All of the hatchery facilities listed above are either operated under NPDES permits, or do not need a NPDES permit because rearing levels in the acclimation pond are below permit minimums. Facility effluent is monitored to ensure compliance with permit requirements. Though compliance with NPDES permit conditions is not an assurance that effects on ESA-listed salmonids will not occur, the facilities use the water specifically for the purposes of rearing steelhead, which have a low mortality during hatchery residence compared to survival in the natural-environment (~55 percent compared to 7 percent (Bradford 1995)). Because the same water used for rearing (where survival is high compared to the natural environment) is then discharged into the surrounding habitat and then further diluted once it is combined with the river water, we believe effluent will have a minimal impact on ESA-listed salmonids in the area.

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. In general, the measures would limit effects to short-term sublethal effects such as fish displacement, and/or startling of fish, and would not result in any deviation beyond normal fish behavioral responses to environmental disturbances. Therefore, routine maintenance effects do not result in harm, harassment or mortality of any listed individuals.

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

Because fisheries in the action area are ongoing, the description of the fisheries and the effects of the fisheries on listed species are described in Section 2.4.4, Harvest, in the Environmental Baseline, and are considered as part of the determination in section 2.8 below.

2.5.2.7.Factor 7. Kelt Reconditioning Program

Snake Basin steelhead are iteroparous, meaning they are able to spawn more than once. In contrast to a semelparous life history strategy (a single reproductive event followed by death, as exhibited by most salmon species), iteroparous individuals invest less energy in reproductive events; meaning less energy is spent per spawning season. The construction of hydropower dams in the Columbia River basin has substantially restricted downstream steelhead migration (Busby et al. 1996), thus minimizing the ability of steelhead to utilize the iteroparous life history strategy. Moreover, the current mortality of downstream-migrating post-spawned steelhead is as high as 96 percent in the Columbia River (Wertheimer and Evans 2005), meaning rates of iteroparity are low (1.7 to 17 percent). The disruption of this life history strategy could threaten population and species level viability. Thus, a kelt reconditioning project was proposed by BPA, CRITFC, and the NPT to increase the rates of repeat spawning in steelhead from the Snake Basin.

Steelhead recovery may be enhanced through increased productivity from kelt reconditioning efforts through the artificial manipulation of maturation timing and mating strategies. The primary goal of reconditioning is to regenerate vigor in kelts in order to increase the chances of repeat spawning, thereby increasing productivity. This is accomplished by capturing, holding, and feeding post-spawned steelhead in an artificial rearing environment until they are ready to be released to spawn again. In addition, providing steelhead with diverse, high lipid content diets during the reconditioning process may encourage repeat spawning activity and reduce the potential for skipped spawners (i.e., fish that require more than a year of conditioning to be able to spawn again). While this project would not eliminate migration challenges for steelhead kelts in the Snake and Columbia Rivers, it may help increase repeat spawning events in fish that have participated in the program.

Recent data for the program (Table 32) has shown that, despite some early setbacks, in recent years the proportion of kelts successfully reconditioned and released has exceeded natural rates of iteroparity of 2-17 percent. From 2011 to 2016, the average percent survival for kelts in the program was 32.8 percent, with 177 released into the Snake Basin to spawn naturally. It is likely that as personnel running the program become more experienced and more permanent facilities are constructed, survival could continue to increase, resulting in an even larger beneficial effect on the Snake River steelhead DPS.

The applicants are also conducting research on reconditioning strategies using spawned steelhead from DNFH. The goal of this work is to determine what program modifications, if any, may improve reconditioning survival of steelhead, before testing these modifications with natural-origin steelhead. None of the reconditioned hatchery fish are released back into the Snake River Basin. On average, over the last five years, about 154 steelhead have been collected and reconditioned with an average 20 percent survival rate over years 2012-16 (Table 33). Because these hatchery-origin fish would be lethally spawned otherwise, their use in this research provides a beneficial effect on the Snake Basin Steelhead DPS through potential improvements to reconditioning strategies for natural-origin steelhead kelts.

Table 32. Summary of number of natural-origin steelhead kelts collected and released in the Snake River; LGD = Lower Granite Dam; TBD = to be decided.

Year	Collection Location	Number Collected	Number Survived Reconditioning	% Survival	Consecutive Spawners Released	Number Retained	Mature Skip Spawners Released	Total Release by Year
2011[1]	LGD	111	2	1.8	2	0	0	2
2012[1]	LGD	124	10	8.1	10	0	0	10
2013	LGD, SF Clearwater	134	69	51.5	69	0	0	69
2014	LGD, SF Clearwater	122	37	30.3	35	2	2	35
2015	LGD, SF Clearwater	140	43	30.7	22	21	18	24[2]
2016	LGD	227	120	52.9	19	101	TBD	37[2]

Source: Hatch et al. (2017)

[1] Survival was compromised by poor water quality. A domestic water source was inadvertently mixed with the kelt water supply line that resulted in chlorinated water in the tanks.

[2] Includes skip spawners from previous year.

Table 33. Summary of number of hatchery-origin steelhead spawned at Dworshak National Fish Hatchery collected and reconditioned; TBD = to be decided.

Year	Number Collected	Number Survived Reconditioning	% Survival	Number Consecutive Spawners	Number Retained	Number Skip Spawners
2012[1]	143	5	3.5	4	0	0
2013	163	61	37.4	12	47	22
2014	149	19	12.8	2	17	5
2015	149	43	28.9	13	30	TBD
2016	165	30	18.2	12	18	TBD

Source: Hatch et al. (2017)

[1] Survival was compromised by poor water quality. A domestic water source was inadvertently mixed with the kelt water supply line that resulted in chlorinated water in the tanks.

The effects of collection of downstream migrating steelhead kelts, and sampling and release below Lower Granite Dam of up to 200 natural-origin pre-spawn steelhead (fallbacks) at the adult fish separator systems of Lower Granite Dam's juvenile bypass facility was previously analyzed and authorized in the NMFS (2014a) Opinion on the Federal Columbia River Power System. The operation of the juvenile fish bypass is an ongoing operational element of the dam for providing downstream fish migration. The handling and sampling of kelts and pre-spawn steelhead at the dam associated with this Opinion is a benefit to the DPS in terms of repeat spawning by kelts, and information gained (i.e., spawning success) from the opportunistic sampling and release of prespawn steelhead.

The Kelt Reconditioning Program requires a year-round water supply. This water comes directly from the Clearwater River and is part of the water supply to the Nez Perce Tribal Hatchery. This facility was consulted on in the Clearwater spring/summer Chinook and coho salmon Opinion (NMFS 2017f). Facilities consulted on in this opinion took a relatively small proportion of the water from the Clearwater River for hatchery use, and its use was non-consumptive. Extra precautions are taken for the kelt water supply, including the use of sand and micron filters to remove large particles and an ultraviolet light to disinfect the water of pathogens. Water is also chilled as needed to ensure water temperature does not exceed 60°F, at which level the quality of egg production is reduced. Thus, fish that are released are likely to have few, if any, pathogen infections that could pose a risk to natural-origin steelhead they may encounter on the spawning grounds.

While the proposed handling of Snake Basin steelhead kelts is invasive and potentially harmful to individual kelts (up to 700 are proposed to be collected and reconditioned), this is not a negative impact overall for the species because the majority of these fish would not be expected to survive after initial spawning. In addition, up to 700 kelts are likely to be PIT-tagged, with genetic samples taken for genotyping annually to monitor kelt distribution and spawning success. It is expected that the reconditioning and subsequent release of kelts will increase the proportion of steelhead that are repeat spawning in the Snake Basin, outweighing any harm done to individual fish. Therefore, these efforts would only be beneficial to the survival, future reproduction, and productivity of Snake Basin steelhead. No additional encounters with listed species will occur from this factor beyond those described for Factor 2 (take at adult collection facilities).

2.5.2.8. 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 PCEs 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 since their construction. 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 31). Because the uses are non-consumptive and are less than 15 percent of the total flow available, these withdrawals would not have a large enough effect to destroy or adversely modify adult spawning and juvenile rearing critical habitat of ESA-listed Chinook salmon, sockeye salmon, or steelhead. These effects are discussed in more detail above.

Another potential effect on critical habitat is the use of chemicals for cleaning or treating pathogens that are present in the hatchery effluent. 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 listed fish. Furthermore, the use of abatement ponds 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. Furthermore, the steelhead programs may actually provide a beneficial effect on critical habitat in the form of marine-derived nutrients (see section 2.5.2.2.2) and as prey for larger natural-origin salmon and steelhead in the action area.

2.6. Cumulative Effects

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

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult if not impossible to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline *vs.* cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline (Section 2.4).

Habitat

Non-Federal habitat and hydropower actions are supported by state, and local agencies; tribes; environmental organizations; and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives, and providing funding to support those projects. A few examples provided by the states of Idaho, Oregon, and Washington are highlighted next, as identified in NMFS' 2014 Environmental Impact Statement on Mitchell Act funding (NMFS 2014b).

Idaho's Department of Lands is pursuing an ESA Section 6 Cooperative Agreement. The intent of the cooperative agreement is to develop forest management practices that would better protect aquatic habitat for ESA-listed fish. This forestry program, if approved, would apply to forestry management and timber harvest on state and private lands (voluntary) in the Salmon and Clearwater River Subbasins in Idaho.

The Oregon Plan for Salmon and Watersheds includes voluntary restoration actions by private landowners, monitoring, and scientific oversight that is coordinated with state and Federal agencies and tribes. The Oregon Legislature allocates monies drawn from the Oregon Lottery and salmon license plate funds, which have provided \$100 million and \$5 million, respectively, to projects benefiting water, salmon, and other fish throughout Oregon. Projects include reducing road-related impacts on salmon and trout streams by improving water quality, fish habitat, and fish passage, providing monitoring and education support, helping local coastal watershed councils, and providing staff technical support.

The Washington Governor's Salmon Recovery Office includes the Salmon Recovery Funding Board (SRFB). The SRFB has helped finance more than 900 salmon recovery projects focused on habitat protection and restoration through two grant programs; general salmon recovery grants, and Puget Sound Acquisition and Restoration grants. Municipalities, tribal governments, non-profit organizations, regional fisheries enhancement groups, and private landowners may apply for these grants.

Some additional examples of other non-federal actions include: growth management programs (planning and regulation); a variety of stream and riparian habitat projects; watershed planning and implementation; acquisition of water rights for instream purposes and sensitive areas; instream flow rules; stormwater and discharge regulation; TMDL implementation to achieve water quality standards;

hydraulic project permitting; and increased spill and bypass operations at hydropower facilities. These activities are likely to have beneficial cumulative effects that will significantly improve conditions for salmon and steelhead, though at this time NMFS is not attributing specific benefits to those actions.

Within the action area non-Federal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and development. Some of these activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired). These activities are generally expected to have adverse effects on ESA-listed salmon and steelhead populations and PBFs, but the degree to which this occurs when considering other habitat activities that are likely to have some beneficial effects is difficult to quantify.

Hatcheries

Our discussion of cumulative effects for hatcheries in the Columbia River Basin was included in our biological opinion on the funding of Mitchell Act hatchery programs (NMFS 2017). In summary, all salmon and steelhead hatchery programs funded and operated by non-federal agencies and tribes have to undergo review under the ESA to ensure that listed species are not jeopardized and that "take" is minimized or avoided. Where needed, reductions in effects on listed salmon and steelhead are likely to occur through:

- Adaptive management based on hatchery monitoring
- Altering times and locations of fish releases to reduce competition and predation
- Management of overlap in hatchery- and natural-origin spawners to meet gene flow objectives
- Decreased use of isolated hatchery programs
- Increased use of integrated hatchery programs for conservation purposes
- Incorporation of research results and improved best management practices
- Creation of wild fish only areas
- Changes in hatchery production levels
- Increased use of marking hatchery-origin fish

Harvest

Conservative management of recreational and tribal treaty fishing is only one element of a large suite of regulations and environmental factors that may influence the overall status of listed salmon populations and their habitat. Fisheries are coordinated with monitoring and adaptive management measures so that fishery managers can respond to changes in the status of affected listed salmon and ensure that the affected ESUs are adequately protected. Because the allowable impacts on listed species follow a maximum allowable impact rate, if other conservation measures are unsuccessful in returning fish to the area, fishery impacts would be constrained.

Summary

Overall, we anticipate that projects to restore and protect habitat, restore access and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. For example, Justice et al. (2017 in Crozier and Siegel 2018) concluded from their research that channel and riparian restoration of streams degraded by intensive land use could mitigate for increasing stream temperatures to benefit juvenile salmonids. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area.

Although we cannot attribute specific benefits at this time, we anticipate these activities will consider ESA-listed species as they are being implemented and developed. In general, we think the level of adverse effects will be lower than those in the recent past, and much lower than those in the more distant past. NMFS anticipates that available scientific information will continue to grow and tribal, public, and private support for salmon recovery will remain high. This will continue to fuel state and local habitat restoration and protection actions as well as hatchery, harvest, and other reforms that are likely to result in improvements in fish survival.

2.7. Integration and Synthesis

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

2.7.1. **Snake River Steelhead DPS**

Best available information indicates that the Snake River Steelhead DPS is at high risk and remains at threatened status (NWFSC 2015). Ford et al. (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). Since our last status review (NWFSC 2015), steelhead abundances have declined, and at this time we do not have updated estimates of productivity. However, we do have abundance estimates for populations where abundance data was not available just five years ago.

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

The most concerning of the effects of the Proposed Action on this DPS are genetic and ecological in nature. Effects from facility operation and broodstock collection are minor and localized, and while RM&E requires handling of a substantial portion of the juvenile population, only a small percentage (i.e., < 2%) 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 programs 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. Our straying analysis concluded that straying is low for all of the programs in the proposed action, and is not expected to affect the abundance, productivity, diversity or spatial structure of the DPS because of the low potential for interbreeding and competition for spawning space between hatchery and natural-origin steelhead. The East Fork Salmon River Natural program is the only integrated program. Genetic effects on the East Fork population are limited by the use of natural-origin broodstock and an expected PNI of < 0.5 on average is a reasonable target for a population targeted for "maintained" in the recovery scenario (NMFS 2016). NMFS believes this to be an appropriate PNI goal for a population designated as maintained in the latest version of the draft recovery plan, and is likely to benefit the DPS through increased abundance and productivity for the East Fork population.

Ecological effects on natural-origin juvenile steelhead associated with releases from the hatchery program are equivalent to loss of about 4.6 percent from the adult return to Lower Granite Dam. Based on current information, this represents a maximum possible loss because of the assumptions and simplicity inherent in the model, and while it could result in a decrease in adult abundance, this decrease is at a level that is likely insignificant to the DPS. In addition, as we continue to improve the model, these estimates will become more refined in the future, and will likely decrease the percentage of adults that are predicted to be lost from this worst case scenario. Thus, while we assume this number of fish lost is possible, we do not believe it would occur regularly, if ever.

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 include improving habitat conditions, and hatchery and harvest practices to protect listed steelhead DPSs, and NMFS expects this trend to continue, and could lead to increases in abundance, productivity, spatial structure and diversity.

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 this ESA-listed DPS in the wild.

2.7.2. **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). For both the fall Chinook and sockeye salmon ESUs the hatchery programs have played a large role in at least maintaining and likely improving species status. The sockeye salmon hatchery program, in particular, is a necessary component of the sockeye salmon recovery plan (NMFS 2015).

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 a genetic reserve for natural populations).

The effects of our proposed action on these ESUs are 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 are equivalent to a maximum potential loss of adults at Lower Granite Dam of ~2.6 percent for sockeye salmon, and ~1.8 percent for Chinook salmon. In addition, pending the improved parameter inputs and model version we anticipate in the future (as explained above for steelhead) should serve to refine our modeled estimates, estimates for effects on ESA-listed Chinook salmon are also likely overestimated by the presence of unlisted spring/summer Chinook from the Clearwater Subbasin. Future estimates of the proportion of juveniles from this Subbasin in the total outmigration may better inform what portion of the Chinook salmon numbers pertain to listed species; this is likely to be less than what we modeled for this analysis. Thus, the predicted ~ 2 percent loss of potential adults does not represent a substantial effect on ESU abundance or productivity for either Chinook or sockeye salmon.

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 listed species.

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. NMFS expects this trend to continue and could lead to increases in abundance, productivity, spatial structure and diversity.

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 small effects of the Proposed Action on abundance, productivity, spatial structure, and diversity, will not appreciably reduce the likelihood of survival and recovery of these ESA-listed ESUs in the wild.

2.7.3. **Critical Habitat**

The hatchery water diversion and the discharge pose a negligible effect on designated critical habitat in the action area (Section 2.5.2.5). 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 PCEs 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 PCEs will be small in scale, would not alter PCEs essential to the conservation of a species or preclude or significantly delay development of such features.

Climate change may have some effects on critical habitat as discussed in Section 2.4.2. 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. However, the continued restoration of habitat, should alleviate some of this potential pressure for suitable rearing and spawning habitat. After reviewing the Proposed Action and conducting the effects analysis, and considering future anticipated effects of climate change, NMFS has determined that the Proposed Action would not diminish the conservation value of this critical habitat for the Snake River Basin steelhead DPS, or the Snake River Fall and Spring/Summer Chinook Salmon and Sockeye Salmon ESUs.

2.8. Conclusion

After reviewing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the Proposed Action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the Proposed Action is not likely to jeopardize the continued existence of the Snake River Basin Steelhead DPS, the Snake River Fall Chinook Salmon ESU, the Spring/Summer Chinook Salmon ESU, or the Sockeye Salmon ESUs, or destroy or adversely modify their designated critical habitat.

2.9. Incidental Take Statement

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

2.9.1. **Amount or Extent of Take**

The primary form of take of ESA-listed summer steelhead is direct take, authorized in the 4(d) authorizations. However, NMFS also expects incidental take of ESA-listed salmon and steelhead will occur as a result of the proposed action for the following factors. The take pathways discussed below are:

- Genetic and ecological effects of hatchery adults on the spawning grounds (Factor 2)
- Handling/tagging of adults at adult collection facilities (Factor 2)
- Ecological effects of juveniles during emigration (Factor 3)
- Ecological and genetic effects of juveniles that residualize (Factor 3)
- Incidental handling/tagging, and mortality of juveniles while conducting RM&E (Factor 4)
- Incidental handling and mortality of juveniles entering DNFH (Factor 5)

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**

There is take for this factor due to three forms of harm: genetic effects, ecological effects and adult handling/tagging and incidental mortality at adult collection facilities. Specifically, take occurs for genetic effects through a reduction in genetic diversity, outbreeding depression, and hatchery-influenced selection. Additionally, take occurs through ecological effects of hatchery adults on the spawning grounds such as competition for spawning sites and redd superimposition. Take due to these two pathways cannot be directly measured because it is not possible to observe gene flow or interbreeding between hatchery and wild fish in a reliable way, or to quantify spawning site competition or redd superimposition. For these two take pathways, NMFS will therefore rely on a single common set of surrogate take indicators: the number of hatchery-origin steelhead on the spawning grounds as defined here:

- A five-year running average[6] PNI of 0.5 or higher for the East Fork Salmon River steelhead population beginning in 2021 when natural-origin steelhead abundance to the mouth of the East Fork River is estimated to be at least 250 steelhead. Until 2021, NMFS will apply the PNI as a five-year running average of 0.4 in years when natural-origin steelhead abundance to the mouth of the East Fork River is estimated to be at least 250 steelhead.
- For the segregated steelhead programs, the percentage of PIT tags from hatchery programs included in the Proposed Action detected as adults at non-natal tributary arrays is expected to be no more than three percent (based on data from Table 15) measured as a 5-year rolling sum of all the PIT tags from a particular program detected at Lower Granite Dam beginning in 2020. For example, if 1,000 fish from the Upper Salmon A-run Steelhead Program are detected at Lower Granite Dam from 2016 to 2020, then no more than 30 of those fish should be detected at non-natal tributary arrays upstream.

This set of take surrogate measurements is logically related to both the genetic and ecological take pathways through assessment of hatchery-origin fish on the spawning grounds. If these fish spawn, they can cause both ecological and genetic effects on natural-origin spawners. Moreover, through weir collections and PIT tag arrays, the take surrogate can be reliably measured and monitored.

The third take pathway for this factor, applied separately from the surrogate PNI and straying factors, is that associated with handling/tagging of listed hatchery and natural-origin steelhead at adult collection facilities to facilitate broodstock collection, and sampling of fish for monitoring and evaluation. The extent of incidental take of ESA-listed steelhead and spring/summer and fall Chinook salmon expected to occur as a result of the proposed action by this pathway is contained in Table 21 and Table 22.

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

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 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 directly or reliably measured

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[6] However, if it is apparent from natural-origin steelhead abundances observed in years prior to the fifth year that the average is certain to fall below the PNI value before five years, operators will contact NMFS in the year the likely shortfall is discovered.

and/or observed. Thus, we will quantify the extent of take of juvenile salmonids by ecological effects using two different surrogates, one specifically addressing the effects of residualism of hatchery steelhead and the second related to take caused by the presence of hatchery steelhead which leave the system.

Residualism causes take in two forms. The first is harm or mortality associated with the potential of residual steelhead to compete with and prey on juvenile natural-origin fish for an extended period of time. The second is harm from genetic effects caused by residual steelhead that spawning naturally (particularly precocial males).

For both of these forms of take associated with residualism, the surrogate take measurement is the percentage of steelhead from the release that are observed to be either parr, precociously maturing, or precociously mature immediately prior to release. This surrogate has a rational connection to the amount of take expected from residualism because precocious steelhead and parr may residualize after release from the hatchery. NMFS expects that no more than five percent of program fish by stock observed from each program[7] should be precociously mature or parr (based on visual observation), using a running five-year average beginning with the 2018 release[8]. Between 2017 and 2022, if the annual rate exceeds five percent, NMFS will be notified and discussion with NMFS will take place. The take surrogate can be reliably measured and monitored through visual assessment of the hatchery population and/or migrant fish prior to release.

For ecological effects of competition and predation caused by emigrating hatchery steelhead, NMFS applies a surrogate take measurement that relates to the median travel time[9] for hatchery steelhead to Lower Granite Dam after release. Specifically, the extent of take from interactions between hatchery and natural-origin juvenile salmonids released above Lower Granite Dam will be the take that occurs when the travel time for emigrating juvenile steelhead is five days longer than the median value (which equates to 50% of the fish) identified in Table 25 for each program for 3 of the next 5 years of 5-year running medians. For example, if the 5-year running median of the median values in Table 25 is 20 days, and then the median for the next three years for a particular release group is 25 days, this would exceed the take threshold. This is a reasonable, reliable, and measurable surrogate for incidental take because, if travel time is five days more than previous estimates, it is a sign that fish are not migrating as quickly as expected, and therefore the expected take from interactions has likely been exceeded as a result of greater overlap between hatchery and natural-origin fish. This threshold will be monitored using emigration estimates from PIT tags, screw traps, or other juvenile monitoring techniques developed by the operators and approved by NMFS.

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

Maximum incidental take of ESA-listed spring/summer and fall Chinook at the SF Clearwater juvenile screw trap can be found in Table 29.

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[7] The SSI project is an exception in that we do not anticipate any effects from residuals beyond naturally occurring residualism levels. This is because these fish are placed into the natural environment as eggs and are allowed a more natural feeding and growth regime as opposed to fish reared in a hatchery.

[8] However, if it is apparent, from numbers observed in years prior to the fifth year, that the average is certain to exceed 5 percent before five years, operators will contact NMFS in the year the likely exceedance is discovered.

[9] NMFS recognizes that this metric can be influenced by factors other than hatchery operation (i.e., environmental variables, hydrosystem operation).

Maximum incidental mortality of ESA-listed adipose-clipped hatchery-origin steelhead PIT-tagged at Lower Granite Dam is expected to be no more than one percent (~50 fish) of those tagged.

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

Incidental take in the form of harassment/handling of < 200 non-DNFH and/or mortality of <100 juvenile salmon and steelhead at DNFH through the hatchery water system annually.

2.9.2. Effect of the Take

In the biological opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to the species or result in the destruction or adverse modification of critical habitat.

2.9.3. Reasonable and Prudent Measures

"Reasonable and prudent measures" are nondiscretionary measures that are necessary or appropriate to minimize the impact of 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 ACOE, USFWS, and the LSRCP shall ensure that:

1. The ACOE, USFWS, and the LSRCP shall ensure that the co-managers' activities are consistent with the funder's portion of the Proposed Action.
2. The NMFS shall ensure that the applicants follow all conditions specified in each authorization issued as well as guidelines specified in this opinion for their respective programs.
3. NMFS shall work with IDFG, and other co-managers as needed, with the goal of sharing state-wide fish health protocols within one year of Opinion signature.
4. The NMFS shall ensure that the applicants provide reports to SFD annually for all hatchery programs, and associated RM&E.
5. NMFS shall ensure that all applicants review the hatchery programs included in the Proposed Action every five years beginning in 2025 to identify any new information gaps, discuss any changes to the Proposed Action, and review requested information.
6. The BPA shall review and approve CRITFC's and/or NPT's activities as described in the annual statements of work for the Snake Basin Kelt Reconditioning Program to ensure they are consistent with the BPA-funded portion of the Proposed Action.

2.9.4. Terms and Conditions

The terms and conditions described below are non-discretionary, ACOE, USFWS, LSRCP, BPA, 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.

1. The ACOE, USFWS, and the LSRCP shall ensure for their respective programs that the applicants implement the hatchery programs as described in the Proposed Action (Section

1.3), the submitted HGMPs, and the Annual Operating Procedures to ensure they are consistent with the funder's portion of the Proposed Action, as approved through annual statements of work including:

   a. Providing advance notice of any change in program operation and implementation 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. Notifying NMFS SFD within 48 hours after knowledge of exceeding any authorized take. The applicants shall submit a written report, and/or convene a discussion with NMFS to discuss why the authorized take was exceeded within two weeks of the event. These discussions will consider the role of each population in the recovery scenario.
   d. The ACOE will coordinate with USFWS, NPT, and NMFS' Environmental Services Branch to bring the DNFH North Fork river intake screen system into compliance with NMFS' most recent passage and screening criteria. The ACOE intends to solicit funds for re-design to meet NMFS design criteria in 2023. Once the design is completed, the ACOE will have an estimate for the construction cost and the necessary funding request to support construction will be initiated.
   e. Continuing to work collaboratively with operators on weir/adult management in Yankee Fork to ensure that the majority of the steelhead run can be managed.

2. NMFS shall ensure that the applicants follow all implementation terms prescribed in the 4(d) authorizations for each program.

3. NMFS shall work with IDFG, and other co-managers as needed, with the goal of sharing a state-wide fish health protocols within one year of Opinion signature. NMFS shall work with the co-managers to provide a clear outline of all aspects of fish health to be considered in the policy within 6 months of Opinion signature.

4. NMFS shall ensure that the applicants provide reports to SFD annually for their respective programs, and associated RM&E. All reports and required notifications are submitted electronically to the NMFS, West Coast Region, Sustainable Fisheries Division, APIF Branch. The current point of contact for document submission is Charlene Hurst (503-230-5409, charlene.n.hurst@noaa.gov).
   a. An annual RM&E report(s) is submitted by applicants no later than December 15 of the year following releases and associated RM&E (e.g., release/RM&E in year 2017, report due December 2018), and should include:
      i. The number and origin (hatchery and natural) of each listed species handled and incidental mortality across all activities
      ii. Hatchery Environment Monitoring Reporting
         - Number and composition of broodstock, and dates of collection
         - Numbers, pounds, dates, locations, size (and coefficient of variation), and tag/mark information of released fish
         - Survival rates of all life stages (i.e., egg-to-fry (SSI only); egg-to-smolt; smolt-to-adult)
         - Disease occurrence at hatcheries

        - Annual residualism rates prior to release by stock for each program (does not apply to SSI program)
        - Any problems that may have arisen during hatchery activities
        - Any unforeseen effects on listed fish
      iii. Natural Environment Monitoring Reporting
        - The number and distribution of returning hatchery and natural-origin adults to all ESA-listed populations, as determined by PIT tag detections where infrastructure exists
        - The number and species of listed fish encountered at each adult collection location, and the number that die
        - Post-release out-of-basin migration timing of each juvenile hatchery-origin fish release to Lower Granite Dam
        - Mean length, coefficient of variation, number, and age of natural-origin juveniles during RM&E activities
        - Number and species of listed juveniles and adults encountered and the number that die during RM&E activities
   b. Annual reports to SFD for the kelt reconditioning program should include:
      i. The number of each ESA-listed species handled and incidental mortality across all activities (kelt collection, holding, release)
      ii. The number of kelts collected, their specific collection location, and origin (hatchery or natural)
      iii. The number of kelts released to spawn naturally and their specific release location any collected pit tag or genetic data, as available, providing indication of immigration to spawning area

5. NMFS shall ensure that all applicants review the hatchery programs included in the Proposed Action every five years beginning in 2025 to identify any new information gaps, discuss any changes to the Proposed Action, and review requested information.
6. BPA shall review and approve CRITFC's and/or NPT's activities as described in the annual statements of work for the Snake Basin Kelt Reconditioning Program to ensure they are consistent with the BPA-funded portion of the Proposed Action.

2.9.5. Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a Proposed Action on listed species or critical habitat (50 CFR 402.02). NMFS has identified one conservation recommendation appropriate to the Proposed Action:

1. Estimate the proportion of spring/summer Chinook salmon juveniles outmigrating from the Clearwater Subbasin into all of the spring/summer Chinook salmon in the Snake River to allow NMFS to partition the Chinook estimates in the PCDRisk model for ecological effects.

2.10. Re-initiation of Consultation

This concludes formal consultation on the approval and implementation of ten hatchery programs rearing and releasing steelhead in the Snake Basin. As 50 CFR 402.16 states, reinitiation of consultation is required and shall be requested by the Federal agency or by the Service 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 taking specified in the ITS is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion, or (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

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

This analysis is based, in part, on descriptions of EFH for Pacific Coast salmon (PFMC 2014b) 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 ten steelhead hatchery programs, as described in Section 1.3. The action area (Section 2.3) 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. For Chinook salmon, EFH encompasses all available watersheds in Idaho. For coho salmon, EFH in Idaho occurs in the Lower Salmon River, and throughout the Clearwater Subbasin with the exception of the Lochsa and Lower North Fork Clearwater Rivers (PFMC 2014a)

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. The aspects of EFH that might be affected by the Proposed Action include effects of hatchery operations on ecological interactions on natural-origin Chinook and coho salmon in spawning and rearing areas and adult migration corridors and adult holding habitat, and genetic effects on natural-origin Chinook salmon in spawning areas (primarily addressing HAPC 3).

3.2. Adverse Effects on Essential Fish Habitat

The Proposed Action has small effects on the major components of EFH. As described in Section 2.5.2, 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." Adult hatchery steelhead returning to the Snake River Basin are expected to largely return to hatcheries or be caught in fisheries and not be available to compete for spawning habitat with Chinook or coho salmon. In addition, salmon spawn in the fall and winter, whereas summer steelhead spawn in the spring, making redd superimposition very unlikely. However, the one exception is the East Fork Salmon River natural program where hatchery-fish are intended to spawn naturally. No coho exist in this system, and it is likely that habitat partitioning has occurred for steelhead and Chinook salmon that have co-existed together for a long time.

Some predation by adult hatchery steelhead on juvenile natural-origin Chinook or coho salmon may occur as steelhead hold for a potentially long time before spawning in freshwater EFH. Predation and competition by juvenile hatchery steelhead on juvenile natural-origin Chinook or coho salmon is likely small. Our analysis in Section 2.5.2.3.1 shows that fewer than 530 Chinook salmon adult equivalents are likely to be lost to predation and competition with hatchery steelhead at the juvenile stage within our action area for this consultation. Although our ecological model did not account for effects on unlisted fish, such as coho salmon, sizes of Chinook and coho salmon are similar and, thus, we anticipate similar adult equivalents for coho salmon as Chinook salmon.

NMFS has determined that the proposed action is not likely to adversely affect EFH for Pacific salmon.

3.3. Essential Fish Habitat Conservation Recommendations

NMFS determined that the Proposed Action, as described in the HGMPs and the ITS (Section 2.9) is not likely to adversely affect EFH. Thus, NMFS has no conservation recommendations specifically for Chinook and coho salmon EFH.

3.4. Supplemental Consultation

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

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

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

4.1. Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion are the NMFS (permitting entity), and the BPA, ACOE, LSRCP, and USFWS (funding entities) as well as IDFG, NPT, SBT, and CRITFC (operating entities). Other interested users could include the scientific community, resource managers, and citizens of the Snake River Basin. Individual copies of this opinion were provided to the BPA, ACOE, LSRCP, USFWS, IDFG, NPT, SBT, and CRITFC. The document will be available within two weeks at the NOAA Library Institutional Repository. 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.

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

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

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

5. APPENDIX A: EFFECTS OF HATCHERY PROGRAMS ON SALMON AND STEELHEAD POPULATIONS: REFERENCE DOCUMENT FOR NMFS ESA HATCHERY CONSULTATIONS (REVISED JUNE 4, 2020)[10]

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

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

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

In choosing the literature we cite in this Appendix, our overriding concern is our mandate to use “best available science”. Generally, this means recent peer-reviewed journal articles and books. However, as appropriate we cite older peer-reviewed literature that is still relevant, as well as “gray” literature. Although peer-review is typically considered the “gold standard” for scientific information, occasionally there are well-known and popular papers in the peer-reviewed literature we do not cite because we question the methodology, results, or conclusions. In citing sources, we also consider availability, and try to avoid sources that are difficult to access. For this reason, we generally avoid citing master’s theses and doctoral dissertations, unless they provide unique information.

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

A primary consideration in analyzing and assessing effects for broodstock collection is the origin and number of fish collected. The analysis considers whether broodstock are of local origin and the biological benefits and risks of using ESA-listed fish (natural or hatchery-origin) for hatchery broodstock. It considers the maximum number of fish proposed for collection and the proportion of the

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[10] This version of the appendix supersedes all earlier dated versions and the NMFS. 2012a. Effects of Hatchery Programs on Salmon and Steelhead Populations: Reference Document for NMFS ESA Hatchery Consultations. December 3, 2012. Northwest Region, Salmon Managment Division, Portland, Oregon. 50p. standalone document.

donor population collected for 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.

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

There are two aspects to this part of the analysis: genetic effects and ecological effects.

5.2.1. Genetic effects

5.2.1.1. Overview

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

NMFS also recognizes there is considerable debate regarding genetic risk, as discussed below. 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). We expect the scientific uncertainty surrounding genetic risks to be reduced considerably in the next decade due to the rapidly increasing power of genomic analysis (Waples et al. 2020).

Four general processes determine the genetic composition of populations of any plant or animal species:

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

Mutations occur at sufficiently low rates that they can be ignored for relatively short-term evaluation of genetic change, but the other three processes are considerations in evaluating the effects of hatchery programs on the productivity and genetic diversity of natural salmon and steelhead populations.

Although there is considerable biological interdependence between them, NMFS considers three major areas of genetic effects of hatchery programs in our analyses (Figure 5):

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

The first two areas are major concerns of conservation biology (e.g., Allendorf et al. 2013), but our emphasis on what conservation geneticists would likely call "adaptation to captivity" (Allendorf et al. 2013, pp. 408-409) reflects the fairly unique position of salmon and steelhead among ESA-listed species. In other listed species, artificial propagation is used only as a conservation tool, and often only as a last-resort. In ESA-listed Pacific salmon and steelhead, however, artificial propagation in hatcheries has been used as a routine management tool for many decades, and in some cases hatchery programs have been a factor in listing decisions.

Although in most cases the genetic effects of hatchery programs are viewed as risks, but in small populations, these effects can sometimes be beneficial, reducing extinction risk and conserving genetic diversity. In the sections below, we discuss these three major areas of risk, but preface this with an explanation of some key terms relevant to genetic risk, and in some cases relevant to ecological risk as well.

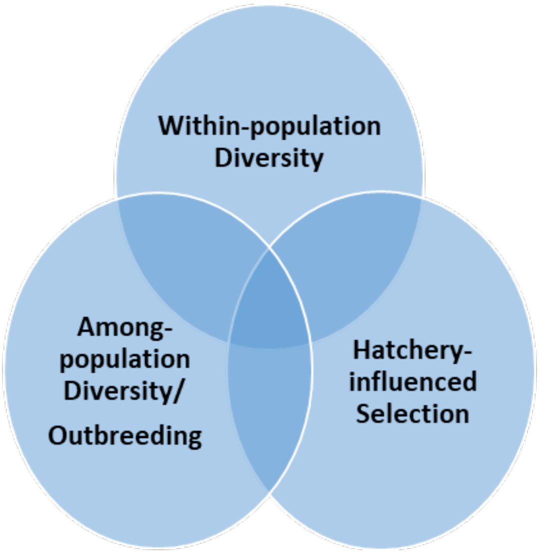

Figure 5. Major categories of hatchery program genetic effects analyzed by NMFS.

5.2.1.2. Key Terms

The terms "wild fish" and "hatchery fish" are commonly used by the public, management biologists, and regulatory biologists, but their meaning can vary depending on context. For risk assessment, terminology that is more precise is needed.

- **Hatchery-origin (HO)** - refers to fish that have been reared and released by a hatchery program, regardless of the origin of their parents. A series of acronyms has been developed to denote subclasses of HO fish:
    - **Hatchery-origin recruits (HOR)** – HO fish returning to freshwater as adults or jacks. Usage varies, but typically, the term refers to post-harvest fish that will either spawn in nature, used for hatchery broodstock, or surplused.

    - **Hatchery-origin spawners (HOS)** - hatchery-origin fish spawning in nature.
    - **Hatchery-origin broodstock (HOB)** - hatchery-origin fish that are spawned in the hatchery (i.e., are used as broodstock).
- **Natural-origin (NO)** - refers to fish that have resulted from spawning in nature, regardless of the origin of their parents. A series of acronyms has been developed to denote subclasses of NO fish:
    - **Natural-origin recruits (NOR)** – NO fish returning to freshwater as adults or jacks. Usage varies, but typically, the term refers to post-harvest fish that either will spawn in nature or used for hatchery broodstock.
    - **Natural-origin spawners (NOS)** - natural-origin fish spawning in nature.
    - **Natural-origin broodstock (NOB)** - natural-origin fish that are spawned in the hatchery (i.e., are used as broodstock).

These terms have led to development of three metrics that are very important to genetic risk assessment. All three are commonly attributed to the Hatchery Scientific Review Group (HSRG), but were developed in 2004 technical discussions between the HSRG and scientists from the Washington Department of Fish and Wildlife (WDFW) and the Northwest Indian Fisheries Commission (NWIFC)(HSRG 2009). All three are typically computed as means based on multiple spawning seasons:

- **pHOS** - proportion of fish on the spawning grounds consisting of HO fish. Mathematically, pHOS = HOS/(HOS + NOS). Genetic risk guidelines discussed below in Section 5.2.1.5 have been developed based on refinements of pHOS:
    - **$pHOS_{census}$** – pHOS based on fish counts
    - **$pHOS_{eff}$** – $pHOS_{census}$ discounted by the spawning success of HO fish relative to that of NO fish. For example, if HO fish are assumed to be 80 percent as reproductively capable as NO fish, then $pHOS_{eff} \approx 0.8 * pHOS_{census}$[11]
- **pNOB** - proportion of fish in the hatchery broodstock consisting of NO fish. Mathematically, pNOB = NOB/(HOB + NOB).
- **Proportionate natural influence (PNI)-**in populations affected by hatchery programs, the relative selective influence of the natural environment. In populations affected by integrated hatchery programs, PNI is represented mathematically either as PNI ≈ pNOB/(pNOB + pHOS) or PNI = pNOB/(pNOB + pHOS). PNI is a confusing concept, which is explained in detail in Section 5.2.1.5.

pHOS is the most widely used of the three metrics, and the only one of the three that is applicable to ecological as well as genetic risk. Assuming random mating, equal reproductive success, and no selection, pHOS is the expected genetic contribution of hatchery-origin spawners to the naturally spawning population. Put another way, it is the expected level of gene flow from hatchery-origin fish into the naturally spawning population. It can safely be assumed based on considerable empirical evidence (see Section 5.2.1.5) that HO spawners will be less productive than NO spawners, and that the spatial distribution of the two classes of spawners differs, so pHOS is an upper estimate of potential gene flow.

The HSRG has developed widely publicized genetic risk guidelines based on pHOS (e.g., HSRG 2009; HSRG 2014) that are discussed in detail in Section 5.2.1.5. As a surrogate metric for gene flow,

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[11] The actual equation is presented in Section 5.2.1.5.

$pHOS_{census}$ computed over an entire basin becomes increasingly less satisfactory as biological complexity is considered (e.g., spawner distributions, sex ratios, varying fecundity). In response, approaches for finer scaled computation of pHOS (Falcy 2019; HSRG 2017), in addition to the previously mentioned adjustment for relative reproductive success.

We can provide additional perspective on pHOS by illustrating the expected proportion of mating types in a mixed population of NO and HO fish (denoted as N and H, respectively, in the figure) as a function of the census pHOS, assuming that NO and HO adults mate randomly[12] (Figure 6). For example, at a census pHOS level of 10 percent, 81 percent of the matings would be expected to be NxN, 18 percent NxH, and 1 percent HxH.

You can also interpret the curves in the diagram as probability of naturally produced progeny of specified, assuming random mating and equal reproductive success of all mating types. Under this interpretation, for example, progeny produced by a population with a pHOS level of 10 percent will have an 81 percent chance of having two NO parents. This logic has specific application to Canada's wild salmon policy (WSP) (DFO 2005), in which wild fish are defined as naturally produced fish whose parents were naturally produced. Withler et al. (2018) used mating type probabilities to refine and extend HSRG gene flow guidelines for compatibility with the WSP.

Random mating as in Figure 6 assumes that the NO and HO spawners overlap completely spatially and temporally. As overlap decreases, the proportion of NxH matings decreases; with no overlap, the proportion of NxN matings equals one minus pHOS and the proportion of HxH matings equals pHOS.

Relative reproductive success (RRS) of NO and HO fish 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 NO fish, resulting in a considerably lower reproductive success because, in that particular situation, the HO fish are spawning in inferior habitat compared to the natural spawning areas (Williamson et al. 2010).

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[12] These computations are based on a simple mathematical binomial squared expansion ($(a+b)^2=a^2 + 2ab + b^2$).

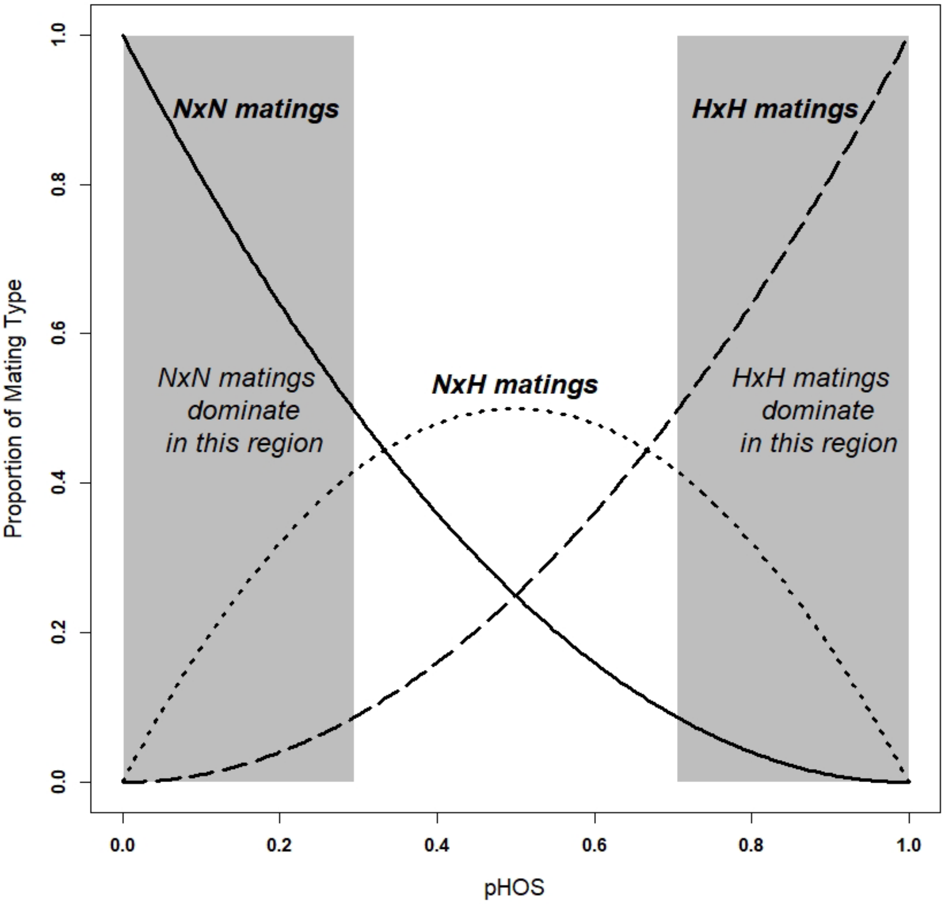

Figure 6. Relative proportions of mating types as a function of proportion of HO fish on the spawning grounds (pHOS), assuming random mating. Line codes: solid = NxN, dashed = NxH, dotted = HxH. Shaded rectangles on left and right denote pHOS ranges at which NxN and HxH matings are most probable, respectively.

5.2.1.3.Within-population diversity effects

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

5.2.1.3.1. Genetic drift

Genetic drift is the random loss of diversity due to population size. The rate of drift is determined not by the census population size (N_c), but rather by the effective population size (N_e). Effective size is the size of a genetically ideal population —equal numbers of males and females, each with equal opportunity to contribute to the next generation— that will display as much genetic drift as the population being examined (e.g., Allendorf et al. 2013; Falconer and MacKay 1996)[13]. N_e can be

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

considerably smaller than N_c. For example, if a breeding population consisted of 100 females but only 3 males, the population could be expected to exhibit as much drift as a population of 6 males and 6 females.

Various guidelines have been proposed for N_e for conservation of genetic diversity. A long-standing guideline is the 50/500 rule (Franklin 1980; Lande and Barrowclough 1987): 50 for a few generations is sufficient to avoid inbreeding depression, and 500 is adequate to conserve diversity over the longer term. One recent review (Jamieson and Allendorf 2012) concluded the rule still provided valuable guidance; another (Frankham et al. 2014) concluded that larger values are more appropriate, basically suggesting a 100/1000 rule. Although N_e can be estimated from genetic or demographic data, often insufficient information is available to do this, so for conservation purposes it is useful to estimate effective size from census size. Frankham et al. (2014) suggested a N_e:N_c range of ~0.1-0.2 based on a review of the literature. For Pacific salmon populations over a generation, Waples (2004) arrived at a similar range of 0.05-0.3.

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

- Removal of fish from the naturally spawning population for use as hatchery broodstock. If a substantial portion of the population is taken into a hatchery, the hatchery becomes responsible for that portion of the effective size, and if the operation fails, the effective size of the population will be reduced (Waples and Do 1994).
- Mating strategy used in the hatchery. N_b can be reduced considerably below the census number of broodstock by using a skewed sex ratio, spawning males multiple times (Busack 2007), and by pooling gametes. Pooling milt is especially problematic because when milt of several males is mixed and applied to eggs, a large portion of the eggs may be fertilized by a single male (Gharrett and Shirley 1985; Withler 1988). This problem can be avoided by more structured mating schemes such as 1-to-1 mating. Factorial mating schemes, in which fish are systematically mated multiple times, can be used to increase N_e (Busack and Knudsen 2007; Fiumera et al. 2004) over what would be achievable with less structured designs. Considerable increases in N_b over what is achievable by 1-to-1 mating can be achieved through a factorial design as simple as a 2 x 2 (Busack and Knudsen 2007).
- Ryman-Laikre effect: On a per-capita basis, a hatchery broodstock fish can often contribute many more progeny to a naturally spawning population than a naturally spawning fish can contribute This difference in reproductive contribution causes the composite N_b to be reduced, which is called a Ryman-Laikre (R-L) effect (Ryman et al. 1995; Ryman and Laikre 1991). The key factors determining the magnitude of the effect are the numbers of hatchery and natural spawners, and the proportion of natural spawners consisting of hatchery returnees.

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

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

Inbreeding depression, another N_e-related phenomenon, is a reduction in fitness and survival caused by the mating of closely related individuals (e.g., siblings, half-siblings, cousins). Related individuals are genetically similar and produce offspring characterized by low genetic variation, low heterozygosity, lower survival, and increased expression of recessive deleterious mutations (Allendorf et al. 2013; Frankham et al. 2010; Hedrick and Garcia-Dorado 2016; Rollinson et al. 2014). Lowered fitness due to inbreeding depression exacerbates genetic risk relating to small population size and low genetic variation, which further shifts a small population toward extinction (Nonaka et al. 2019). The protective hatchery environment masks the effects of inbreeding which becomes apparent when fish are released into the natural environment and experience decreased survival (Thrower and Hard 2009). Inbreeding concerns in salmonids related to hatcheries have been reviewed by Wang et al. (2002) and Naish et al. (2008a).

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

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

5.2.1.3.2. Biased/nonrepresentational sampling

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

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

These examples illustrate the overlap between diversity effects and selection. Selection, natural or artificial, affects diversity, so could be regarded as a subcategory of within-population diversity. Analytically, we consider specific effects of sampling or selection on diversity here. Broodstock collection or spawning guidelines that include specifications about non-random use of fish with respect to age or size are of special interest. General effects of unintentional selection due to the hatchery that are not related to individual traits are considered in Section 5.2.1.5.

5.2.1.4. Among-population diversity/ Outbreeding effects

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

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

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). Based on fundamental population genetic principles, a scientific workgroup convened by NMFS concluded that gene flow from non-native HO fish should be kept below 5 percent (Grant 1997), and this is the recommendation NMFS uses as a reference in hatchery consultations.

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

In addition, unusual rates of straying into other populations within or beyond the population's MPG, salmon ESU, or a steelhead DPS, can have a homogenizing effect, decreasing intra-population genetic variability (e.g., Vasemagi et al. 2005), and increasing risk to population diversity, one of the four attributes measured to determine population viability (McElhany et al. 2000). There is a growing appreciation of the extent to which diversity contributes to a "portfolio" effect (Schindler et al. 2010), and lack of among-population diversity is considered a contributing factor to the depressed status of California Chinook salmon populations (Carlson and Satterthwaite 2011; Satterthwaite and Carlson 2015). Eldridge et al. (2009) found that among-population genetic diversity had decreased in Puget Sound coho salmon populations during several decades of intensive hatchery culture.

As discussed in Section 5.2.1.2, pHOS[14] is often used as a surrogate measure of gene flow. Appropriate cautions and qualifications should be considered when using this proportion to analyze outbreeding effects.

- Adult salmon may wander on their return migration, entering and then leaving tributary streams before spawning (Pastor 2004). These "dip-in" fish may be detected and counted as strays, but may eventually spawn in other areas, resulting in an overestimate of the number of strays that potentially interbreed with the natural population (Keefer et al. 2008). On the other hand, "dip-ins" can also be captured by hatchery traps and become part of the broodstock.
- Strays may not contribute genetically in proportion to their abundance. Several studies demonstrate little genetic impact from straying despite a considerable presence of strays in the spawning population (Blankenship et al. 2007; Saisa et al. 2003). The cause of poor reproductive success of strays are likely similar to those responsible for reduced productivity of HO fish in general, e.g., differences in run and spawn timing, spawning in less productive habitats, and reduced survival of their progeny (Leider et al. 1990; Reisenbichler and McIntyre 1977; Williamson et al. 2010).

5.2.1.5. Hatchery-influenced selection effects

Hatchery-influenced selection (often called domestication[15]), the third major area of genetic effects of hatchery programs that NMFS analyses, occurs when selection pressures imposed by hatchery

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

[15] We prefer "hatchery-influenced selection" or "adaptation to captivity" Fisch, K. M., C. C. Kozfkay, J. A. Ivy, O. A. Ryder, and R. S. Waples. 2015. Fish hatchery genetic management techniques: integrating theory with implementation. North American Journal of Aquaculture 77(3):343-357. to "domestication" because in discussions of genetic risk in salmon "domestication" is often taken as equivalence to species that have been under human management for thousands of years; e.g., perhaps 30,000 yrs for dogs Larson, G., and D. Q. Fuller. 2014. The evolution of animal domestication. Annual Review of Ecology, Evolution, and Systemmatics 45:115-136., and show evidence of large-scale genetic change Freedman, A. H., K. E. Lohmueller, and R. K. Wayne. 2016. Evolutionary history, selective sweeps, and deleterious variation in the dog. Annual Review of Ecology, Evolution, and Systematics 47:73–96.. By this standard, the only domesticated fish species is the carp (*Cyprinus carpio*) Larson, G., and D. Q. Fuller. 2014. The evolution of animal domestication. Annual Review of Ecology, Evolution, and Systemmatics 45:115-136.. "Adaptation to captivity", a term commonly used in conservation biology Allendorf, F. W., G. Luikart, and S. N. Aitken. 2013. Conservation and the genetics of populations. Second edition. Wiley-Blackwell, Oxford, U.K, Frankham, R. 2008. Genetic adaptation to captivity in species conservation programs. Molecular Ecology 17:325-333., and becoming more common in the fish literature Christie, M. R., M. L. Marine, R. A. French, and M. S. Blouin. 2011. Genetic adaptation to captivity can occur in a single generation. Proceedings

spawning and rearing differ greatly from those imposed by the natural environment and causes genetic change that is passed on to natural populations through interbreeding with HO fish. These differing selection pressures can be a result of differences in environments or a consequence of protocols and practices used by a hatchery program.

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

Genetic change and fitness reduction 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 fish, the amount of time a fish spends in the hatchery depends primarily on species but also on management. Some species are typically released as yearlings (steelhead, and coho and "stream-type" Chinook salmon), while others ("ocean-type" Chinook, pink, and chum salmon) are typically released at younger ages. On a population basis, exposure is determined by pNOB and pHOS (Ford 2002; Lynch and O'Hely 2001), and the number of years the program has been operating. 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.

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

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

- RRS studies often have little experimental power because of limited sample sizes and enormous variation among individual fish in reproductive success (most fish leave no offspring and a few leave many). This can lead to lack of statistical significance for HO:NO comparisons even if a true difference does exist. Kalinowski and Taper (2005) provide a method for developing confidence intervals around RRS estimates that can shed light on statistical power.
- An observed difference in RRS may not be genetic. For example, Williamson et al. (2010) found that much of the observed difference in reproductive success between HO and NO fish was due to spawning location; the HO fish tended to spawn closer to the hatchery. Genetic differences in reproductive success require a multiple generation design, and only a handful of these studies are available.

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of the National Academy of Sciences 109(1):238–242, Fisch, K. M., C. C. Kozfkay, J. A. Ivy, O. A. Ryder, and R. S. Waples. 2015. Fish hatchery genetic management techniques: integrating theory with implementation. North American Journal of Aquaculture 77(3):343-357. is more precise for species that have been subjected to semi-captive rearing for a few decades. We feel "hatchery-influenced selection" is even more precise, and less subject to confusion.

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

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

In addition to pink salmon RRS, results are now available for:

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

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

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

This suggests that perhaps the impacts of hatchery-influenced selection on fitness differs between Chinook salmon and steelhead.[16] The possibility that steelhead may be more affected by hatchery-influenced selection than Chinook salmon by no means suggest that effects on Chinook are trivial, however. A small decrement in fitness per generation can lead to large fitness loss.

In hatchery consultations, critical information for analysis of hatchery-influenced selection includes the number, location, and timing of naturally spawning hatchery fish, the estimated level of gene flow between HO and NO 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

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[16] This would not be surprising. Although steelhead are thought of as being quite similar to the "other" species of salmon, genetic evidence suggests the two groups diverged well over 10 million years ago Crête-Lafrenière, A., L. K. Weir, and L. Bernatchez. 2012. Framing the Salmonidae family phylogenetic portrait: a more complete picture from increased taxon sampling. PLoS ONE 7(10):1-19..

hatchery-influenced selection are currently largely focused on gene flow between NO and HO fish[17]. Key concepts related to gene flow were developed and promulgated throughout the Pacific Northwest by the Hatchery Scientific Review Group (HSRG). Because these concepts have been so influential, we devote the next few paragraphs to explaining them.

The HSRG developed gene-flow guidelines based on mathematical models developed by Ford (2002) and by (Lynch and O'Hely 2001). Guidelines for segregated programs are based on pHOS, but guidelines for integrated programs also include PNI, which is a function of pHOS and pNOB[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 (Table 35). Multiple conservation importance classifications have been developed by regional technical recovery teams; the classifications used by the HSRG were developed by the Willamette/Lower Columbia Technical Recovery Team (McElhany et al. 2003)

Table 34. HSRG gene flow guidelines

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

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

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

In a segregated program, pNOB=0, so by this equation PNI would also be zero. You could easily infer that PNI is zero in segregated programs, but this would be incorrect. The error comes from applying the equation to segregated programs. In integrated programs PNI can be estimated fairly accurately by the simple equation, and the simplicity of the equation makes it very easy to use. In segregated programs, however, a more complicated equation must be used to estimate PNI. A PNI equation applicable to both integrated and segregated programs was developed over a decade ago by the HSRG

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

[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. Details of the equation are presented in HSRG. 2009. Columbia River Hatchery Reform Project Systemwide Report. Appendix A. White Paper No. 1. Predicted Fitness Effects of Interbreeding between Hatchery and Natural Populations of Pacific Salmon and Steelhead. 38p..

(HSRG 2009, equation 9), but has been nearly completed ignored by parties dealing with the gene flow guidelines:

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

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

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

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

Another scientific team reviewed California hatchery programs and developed guidelines that differed somewhat from those developed by the earlier group (California HSRG 2012).

- They felt that truly isolated programs in which no HO returnees interact genetically with natural populations were impossible in California, and was “generally unsupportive” of the concept. 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 NO fish in areas integrated with the hatchery, the value of pNOB, the importance of the integrated population to the larger stock, the fitness differences between HO and NO fish, and societal values, such as angling opportunity.”
- 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 recommended for conservation programs that pNOB approach 100 percent, but pNOB levels should not be so high they pose demographic risk to the natural population by taking too large a proportion of the population for broodstock

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

NMFS has not adopted the HSRG gene flow guidelines per se. However, at present the HSRG guidelines and the 5% stray guideline from Grant (1997) are the only acknowledged scientifically based quantitative guidelines available. NMFS has considerable experience with the guidelines. They are based on a model (Ford 2002) developed by a NMFS geneticist, they have been evaluated by a NMFS-lead scientific team (RIST 2009), and NMFS has extended the Ford model for more flexible application of the guidelines to complex situations (Busack 2015) (see Section 5.2.1.5.1). At minimum, NMFS considers the HSRG guidelines a useful screening tool. For a particular program, based on specifics of the program, broodstock composition, and environment, NMFS may 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 typically consider the risk levels to be acceptable. However, NMFS has concerns about two aspects of application of HSRG guidelines: use of $pHOS_{eff}$ and application of gene flow guidelines to HSRG-defined recovery phases. These concerns are discussed below.

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

$$pHOS_{eff} = (RRS * HOS_{census})/(NOS+RRS*HOS_{census}) \text{ (HSRG 2014)}$$

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

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

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

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

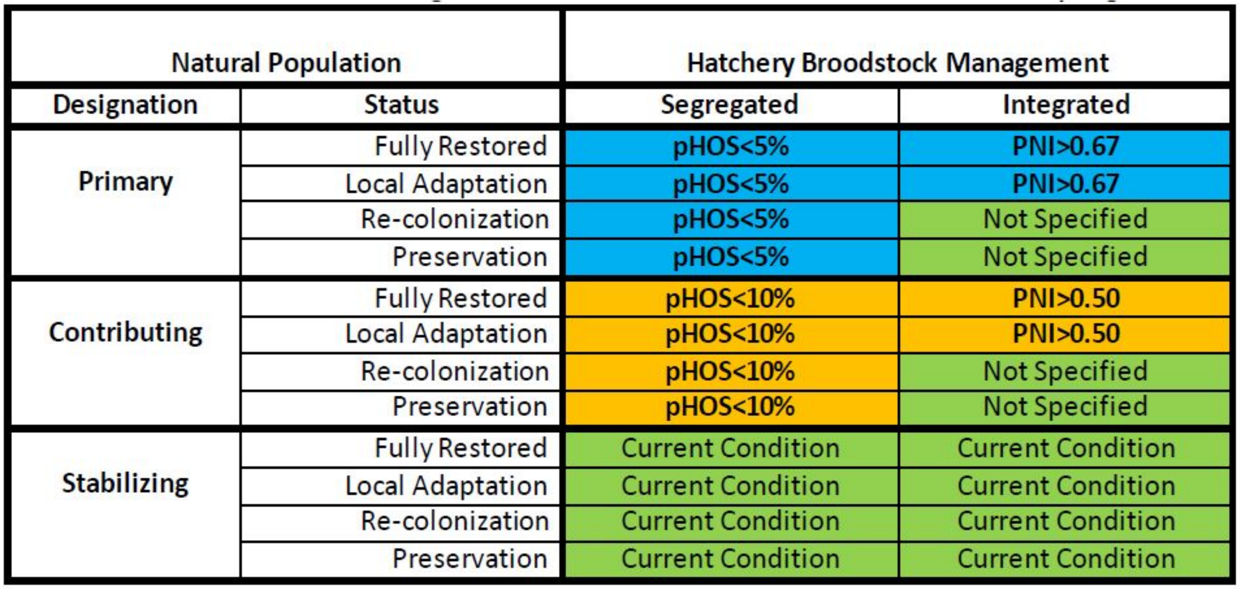
It is also important to recognize that PNI is only an approximation of relative trait value, based on a model that is itself very simplistic. To the degree that PNI fails to capture important biological information, it would be better to work to include this biological information in the underlying models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

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

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

The HSRG also provided guidance on development of quantitative "triggers" for determining when a population had moved (up or down) from one phase to another. As explained in HSRG (2015), in the preservation and re-colonization phase, no PNI levels were specified for integrated programs (Table 35). The emphasis in these phases was to "Retain genetic diversity and identity of the existing population". In the local adaptation phase, when PNI standards were to be applied, the emphasis shifted to "Increase fitness, reproductive success and life history diversity through local adaptation (e.g., by reducing hatchery influence by maximizing *PNI*)". Additional guidance was provided in HSRG (2017), which encouraged managers to use pNOB to "…the extent possible…" during the preservation and recolonization phases.

Table 35. HSRG gene flow guidelines/standards for conservation and harvest programs, based on recovery phase of impacted population (Table 2 from HSRG 2015).



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

NMFS agrees that conservation of populations at perilously low abundance may require prioritization of demographic over genetic concerns, but is concerned that high pHOS/low PNI regimes imposed on small recovering populations may prevent them from advancing to higher recovery phases[19]. A WDFW scientific panel reviewing HSRG principles and guidelines reached the same conclusion (Anderson et al. 2020).

The gene flow guidelines developed by the HSRG have been implemented for at most 15 years, so there has been insufficient time to judge their effect. However, the benefits of high pNOB (in the following cases 100 percent) has been credited with limiting genetic change and fitness loss in supplemented Chinook populations in the Yakima (Washington) (Waters et al. 2015) and Salmon (Idaho) (Hess et al. 2012; Janowitz-Koch et al. 2018) basins.

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

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

The Ford model (Ford 2002) considered a single population affected by a single hatchery program—basically two populations connected by gene flow—but the recursion equations underlying the model are easily expanded to more than two populations (Busack 2015). This has resulted in tremendous flexibility in applying the PNI concept to hatchery consultations.

A good example is the HSRG's (2014) "stepping-stone" concept, in which returnees from a smaller integrated hatchery program are used as broodstock for a larger segregated program, and both programs contribute to pHOS (Figure 7). It seemed logical that this would result in less impact to the natural population than if the segregated program used only its own returnees as broodstock, but the two-population implementation of the Ford model did not apply, there was no way to calculate PNI for this system.

Extending the model to three populations allowed PNI to be calculated. As illustrated in Busack (2015), this approach was successfully applied to the two spring Chinook salmon hatchery programs: Winthrop (segregated) and Methow (integrated). By using some level of Methow returnees as broodstock, PNI for the natural population could increase significantly[20]. The multi-population PNI model has now been used in numerous hatchery program consultations in Puget Sound and the Columbia basin, and has been extended to as many as ten hatchery programs and natural production areas.

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[19] According to Andy Appleby, past HSRG co-chair, the HSRG never intended this guidance to be interpreted as total disregard for pHOS/PNI standards in the preservation and recovery phases Appleby, A. 2020. Personal communication email from Andy Appleby to Craig Busack. Thoughts on pHOS/PNI standards. March 31, 2020. 2p.

[20] Such programs can lower the effective size of the system, but the model of Tufto (Section 5.2.1.4) can easily be applied to estimate this impact.

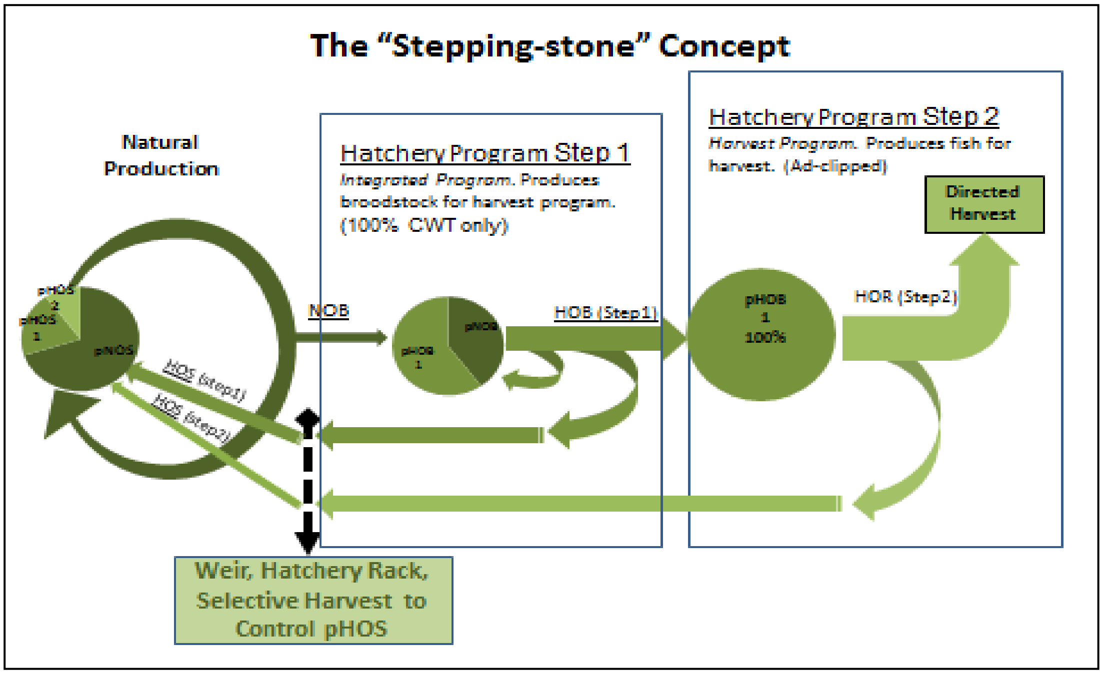

Figure 7. Gene flow between genetically linked segregated and integrated hatchery programs and the natural population they affect *(Figure 3-1 from HSRG 2014)*. By using some level of returnees from the integrated program as broodstock, the effects of the segregated program on the natural population are diminished.

5.2.2. **Ecological effects**

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

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

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

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

5.2.3. **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- and hatchery-origin fish that are intended to spawn naturally and on ESA-listed species. The information NMFS uses for this analysis includes a description of the facilities, practices, and protocols for collecting broodstock, the environmental conditions under which broodstock collection is conducted, and the encounter rate for ESA-listed fish.

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

5.3. 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.

5.3.1. **Competition**

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

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

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

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

En masse hatchery salmon 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 time near the release point. These non-migratory smolts (residuals) may directly compete for food and space with natural-origin juvenile salmonids of similar age (Bachman 1984; Tatara and Berejikian 2012). Although this behavior has been studied and observed, most frequently in the case of hatchery steelhead, residualism has been reported as a potential issue for hatchery coho and Chinook salmon as well (Parkinson et al. 2017). Adverse impacts of residual hatchery Chinook and coho salmon on natural-origin salmonids can occur, especially given that the number of smolts per release is generally higher; 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 near hatchery release points may be necessary to determine the potential effects of hatchery smolt residualism on natural-origin juvenile salmonids.

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

- Releasing hatchery smolts that are physiologically ready to migrate. Hatchery fish released as smolts emigrate seaward soon after liberation, minimizing the potential for competition with juvenile 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,[21] including the distribution of spawning and rearing habitat by quality and best estimates for spawning and rearing habitat capacity. Additional important information includes the abundance, distribution, and timing for naturally spawning hatchery fish and natural-origin fish; the timing of emergence; the distribution and estimated abundance for progeny from both hatchery and natural-origin natural spawners; the abundance, size, distribution, and timing for juvenile hatchery fish in the action area; and the size of hatchery fish relative to co-occurring natural-origin fish.

5.3.2. **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

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[21] "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.

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.

Predation may be greatest when large numbers of hatchery smolts encounter newly emerged fry or fingerlings, or when hatchery fish are large relative to natural-origin fish (Rensel et al. 1984). Due to their location in the stream, size, and time of emergence, newly emerged salmonid fry are likely to be the most vulnerable to predation. Their vulnerability is 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; Daly et al. 2009; 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:

- Ensuring that a high proportion of the hatchery fish 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 to minimize the potential for residualism.

5.3.3. **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. 2008b), 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. 2008b; 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; ODFW 2003; USFWS 2004; WWTIT and WDFW 2006). 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. 2008b). 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. 2008b). Treating the hatchery effluent would also minimize amplification, but would not reduce disease outbreaks within the hatchery itself caused by pathogens present in the incoming water supply. Another challenge with treating hatchery effluent is the lack of reliable, standardized guidelines for testing or a consistent practice of controlling pathogens in effluent (LaPatra 2003). However, hatchery facilities located near marine waters likely limit freshwater pathogen amplification downstream of the hatchery without human intervention because the pathogens are killed before transmission to fish when the effluent mixes with saltwater.

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

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

5.4. 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. 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)
- Tagging and fin-clipping, and observing the fish (in-water or from the bank)

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.

5.4.1. **Observing/Harassing**

For some activities, 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.

Fish frightened by the turbulence and sound created by observers are likely to seek temporary refuge in deeper water, or behind/under rocks or vegetation. In extreme cases, some individuals may leave a particular pool or habitat type and then return when observers leave the area. These avoidance behaviors are expected to be in the range of normal predator and disturbance behaviors.

5.4.2. **Capturing/handling**

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

NMFS has developed general guidelines to reduce impacts when collecting listed adult and juvenile salmonids (NMFS 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).

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

Most studies have concluded that PIT tags generally have very little effect on growth, mortality, or behavior. Early studies of PIT tags showed no long-term effect on growth or survival (Prentice 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.

5.4.4. **Masking**

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

5.5. 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.

5.6. 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:

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

"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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