UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
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Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion, Section 7(a)(2) Not Likely to Adversely Affect Determination, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation

Snake River Sockeye Salmon Hatchery Program, ESA Section 10(a)(1)(A) (Reinitiation 2023)

NMFS Consultation Number: WCRO-2022-03627

Action Agency: National Marine Fisheries Service (for issuance of permits)

Program Operator: Idaho Department of Fish and Game
National Marine Fisheries Service

Affected Species and Determinations:

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

Fishery Management Plan That Describes EFH in the Project Area	Does the Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Pacific Coast Salmon	Yes	Yes

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

Issued By: ______________________
Ryan J. Wulff
Assistant Regional Administrator

Date: September 20, 2023

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1. INTRODUCTION

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

The Proposed Action is the National Marine Fisheries Service's (NMFS') issuance of Endangered Species Act (ESA) section 10(a)(1)(A) permits to the Idaho Department of Fish and Game (IDFG) and to NMFS' Northwest Fisheries Science Center (NWFSC) for the operation of the Snake River sockeye salmon Captive Broodstock Program (Table 1). The proposed permits would be in effect for up to three years.

Snake River sockeye salmon are listed as endangered under the ESA (70 FR 37160) (NMFS 2005e). The purpose of the hatchery program is to support Snake River sockeye conservation, and the goal is to restore sockeye salmon runs to Stanley Basin waters leading, eventually, to sockeye salmon recovery and tribal and non-tribal harvest opportunity. The near-term program goal is to prevent species extinction, slow the loss of genetic diversity, and to begin to increase the number of individuals in the Evolutionarily Significant Unit (ESU). The Bonneville Power Administration (BPA) funds the Snake River sockeye salmon hatchery program to mitigate for fish losses caused by the construction and operation of the Federal Columbia River Power System (FCRPS). The program is coordinated by the Stanley Basin Sockeye Technical Oversight Committee (SBSTOC), which was formed in 1991 to guide new research, coordinate ongoing research, and actively participate in all elements of the Snake River sockeye recovery effort. SBSTOC members include representatives of Idaho Department of Fish and Game (IDFG), Bonneville Power Administration (BPA), NMFS, the Shoshone-Bannock Tribes, and an NGO representative (NMFS 2013b). The opinion documents consultation on NMFS' issuance of section 10(a)(1)(A) permits for Snake River sockeye salmon to IDFG and the NWFSC for the Snake River sockeye salmon hatchery program. This Biological Opinion is a reinitiation of the original Biological Opinion completed in 2013 (NMFS 2013a).

Table 1. Hatchery program to be permitted under the Proposed Action, including program operator and funding agency.

Hatchery and Genetics Management Plan (HGMP)	Program Operator	Funding Agency
Snake River sockeye salmon	IDFG, NMFS' NWFSC, SBT, and ODFW	BPA, State of Oregon

1.1. BACKGROUND

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

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

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (DQA) (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available within 2 weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. A complete record of this consultation is on file with the Sustainable Fisheries Division of NMFS in Portland, Oregon.

1.2. Consultation History

The first hatchery consultations in the Columbia Basin followed the first listings of Columbia Basin salmon under the ESA. Snake River sockeye salmon were listed as an endangered species on November 20, 1991, Snake River spring/summer 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; 2008g). 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 1995a). This opinion determined that hatchery actions at that time jeopardized listed Snake River salmon and required implementation of reasonable and prudent alternatives (RPAs) to avoid jeopardy.

A new opinion was completed on March 29, 1999, after Upper Columbia River (UCR) steelhead were listed under the ESA (62 FR 43937, August 18, 1997) and following the expiration of the previous opinion on December 31, 1998 (NMFS 1999). That opinion concluded that Federal and non-Federal hatchery programs jeopardize Lower Columbia River (LCR) steelhead and Snake River steelhead protected under the ESA, and described RPAs necessary to avoid jeopardy. Those measures and conditions included restricting the use of non-endemic steelhead for hatchery broodstock and limiting stray rates of non-endemic salmon and steelhead to less than 5 percent of the annual natural population in the receiving stream. Soon after, NMFS reinitiated consultation when LCR Chinook salmon, UCR spring 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." 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 Federally-funded hatchery programs ordered by Congress was underway at about the same time that the 2000 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 (Brown 2001). 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 (Jones 2002; Foster 2004). HGMPs were submitted to NMFS under RPA 169; however, many were incomplete and, therefore, were not found to be sufficient for ESA consultation.

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

On May 5, 2008, NMFS published a Supplemental Comprehensive Analysis (SCA) (NMFS 2008g) and an opinion and RPAs for the FCRPS to avoid jeopardizing ESA-listed salmon and steelhead in the Columbia Basin (NMFS 2008a). 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 2008g, 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…."

A complete record of this consultation is on file with the SFD in Portland, Oregon. On May 15, 2012, IDFG submitted an HGMP describing the proposed hatchery program and the potential effects of the program on ESA-listed Snake River sockeye salmon, Snake River spring/summer Chinook salmon, and Snake River steelhead. Additional details on the hatchery program are found in the Springfield Hatchery Master Plan (IDFG 2010). On June 13, 2012, NMFS completed its review of the HGMP and determined it sufficient for formal consultation (Jones 2012). That HGMP included an application for a direct take permit for the propagation of sockeye salmon. On September 28, 2013, NMFS completed its consultation of the issuance of the requested permit.

Because NMFS' NWFSC operates some of the hatcheries that support the Snake River sockeye salmon hatchery program, NMFS proposes to issue one permit to IDFG and a second permit to NMFS' NWFSC, as described below. The initial permits were in effect for ten years so that research, monitoring, and evaluation (RM&E) included in the 2012 HGMP (IDFG 2012) could provide meaningful results and inform future management decisions. The permits are set to expire on September 27, 2023.

On November 29, 2022, IDFG submitted an updated HGMP to initiate the permit renewal process on ESA-listed Snake River sockeye salmon, Snake River spring/summer Chinook salmon, and Snake River steelhead, and extend the expiration date 3 years until September 27, 2026 (IDFG 2022). On January 27, 2023, NMFS completed its review of the updated HGMP and determined it sufficient for reinitiation and formal consultation (Preston 2023). On September 20 2023, NMFS completed its consultation of the issuance of the requested permit.

BPA is continuing to fund the Snake River Captive Broodstock Program, along with state general funds.

On July 5, 2022, the U.S. District Court for the Northern District of California issued an order vacating the 2019 regulations that were revised or added to 50 CFR part 402 in 2019 ("2019 Regulations," see 84 FR 44976, August 27, 2019) without making a finding on the merits. On September 21, 2022, the U.S. Court of Appeals for the Ninth Circuit granted a temporary stay of the district court's July 5 order. On November 14, 2022, the Northern District of California issued an order granting the government's request for voluntary remand without vacating the 2019 regulations. The District Court issued a slightly amended order two days later on November 16, 2022. As a result, the 2019 regulations remain in effect, and we are applying the 2019 regulations here. For purposes of this consultation and in an abundance of caution, we considered whether the substantive analysis and conclusions articulated in the biological opinion and incidental take statement would be any different under the pre-2019 regulations. We have determined that our analysis and conclusions would not be any different.

1.3. Proposed Action

Under the ESA, "action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies (see 50 CFR 402.02). The Proposed Action is NMFS' issuance of section 10(a)(1)(A) permits to IDFG and NMFS' NWFSC for the Snake River sockeye salmon hatchery program as described in the November 29, 2022, HGMP (IDFG 2022).

We considered, under the ESA, whether or not the proposed action would cause any other activities and determined that it would not.

Under the MSA, "Federal action" means any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken by a Federal agency (see 50 CFR 600.910).

NMFS describes a hatchery program as a group of fish that have a separate purpose and that may have independent spawning, rearing, marking and release strategies (NMFS 2008b). 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).

The captive broodstock program described in the HGMP was founded in 1991 by the IDFG and NMFS to prevent the extinction of the Snake River Sockeye Salmon ESU. The ESU was listed as an endangered species on November 20, 1991 (56 FR 58619). Since then, the program has used a captive broodstock to produce eggs, juveniles, and adults for reintroduction into the Stanley Basin lakes. To guard against catastrophic loss at any one brood facility, the captive broodstock components of the program are duplicated at facilities in Idaho (Eagle Fish Hatchery) and Washington (Manchester Research Station and Burley Creek Fish Hatchery). Eggs produced from annual spawning events at Eagle Fish Hatchery and at the Burley Creek Fish Hatchery are transferred to Springfield Hatchery in Idaho for continued culture.

A small number of eggs (50,000) are sent to Oxbow Hatchery in Oregon for continued culture. Once juveniles, the fish are transferred to Bonneville Fish Hatchery (Oregon) for final rearing and acclimation, and then released into Tanner Creek.

NMFS has developed draft viability criteria for the Snake River Sockeye Salmon ESU (Table 2). To help meet these criteria, the proposed hatchery program is using a three-phase approach with the following objectives–only the current status (Phase 2) is fully addressed in the HGMP, therefore Phase 3 is not addressed in the proposed permits:

- Phase 1: increase genetic resources and the number of adult sockeye returns (captive brood phase)
- Phase 2: incorporate more natural-origin returns into hatchery spawning designs and increase natural spawning escapement (population re-colonization phase)
- [Phase 3: move towards the development of an integrated program that meets proportionate natural influence (PNI) goals established by the Columbia River Hatchery Scientific Review Group (HSRG) (local adaptation phase). During Phase 3, captive broodstock will be phased out, and only anadromous-origin fish returning to Stanley Basin lakes will be used.]

Table 2. Viable Salmonid Population (VSP) parameters and proposed biological viability criteria for Snake River sockeye salmon (NMFS 2015).

Viable Salmonid Population Parameter	**Proposed Criteria**
Abundance	Minimum spawning abundance threshold: 1,000 natural-origin fish each for Redfish Lake and Alturas Lake populations (intermediate size category) Minimum spawning abundance threshold: 500 natural-origin fish for populations in the smaller historical size category (Pettit, Stanley, or Yellowbelly Lakes)
Productivity	Population growth rate is stable or increasing
Spatial structure and diversity	Very low to low risk rating for a highly viable population Moderate risk rating for a viable population

In the 2008 FCRPS opinion, NMFS established a juvenile sockeye salmon production target for this hatchery program of 1,000,000 smolts (NMFS 2008c). These smolts would be released into Redfish Lake Creek with the option of emergency release directly into the Salmon River. Additionally, adults would be released into both Redfish and/or Pettit Lake consistent with the Snake River sockeye salmon recovery plan (NMFS 2015) and SBSTOC recommendations. Eyed-eggs and pre-smolt releases into Pettit and Redfish Lakes were phased out, but some eyed-egg and pre-smolt releases into Pettit and Redfish Lake may occur to reduce inventory at Springfield Fish Hatchery. In addition, eyed eggs from females with moderate ELISA values, for BKD infection, may be released into Pettit Lake.

In 2013, IDFG purchased an abandoned trout hatchery, the Springfield Hatchery, in eastern Idaho, and renovated it to make it suitable to accommodate increased production targets. With the creation of Springfield Hatchery, smolt production at Oxbow Hatchery and Sawtooth Hatchery was phased out. However, in 2022 a rearing experiment started that could be repeated for up to five years, where small number of eggs are sent to Oxbow Hatchery for rearing. Springfield Hatchery is used to incubate and rear most eggs from spawning events at the IDFG Eagle Fish Hatchery and NMFS Burley Creek Hatchery. Springfield Hatchery is able to accommodate up to 1,000,000 smolts to meet the program targets. Captive brood operations at the Manchester Research Station and Burley Creek Hatchery may be terminated when the 5-year geometric mean of the total anadromous sockeye salmon run exceeds 1,000 (natural-origin and hatchery-origin combined to the basin). The Eagle Hatchery's captive brood operation may be terminated when the 5-year geometric mean of the total anadromous sockeye salmon run exceeds 2,150 (natural-origin and hatchery-origin combined to the basin). However, captive brood efforts may continue beyond trigger dates if captive broods are needed as a genetic safety net or to culture fish from Alturas or other lakes.

The proposed permits (1454-2R and 1455-2R) would only cover activities in Phase 2 of the hatchery program. Phase 1 has been completed and Phase 3 triggers are not expected to be met during the 3-year permit period. The submitted HGMP does not include enough details on Phase 3 activities for them to be evaluated in this opinion (i.e., NMFS would need an adult management plan to fully evaluate the effects of Phase 3 activities). Therefore, Phase 3 activities are not covered under the proposed permits. Activities that would be authorized by the proposed permits include:

- Annual operation of permanent weir and fish trap on Redfish Lake Creek for broodstock collection
- Annual operation of the Sawtooth Hatchery's permanent weir and fish trap for broodstock collection
- Collection of anadromous-origin adults returning to the Bonneville Hatchery. These fish are transported to Eagle Fish hatchery for processing and released into Stanley Basin Lakes. These fish are not incorporated into the captive broodstock
- Removal of sockeye salmon from the Lower Granite Dam trap when low-flow or temperature conditions are expected to limit adult survival to spawning grounds
- Biological sampling of sockeye salmon at the Lower Granite Dam trap
- Transfer of fish between fish traps, hatchery facilities, and release locations
- Holding, spawning, and incubating fish at Eagle Hatchery, Burley Creek Hatchery, Bonneville Hatchery, Springfield Hatchery, Oxbow Hatchery, and Manchester Research Station
- Rearing fish at Eagle Hatchery, Springfield Hatchery, Oxbow Hatchery, Burley Creek Hatchery, Bonneville Hatchery and Manchester Research Station
- Acclimation of juvenile sockeye salmon 1 to 2 weeks at Sawtooth Hatchery prior to release
- Internal and external marking of hatchery-origin fish (e.g., adipose clips and tags)
- Tagging of natural-origin sockeye for monitoring purposes
- Observing, handling, anesthetizing, weighing, measuring, examining, medicating, autopsying, tagging, and genetic sampling of sockeye salmon while in the hatchery facilities

- Culling of diseased sockeye salmon eggs, juveniles, adults, and unproductive adults
- Release of hatchery-origin juvenile sockeye salmon into Redfish Lake, Redfish Lake Creek, Pettit Lake, the Salmon River, and Tanner Creek
- Release of natural-origin and hatchery-origin sockeye salmon into Redfish Lake, and Pettit Lake
- Release of Alturas-origin sockeye salmon adults into Alturas Lake
- Maintenance of the following facilities as needed to support the proposed hatchery program: Springfield Hatchery (IDFG), Eagle Hatchery (IDFG), Oxbow Hatchery (Oregon Department of Fish and Wildlife (ODFW)), Sawtooth Hatchery (IDFG), Burley Creek Hatchery (NMFS), Manchester Research Station (NMFS) and Bonneville Fish hatchery (ODFW)
- Operation of juvenile traps on Redfish lake to monitor juvenile sockeye salmon
- Genetic sampling of juvenile sockeye salmon encountered in juvenile traps

Additional RM&E is permitted through permits 1124-7R to IDFG and 1341-6R to the Shoshone Bannock Tribes. These activities include use of mid-water trawls and screw traps to monitor the status of the Snake River Sockeye Salmon ESU.

Fisheries would not be permitted as part of the Proposed Action, and there are no fisheries that exist because of the proposed hatchery program; i.e., the "but for" test does not apply, because there are no fishery actions directly resulting from the Proposed Action. Although one of the long-term goals of this hatchery program is to provide tribal and non-tribal harvest opportunity, these fisheries are not currently being proposed. There are existing fisheries that incidentally catch Snake River sockeye salmon, but these fisheries would exist with or without the proposed hatchery program (and have previously been evaluated in a separate biological opinion (NMFS 2008h; 2011c; 2018b; 2019b; 2019c).

Describing the Proposed Hatchery Program

Proposed hatchery broodstock collection

- Broodstock origin and number: Captive broodstocks exist at the IDFG Eagle Fish Hatchery and at NMFS NWFSC facilities in Washington State. In the near-term, broodstock from both the IDFG and NMFS' NWFSC facilities would continue to be used to produce eggs for annual release. Currently (Phase 2), 1,640 captive broodstock spawners are required to meet the production goal of one million smolts (approx. 1,115,000 eyed eggs). As hatchery production levels increase, the broodstock would eventually come from sockeye salmon returns collected at weirs, and IDFG expects to phase out the use of captive broodstock in annual spawning events. With the change towards more anadromous broodstock, the total number needed to achieve release targets is estimated to be 1,150 adults.

- Proportion of natural-origin fish in the broodstock (pNOB): The broodstock would continue to be a minimum of 10 percent natural-origin adults in Phase 2 (population re-colonization phase). Until NORs reach numbers sufficient to meet this criterion, returning anadromous hatchery adults will be used along with naturally produced adults to achieve the 10 percent threshold[11].

- Broodstock selection: Sockeye salmon returning to the Redfish Lake Creek and Sawtooth Fish Hatchery weirs that may be incorporated into the broodstock would be collected daily and transferred to Eagle Fish Hatchery within 48 hours for sorting. Sockeye salmon that are not incorporated into the broodstock program are held until early September before being released to spawn naturally. Adults collected in excess of projected brood need may be directly released into Stanley Basin waters. Additional sockeye salmon may be collected from the Lower Granite trap or through seines or dip nets in some years. Returning adults captured at Bonneville Hatchery will be transported to Eagle Fish Hatchery for parental-based tagging (PBT) evaluation before being released into Stanley Basin lakes. These fish would not be incorporated into the captive broodstock program. Genetic samples would be taken from all fish and, based on the results, a spawning design would be developed that represents the genetic diversity of the entire run, and that equalizes sex ratios and family contribution. The SBSTOC would continue to review and approve the plan annually, and determine when random broodstock selection and random mating would be implemented.
- Method and location for collecting broodstock: Broodstock would typically be collected at the Redfish Lake Creek trap (approximately 1 mile below the mouth of Redfish Lake), and Sawtooth Hatchery trap (Figure 1). If fish do not enter traps voluntarily, seines and dip nets may be used. In low-flow years, when survival to the spawning grounds is expected to be low, fish may be collected at the Lower Granite Dam trap. The Lower Granite Dam trap is located on the Snake River, 450 miles downstream from Redfish Lake and the Stanley Basin.
- Duration of collection: Adults would continue to be collected at the Redfish Lake trap and Sawtooth Hatchery trap from the start of June through the end of October.[2]
- Encounters, sorting and handling, with ESA listed adults: Sockeye salmon encountered at the Redfish Lake Creek trap or Sawtooth Fish Hatchery trap that may be incorporated into the broodstocks and all Snake River sockeye collected at the Bonneville hatchery ladder will be genetically sampled and released to spawn naturally. Sockeye salmon collected at Redfish Lake Creek, and Sawtooth Fish Hatchery in excess of brood need may be directly released into Stanley Basin waters. Additionally, sockeye salmon that are not incorporated into the broodstock would be held until early September before being released to spawn naturally. There would be no steelhead intercepted at any trap during operations for adult sockeye collection, because steelhead do not migrate past the

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[1] As the hatchery program transitions into Phase 3 (local adaptation phase), an increasing number of natural-origin adults would be incorporated into the broodstock (35 percent minimum). Concurrently during Phase 3, the proportion of hatchery-origin anadromous adults released to spawn naturally will be limited (<16 percent of total adults released to Redfish Lake). However, Phase 3 activities are not covered under the proposed permits because Phase 3 triggers are not expected to be reached within the proposed 3-year permit extension.

[2] In some years, fish would be collected at the Lower Granite trap between late June and late August and transported to the Sawtooth Basin. However, operation of the Lower Granite trap would not be covered by the proposed permits. In most years, sockeye salmon would be collected from the Redfish Lake Creek and Sawtooth Hatchery traps between mid-July and mid-October. However, in some years, collection at the Redfish Lake Creek trap and Sawtooth Hatchery traps may occur early if sockeye begin returning to the traps earlier.

Sawtooth Hatchery or into Redfish Lake Creek after April, and broodstock collection for the sockeye hatchery program usually does not start until mid-July. The Redfish Lake Creek trap may incidentally intercept some adult spring Chinook salmon. Spring Chinook salmon intercepted at the Redfish Lake Creek trap would be passed upstream to spawn naturally or transported to Sawtooth Hatchery to be used as broodstock for the Sawtooth spring Chinook salmon hatchery program. The Sawtooth Hatchery trap is operated primarily for the purpose of collecting spring Chinook salmon broodstock for the Sawtooth spring Chinook salmon hatchery program, and most, if not all, sockeye salmon collection occurs during that operation. Spring Chinook salmon intercepted at Sawtooth Fish Hatchery would be incorporated into the broodstock or passed upstream to spawn naturally. All Snake River sockeye returning to Bonneville will be genetically sampled and released to spawn naturally. These fish are not incorporated into the broodstock program and are released to spawn naturally.

Proposed mating protocols

- Genetic samples would continue to be taken from all returning anadromous sockeye salmon. A spawning design would then be developed that incorporates a portion of the returning anadromous sockeye. No back-up males or pooled samples would be used in spawning. A spawning matrix would be used with eggs from a single female split into two equal subfamilies. Each subfamily would be spawned with a randomly selected unique male. Full and half-siblings are identified and crosses between these individuals are not made. The SBSTOC would continue to review and approve the plan annually and determine when one-to-one crosses should occur.

Proposed protocols for each release group (annually)

- Life stage: eyed-eggs; pre-smolts at 60-80 fish per pound; smolts at 8-20 fish per pound; and adults at 0.35 fish per pound.
- Acclimation (Y/N) and duration of acclimation: Eggs: No; Pre-smolts: Yes. Approximately 7 days when possible, but depends on raceway availability at Sawtooth Hatchery; Smolts: Yes, 7-14 days. All stages of acclimation occur at Sawtooth Hatchery immediately prior to release into Redfish Lake Creek.
- Volitional release (Y/N): No. Fish will be forced out of transport vehicles.
- External mark(s): All pre-smolts, smolts, and adults may have clipped adipose fins. Adipose clipping will be the preferred alternative. However, RM&E actions (e.g., growth trials) may prevent fish from attaining sufficient size prior to the marking window. Additionally, marking trailer availability may be limited. In those instances, Chinook salmon and steelhead trout marking would be prioritized, due to mark-selective fisheries on those stocks. The SBTOC would review and approve the plan annually and determine how adipose intact sockeye salmon returning to the Sawtooth Fish Hatchery weir would be handled (e.g., returned to Eagle Fish Hatchery for genetic analyses or passed for continued migration to Pettit or Alturas Lakes).
- Internal marks/tags: Currently, all captive adults from Eagle and Manchester have passive integrated transponder (PIT) tags and a representative sample of smolts from Springfield Hatchery have PIT tags. Smolts released from Oxbow Hatchery are adipose

fin-clipped and receive coded-wire tags in place of PIT tags. All hatchery reared sockeye are genetically tagged through parental-based tagging (PBT).

- Maximum number released/release locations:

  Target program: 1,000,000 smolts would continue to be planted at the outlet of Redfish Lake, a minimum of 250 full-term hatchery adults would be released into Redfish Lake, and 100 full-term hatchery adults would be released in Pettit Lake. In addition, approximately 40,000-47,000 smolts from the 50,000 eggs would be released into Tanner Creek.

  The number of fish released into Alturas Lake each year will be determined based on the Snake River Sockeye Recovery Plan (NMFS 2015).

- Time of release: November/December (eggs); October (pre-smolts); April/May (smolts); August/September/October (adults).
- Fish health certification: Certification of fish health would be conducted prior to release (major bacterial, viral, and parasitic pathogens). IDFG and NMFS fish health professionals' sample and certify all release and/or transfer groups.

Proposed adult management

- Anticipated number or range in hatchery fish returns originating from this program: An average of 389 hatchery-origin sockeye have returned annually to Redfish Lake over the last eleven years (2010-2021). It was expected that these numbers would increase in Phase 2 of the proposed Snake River sockeye salmon hatchery program; however, due to increasingly poor river conditions, the number of returns decreased (Ford 2022).
- Removal of hatchery-origin fish and the anticipated number of natural-origin fish encountered: An average of 94 natural-origin sockeye have returned annually to Redfish Lake over the last eleven years (2010-2021). Hatchery-origin fish are not removed during Phase 2 of the hatchery program. Although hatchery-origin sockeye salmon would be removed under Phase 3 to meet PNI goals, Phase 3 activities are not covered under the proposed permits because Phase 3 triggers are not expected to be reached within the proposed 3-year permit period. Additionally, the submitted HGMP does not include enough details on Phase 3 activities for them to be evaluated in this opinion (i.e., NMFS would need an adult management plan to fully evaluate the effects of Phase 3 activities).
- Appropriate uses for hatchery fish that are removed: Not applicable.
- Are hatchery fish intended to spawn naturally (Y/N): Yes.
- Performance standard for pHOS (proportion of naturally spawning fish that are of hatchery-origin): There is not a pHOS standard during Phase 2 (population re-colonization phase). The pHOS would likely be limited to less than 30 percent in Redfish Lake during Phase 3 (local adaptation phase). However, Phase 3 activities are not covered under the proposed permits.
- Performance standard for stray rates into natural spawning areas: The straying rate of hatchery-origin Snake River sockeye salmon straying into the natural-spawning areas of other sockeye salmon (listed ort un-listed) is expected to be less than 1 percent (IDFG

2022). In 2022, an estimated 300 sockeye of Springfield origin were detected straying into the Columbia but were not seen in the Okanagan or Wenatchee.

Proposed research, monitoring, and evaluation

- Adult sampling, purpose, methodology, location, and the number of ESA-listed fish handled: The proposed permits would authorize annual genetic monitoring of all adult sockeye salmon captured at adult weirs and traps in the Snake River basin as well as those collected at Bonneville Fish Hatchery at the Eagle Fish Genetics Laboratory. This biological sampling reduces the genetic risks associated with artificial propagation by enabling pedigree-based broodstock management and evaluation of supplementation releases. The proposed permits would also authorize biological sampling of adult sockeye salmon at Lower Granite Dam. This biological sampling would enable managers to determine which sockeye were surviving the migration from Lower Granite Dam to the Stanley Basin.
- Juvenile sampling, purpose, methodology, location, and the number of ESA-listed fish handled: Monitoring of the status of juvenile sockeye salmon populations in Alturas, Pettit, and Redfish Lakes would continue to be authorized under Research Permits 1124-7R and 1341-6R. Monitoring juvenile emigration from Alturas and Pettit Lakes would continue to be authorized under Research Permit 1341-6R. These activities would not be included as part of the Proposed Action. However, information provided by research permitted under permits 1124-7R and 1341-6R would be used to monitor the success of the Snake River sockeye salmon hatchery program. The Proposed Action would permit the capture, sampling, tagging, and release of juvenile sockeye salmon at juvenile traps in Redfish Lake and Lower Granite Dam to determine sockeye abundance, productivity, and run timing.

Proposed operation, maintenance, and construction of hatchery facilities

- Water source(s) and quantity for hatchery facilities: The Proposed Action would not permit the construction of any hatchery facilities. The Proposed Action would permit the operation and maintenance of the Eagle Fish Hatchery, Springfield Hatchery, Oxbow Fish Hatchery, Sawtooth Fish Hatchery, Burley Creek Fish Hatchery, and Manchester Research Station as needed to implement the proposed Snake River sockeye salmon hatchery program. Table 3 summarizes the water source and use by hatchery facility.

Table 3. Water source and use by hatchery facility for Snake River sockeye salmon program.

Hatchery Facility	Total Surface Water Use	Total Ground-water Use	Maximum Proportion used for Proposed Hatchery Program (%)	Surface Water Source	Minimum Surface Water Flows	Maximum Percentage of Surface Water Diverted for Proposed Program (%)	Discharge Location
Springfield Hatchery	0	50 cfs	100	N/A	N/A	N/A	Boom Cr., Snake River

Eagle Fish Hatchery	0	6.57 cfs	100	N/A	N/A	N/A	Boise River
Oxbow Fish Hatchery	8.5 cfs	0	10	Oxbow Springs	.66 cfs	10	Columbia River
Sawtooth Fish Hatchery	43 cfs	11.6 cfs	10	Salmon River	150 cfs	2	Salmon River
Burley Creek Fish Hatchery	0	2.14 cfs	100	N/A	N/A	N/A	Burley Cr.
Manchester Research Station[3]	NA	NA	NA	NA	N/A	N/A	Clam Bay, Puget Sound
Bonneville Hatchery	25.4 cfs	27.85 cfs	.02	Tanner Creek	11.14 cfs	.04	Tanner Creek, Columbia

N/A: not applicable; cfs: cubic feet per second.
Source: waterdata.usgs.gov, HGMPs, and hatchery managers.

- Water diversions meet NMFS screen criteria (Y/N): Yes. The water intakes at the Oxbow Fish Hatchery, the Sawtooth Fish Hatchery, Bonneville Fish Hatchery and the Manchester Research Station are screened in compliance with NMFS guidelines (NMFS 1994) to protect juvenile fishes.
- Permanent or temporary barriers to juvenile or adult fish passage (Y/N): Yes. Three permanent weirs in the Stanley Basin: a weir at the Sawtooth Fish Hatchery, a weir on Redfish Lake Creek, and a weir on Pettit Lake, and a rotary screw trap on the Upper Salmon River, Alturas Lake Creek. There are no other barriers to juvenile or adult passage.
- Instream structures (Y/N): Yes. There are water diversion structures at Oxbow Hatchery, and Sawtooth Hatchery. There are fish ladders at Bonneville and Sawtooth Hatchery to collect returning adults. There are water discharge structures at each hatchery facility used by the proposed hatchery program (Table 3).
- Streambank armoring or alterations (Y/N): Yes. Minor armoring would be maintained at diversion structures and at water discharge structures.
- Pollutant discharge and location(s): All hatchery facilities that support the Snake River sockeye salmon hatchery program operate consistent with their National Pollutant Discharge Elimination System (NPDES) permits. Table 3 shows discharge locations for each hatchery facility.

[3] Manchester Research Station no longer uses surface water as a freshwater resource

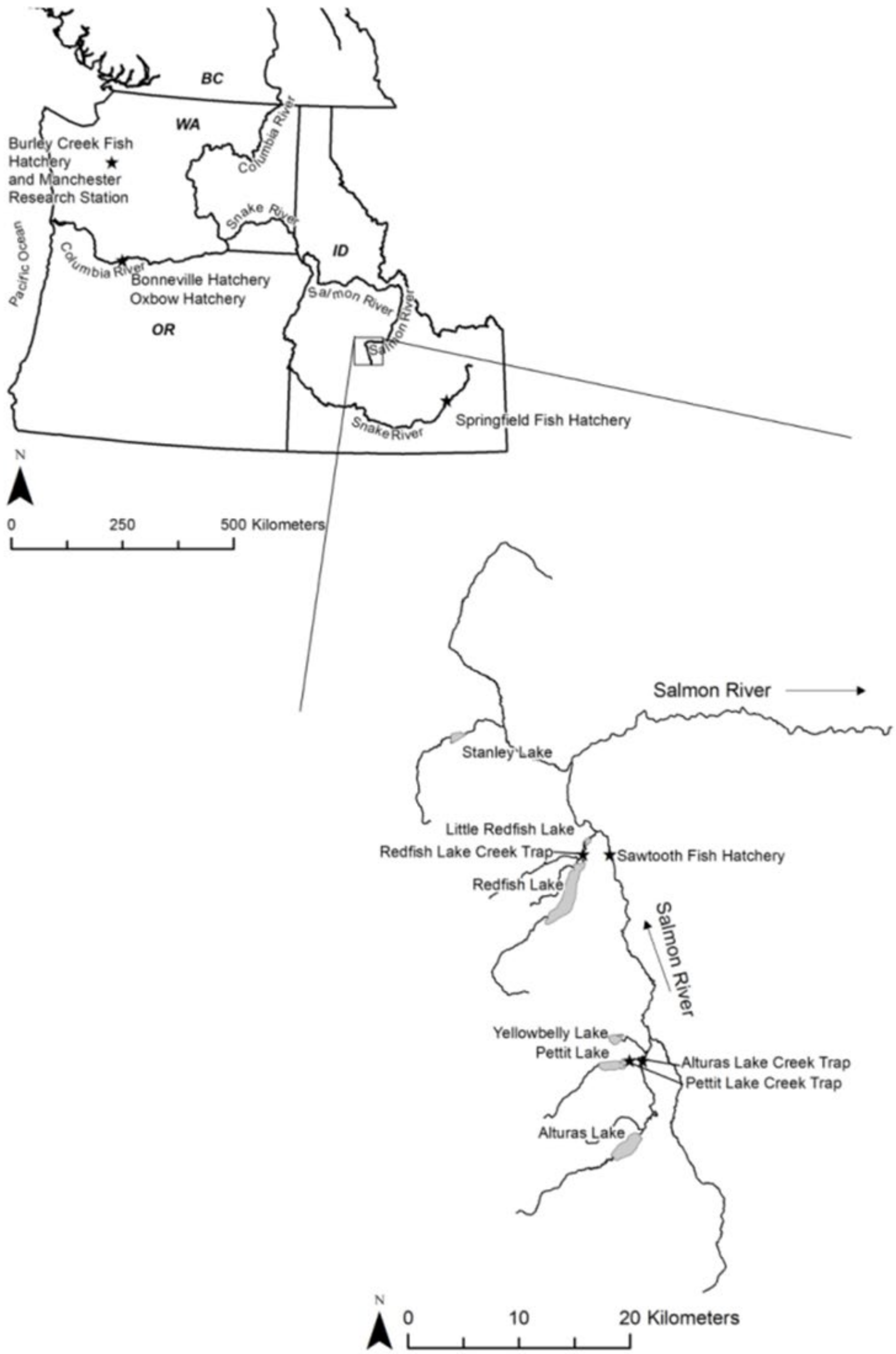

Figure 1: Location of Snake River Sockeye Salmon Hatchery Program in the Upper Salmon River of Idaho.

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

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

2.1. ANALYTICAL APPROACH

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

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

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

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

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

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

2.2. RANGEWIDE STATUS OF THE SPECIES AND CRITICAL HABITAT

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

Table 4.[4] Federal Register notices for the final rules that list species, designate critical habitat, or apply protective regulations to ESA listed species considered in this consultation.

Species	Listing Status	Critical Habitat	Protective Regulations
Chinook salmon *(Oncorhynchus tshawytscha)*			
Snake River spring/summer-run	Threatened, 79 FR[5] 20802, April 14, 2014	64 FR 57399, October 25, 1999	70 FR 37159, June 28, 2005
Sockeye salmon *(O. nerka)*			
Snake River	Endangered, 79 FR 20802, April 14, 2014	58 FR 68543, December 28, 1993	Issued under ESA Section 9
Steelhead *(O. mykiss)*			
Snake River Basin	Threatened, 79 FR 20802, April 14, 2014	70 FR 52769, September 2, 2005	70 FR 371659, June 28, 2005

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

2.2.1. Status of Listed Species

For Pacific salmon and steelhead, NMFS commonly uses four parameters to assess the viability of the populations that, together, constitute the species: abundance, productivity, spatial structure, and diversity (McElhany et al. 2000b). These "viable salmonid population" (VSP) criteria therefore encompass the species' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. When these parameters are collectively at appropriate levels, they maintain a population's capacity to adapt to various environmental conditions and allow it to sustain itself in the natural environment. These parameters or attributes are substantially influenced by habitat and other environmental conditions.

[4] ESA-listed bull trout (*Salvelinus confluentus*) and many other species are administered by the FWS, and NMFS is in consultation with the FWS on the proposed issuance of section 10(a)(1)(A) permits for the Snake River sockeye salmon hatchery program.

[5] Citations to "FR" are citations to the Federal Register.

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

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

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

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

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

2.2.1.1. Life History and Current Rangewide Status of Snake River Spring/Summer Salmon ESU

On June 3, 1992, NMFS listed the Snake River Spring/Summer-run Chinook Salmon ESU as a threatened species (57 FR 23458). More recently, the threatened status was reaffirmed on June 28, 2005 (70 FR 37160) and on April 14, 2014 (79 FR 20802) (Table 4). Critical habitat was originally designated on December 28, 1993 (58 FR 68543) but updated most recently on October 25, 1999 (65 FR 57399) (Table 4).

The Snake River Spring/Summer Chinook Salmon ESU includes all naturally spawned populations of spring/summer Chinook salmon in the mainstem Snake River and the Tucannon River, Grande Ronde River, Imnaha River, and Salmon River sub-basins, including 13 artificial propagation programs (Ford 2022). However, inside the geographic range of the ESU, there are a total of 19 hatchery spring/summer-run Chinook salmon programs currently operational (NMFS 2022a). Table 5 lists the natural and hatchery populations included in (or excluded from) the ESU.

Table 5. Snake River Spring/Summer-Run Chinook Salmon ESU description and MPGs (Jones Jr. 2015; NWFSC 2015; Ford 2022)

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

Twenty-eight historical populations (4 functionally extirpated) within five MPGs comprise the Snake River Spring/Summer-run Chinook Salmon ESU. The natural populations are aggregated into the five extant MPGs based on genetic, environmental, and life history characteristics. Figure 2 shows a map of the current ESU and the MPGs within the ESU.

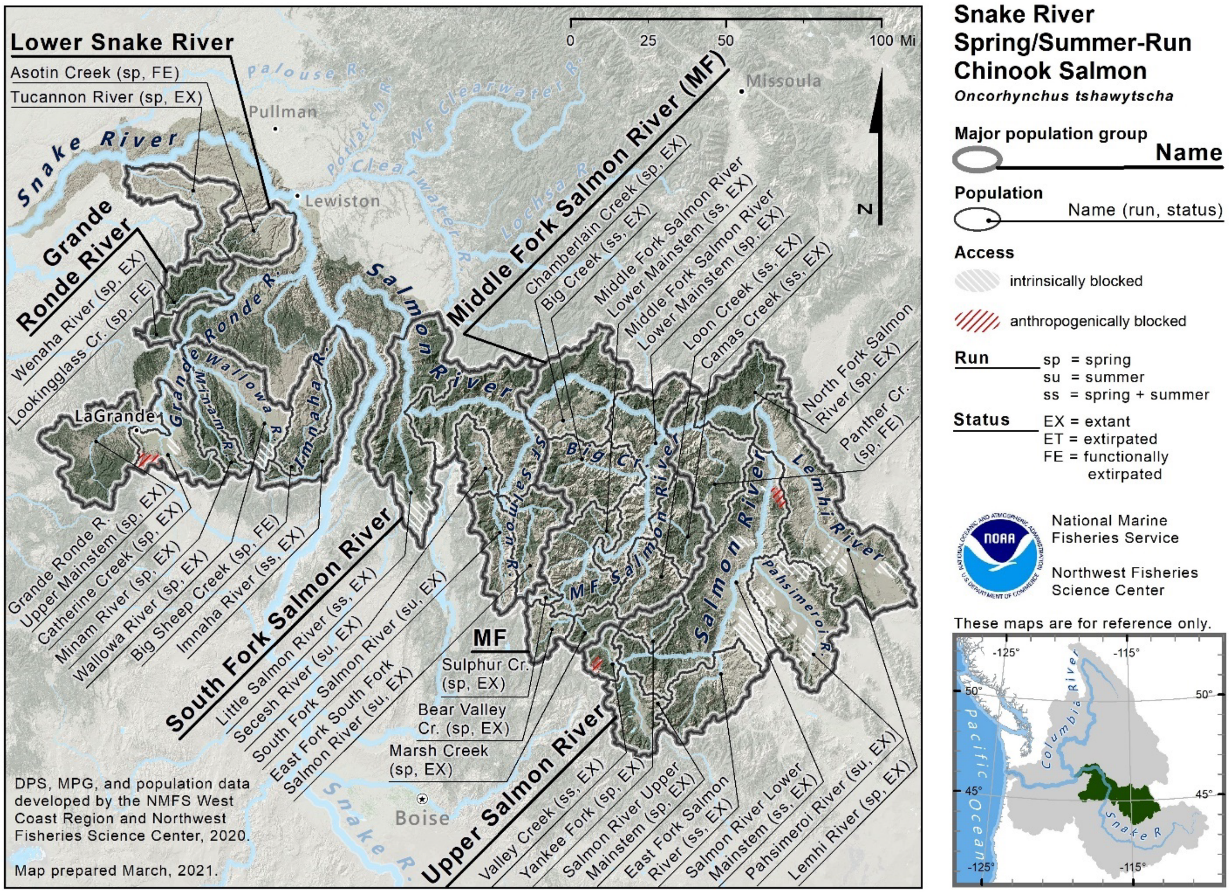

Figure 2. Snake River Spring/Summer-Run Chinook Salmon ESU spawning and rearing areas, illustrating natural populations and MPGs (Ford 2022).

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

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

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

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

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on Viable Salmonid Population (VSP) criteria including abundance, productivity, spatial structure, and diversity of its constituent natural populations (McElhany et al. 2000b). NMFS has initiated recovery planning for the Snake River drainage, organized around a subset of management unit plans corresponding to state boundaries. The recovery plans will incorporate VSP criteria recommended by the Interior Columbia Technical Recovery Team (ICTRT). The ICTRT recovery criteria are hierarchical in nature, with ESU/DPS level criteria being based on the status of natural-origin Chinook salmon assessed at the population level. The population level assessments are based on a set of metrics designed to evaluate risk across the four VSP elements. The ICTRT approach calls for comparing estimates of current natural-origin abundance and productivity against predefined viability curves (NWFSC 2015). Achieving recovery (i.e., delisting the species) of each ESU is the longer-term goal of the recovery plan. Table 6 shows the most recent metrics for the Snake River Spring/Summer-run Chinook Salmon ESU.

The majority of populations in the Snake River spring/summer-run Chinook salmon ESU remained at high overall risk, with three populations (Minam River, Bear Valley, and Marsh Creek) improving to an overall rating of “maintained” due to an increase in abundance/ productivity when measured over a 10-20 year period (Table 6)(Ford 2022). However, natural-origin abundance has generally decreased over the levels reported in the prior review for most populations in this ESU, in many cases sharply. Relatively low ocean survivals in recent years are likely a major factor in recent abundance patterns. All but three populations in this ESU remained at high risk for abundance and productivity (Ford 2022). Spatial structure ratings remain unchanged from the prior reviews, with low or moderate risk levels for the majority of populations in the ESU. Four populations from three MPGs (Catherine Creek and Grande Ronde River Upper Mainstem, Lemhi River, and Middle Fork Salmon River Lower Mainstem) remain at high risk for spatial structure loss. Overall, Ford (2022) concludes that the Snake River Spring/Summer Chinook salmon ESU continues to be at moderate-to-high risk.

Table 6. Snake River spring/summer-run Chinook salmon population status relative to ICTRT viability criteria, grouped by MPG. Natural spawning abundance: most recent 10-yr geometric mean (range). ICTRT productivity: 20-yr geometric mean for parent escapements below 75 percent of population threshold. Current abundance and productivity estimates are geometric means. Range in annual abundance, standard error, and number of qualifying estimates for productivities in parentheses. Populations with no abundance and productivity data are given a default High A/P Risk rating (Ford 2022)[6].

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

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

North Fork Salmon River	2,000	71 (sd 87)	1.30 (0.23 20/20)	High	Low	Low	Low	High
Lemhi River	1,000	326 (sd 270)	1.13 (0.31 18/20)	High	Low	Low	Low	High
Salmon River Lower Mainstem	1,000	218 (sd 168)	1.26 (0.20 20/20)	High	Moderate	High	High	High
Pahsimeroi River	2,000	250 (sd 159)	1.63 (0.28 19/20)	High	High	High	High	High
East Fork Salmon River	500	113 (sd 100)	1.63 (0.26 17/20)	High	Low	Moderate	Moderate	High
Yankee Fork	1,000	288 (sd 291)	2.00 (0.28 17/20)	High	Low	High	high	High
Salmon River Upper Mainstem	500	62 (sd 139)	0.99 (0.51 17/20)	High	Moderate	High	High	High
Valley Creek	500	*Insf. data*	*Insf. data*	-	Low	Low	Low	High
Panther Creek	750	*Insf. data*	*Insf. data*					See text

Limiting Factors

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

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

NMFS (2012b) determined the rangewide status of critical habitat by examining the condition of its PBF (also called PCEs, in some designations) that were identified when critical habitat was designated. These features are essential to the conservation of the listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration and foraging). PCEs for Snake River spring/summer Chinook salmon are shown in Table 7.

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

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

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

On April 5, 1991, NMFS listed the Snake River Sockeye Salmon ESU as an endangered species (56 FR 14055) under the Endangered Species Act (ESA). This listing was affirmed in 2005 (70 FR 37160), and again on April 14, 2014 (79 FR 20802) (Table 4). Critical habitat was designated on December 28, 1993 (58 FR 68543) and reaffirmed on September 2, 2005 (Table 4).

This ESU includes all anadromous and residual sockeye salmon originating from the Snake River Basin, Idaho, as well as artificially propagated sockeye salmon from the Snake River Sockeye Salmon Captive Broodstock Program (Table 8).

Table 8. Snake River Sockeye Salmon ESU description and MPG (Jones Jr. 2015; NMFS 2015).

ESU Description	
Threatened	Listed under ESA in 1991; updated in 2014 (see Table 4)
1 major population group	6 historical populations (5 extirpated)
Major Population Group	***Population***
Stanley Basin Sockeye	Redfish Lake
Artificial production	
Hatchery programs included in ESU (1)	Redfish Lake Captive Broodstock

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

The extant MPG contains one extant population (Redfish Lake) and two to four historical populations (Alturas, Pettit, Stanley, and Yellowbelly Lakes) (NMFS 2015) (Figure 3). At the time of listing in 1991, the only confirmed extant population included in this ESU was the beach-spawning population of sockeye salmon from Redfish Lake, with about 10 fish returning per year (NMFS 2015). Historical records indicate that sockeye salmon once occurred in several other lakes in the Stanley Basin, but no adults were observed in these lakes for many decades; once residual sockeye salmon were observed, their relationship to the Redfish Lake population was uncertain (McClure, Cooney and ICTRT 2005). Since ESA-listing, progeny of the Redfish Lake sockeye salmon population have been out planted to Pettit and Alturas Lakes within the Stanley Basin for recolonization purposes (NMFS 2011e).

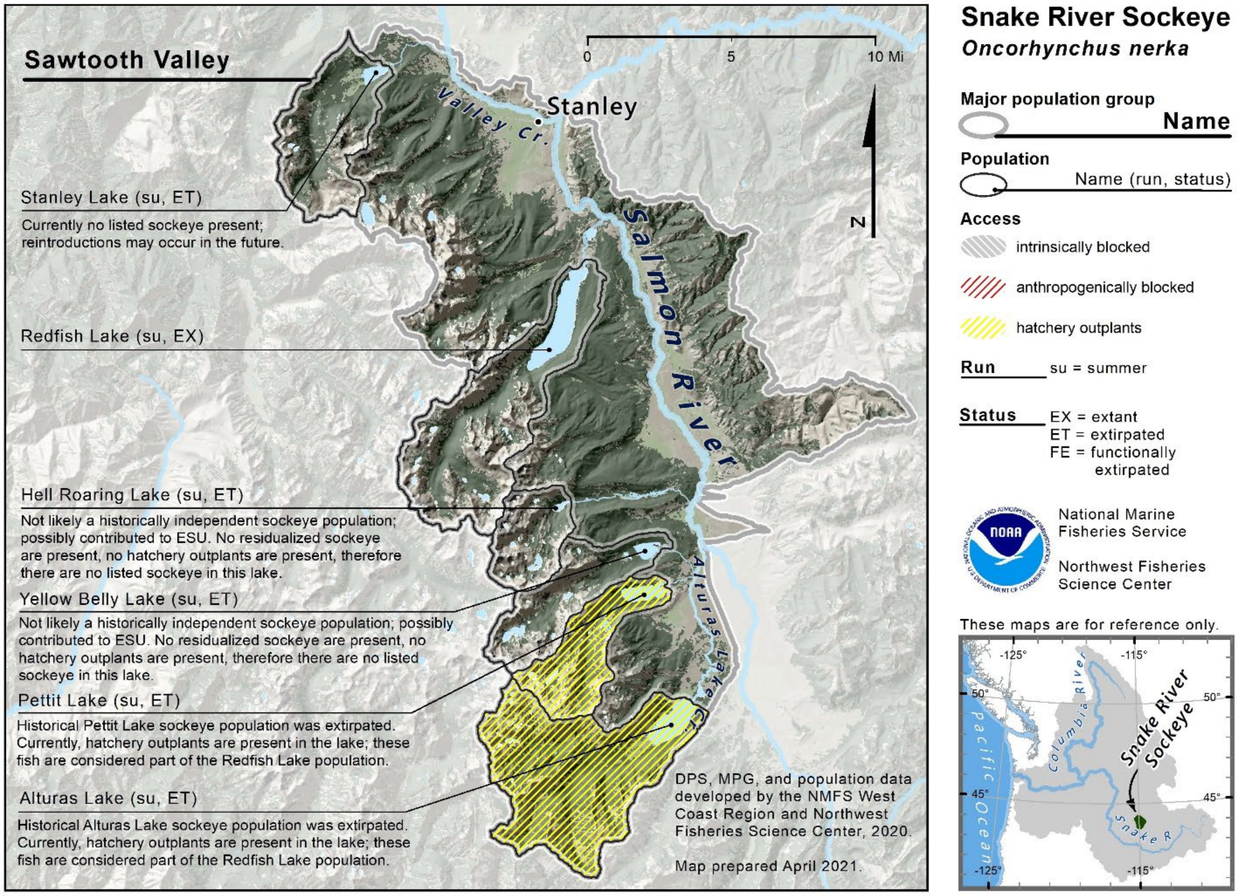

Figure 3. Map of the Snake River Sockeye Salmon ESU's spawning and rearing areas, illustrating populations and MPGs (Ford 2022).

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

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

Abundance, Productivity, Spatial Structure, and Diversity

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

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

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

Limiting Factors

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

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

On August 18, 1997, NMFS listed the Snake River Basin Steelhead DPS as a threatened species (62 FR 43937). The threatened status was reaffirmed in 2006 and most recently on April 14, 2014 (79 FR 20802) (Table 4). Critical habitat for the DPS was designated on September 2, 2005 (70 FR 52769) (Table 4).

The Snake River Basin steelhead DPS includes all naturally spawned anadromous *O. mykiss* (steelhead) populations below natural and manmade impassable barriers in streams in the Snake River basin of southeastern Washington, northeastern Oregon, and Idaho, as well as several hatchery programs (Ford 2022). The Snake River Basin Steelhead DPS comprises twenty-four historical populations within six MGPs comprise the Snake River Basin Steelhead DPS. Inside the geographic range of the DPS, 19 hatchery steelhead programs are currently operational. Nine of these artificial programs are included in the DPS (Table 9). Managers classify Snake River summer steelhead runs into two groups based primarily on ocean age, run timing and adult size on return to the Columbia River: A-run steelhead are primarily returning to spawning areas beginning in the summer and the B-run steelhead are larger, predominated by age-2 ocean fish and begin their migration in the fall. Figure 4 shoes a map of the current DPS and the MPGs within the DPS.

Table 9. Snake River Basin Steelhead DPS description and MPGs (NMFS 2012b; Jones Jr. 2015; NWFSC 2015).

DPS Description	
Threatened	Listed under ESA as threatened in 1997; updated in 2014 (see Table 4)
6 major population groups	27 historical populations (1 extirpated)
Major Population Group	***Populations***
Grande Ronde	Joseph Creek, Upper Mainstem, Lower Mainstem, Wallowa River

DPS Description	
Imnaha River	Imnaha River
Clearwater	Lower Mainstem River, Lolo Creek, Lochsa River, Selway River, South Fork Clearwater
Salmon River	Little Salmon/Rapid, Chamberlain Creek, Secesh River, South Fork Salmon, Panther Creek, Lower Middle Fork Salmon, Upper Middle Fork Salmon, North Fork, Lemhi River, Pahsimeroi River, East Fork Salmon, Upper Mainstem Salmon
Lower Snake	Tucannon River, Asotin Creek
Hells Canyon Tributaries	n/a – area excluded from listing due to lack of available habitat
Artificial production	
Hatchery programs included in DPS (7)	Tucannon River summer, Little Sheep Creek/Imnaha River Hatchery summer, EF Salmon River A, Dworshak NFH B, Lolo Creek B, Clearwater Hatchery B, SF Clearwater (localized) B

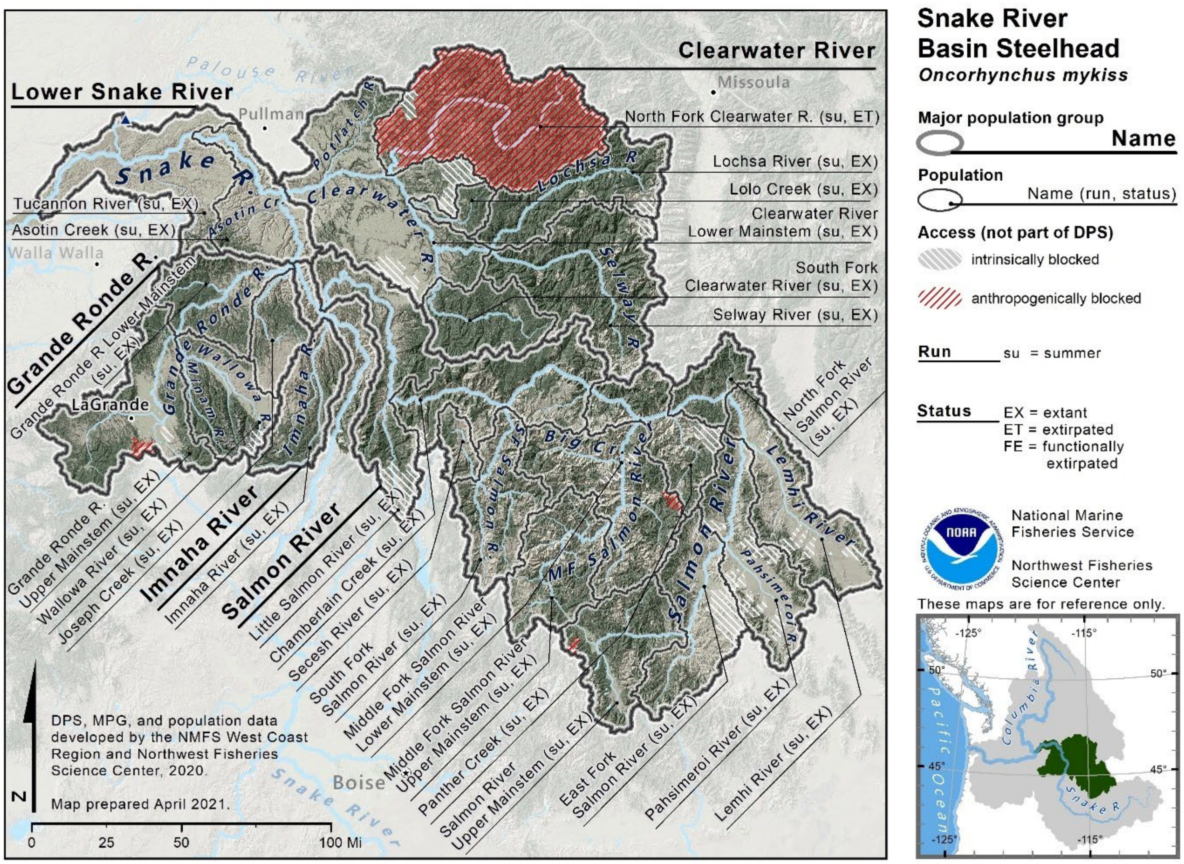

Figure 4. Snake River Basin Steelhead DPS spawning and rearing areas, illustrating natural populations and MPGs (Ford 2022).

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

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

Abundance, Productivity, Spatial Structure, and Diversity

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

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

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

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

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

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

2.2.2. Rangewide Status of Critical Habitat

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

NMFS determines the rangewide status of critical habitat by examining the condition of its PBFs that were identified when critical habitat was designated. These features are essential to the conservation of the listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration and foraging). An example of some PBFs are below. These are often similar among listed salmon and steelhead; specific differences can be found in the critical habitat designation for each species (Table 4).

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

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

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

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

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

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

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

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

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

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

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

Critical habitat has been designated in the Interior Columbia (IC) recovery domain, which includes the Snake River Basin, for the Snake River Spring/Summer-run Chinook Salmon ESU, Snake River Fall-run Chinook Salmon ESU, Snake River Sockeye Salmon ESU, and Snake River Basin Steelhead DPS (Table 4). In the Snake River Basin, some watersheds with PCEs for steelhead (Upper Middle Salmon, Upper Salmon/Pahsimeroi, MF Salmon, Little Salmon, Selway, and Lochsa Rivers) are in good-to-excellent condition with no potential for improvement. Additionally, several Lower Snake River watersheds in the Hells Canyon area, straddling Oregon and Idaho, are in good-to-excellent condition with no potential for improvement (NMFS 2016c).. While critical habitat is in good-to-excellent condition, the Snake River Spring/Summer Chinook Salmon ESU (Table 6) and the Snake River Basin Steelhead DPS remain at moderate to high risk for extinction.

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

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

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

2.3. ACTION AREA

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

The action area for analysis of effects primarily comprises the Stanley Basin area of the upper Salmon River Basin, which is where the proposed hatchery program would release sockeye salmon. The action area includes (1) Redfish Lake, Pettit Lake, and Alturas Lake; (2) the migration corridor between the lakes and the mainstem Salmon River; and (3) the mainstem Salmon River down to its confluence with the Valley Creek near the town of Stanley, Idaho. ESA-listed species in the Stanley Basin include Snake River sockeye salmon, Snake River steelhead, and Snake River spring/summer Chinook salmon.

NMFS considered whether the mainstem Snake River, mainstem Columbia River, the estuary, and the ocean should be included in the action area. The potential concern is a relationship between hatchery production and density-dependent interactions affecting salmon growth and survival. However, NMFS has determined that, based on best available science, it is not possible to establish any meaningful causal connection between hatchery production on the scale anticipated in the Proposed Action and any such effects.

The operation of hatchery facilities has the potential to affect ESA-listed salmon and steelhead in streams adjacent to hatchery facilities through the diversion of surface water or the maintenance of instream structures (e.g., the water intake and discharge structures). The proposed hatchery program would use seven hatchery facilities to spawn, incubate, rear, and release sockeye salmon:

- Sawtooth Hatchery, on the Salmon River near Stanley, Idaho
- Burley Creek Hatchery, in Kitsap County near Port Orchard, Washington
- Manchester Research Station, on the Puget Sound near Port Orchard, Washington
- Eagle Fish Hatchery, in Ada County near the town of Eagle, Idaho
- Springfield Hatchery, in Bingham County near the town of Springfield, Idaho
- Oxbow Hatchery, in Hood River County, near the town of Cascade Locks, Oregon
- Bonneville hatchery, on the Columbia River near Bonneville Dam, Oregon

Two hatchery facilities that support the Snake River sockeye salmon hatchery programs are located outside of the Columbia River Basin: the Manchester Research Station and Burley Creek Fish Hatchery. These hatcheries are not included in the action area because both facilities do not release any broodstock. These facilities are used for rearing purposes only with fish being transported to and from the facilities. Both facilities do not use surface water, and are not expected to have a large effect on the water quality. Effects of these hatchery facilities were found in the previous Biological Opinion (NMFS 2013a) to be small, localized, and temporary, that they are inconsequential when added to effects of other activities affecting species in these areas.

Sockeye salmon may be removed at Lower Granite Dam, when conditions warrant, and transported to the Stanley Basin to avoid mortality during their upstream migration through the Snake and Salmon Rivers. Conditions that would warrant the removal of sockeye salmon from the trap at Lower Granite Dam include adverse migration conditions in the Snake and Salmon Rivers; for example, low-flow conditions and recruitment failures resulting in low adult returns. Operation of the Lower Granite Dam trap during the time that sockeye are present is permitted under the FCRPS Biological Opinion (NMFS 2008c), and it is, therefore, not included in the action area for this consultation.

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 Restoration Activities

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

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

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

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

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

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

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

2.4.3. Climate Change

One factor affecting the status of ESA-listed species considered in this opinion, and aquatic habitat at large, is climate change. Climate change is likely to play an increasingly important role in determining the abundance and distribution of ESA-listed species, and the conservation value of designated critical habitats, in the Pacific Northwest. These changes will not be spatially homogeneous across the Pacific Northwest. Major ecological realignments are already occurring in response to climate change (IPCC 2022). Long-term trends in warming have continued at global, national and regional scales. Global surface temperatures in the last decade (2010s) were estimated to be 1.09 °C higher than the 1850-1900 baseline period, with larger increases over land ~1.6 °C compared to oceans ~0.88 (IPCC 2021). The vast majority of this warming has been attributed to anthropogenic releases of greenhouse gases (IPCC 2021). Globally, 2014-2021 were all in the top 10 warmest years on record both on land and in the ocean (2021 was the 6th warmest)((NCEI) 2022). Events such as the 2013-2016 marine heatwave (Jacox et al. 2018) have been attributed directly to anthropogenic warming in the annual special issue of Bulletin of the American Meteorological Society on extreme events (Herring et al. 2018). Global warming and anthropogenic loss of biodiversity represent profound threats to ecosystem functionality (IPCC 2022). These two factors are often examined in isolation, but likely have interacting effects on ecosystem function.

Updated projections of climate change are similar to or greater than previous projections (IPCC 2021). NMFS is increasingly confident in our projections of changes to freshwater and marine systems because every year brings stronger validation of previous predictions in both physical and biological realms. Retaining and restoring habitat complexity, access to climate refuges (both flow and temperature) and improving growth opportunity in both freshwater and marine environments are strongly advocated in the recent literature (Siegel and Crozier 2020). Climate change is systemic, influencing freshwater, estuarine, and marine conditions. Other systems are also being influenced by changing climatic conditions. Literature reviews on the impacts of climate change on Pacific salmon (Crozier 2011; 2012; 2013; 2014; 2015; 2016; 2017; Crozier and Siegel 2018; Siegel and Crozier 2019; 2020) have collected hundreds of papers documenting the major themes relevant for salmon. Here we describe habitat changes relevant to Pacific salmon and steelhead, prior to describing how these changes result in the varied specific mechanisms impacting these species in subsequent sections.

Climate change effects on salmon and steelhead

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

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

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

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

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

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

2.4.4. Artificial Propagation

A more comprehensive discussion of hatchery programs in the Snake River Basin can be found in our opinion on Mitchell Act funded programs (NMFS 2017c). 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 can also be used to help improve viability by supplementing natural population abundance and expanding spatial distribution. However, the long-term benefits and risks of hatchery supplementation remain untested (Christie, Ford and Blouin 2014).

Below we have included more detail on the history and purpose of the Snake River sockeye salmon hatchery program. The sockeye salmon hatchery program is currently ongoing and has been operated since the mid 1990's.

The purpose of the Snake River sockeye salmon hatchery program is to mitigate for the extinction of the ESU due to climate change, habitat degradation and other external factors. The Snake River sockeye salmon hatchery program was initiated in 1991. Since its inception, all returning anadromous adult sockeye salmon (16 natural-origin fish), several hundred Redfish Lake wild out-migrating smolts, and several residual sockeye salmon have been captured and used to develop a captive broodstock. In 1999, the first hatchery-origin, anadromous sockeye salmon returned to the Stanley Basin. In that year, seven age-3 adults (six males and one female) were trapped at project locations. In 2000, the hatchery program experienced its first substantial return of hatchery-origin adults when 257 sockeye salmon returned to the Redfish Lake Creek and Sawtooth Hatchery traps. Between 2001 and 2011, over 4,000 hatchery-origin sockeye salmon returned to the action area.

The Snake River Sockeye Salmon ESU might now be extinct if not for the hatchery program (NMFS 2013). This has been achieved largely through captive broodstock operations, which pose a considerable risk of hatchery-induced selection because cultured organisms spend most or all of their lives in captivity. However, the alternative of potential extinction was a far greater risk. Although the ESU may have undergone some unavoidable genetic change due to hatchery-induced selection, the program has done a very good job of conserving genetic diversity in general. Kalinowski et al. (2012) concluded by means of a modeling exercise that the Snake River sockeye salmon hatchery program had a considerably lower inbreeding rate than was expected. In general, reducing inbreeding rates reduces the loss of population diversity. In summary, the program to date has been a considerable benefit demographically and genetically for the population

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

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

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

Currently almost all aspects of hatchery programs—most importantly numbers, locations, and marking of fish released—are regulated by the *U.S. v. Oregon* Management Agreement. Production of all species discussed in this opinion may be increased, decreased, or relocated by the *U.S. v. Oregon* parties. Changes to the Proposed Action, including increased production, may trigger reinitiation. Relocation of releases (e.g., Pittsburg Landing) to the Salmon River or a decrease in production from what is in the current Proposed Action may not trigger reinitiation, but may require additional discussion and analyses.

2.4.5. Harvest

The five hatchery programs primarily contribute to spring/summer Chinook salmon fisheries in the mainstem Snake and Columbia Rivers and terminal areas. The 2008-2017 management agreement defines mainstem Columbia River harvest rates on a sliding scale. This abundance-based sliding scale harvest rate (5.5 to 17 percent) in the mainstem is based on natural-origin spring/summer Chinook salmon returning to the Snake River basin. Terminal harvest rates are also managed on an abundance-based sliding scale based on NORs. Few spring/summer Chinook salmon from the Upper Salmon River are thought to be harvested in ocean fisheries.

The following outlines the various fisheries that occur in the Action Area that may affect listed species. Fisheries are covered under separate Fishery Management and Evaluation Plans and Tribal Resource Management Plans.

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 10 below shows that an average of ~ 0.7 percent of the Snake River Spring/Summer Chinook Salmon ESU is killed in IDFG fisheries. This may be an overestimate of the percentage impact because the above 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 10. Number of ESA-listed natural-origin spring/summer Chinook salmon encountered and incidentally killed in In IDFG fisheries from 2017-2022 (Powell 2023).

Year	Incidental Mortality take Authorized	Encounters	Incidental Mortality	Natural-Origin estimated escapement above LGR	% Natural-Origin incidental mortality above LGR
2017	52	121	11	1,821	0.6
2018	104	376	35	3,393	1.0
2019	16	28	2	1,786	0.1
2020	38	130	13	4,898	0.3
2021	58	208	21	3,865	0.5
2022	219	1,278	128	8,380	1.5

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

Additionally, sockeye salmon typically do not strike at lures used by recreational anglers fishing for spring/summer Chinook salmon.

Steelhead

Steelhead fisheries above Lower Granite Dam typically occur from September through March of the following year. Although steelhead bound for Idaho enter the Columbia River from about June 1 through October 1 each year, a portion of the run spends the winter in the Columbia and Snake rivers downstream of Lower Granite Dam, and migrates into Idaho in the spring of the following year. Similar to spring/summer Chinook salmon fisheries, the non-tribal fisheries selectively target hatchery fish with a clipped adipose fin. Tribal fisheries target both hatchery and natural-origin fish regardless of external marking, meaning there is no incidental take of the target species for their fisheries. Table 11 below shows that an average of ~ 4 percent of the Snake River steelhead DPS is killed annually in IDFG fisheries. This may be an overestimate of the percentage impact because the above Lower Granite Dam natural-origin return estimate only includes Idaho bound stocks (Clearwater and Salmon MPGs).

Table 11. Number of ESA-listed natural-origin steelhead encountered and killed in IDFG fisheries from 2017-2022 (Powell 2023).

Year	Encounters	Incidental Mortality	Natural-origin estimated escapement of Idaho Stocks above LGR	% Natural-origin incidental mortality of Idaho Stocks above LGR
2017	3,703	185[7]	7,276	2.5
2018	4,857	243[7]	5,929	4.1
2019	4,154	208[7]	3,634	5.7
2020	4,512	226[7]	3,890	5.8
2021	4,669	233[7]	7,813	3.0
2022	3,101	155[7]	4,990	3.1

Other Fisheries

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

[7] For the state fishery, all mortality of natural-origin fish is incidental (catch-and-release mortality), and is estimated at 5 percent of those caught.

2.4.6. Other Actions Included in this Baseline

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

Information relevant to the Environmental Baseline is also discussed in detail in Chapter 5 of the Supplemental Comprehensive Analysis (SCA), and the related 2008 FCRPS Biological Opinion (NMFS 2008f; 2008e). Chapter 5 of the SCA (NMFS 2008e) and related portions of the FCRPS Opinion provide an analysis of the effects of past and ongoing human and natural factors on the current status of the species, their habitats and ecosystems, within the entire Columbia River Basin. Relevant information is also discussed in Section 2.2.2 of the updated 2020 FCRPS Biological Opinion (NMFS 2020).

2.5. Effects of the Action

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action (see 50 CFR 402.02). 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 the factors set forth in 50 CFR 402.17(a) and (b).

This section describes the effects of the Proposed Action, independent of the Environmental Baseline and Cumulative Effects. The methodology and best scientific information NMFS follow for analyzing hatchery effects is summarized first in Section 2.5.1 and then application of the methodology and analysis of the Proposed Action itself follows in Section 2.5.2.

The Proposed Action, the status of ESA-protected species and designated critical habitat, the Environmental Baseline, and the Cumulative Effects are considered together later in this document to determine whether the Proposed Action is likely to appreciably reduce the likelihood of survival and recovery of ESA protected species or result in the destruction or adverse modification of their designated critical habitat.

2.5.1. Factors That Are Considered When Analyzing Hatchery Effects

NMFS has substantial experience with hatchery programs and has developed and published a series of guidance documents for designing and evaluating hatchery programs following best available science (Hard et al. 1992; McElhany et al. 2000b; NMFS 2004; 2005a; Jones Jr. 2006; NFMS 2008; NMFS 2011d). For Pacific salmon, NMFS evaluates extinction processes and effects of the Proposed Action beginning at the population scale (McElhany et al. 2000b).

NMFS defines population performance measures in terms of natural-origin fish and four key parameters or attributes; abundance, productivity, spatial structure, and diversity and then relates effects of the Proposed Action at the population scale to the MPG level and ultimately to the survival and recovery of an entire ESU or DPS.

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

NMFS' analysis of the Proposed Action is in terms of effects it would be expected to have on ESA-listed species and on designated critical habitat, based on the best scientific information available. This allows for quantification (wherever possible) of the effects of the six factors of hatchery operation on each listed species at the population level (in Section 2.5.2), which in turn allows the combination of all such effects with other effects accruing to the species to determine the likelihood of posing jeopardy to the species as a whole (Section 2.6).

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

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

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

2.5.2. Effects of the Proposed Action

This section describes the effects of the Proposed Action, independent of the environmental baseline, and cumulative effects. Under the ESA, "effects of the action" means the direct and indirect effects of an action on critical habitat and on the individuals within a population and how these affect the VSP parameters for the natural population(s) that make up the species, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the Proposed Action and are later in time, but still are reasonably certain to occur. The methodology and best scientific information NMFS follows for analyzing hatchery effects is summarized in Section 2.5 and then application of the methodology and analysis of the Proposed Action itself follows in Section 2.5.2 Effects of the Proposed Action that are expected to occur later in time (i.e., just after timeframe of the Proposed Action) are included in the analysis in this opinion to the extent they can be meaningfully evaluated. In Section 2.2, the Proposed Action, the status of ESA-protected species and designated critical habitat, the environmental baseline, and the cumulative effects of future state and private activities within the Action Area that are reasonably certain to occur are analyzed comprehensively to determine whether the Proposed Action is likely to appreciably reduce the likelihood of survival and recovery of ESA-protected species or result in the destruction or adverse modification of their designated critical habitat.

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

For Snake River spring/summer Chinook salmon and Snake River steelhead, this factor is not applicable, as these species are not proposed for artificial propagation in this program. However, during targeted sockeye salmon broodstock collection (direct take), the proposed action may incidentally encounter listed spring/summer salmon at some of the weirs. Incidental effects on spring/summer Chinook salmon, and steelhead salmon during broodstock collection activities are considered under Factor 2, below. This section will focus on Factor 1 impacts to the Snake River Sockeye ESU.

The Snake River Sockeye Captive Broodstock Program intends to remove natural-origin fish for broodstock within the Stanley Basin. In order to meet the smolt release requirements outlined in the management plan (NMFS 2015), a total number of 1,150 broodstock are needed. The Snake River hatchery program is proposing a minimum of 10 percent natural-origin broodstock, or 115 natural origin returns, to be removed from spawning naturally. Eventually as more fish return, the number of natural-origin returns incorporated into the broodstock will increase, and the number of captive broodstock will decrease.

Due to the low numbers of natural-origin returns into the Stanley Basin, the removal of natural-origin fish for broodstock are used to propagate the next generation of salmon. With this comes the negative impacts of removing natural-origin genetics from the spawning pool, further limiting the genetics pool of returning adults. However, these genetic risks are mitigated by monitoring the genetics by IDFG and the SBTOC to ensure no genetic concerns with the genetic variability of the broodstock occurs, and to help meet the Hatchery Scientific Review Group (HSRG) recommended PNI goals. So, while the natural-origin sockeye salmon are removed from the natural environment, their contribution to increased abundance to future generations remains a beneficial effect. Therefore, removal of natural-origin fish for broodstock is considered to have a negligible negative impact on the abundance of the sockeye population, which is eventually offset by increases in future abundance, productivity and spatial structure.

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

For Factor 2, the proposed hatchery program poses both beneficial and negative effects on the Snake River Sockeye Salmon ESU, but, based on the current scientific understanding, the net effect is expected to be beneficial. Factor 2 would have a negligible effect on other listed species.

The proposed hatchery program is designed to prevent the extinction of Snake River sockeye salmon, slow the loss of genetic diversity, and to begin to increase the number of individuals in the population. As described in Section 1.3, Proposed Action, the proposed hatchery program would use a three-phase approach with the following objectives:

Phase 1: increase genetic resources and adult sockeye returns (captive brood phase)
Phase 2: incorporate more natural-origin returns into hatchery spawning designs and increase natural spawning escapement (population re-colonization phase)
Phase 3: move towards the development of an integrated program that meets proportionate natural influence (PNI) goals established by the HSRG (local adaptation phase)

The Snake River sockeye salmon hatchery program was initiated in 1991 to prevent species extinction. Since then, all returning anadromous adult sockeye salmon, several hundred Redfish Lake natural-origin out-migrating smolts, and several residual sockeye salmon adults have been captured and used to develop captive broodstocks at the IDFG Eagle Hatchery and NMFS facilities in Washington State. Because of the success of the hatchery program to date, the program moved into Phase 2 (population re-colonization phase), in which they would phase out the use of captive broodstocks to reduce genetic risks associated with rearing fish for their entire lives in captivity. During Phase 2, returning anadromous sockeye salmon would be used as broodstock for the proposed hatchery program. Genetic risks would be minimized by continuing to use only local-origin broodstock and mating the least related individuals in the population. The hatchery program would not backfill with fish that are not included in the Snake River Sockeye Salmon ESU. PNI would not be managed during Phase 2 and there would be no restrictions on hatchery-origin fish spawning naturally. Between 2013 and 2021, 2,812 anadromous sockeye salmon returned to the action area.

Phase 3 of the hatchery program is not being permitted by NMFS as part of the Proposed Action because Phase 3 triggers are not expected to be met within the 3-year extended permit period and specific management actions have not been identified (e.g., methods for controlling the proportion of hatchery-origin fish that spawn naturally). However, the implementation of Phases 1 and 2 are intended to bring about conditions that would enable Phase 3. During Phase 3 (the local adaptation phase), the hatchery program would move towards the development of an integrated program that meets PNI goals established by the HSRG.

2.5.2.2.1. Effects on Diversity

NMFS generally views genetic effects of hatchery programs as detrimental because artificial breeding and rearing is likely to result in some degree of genetic change and fitness reduction in hatchery fish and their progeny, particularly if they interbreed with fish from natural populations. However, the proposed hatchery program is expected to accelerate recovery of the Snake River Sockeye Salmon ESU by increasing the number of natural-origin spawners faster than what may occur naturally. Additionally, the proposed hatchery program would continue to provide a genetic reserve for the natural population to prevent the loss of unique traits due to catastrophes.

NMFS considers three major areas of genetic effects of hatchery programs: (1) within-population diversity; (2) outbreeding effects; and (3) hatchery-induced selection. In most cases, these effects are viewed as risks, but in small populations, such as Snake River sockeye salmon populations, these effects can be beneficial and reduce extinction risk over the near term. Below, we analyze the effects of the proposed hatchery program in each of the three areas.

2.5.2.2.1.1. Within-population diversity

The proposed hatchery program would mitigate negative effects for within-population diversity by providing each fish more opportunity to contribute to the next generation than would occur in nature. This would be done using a factorial spawning matrix with eggs from a single female split into two equal subfamilies. No back-up males or pooled samples would be used to spawn crosses. Each subfamily would be spawned with a unique male to achieve a one-to-one sex ratio (IDFG 2022). Genetic samples would be taken from each adult sockeye salmon collected so that the least related fish would be crossed to minimize inbreeding depression. This is a continuation of the protocol used in previous years of the captive brood program, which has proven to be successful. The extensive, careful, technical oversight of hatchery operations used in previous years will continue under the proposed program. Management of the Snake River sockeye salmon hatchery effort has a proven record in conserving diversity. Kalinowski et al. (2012) found that the program had a rate of inbreeding that was considerably lower than expected. Risks from catastrophic loss at a hatchery facility would be greatly reduced by keeping fish at multiple facilities during the remainder of captive brood production.

For a population to maintain genetic diversity, the effective population size should be in the hundreds, at a minimum (Lande and Barrowclough 1987). Diversity loss can be severe if effective size drops to a few dozen fish. During Phase 1 (captive brood operation), the sockeye salmon population reached this level but the program was effective at boosting numbers into the thousands, so effective size has been increased substantially. As the program moves into Phase 2, the key criteria for assessing the success of the first two phases of the program would be to (1) achieve an average minimum natural-origin escapement of at least 500 naturally spawning adult sockeye salmon, and (2) achieve a total escapement (i.e., natural-origin and hatchery-origin fish combined) of at least 1,150 adult sockeye salmon. Meeting these criteria would further increase effective population size. In terms of conservation/promotion of within-population diversity, the proposed program represents a substantial improvement over the baseline condition, and is a net benefit to the level of risk associated with diversity.

2.5.2.2.1.2. OUTBREEDING EFFECTS ON DIVERSITY

The proposed program poses minimal outbreeding effects at this point. Snake River sockeye salmon stray rates are very low (< 1 percent) and are not known to stray into other sockeye salmon ESUs, so there is very minimal risk of this program influencing other sockeye salmon ESUs through gene flow. Conversely, there is no evidence of sockeye salmon from other ESUs straying into the Snake Basin, where they could inadvertently be taken as broodstock for the proposed program, and the continuation of the program would not lead to any change in this risk.

The ICTRT considers three of the Stanley Basin lakes – Redfish, Pettit, and Alturas – candidates for recovery as distinct populations (ICTRT 2007). In both Alturas and Pettit Lakes, sockeye production has been extirpated. To the extent that production in Pettit Lake will be driven, during phase 2, by the hatchery program, the opportunity for developing diversity at the subpopulation scale during this "re-colonization" phase will be limited. Once re-colonization is successful and the risk of extinction, in the short-term, is reduced, the issue of increasing diversity can be reconsidered.

2.5.2.2.1.3. HATCHERY-INDUCED SELECTION

Hatchery-induced selection (domestication selection) is caused by adaptation to the artificial environments offered by hatcheries. This means that hatchery fish and their progeny are less adapted to conditions in the natural environment and consequently less fit to survive. Captive brood programs differ from the more common smolt release hatchery programs in that, rather than all fish experiencing the natural environment during at least part of their lives, there may be multiple generations of fish without exposure to the natural environment. Thus, captive brood programs inherently pose more risk of hatchery-induced selection than "smolt release" programs. Because of this, captive brood programs are typically recommended only where the risk of extinction far outweighs any risk due to hatchery-induced selection, which certainly has been the case with Snake River sockeye salmon.

The proposed program increases production, but it would also shift production from a captive brood operation to primarily a smolt-release-based operation, which, for the reasons described above, should reduce the selective pressure of the hatchery environment. The switch to a smolt-release-based operation does not remove the negative effects on the hatchery program, but helps provide a strategy that trends towards lower risk.

Phase 3 of the hatchery program is not included as part of the Proposed Action because Phase 3 triggers are not expected to be met within the 3-year permit period and specific management actions have not been identified (e.g., methods for controlling the proportion of hatchery-origin fish that spawn naturally). However, as stated above, the overall intention is to culminate in Phase 3--during Phase 3 (the local adaptation phase), the hatchery program would move towards the development of an integrated program that meets PNI goals established by the HSRG, which would further reduce hatchery-induced selection relative to baseline conditions.

2.5.2.2.2. Ecological Effects

NMFS considers several ecological effects for this factor, including effects from competition for spawning sites and redd superimposition, contributions to marine derived nutrients, and the removal of fine sediments from spawning gravels by naturally spawning fish. Because natural-origin Snake River sockeye salmon are in very low abundance (Section 2.2.1.2, Life History and Current Rangewide Status of Snake River Sockeye Salmon ESU), there is little risk of hatchery-origin fish superimposing or destroying the eggs and embryos of natural-origin sockeye salmon during spawning.

There is unlikely to be spawning site competition or redd superimposition with hatchery-origin sockeye salmon and the Snake River Basin Steelhead DPS (Table 12). This is because their spawn timings largely do not overlap; therefore, there is limited opportunity for these potential ecological interactions to occur. It is possible that hatchery-origin sockeye salmon could compete with natural-origin spring/summer Chinook salmon because there is a slight overlap in both run timing and spawn timings. However, the Snake River Sockeye Salmon ESU utilizes different habitat from Snake River Spring/Summer Chinook salmon (NMFS 2017a), with sockeye salmon smolts spending very little time rearing in the migration corridor (NMFS 2015). In addition, sockeye are known to be exclusively planktivorous, mostly eating zooplankton minimizing competition and predation effects on natural-origin salmonids and steelhead (Burgner 1987; NMFS 2015; 2017a). IDFG tracks sockeye migration and returns, and attempt to close the spring/summer chinook fishery when sockeye begin to arrive. This allows only a small amount of incidental catch and allows hatchery staff to be able to properly handle all returning salmonids and minimize any harmful interactions.

Table 12. Run and spawn timing of Snake River sockeye salmon, steelhead, and spring/summer Chinook salmon

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

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

The proposed hatchery program would increase the total number of spawners in the Stanley Basin, which would improve habitat conditions for natural-origin sockeye salmon by removing fine sediment from spawning gravels and contributing marine-derived nutrients to Stanley Basin lakes. The Stanley Basin lakes are naturally oligotrophic, and nutrient supplementation through sockeye salmon carcasses would continue to stimulate primary productivity, which would increase the amount of zooplankton available for sockeye salmon to eat (NMFS 2015).

2.5.2.2.3. ADULT COLLECTION FACILITY EFFECTS

Broodstock collection facilities may have negligible effects on fish passage of juvenile and adult spring/summer Chinook salmon and sockeye salmon and steelhead. Potential impacts on migrating adult salmon from the collection of broodstock at weirs include: (1) delays in upstream migration; (2) displaced spawning caused by rejection of the fishway structure or weir by adults; (3) adults falling back downstream after passing upstream of the trap or upstream of the weir; (4) injury or death from attempts by adult salmonids to pass or jump the barrier; and (5) induced stress from handling of adults (NMFS 1999).

The proposed hatchery program would collect broodstock primarily from the Redfish Lake Creek trap and the Sawtooth Hatchery trap. The Redfish Lake Creek trap is attached to a weir that is installed each year during broodstock collection for the Snake River sockeye salmon hatchery program. The Redfish Lake Creek trap may also incidentally capture some spring/summer Chinook salmon, which would be passed above the weir to spawn naturally or transported to the Sawtooth Hatchery to be used as broodstock. The Sawtooth Hatchery trap is attached to a permanent weir with removal grates. Its primary purpose is to collect spring/summer Chinook salmon for the Sawtooth spring/summer Chinook salmon hatchery program. There would be no steelhead intercepted at either trap because steelhead do not migrate past the Sawtooth Hatchery after April, and broodstock collection for the sockeye hatchery program usually does not start until mid-July.

IDFG would monitor spawning distribution above and below the weirs/traps to ensure their operation does not significantly alter the spatial distribution of any population. In addition, IDFG would ensure all weirs/traps associated with the hatchery program minimize or eliminate stress, injury, or mortality to listed salmon. The biologists that work at the weirs would monitor for fish delay and injury as part of their daily work. All weirs and traps would be checked at least twice a day. All captured fish would be processed for biological data collection and released immediately or transferred to the Eagle Fish Hatchery for incorporation into the captive broodstock program. All encounters/mortalities with listed fish at the weirs/traps would be reported to NMFS in an annual report.

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

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

We include in the action area the Stanley Basin area of the upper Salmon River Basin because we can only reasonably expect to detect effects of hatchery-origin fish in juvenile ecological rearing areas and the migratory corridor within the Stanley Basin. The only juvenile ecological interactions not previously described in the 2013 biological opinion (NMFS 2013a) are the release of ~45,000 juvenile sockeye into Tanner Creek included in the proposed action. These fish are released lower in the system to increase survival. NMFS expects the interactions with natural-origin fish to be lower than fish released further within the system and pose no extra risk. Overall, the effects of Factor 3 on all listed species analyzed in this opinion are considered negative.

2.5.2.3.1. HATCHERY RELEASE COMPETITION AND PREDATION EFFECTS

Growth of sockeye salmon in the Stanley Basin lakes is often density-dependent and related to zooplankton density (NMFS 2015). Juvenile sockeye rear one or two years in the lakes before emigrating to the ocean, and, during their stay in the lakes, sockeye juveniles feed almost entirely on certain assemblages of zooplankton (Burgner 1987). The Stanley Basin lakes' zooplankton communities declined drastically after the sockeye populations declined and other fish (e.g., trout and non-native kokanee) were introduced (NMFS 2015), and the types of zooplankton available changed to assemblages less supportive of sockeye salmon (Koenings and Kyle 1997). The proposed hatchery program would continue to help sockeye salmon reestablish their biological niche and may result in an increase in zooplankton levels as kokanee abundance declines. This change would be expected to increase the growth rate of juvenile sockeye salmon and improve their survival during the long seaward migration from their nursery lakes. However, in the short-term, increasing the number of juvenile sockeye salmon in the lakes may increase competition for food. Therefore, ongoing studies to determine the carrying capacity of the lakes will continue and allow permit holders to adjust release levels if needed.

More recently, NMFS has reviewed the literature for new and emerging scientific information over the role and the consequences of density-dependent interactions in estuarine and marine areas. While there is evidence of density-dependent effects such as predation on salmon survival, available information does not support a meaningful causal link to a particular category of hatchery program. The SCA for the FCRPS opinion (NMFS 2008g) and the September 2009 FCRPS Adaptive Management Implementation Plan (AMIP) (NMFS 2009) both concluded that available knowledge and research abilities are insufficient to discern any important role or contribution of hatchery fish in density-dependent interactions affecting salmon and steelhead growth and survival in the mainstem Columbia River, the Columbia River estuary, and the Pacific Ocean. A review by the Independent Scientific Advisory Board (ISAB) identified uncertainty about the aggregate carrying capacity for juvenile salmonids as the highest priority for research, management, and restoration activities in the basin (ISAB 2011); "It is important to recognize that the concept of carrying capacity is based on specified conditions which might vary temporarily (seasonally) or be impacted by climate change and shifts in ocean regimes. Some of this information is being collected, but general access to data remains problematic."

NMFS expects that hatchery production on the scale proposed in this action and considered in this opinion would have a negligible effect on the survival and recovery of the Snake River

Sockeye Salmon ESU, Snake River Spring/Summer Chinook Salmon ESU, and the Snake River Steelhead DPS. At full production, releases in the Stanley Basin would constitute less than 1 percent of all juvenile salmonids in the Columbia Basin, and about 5 percent of releases within the Snake River Basin (NMFS 2018a; 2019a). After approximately a year in the hatchery, these fish would be released and migrate 900 miles to the Columbia River estuary. As a consequence, less than half would survive the journey to the Pacific Ocean to join over 125 million of other juvenile salmon and steelhead[8]. After entering the ocean, there is no information on the migratory habits of Snake River sockeye salmon – where they may mingle with other fish, which fish, and for how long – and therefore any effects of the hatchery program on density related processes in the ocean are unknown. The proposed hatchery program would not increase competition with Snake River spring/summer Chinook salmon or Snake River steelhead in their juvenile rearing areas, because the juvenile rearing areas for spring/summer Chinook salmon and steelhead do not overlap with the juvenile rearing areas for sockeye salmon (NMFS 2015).

2.5.2.3.2. NATURALLY-PRODUCED PROGENY COMPETITION

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

2.5.2.3.3. DISEASE

The risk of pathogen transmission to natural-origin salmon and steelhead is negligible for these Chinook salmon programs. Please refer to Table 13 for information on pathogen incidences at hatchery facilities from 2013 to present. Despite these detections/outbreaks with pathogens that could be transmitted to natural-origin salmon and steelhead, all are easily treatable (if determined necessary), controlled by IDFG's Fish Health Laboratory, and are endemic to the Columbia Basin. Therefore, there is little risk of native pathogen transmission and no risk of non-native pathogen transmission to ESA listed natural-origin fish.

[8] NMFS (2010) estimated that (1) over 143 million salmon and steelhead are released annually from hatcheries in the Columbia River Basin, and (2) more than 125 million juvenile salmon and steelhead (a combination of natural-origin and hatchery-origin) migrate annually through the estuary.

Table 13. Pathogen information from 2013 to present of data at facilities where fish are reared and/or acclimated (NMFS 2023).

Facility	Species	Year	Pathogen-caused Disease	Comment
Eagle Fish Hatchery	Snake River Sockeye Captive Broodstock	Annual	*Saprolegnia*	1,667 ppm formalin 20-minute flow through for eggs (preventative treatment)
		Annual	*Saprolegnia*	167 ppm formalin, 1-hour static bath for anadromous adults (preventative treatment)
		Annual	*BKD*	Protocols in place for rearing eggs from Positive Females (anadromous adults)
		2016	*IHNv*	Fertilized eggs water hardened in 100 ppm Argentyne (anadromous adults); Outbreak
		Annual	*Parvicapsula sp* *Myxobolus sp*	Monitor for prevalence anadromous adults
Sawtooth Hatchery		2013 - Present	None	2018-Present: on station approx. 2 weeks for acclimation. BY13 and BY17 reared there. No disease history.
Springfield Hatchery		Annual	Softshell	Egg bath 500 ml Argentyne/4 gal/10 min (preventative treatment)
Manchester Research Station		2013 - Present	None	No disease outbreak history
Burley Creek Hatchery		Annual	*Saprolegnia*	No disease outbreaks. Preventative egg treatment of 1,667 ppm formalin 15-minute flow through
		Annual	*IHNv*	No disease outbreaks. Preventative egg treatment of 100 ppm Argentyne; 20-min static bath for fertilized eggs.
		Annual	*Vibriosis*	No disease outbreaks. Preventative treatment of smolts in dip bath 5 L Vibrio vaccine/45 gal/1 min 2 weeks before saltwater transition.
Oxbow Hatchery		2013-2015	*BKD*	Aquamycin treatment
		2013-2015	*CWD*	Aquamycin treatment
		2022-present	None	No disease outbreak history.
Bonneville Hatchery		2013-Present	N/A	No disease outbreaks for sockeye salmon.

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

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

The monitoring and evaluation activities directly related to the proposed hatchery programs are part of a larger effort to determine the overall status of the Snake River Sockeye Salmon ESU. Because the intent is to improve our understanding of listed populations status, the information gained through these studies means that the benefits outweigh the associated risks to the populations. This is because only a small portion of the population is likely to be encountered during these efforts, resulting in an overall negligible effect of RM&E on Snake River sockeye salmon. The effects on Snake River spring/summer Chinook, and steelhead are also negligible.

RM&E associated with the proposed hatchery program would ensure that the proposed program is effective in recolonizing the Stanley Basin lakes. RM&E includes the marking and tagging of juvenile fish, genetic testing to determine the origin of sockeye salmon, and the use of a smolt trap and screw trap to count and sample juveniles as they emigrate to the Pacific Ocean (Table 14). Efficiency of the Redfish Lake smolt trap is 28 percent with Pettit lake smolt trap just under it at 27 percent (IDFG 2022).

Table 14. Juvenile Sockeye Salmon outmigration catches in Pettit Lake smolt trap Redfish Lake smolt trap, and Alturas Lake screw trap by segregation year (Evans et al. 2020; Tardy 2023; Venditti 2023).

Migration Year	Pettit Lake Wild Smolts	Redfish Lake Wild Smolts	Alturas Lake Wild Smolts
2010	3,476	14,012	45
2011	11,890	6,879	22
2012	502	31,297	22
2013	787	18,673	59
2014	623	3,583	33
2015	1	9,734	4,159
2016	476	19,863	0
2017	885	3,151	1,452
2018	3,944	27,557	2,508
2019	261	35,655	2,970
2020	205	4,709	1,754
2021	9,066	7,824	55
2022	4,935	15,512	0

The benefits of the RM&E include (1) IDFG would be able to select a broodstock that represents the genetic diversity of the entire run and equalizes family contribution, (2) IDFG and NMFS would be able to determine the effectiveness of the program in meeting its goals and objectives, and (3) new information would provide a better understanding of the life history and population dynamics of Snake River sockeye salmon. Operation of smolt traps would incidentally intercept listed juvenile spring/summer Chinook salmon and steelhead. The potential for lethal or sub-lethal effects on ESA-listed salmon and steelhead would be minimized by (1) keeping fish in the water to the maximum extent possible during sampling and processing procedures, (2) ensuring adequate circulation and replenishment of water in holding units, and (3) not handling the fish when water temperatures exceed 70 degrees Fahrenheit.

Moreover, adult weir trapping activities that exist as result of hatchery operations are likely to include take of listed species. Please refer to the Proposed Action (Section 1.3) regarding broodstock collection activities and the direct take of sockeye salmon. During broodstock collection, RM&E activities also take place that are often opportunistic and in addition to meeting broodstock goals. These RM&E activities at adult weirs include capture (Table 15), marking, tagging, taking tissue samples, and releasing live animals. In addition, other fish not directly intended for "take" may be incidentally caught, at which point RM&E activities may be utilized. Other than the incidental encounters of spring/summer Chinook mentioned, there is likely to be no effect of the activities on other listed species. This is because steelhead are separated spatially and/or temporally from this activity, and have not been encountered previously.

Table 15. Redfish Lake Sockeye salmon returns to traps on Redfish Lake Creek and the Upper Salmon River at the Sawtooth Fish Hatchery (IDFG 2022).

Return Year	Natural-origin Return	Hatchery-origin Return
2010	178	1,144
2011	145	954
2012	52	190
2013	79	191
2014	453	1,063
2015	14	77
2016	33	539
2017	11	151
2018	13	100
2019	14	3
2020	125	26
2021	13	227

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

The construction/installation, operation, and maintenance of hatchery facilities can alter fish behavior and can injure or kill eggs, juveniles and adults. It can also degrade habitat function and reduce or block access to spawning and rearing habitats altogether. Here, NMFS analyzes changes to riparian habitat, channel morphology and habitat complexity, in-stream substrates, and water quantity and water quality attributable to operation, maintenance, and construction activities and confirms whether water diversions and fish passage facilities are constructed and operated consistent with NMFS criteria. This factor can potentially affect a population's abundance, productivity, and spatial structure VSP parameters (Section 2.5). The effect of this factor ranges from negligible to negative. We anticipate that any effects from routine hatchery maintenance would not result in any deviation beyond normal fish behavioral responses to environmental disturbances.

No new construction is included as part of the Proposed Action. The best management practices regarding specific water withdrawal, screening criteria, facility upgrades, maintenance activities, and NPDES permit information for each hatchery facility are described in the Proposed Action (Section 1.3). These best management practices will limit effects on listed salmonids and their associated critical habitat. Furthermore, the hatchery facility activities described in the Proposed Action (Table 3) do not include any facility construction actions. Therefore, the Springfield Fish Hatchery, Sawtooth Fish Hatchery and trap, Eagle Fish Hatchery, Manchester Research Station, Burley Creek Fish hatchery, Oxbow Fish Hatchery and the Bonneville Fish hatchery will have a small negative effect on listed salmon and steelhead as described in the 2013 Biological Opinion (NMFS 2013), the Upper Salmon Chinook Biological Opinion (NMFS 2017b) and the *U.S. v. Oregon* Biological Opinion (NMFS et al. 2018).

The Proposed Action does not propose any change in water withdrawals from current operations; therefore, current effects are assumed to continue at a consistent level into the future and are as described in the 2013 Biological Opinion (NMFS 2013), the Upper Salmon Chinook Biological Opinion (NMFS 2017b) and the *U.S. v. Oregon* Biological Opinion (NMFS et al. 2018). The current surface water withdrawals measured in maximum percent of flow diversions (in cubic feet per second; cfs) from hatchery facility operations are show in Table 16. The maximum percent of flow is highest in the Sawtooth Hatchery at 2-15 percent; however; this depends on flow conditions, where lower flows might see a higher percentage of surface water diverted. Generally, the percent diverted is closer to around 2 percent but may reach up to 18.7 percent of the flow in the worst years (USGS 2012). Oxbow Hatchery and Bonneville Hatchery both divert a small amount of water (spring and surface water); however flows in the Columbia River, in the vicinity of Oxbow Hatchery, average 165 billion cubic meters. This diversion does not affect salmon and steelhead in the Columbia River because the diversion would have an undetectable effect on flows in the Columbia River. Burley Creek Hatchery, Eagle Fish Hatchery, Manchester Research Station, and Springfield Hatchery do not divert surface water, so these hatcheries do not have the potential to affect ESA-listed salmon and steelhead in the streams adjacent to the facilities. In addition, Springfield Hatchery and Eagle Fish Hatchery are not located on watersheds with anadromous fish.

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

Table 16. Range of daily minimum average streamflow (in cfs) measure all months of the year, maximum daily water use per facility, and calculated range of maximum percent flow divergence from facility operations.

Program	Range of daily minimum average	Maximum daily surface water use (in cfs)	% flow divergence
Sawtooth Fish Hatchery	234 – 1600 (USGS gauge #13296500 on Snake River)	35	2-15
Springfield Hatchery[9,10]	N/A		
Eagle Fish Hatchery[9,10]	N/A		
Oxbow Fish Hatchery	N/A[11]	8.5	<10
Manchester Research Station[9,10]	N/A		
Burley Creek Hatchery[9,10]	N/A		
Bonneville Fish Hatchery	N/A[11]	25.4	.04

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

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

[9] Not applicable since hatchery does not divert surface water.
[10] These Hatcheries are not located in watersheds with anadromous fish so any sediment from maintenance of instream structures would not affect anadromous fish.
F[11] No USGS Gage available for measurement.

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

All of the hatchery facilities (Table 15) are either operated undFer NPDES permits, or do not need a NPDES permit because rearing levels in the acclimation pond are below permit minimums. To the extent that permits are current and on file, the effects of operations are in the baseline, but for the sake of analysis we consider them here. Facility effluent is monitored to ensure compliance with permit requirements. Though compliance with NPDES permit conditions is not an assurance that effects will not occur to ESA-listed salmonids, the facilities use the water specifically for the purposes of rearing ESA-listed Chinook salmon, and juveniles are directly exposed to effluent levels in the hatchery facilities. Those juveniles have a low mortality during hatchery residence. This suggests that the effects of effluent do not have an effect on the hatchery-reared Chinook juveniles. It stands to reason that the same effluent, which is further diluted once discharged, will not have a measurable impact on natural-origin salmon populations in the area.

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

There are two aspects of fisheries that are potentially relevant to NMFS' analysis of hatchery program effects. One is where fisheries exist because of the Proposed Action (i.e., the fishery explicitly supported by and dependent upon the hatchery) and listed natural-origin species are inadvertently and incidentally taken in those fisheries. These fisheries would have negative effects on the *abundance* VSP parameter of the affected populations (Section 2.5). The other is when fisheries are used as a tool to prevent the hatchery fish associated with the Proposed Action, including hatchery-origin fish included in an ESA-listed salmon ESU or steelhead DPS, from spawning naturally. The effects of these fisheries can range from positive to negative.

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

2.5.2.7. Effects of the Action on Critical Habitat

This consultation analyzed the Proposed Action for its effects on designated critical habitat and has determined that operation of the hatchery programs will have a negligible effect on PCEs in the Action Area, and may have an overall beneficial effect in the Action Area. The beneficial effects on critical habitat, specifically freshwater spawning and rearing habitat, are from the conveyance of marine-derived nutrients from the carcasses of hatchery spawners and from conditioning of spawning gravel by hatchery spawners (Cederholm et al. 1999; Montgomery et al. 1996). Salmon carcasses provide a direct food source for juvenile salmonids and other fish, aquatic invertebrates, and terrestrial animals, and their decomposition supplies nutrients that may increase primary and secondary production. These marine-derived nutrients can increase the growth and survival of the ESA-listed species by increasing forage species (i.e., aquatic and terrestrial insects), aquatic vegetation, and riparian vegetation, to name a few.

Other PCEs likely affected in the Action Area would be water quantity and water quality associated with water withdrawals and effluent return. Proposed surface water diversions for rearing juvenile fish include strict criteria for diverting water from the river and will not have any discernible effect or result in any adverse modification to critical habitat concerning freshwater spawning, rearing, and migration conditions. This is because the facilities typically divert a small proportion of the water source, water use is non-consumptive, and the distance over which water is diverted is relatively small (Table 3, Table 13 and Section 2.5.2.5). In addition, all hatchery facilities have current NPDES permits, and effluent would be monitored to ensure compliance with permit requirements. All chemicals used for sanitation and for treatment of diseases would be diluted to manufacturer's instructions prior to release into the main water body.

Operation and maintenance activities would include pump maintenance, debris removal from intake and outfall structures, building maintenance, and ground maintenance. These activities would not be expected to degrade water quality or adversely modify designated critical habitat, because they would occur infrequently, and only result in minor temporary effects. Semi-routine maintenance (e.g., construction of facilities or reconstruction of in-river hatchery structures) is not considered in this opinion and would require separate consultation.

Beneficial effect: PCEs for Snake River spring/summer Chinook and Snake River sockeye salmon are described in Table 7. PCEs for Snake River steelhead are described in Section 2.2.1.3, Rangewide Status of Critical Habitat for Snake River Steelhead. As described in the sections above, the proposed hatchery program would have a beneficial effect on Snake River sockeye salmon critical habitat and a negligible effect on critical habitat for Snake River spring/summer Chinook salmon and Snake River steelhead for the following reasons:

- No new construction of hatchery facilities is proposed.
- Hatchery smolts and the juvenile progeny of naturally spawning hatchery sockeye salmon are not expected to affect, in any measurable way, natural-origin sockeye in the juvenile rearing areas because: (1) eyed-egg and pre-smolt releases would be phased out and all sockeye salmon would be released as smolts in Redfish Lake Creek, which is below sockeye salmon juvenile rearing areas, (2) IDFG with its cooperators would conduct annual investigations to help determine habitat carrying capacity, population dynamics, and system productivity, and (3) the proposed hatchery program would not increase competition with Snake River spring/summer Chinook salmon in their juvenile rearing areas, because the juvenile rearing areas for sockeye salmon and spring/summer Chinook do not overlap.

- The proposed hatchery program would increase the total number of spawners in the Stanley Basin, which would improve habitat conditions for natural-origin sockeye salmon by removing fine sediment from spawning gravels and contributing marine-derived nutrients to Stanley Basin lakes. The Stanley Basin lakes are naturally oligotrophic, and nutrient supplementation through sockeye salmon carcasses would continue to stimulate primary productivity, which would increase the amount of zooplankton available for sockeye salmon to eat.
- The proposed hatchery program would help sockeye salmon reestablish their biological niche and may result in an increase in zooplankton levels as kokanee abundance declines, which would be expected to increase the growth rate of juvenile sockeye salmon and improve their survival during the long seaward migration from their nursery lakes.
- The proposed hatchery program would have negligible effects on ESA-listed fish in the migration corridor, estuary, and Pacific Ocean because the science does not show a likelihood of impacts generally.
- The water diversion at the Sawtooth Hatchery is screened to protect juvenile fish from entrainment and injury and satisfies NMFS screening criteria for anadromous fish passage facilities (NMFS 1995b; 2011b; 2022c).
- The Sawtooth Hatchery would divert less than 2 percent of the water from the Salmon River to support the Snake River sockeye salmon hatchery program, and this small level would not affect passage or rearing capacity for Snake River spring/summer Chinook or sockeye salmon populations.
- The Eagle Hatchery and Springfield Hatchery do not divert surface water, so these do not have the potential to affect ESA-listed salmon and steelhead in streams adjacent to the facilities.
- Eagle Hatchery and Springfield Hatchery are not located in watersheds with anadromous fish, so any sediment from maintenance of instream structures would not affect anadromous fish.
- The Oxbow Hatchery would have an undetectable effect on flows in the Columbia River.
- Any sediment from the maintenance of instream structures at Oxbow Hatchery would be localized and temporary and would not be expected to affect ESA-listed salmon or steelhead. IDFG would monitor spawning distribution above and below the weirs/traps to ensure that their operation does not significantly alter the spatial distribution of any population. Experience with these weirs during the previous 22 years shows that they do not negatively affect the survival or spawning distribution of juvenile and adult sockeye salmon.
- Walkways would be used at the Redfish Lake Creek trap, and the weir trolley would be used at the Sawtooth Fish Hatchery to avoid unnecessary in-water activity during annual weir panel placement and removal.
- IDFG would ensure all weirs/traps associated with the hatchery program minimize or eliminate stress or injury to listed salmon.

2.6. Cumulative Effects

"Cumulative effects" are those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation [50 CFR 402.02 and 402.17(a)]. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult 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 earlier in the discussion of environmental baseline (Section 2.4).

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

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

More detailed discussion of cumulative effects for the Columbia River Basin can be found in our biological opinion on the funding of Mitchell Act hatchery programs (NMFS 2017). These actions include activities to help restore and protect habitat, restore access and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites. In summary, it is likely that the type and extent of salmon and steelhead hatchery programs and the numbers of fish released in the analysis area and throughout the Columbia Basin generally will change over time. Although adverse effects will continue, these changes are likely to reduce effects such as competition and predation on natural-origin salmon and steelhead compared to current levels, especially for those species that are listed under the ESA. This is because all salmon and steelhead hatchery and harvest programs funded and operated by non-federal agencies and tribes in the Columbia Basin have to undergo review under the ESA to ensure that listed species are not jeopardized and that "take" under the ESA from salmon and steelhead hatchery programs is minimized or avoided. Where needed, reductions in effects on listed salmon and steelhead are likely to occur through:

- Hatchery monitoring information
- Times and locations of fish releases to reduce risks of competition and predation
- Management of overlap in hatchery- and natural-origin spawners to meet gene flow objectives
- Decreased use of isolated hatchery programs
- Increased use of integrated hatchery programs for conservation purposes
- Incorporation of new research results and improved best management practices for hatchery operations
- Creation of wild fish only areas
- Changes in hatchery production levels
- Increased use of marking of hatchery-origin fish
- Improved estimates of natural-origin salmon and steelhead abundance for abundance-based fishery management.

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

2.7. INTEGRATION AND SYNTHESIS

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

We considered the baseline effects (including the exacerbating effects of climate change) and species status, where we found that abundance, productivity, and diversity were the critical problems in most populations, consistent with the recovery plan's identification of limiting factors. The effects of the action are limited to a small impact on abundance, productivity, and diversity as a result of the hatchery releases, but over time the impact could provide positive benefits. The cumulative effects consist primarily of ongoing hatchery programs, harvest, hydropower, agriculture and other forms of development that have reduced habitat and productivity, problems that will be positively addressed by expected reforms though compounded to a degree by climate change (Section 2.6).

2.7.1. Listed Species

2.7.1.1. Snake River Sockeye Salmon ESU

Best available information indicates that the Snake River Sockeye Salmon ESU remains at "extremely high risk" (Ford 2022). The overall risk rating is a result of threats on multiple viability parameters effecting abundance, productivity, spatial structure and diversity. Adult returns, both hatchery-origin and natural-origin, crashed in 2015 due to unusually warm waters in the Columbia River Basin (Ford 2022). Return numbers have remained low since the crash, causing the return of natural returning fish to remain low imposing a high risk on diversity and abundance of the program. However, substantial progress has been made with the Snake River sockeye salmon captive broodstock-based hatchery program (Ford 2022). The Biological Review Team (BRT) identified the most serious risk to the ESU was low natural productivity, and climate change (Ford 2022).

The effects of the program on Snake River sockeye salmon are focused on the upper basin effects, though it should be noted that the ESU consists solely of this population, so the effects analyzed above are ESU-level effects. Our environmental baseline analysis considers the effects of hydropower, changes in habitat (both beneficial and adverse), fisheries, and hatcheries on this ESU. As we continue to deal with a changing climate, management of these factors may also alleviate some of the potential adverse effects on VSP parameters (abundance, productivity, diversity, and spatial structure) covered in Section 5 (e.g., through hatcheries serving as a genetic reserve for natural populations).

The majority of the effects of the Proposed Action on this ESU are genetic and ecological in nature. This is a factor in the abundance (ecological), productivity (ecological), and diversity (genetic) parameters. Effects of facility operation and broodstock collection are small and localized. While RM&E requires handling of a substantial portion of the juvenile and adult population, the broodstock collection is an essential component of the action, and information gained from conducting the work is essential for understanding the effects of the hatchery program on natural-origin sockeye salmon populations. NMFS will monitor whether decreased productivity, diversity, or abundance of natural-origin fish may necessitate more aggressive adult management, and/or reconsideration of hatchery program size in the future to limit impacts on these VSP parameters in these ESUs (Section 5).

In general, for hatchery programs, the ecological genetic effects on the adult life stage are limited by minimizing the proportion of hatchery-origin fish spawning naturally as well as the proportion of natural-origin fish used in broodstock. For this program, this is managed through the use of implementing all natural-origin fish captured into the broodstock program as well as using only local-origin broodstock. IDFG, through PBT, monitors genetics of returning fish (hatchery-origin and natural-origin) to mate the least-related individuals to minimize genetic risks. The hatchery program also continues to provide a genetic reserve for the Snake River Sockeye Salmon ESU to prevent the loss of unique traits due to catastrophes.

This program, while containing some of the same risks as all hatchery programs, is unique in that its continued operation is substantially beneficial to the species as it is the main mechanism for maintaining abundance and preventing extinction. Therefore, while the negative effects of the hatchery are not discounted, they are weighed against this important purpose. While low natural productivity is a primary risk for the species, it is worth bearing in mind that the program is explicitly designed to reestablish their biological niche. At this point in time, natural production of anadromous Snake River sockeye salmon remains limited to extremely low levels seen within the Stanley Basin. The captive broodstock program has been able to achieve the goal of Phase 1 with rearing and release of captive broodstock and has transitioned into Phase 2--recolonization with natural-origin fish. A minimum of 10 percent of natural-origin fish are required to keep the broodstock program genetically distinct. Although return numbers are low, the hatchery program is working to increase the total number of spawners in the Stanley Basin lakes. As smolt production and releases continue, we expect the number of returning sockeye salmon to increase. As the return numbers increase, the amount of natural-origin returns incorporated into the broodstock program will also increase. It is expected that the increase in returns will aid in improving habitat conditions for natural-origin sockeye salmon by removing fine sediment from spawning gravels and contributing marine-derived nutrients to Stanley Basin lakes (NMFS 2015). The proposed hatchery program is explicitly designed to help sockeye salmon reestablish their biological niche and may result in an increase in zooplankton levels as kokanee abundance declines. This change would be expected to increase the growth rate of juvenile sockeye salmon and improve their survival during the long seaward migration from their nursery lakes. All of these actions should contribute to an increase in abundance and productivity for this population in the long-term. Overall, the combined genetic effects from the proposed hatchery programs will not result in a substantial negative effect on the diversity of Snake River Sockeye Salmon ESU.

The benefits of the proposed RM&E include (1) IDFG would be able to select a broodstock that represents the genetic diversity of the entire run and equalizes family contribution, (2) IDFG and NMFS would be able to determine the effectiveness of the program in meeting its goals and objectives, and (3) new information would provide a better understanding of the life history and population dynamics of Snake River sockeye salmon.

Added to the Environmental Baseline and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the action area. The recovery plan for this ESU (NMFS 2015) describes the on-going and proposed Federal, state, tribal and local government actions that are targeted to reduce known threats to the ESA-listed Snake River sockeye salmon. Such actions are improving habitat conditions and hatchery and harvest practices to protect ESA-listed sockeye salmon, and NMFS expects this trend to continue, ultimately improving the abundance, diversity, and productivity of natural populations. Spatial structure is not likely to be affected by the proposed hatchery programs.

In summary, we considered the baseline effects (including the exacerbating effects of climate change) and species status, where we found that abundance, productivity, and diversity were the critical problems in most populations, consistent with the recovery plan's identification of limiting factors. The effects of the action are limited to a small impact on abundance, productivity, and diversity as a result of the hatchery releases, but over time the impact could provide positive benefits. The cumulative effects consist primarily of ongoing hatchery programs, harvest, hydropower, agriculture and other forms of development that have reduced habitat and productivity, problems that will be positively addressed by expected reforms though compounded to a degree by climate change (Section 2.4.3). Taken together, these activities are not likely to appreciably reduce the survival and recovery of ESA-listed Snake River sockeye salmon.

2.7.1.2. Snake River Steelhead and Spring/Summer Chinook Salmon DPS and ESUs

Best available information indicates that the Snake River Steelhead DPS and the Spring/Summer Chinook Salmon ESU are at high risk and remain at threatened status (Ford 2022). After considering the current viability status of these species, the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the effects of the Proposed Action will not appreciably reduce the likelihood of survival and recovery of these ESA-listed ESUs in the wild, as discussed here.

Our environmental baseline analysis considers the effects of hydropower, changes in habitat (both beneficial and adverse), fisheries, and hatcheries on these ESUs. Although all may have contributed to the listing of these ESUs, all factors have also seen improvements in the way they are managed/operated. As we continue to deal with a changing climate, management of these factors may also alleviate some of the potential adverse effects on VSP parameters (abundance, productivity, diversity, and spatial structure) covered in Section 5 (e.g., hatcheries serving as a genetic reserve for natural populations).

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

We considered the baseline effects (including the exacerbating effects of climate change) and species status, where we found that abundance, productivity, and diversity were the critical problems in most populations, consistent with the recovery plan's identification of limiting factors. The effects of the action are limited to a small impact on abundance, productivity, and diversity on the South Fork, Upper Fork and Upper Salmon River MPGs, and will consequently have a discountable impact on the affected species. These MPGs co-exist with both hatchery and natural-origin sockeye salmon, and as a result of the hatchery releases, create an opportunity for beneficial to adverse effects on the MPGs. However, over time, the increase in hatchery production could provide positive benefits. The cumulative effects consist primarily of ongoing hatchery programs, harvest, hydropower, agriculture, and other forms of development that have reduced habitat and productivity. These problems will be positively addressed by expected reforms, though compounded to a degree by climate change (Section 2.4.3). The effects of the

Proposed Action, when added to activities described above, is not likely to appreciably reduce the survival and recovery of listed Snake River steelhead DPS, or Spring/Summer Chinook salmon ESU.

2.7.1.2.1. SNAKE RIVER SPRING/SUMMER CHINOOK SALMON

The effects of our Proposed Action on Snake River Spring/summer Chinook salmon will occur incidental to collection of sockeye salmon for broodstock and during RM&E activities. In addition, ecological effects will occur because of the overlap in outmigration timing. These effects may result in changes to the abundance and productivity of the various natural-origin fish populations within the South Fork, Middle Fork and Upper Salmon River MPG (Table 6); however, NMFS believes the impacts are small to the various MPGs and the ESU as a whole.

Effects of broodstock collection targeting sockeye salmon are small because of the differences in spatial and temporal overlap between spring/summer Chinook salmon and sockeye mean that the overlap is only during a short window at the early part of the run (Table 12). Because the various returning MPGs to the Sawtooth Fish Hatchery are not a target species, they are released unharmed. Direct monitoring and collection would only occur as part of the Snake River Spring/Summer Chinook salmon Hatchery Program (authorized separately). However, juveniles may potentially undergo larger effects because of the overlap in outmigration timing. The small percentage loss of the various MPGs within the ESU is unlikely to affect the productivity of these natural-origin fish in the Snake River Basin. These would equate to a potential loss of less than one percent of the potential natural-origin adults return from competition and predation during the juvenile life stage. The co-managers will monitor and NMFS will determine whether decreased productivity or abundance of natural-origin fish may necessitate reconsideration of hatchery program size in the future to limit impacts on these VSP parameters in these ESUs (Section 5). Thus, there is very little incidental effect on Snake River Spring/Summer Chinook salmon, and it is unlikely that these activities would lead to a decrease in the abundance, productivity, spatial structure, or diversity of the ESU.

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

2.7.1.2.2. SNAKE RIVER BASIN STEELHEAD

The effects of our Proposed Action on Snake River Basin Steelhead will occur incidental to collection of sockeye salmon for broodstock and during RM&E activities. In addition, ecological effects can occur because of the potential overlap in outmigration timing. These effects may result in changes to the abundance and productivity of the various natural-origin fish popualtions within the Salmon River MPG (Table 9); however, NMFS believes the impacts are small to the MPG and the DPS as a whole.

Effects of broodstock collection targeting sockeye salmon are small because of the differences in spatial and temporal overlap between sockeye salmon and steelhead mean that there is only potential overlap during the very end of the sockeye salmon run timing and during juvenile outmigration (Table 12). Because they are not a target species, they are released unharmed. Direct monitoring and collection would only occur as part of another program (authorized separately). Thus, there is very little incidental effect on the Salmon River MPG of Snake River Basin Steelhead, and it is unlikely that these activities would lead to a decrease in the abundance, productivity, spatial structure, or diversity of the DPS.

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

2.7.2. Critical Habitat

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

Climate change may have some effects on critical habitat as discussed in Section 2.4.3. With continued losses in snowpack and increasing water temperatures, it is possible that increases in the density and residence time of fish using cold-water refugia could result in increases in ecological interactions between hatchery and natural-origin fish of all life stages, with unknown but likely small effects. Within the Action Area, the rising air and water temperatures poses a concern to returning hatchery-origin and natural-origin salmonids.

2.8. Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, the effects of other activities caused by the proposed action, and the cumulative effects, it is NMFS' biological opinion that the Proposed Action is not likely to jeopardize the continued existence or recovery of the Snake River Spring/Summer Chinook Salmon ESU, the Snake River Sockeye Salmon ESU and the Snake River Basin Steelhead DPU listed in the Columbia River Basin or destroy or adversely modify designated critical habitat.

2.9. Incidental Take Statement

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by regulation to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering (50 CFR 17.3). Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. "Incidental take" is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this ITS.

2.9.1. Amount or Extent of Take

The primary form of take on ESA-listed sockeye salmon is direct take, under the proposed action, the issuance of Section 10 Authorizations for the hatchery programs. That take is therefore not incidental to the proposed action and not covered here. However, NMFS also expects that incidental take of ESA-listed salmonids is reasonably certain to occur as a result of the Proposed Action for the following factors.

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

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

Effects of hatchery fish on the genetics of natural-origin fish can occur through a reduction in genetic diversity, outbreeding depression, and hatchery-influenced selection. There is further take caused by ecological interactions between hatchery- and natural-origin adults; specifically, spawning site competition and redd superimposition. These genetic and ecological effects cannot be directly measured because it is not possible to observe gene flow or interbreeding between hatchery and natural fish in a reliable way.

For each form of take described above, NMFS will rely on a single surrogate measure of incidental take, 10 percent of the proportion of natural-origin spawners used in hatchery broodstock. This metric is rationally connected to incidental take in the form of genetic effects, because the proportion of natural-origin fish used in broodstock has a direct link to the overall incidental genetic impacts resulting from the operation of the hatchery program. In other words, maximizing the proportion of natural-origin broodstock reduces take by genetic effects. While this metric does not directly address ecological interactions (e.g., redd superimposition and spawning site competition), a higher proportion of natural-origin spawners used in broodstock is expected to decrease the level of hatchery influence (and so any ecological interactions) on natural spawners. Therefore, the take surrogate is rationally connected to the take expected to occur. Moreover, this can be effectively measured and monitored for the purposes of tracking the program's performance.

Snake River Spring/Summer Chinook will also be taken as a result of the capture and handling associated with operation of the adult trap. Please see Table 17 below for the extent of incidental take information for factor 2.

Table 17. Incidental take of Snake River spring/summer Chinook during sockeye salmon broodstock collection

Program	Species	Life stage	Maximum incidental handling number (adults)	Maximum incidental mortality (adults)
Redfish Lake trap	Snake River spring/summer Chinook salmon	Adult	20	2

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

Take associated with research, monitoring, and evaluation is summarized in Table 18.

Table 18. Incidental capture and mortality of all ESA listed Salmonids resulting from RM&E activities (e.g., smolt traps). Capture, handling, and sampling is considered direct take.

Program	Species	Life stage	Maximum incidental handling number (adults)	Maximum incidental mortality
Redfish Lake smolt trap	Snake River spring/summer Chinook salmon	Juvenile	75	2
Redfish Lake smolt trap	Snake River Basin Steelhead	Juvenile	50	2
Redfish Lake smolt trap	Snake River Basin Steelhead	Adult	5	1

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

2.9.3. Reasonable and Prudent Measures

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

NMFS concludes that the following reasonable and prudent measures are necessary and appropriate to minimize incidental take. NMFS and the permit holders must ensure that:

1. NMFS shall ensure that the applicants implement the hatchery programs and operate the hatchery facilities as well as guidelines specified in this opinion for their respective programs.
2. NMFS shall ensure that the applicants provide reports to SFD annually for all hatchery programs, and associated RM&E.

2.9.4. Terms and Conditions

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

1. The applicants implement the hatchery programs and operate the hatchery facilities as well as guidelines specified in this opinion for their respective programs, including:
    a. Provide advance notice of any change in program operation and implementation that may increase the amount or extent of take, or results in an effect of take not previously considered.
    b. Notify NMFS SFD within 2 working days after knowledge of exceeding authorized take. The applicants shall submit a written report, and/or convene a discussion with NMFS to discuss why the authorized take was exceeded.
    c. Provide plans for future projects and /or changes in hatchery operations, release locations, release size or protocols and obtain concurrence from NMFS prior to implementation of such changes.

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

    a. An annual RM&E report(s) is submitted by applicants no later than March 31st of the year following releases and associated RM&E (e.g., release/RM&E in year 2023, report due March 2024) that will include:

i. The number and origin (new integrated hatchery program, and natural) of each listed species handled and incidental mortality across all activities and facilities and their post-release distribution and disposition (e.g., normal, injury, or mortality).
ii. Hatchery Environmental Monitoring Reporting
    1. Number and composition of broodstock, dates of collection, and egg to smolt survival rates.
    2. Numbers, dates, locations, size, coefficient of variation, and tag/mark information of released fish.
    3. Disease occurrence at hatcheries.
    4. Any problems that may have arisen during hatchery activities.
    5. Any unforeseen effects on ESA-listed fish.
    6. Estimate emigration rate of hatchery fish collected in smolt traps.
iii. Natural Environmental Monitoring Reporting
    1. The number of returning hatchery and natural-origin adults
    2. The number and species of listed fish encountered at each adult collection location, and the number that die
    3. Mean length, coefficient of variation, number, and age of natural-origin juveniles during RM&E activities

2.10. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a Proposed Action on listed species or critical habitat (50 CFR 402.02). NMFS has not identified any conservation measures.

2.11. RE-INITIATION OF CONSULTATION

This concludes formal consultation on the authorization, funding, and operation of the Snake River sockeye Captive Broodstock Program in the Stanley Basin of Idaho.

Under 50 CFR 402.16(a): "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: (1) If the amount or extent of taking specified in the incidental take statement is exceeded; (2) If new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) If the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion or written concurrence; or (4) If a new species is listed or critical habitat designated that may be affected by the identified action."

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

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

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

As described by (PFMC 2014b), the freshwater EFH for Chinook salmon has five habitat areas of particular concern (HAPCs): (1) complex channels and floodplain habitat; (2) thermal refugia; (3) spawning habitat; (4) estuaries; and (5) marine and estuarine submerged aquatic vegetation. HAPCs 1 and 3 are potentially affected by the Proposed Action.

3.2. ADVERSE EFFECTS ON ESSENTIAL FISH HABITAT

The Proposed Action has small effects on the major components of EFH. The HAPCs that are potentially being affected are the complex channels and floodplain habitat in and around the hatchery facilities as well as the spawning habitat in the Stanley Basin.

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

The PFMC (PFMC 2003) recognized concerns regarding the "genetic and ecological interactions of hatchery and wild fish… [which have] been identified as risk factors for wild populations." The Biological Opinion describes in considerable detail the impacts hatchery programs might have on natural populations of sockeye salmon (Section 2.5.2.2; Section 5). The effects on steelhead and Chinook salmon are typically much smaller, due to the species-specific nature of many of the interactions and relatively small overlap in habitat usage by these species. Ecological effects of juvenile and adult hatchery-origin fish on natural-origin fish are discussed in Sections 2.5.2.2 and 2.5.2.3. Hatchery fish returning to the Snake River Basin are expected to largely spawn and rear near the hatchery and not compete for space with spring/summer Chinook or steelhead. Stray rates are low, and not expected to be a concern. Due to a difference in habitat usage and timing, predation by adult hatchery sockeye salmon on juvenile natural-origin Chinook salmon and steelhead is expected to be small. Predation and competition by juvenile hatchery sockeye salmon on juvenile natural-origin Chinook or steelhead is minimal because these fish out-migrate quickly and the juvenile rearing areas do not overlap.

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

3.3. Essential Fish Habitat Conservation Recommendations

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

For each of the potential adverse effects of the Proposed Action on EFH for Pacific salmon, NMFS believes that the Proposed Action, as described in the HGMP (IDFG 2022) and the ITS (Section 2.9), includes the best approaches to avoid or minimize those adverse effects. The Reasonable and Prudent Measures and Terms and Conditions included in the ITS associated with ecological interactions constitute NMFS recommendations to address potential EFH effects. NMFS and BIA shall ensure that the ITS, including Reasonable and Prudent Measures and implementing Terms and Conditions, are carried out.

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

3.4. Statutory Response Requirement

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

Recommendation from NMFS. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS' EFH Conservation Recommendations, unless NMFS and the Federal agency have agreed to use alternative time frame for the Federal agency response. The response must include a description of measures proposed by the agency for avoiding, mitigating, or offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with NMFS Conservation Recommendations, the Federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects (50 CFR 600.920(k)(1)).

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

3.5. SUPPLEMENTAL CONSULTATION

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

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

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

4.1. UTILITY

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users are NMFS, BPA, LSRCP, and the program operators and their co-operators. The scientific community, resource managers, and stakeholders benefit from the consultation through the anticipated increase in returns of sockeye salmon to the Snake River Basin, and through the collection of data on the effects of supplementing an endangered salmon ESU with hatchery-origin fish. This information will improve scientific understanding of the effects of salmon supplementation that can be applied broadly within the Pacific Northwest area for managing benefits and risks associated with hatchery operations. The document will be available within 2 weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. The format and naming adhere to conventional standards for style.

4.2. INTEGRITY

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

4.3. OBJECTIVITY

Information Product Category: Natural Resource Plan

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

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

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

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

5. APPENDIX: EFFECTS OF HATCHERY PROGRAMS ON SALMON AND STEELHEAD POPULATIONS: REFERENCE DOCUMENT FOR NMFS ESA HATCHERY CONSULTATIONS (REVISED MAY 2023)[12]

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

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

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

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

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

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

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

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 donor population collected for hatchery broodstock. "Mining" a natural population to supply hatchery broodstock can reduce population abundance and spatial structure.

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

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

5.2.1. Genetic effects

5.2.1.1. Overview

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

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

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

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

Mutations are changes in DNA sequences that are generally so rare[13] that they can be ignored for relatively short-term evaluation of genetic change, but the other three processes are considerations in evaluating the effects of hatchery programs on the productivity and genetic diversity of natural salmon and steelhead populations. Although there is considerable biological interdependence among them, we consider three major areas of genetic effects of hatchery programs in our analyses (Figure 5):

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

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

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

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

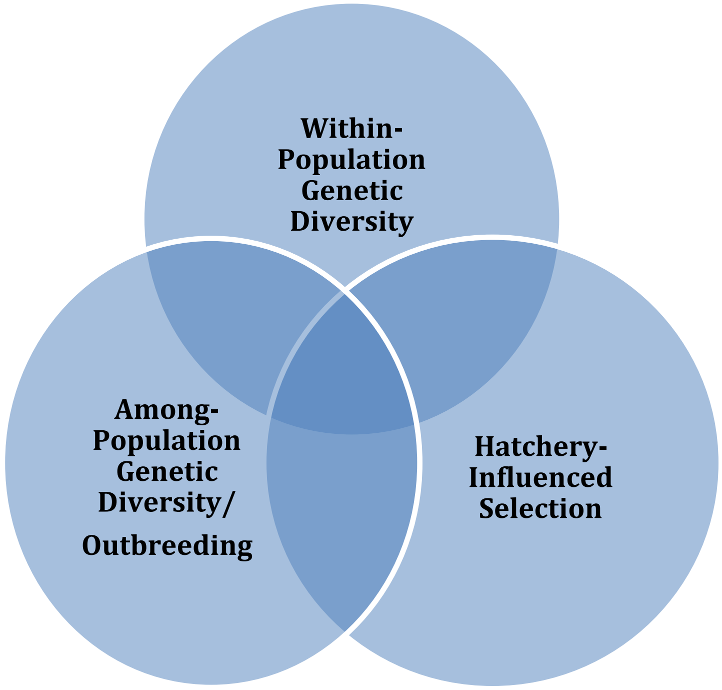

Figure 5. Major categories of hatchery program genetic effects analyzed by NMFS

5.2.1.1.1. KEY TERMS

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

- **Hatchery-origin (HO)**- refers to fish that have been reared and released by a hatchery program, regardless of the origin (i.e., from a hatchery or from spawning in nature) of their parents. A series of acronyms has been developed for subclasses of HO fish:
    - **Hatchery-origin recruits (HOR)** – HO fish returning to freshwater as adults or jacks. Usage varies, but typically the term refers to post-harvest fish that will either spawn in nature, used for hatchery broodstock, or surplused.
    - **Hatchery-origin spawners (HOS)**- hatchery-origin fish spawning in nature. A very important derivative term, used both in genetic and ecological risk, is **pHOS,** the proportion of fish on the spawning grounds of a population consisting of HO fish. pHOS is the expected maximum genetic contribution of HO spawners to the naturally spawning population.

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

- **Natural-origin (NO)**- refers to fish that have resulted from spawning in nature, regardless of the origin of their parents. A series of acronyms parallel to those for HO fish has been developed for subclasses of NO fish:
  - **Natural-origin recruits (NOR)** – NO fish returning to freshwater as adults or jacks. Usage varies, but typically the term refers to post-harvest fish that will either spawn in nature or used for hatchery broodstock.
  - **Natural-origin spawners (NOS)**- natural-origin fish spawning in nature.
  - **Natural-origin broodstock (NOB)**- natural-origin fish that are spawned in the hatchery (i.e., are used as broodstock). An important derivative term is **pNOB**, the proportion of a hatchery program's broodstock consisting of NO fish.

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

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

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

5.2.1.2. Within-population diversity effects

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

5.2.1.2.1. GENETIC DRIFT

Genetic drift is random loss of diversity due to population size. The rate of drift is determined not by the census population size (N_c), but rather by the effective population size (N_e). The effective size of a population is the size of a genetically "ideal" population (i.e., equal numbers of males and females, each with equal opportunity to contribute to the next generation) that will display as much genetic drift as the population being examined (e.g., Falconer and MacKay 1996; Allendorf, Luikart and Aitken 2013)[14].

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

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

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

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

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

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

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

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

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

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

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

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

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). Small populations are at increased risk of both inbreeding depression and genetic drift (e.g., Willi, Buskirk and Hoffmann 2006). Genetic drift is the stochastic loss of genetic variation, which is most often observed in populations with low numbers of breeders. Inbreeding exacerbates the loss of genetic variation by increasing genetic drift when related individuals with similar allelic diversity interbreed (Willoughby et al. 2015).

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

5.2.1.2.2. BIASED/NONREPRESENTATIONAL SAMPLING

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

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

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

Asia and Europe (Dellefors and Faremo 1988; Kato 1991; Munakata et al. 2001; Morita, Tsuboi and Nagasawa 2009).

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

The examples above illustrate the overlap between diversity effects and selection. Selection, natural or artificial, affects diversity, so could be regarded as a subcategory of within-population diversity. Analytically, here we consider specific effects of sampling or selection on genetic diversity. Broodstock collection or spawning guidelines that include specifications about non-random use of fish with respect to age or size, spawn timing, etc. (e.g., Crawford 1979) are of special interest. We consider general non-specific effects of unintentional selection due to the hatchery that are not related to individual traits in Section 5.2.1.4.

5.2.1.3. Among-population diversity/ Outbreeding effects

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

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

Rearing and release practices and ancestral origin of the hatchery fish can all play a role in straying (Quinn 1997). Based on fundamental population genetic principles, a 1995 scientific workgroup convened by NMFS concluded that aggregate gene flow from non-native HO fish from all programs combined should be kept below 5 percent (Grant 1997), and this is the recommendation NMFS uses as a reference in hatchery consultations. It is important to note that this 5 percent criterion was developed independently and for a different purpose than the HSRG’s 5% pHOS criterion that is presented in Section 5.2.1.4.

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

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

There is a growing appreciation of the extent to which among-population diversity contributes to a "portfolio" effect (Schindler et al. 2010), and lack of among-population genetic diversity is considered a contributing factor to the depressed status of California Chinook salmon populations (Carlson, Satterthwaite and Fleming 2011; Satterthwaite and Carlson 2015). Eldridge, Myers and Naish (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 5.2.1.4, pHOS[15] is often used as a surrogate measure of gene flow. Appropriate cautions and qualifications should be considered when using this proportion to analyze outbreeding effects.

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

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

[15] 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.

5.2.1.4. Hatchery-influenced selection effects

Hatchery-influenced selection (often called domestication[16]), the third major area of genetic effects of hatchery programs that NMFS analyses, occurs when selection pressures imposed by hatchery spawning and rearing differ greatly from those imposed by the natural environment and causes genetic change that is passed on to natural populations through interbreeding with HO fish. These differing selection pressures can be a result of differences in environments or a consequence of protocols and practices used by a hatchery program.

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

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

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

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

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

All three factors should be considered in evaluating risks of hatchery programs. However, because gene flow is generally more readily managed than the selection strength of the hatchery environment, current efforts to control and evaluate the risk of hatchery-influenced selection are currently largely focused on gene flow between NO and HO fish[17]. Strong selective fish culture with low hatchery-wild interbreeding can pose less risk than relatively weaker selective fish culture with high levels of interbreeding.

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

[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.

5.2.1.4.1. Relative Reproductive Success Research

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

RRS studies can be easy to misinterpret (Christie, Ford and Blouin 2014) for at least three reasons:

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

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

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

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

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

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

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

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

Detecting a genetic component of fitness loss in one species and not another suggests that perhaps the impacts of hatchery-influenced selection on fitness differs between Chinook salmon and steelhead.[18] 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.

5.2.1.4.2. HATCHERY SCIENTIFIC REVIEW GROUP (HSRG) GUIDELINES

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

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

[18] 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, Weir and Bernatchez 2012).

The HSRG guidelines (HSRG 2009a) vary according to type of program and conservation importance of the population. The HSRG used conservation importance classifications that were developed by the Willamette/Lower Columbia Technical Recovery Team (McElhany et al. 2003).[19] (Table 19). In considering the guidelines, we equate "primary" with a recovery goal of "viable" or "highly viable", and "contributing" with a recovery goal of "maintain". We disregard the guidelines for "stabilizing", because we feel they are inadequate for conservation guidance.

Table 19. HSRG gene flow guidelines (HSRG 2009a).

	Program classification	
Population conservation importance	**Integrated**	**Segregated**
Primary	**PNI ≥ 0.67 and pHOS ≤ 0.30**	**pHOS ≤ 0.05**
Contributing	**PNI ≥ 0.50 and pHOS ≤ 0.30**	**pHOS ≤ 0.10**
Stabilizing	**Existing conditions**	**Existing conditions**

Although they are controversial, the HSRG gene flow guidelines have achieved a considerable level of regional acceptance. They were adopted as policy by the Washington Fish and Wildlife Commission (WDFW 2009), and were recently reviewed and endorsed by a WDFW scientific panel, who noted that the "…HSRG is the primary, perhaps only entity providing guidance for operating hatcheries in a scientifically defensible manner…" (Anderson et al. 2020). In addition, HSRG principles have been adopted by the Canadian Department of Fisheries and Oceans, with very similar gene-flow guidelines for some situations (Withler et al. 2018)[20].

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

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

NMFS has not adopted the HSRG gene flow guidelines per se. However, at present the HSRG guidelines are the only scientifically based quantitative gene flow guidelines available for reducing the risk of hatchery-influenced selection. NMFS has considerable experience with the

[19] Development of conservation importance classifications varied among technical recovery teams (TRTs); for more information, documents produced by the individual TRT's should be consulted.
[20] Withler et al. (2018) noted a non-genetic biological significance to a pHOS level of 30%. Assuming mating is random with respect to origin (HO or NO) in a spawning aggregation of HO and NO fish, NOxNO matings will comprise the majority of matings only if pHOS is less than 30%.

HSRG guidelines. They are based on a model (Ford 2002) developed by a NMFS geneticist, they have been evaluated by a NMFS-lead scientific team (RIST 2009), and NMFS scientists have extended the Ford model for more flexible application of the guidelines to complex situations (Busack 2015) (Section 5.2.1.4.3).

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

5.2.1.4.2.4. PNI AND SEGREGATED HATCHERY PROGRAMS

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

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

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

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

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

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

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

5.2.1.4.2.5. THE EFFECTIVE PHOS CONCEPT

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

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

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

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

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

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

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

5.2.1.4.2.6. GENE FLOW GUIDELINES IN PHASES OF RECOVERY

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

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

The HSRG provided guidance on development of quantitative "triggers" for determining when a population had moved (up or down) from one phase to another. As explained in HSRG (2015), in the preservation and re-colonization phase, no PNI levels were specified for integrated programs (Table 19). The emphasis in these phases was to "Retain genetic diversity and identity of the existing population". In the local adaptation phase, when PNI standards were to be applied, the emphasis shifted to "Increase fitness, reproductive success and life history diversity through local adaptation (e.g., by reducing hatchery influence by maximizing *PNI*)". The HSRG provided additional guidance in HSRG (2017), which encouraged managers to use pNOB to "…the extent possible…" during the preservation and recolonization phases.

Table 20. HSRG gene flow guidelines/standards for conservation and harvest programs, based on recovery phase of impacted population (Table 2 from HSRG 2015).

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

We have two concerns regarding the phases of recovery approach. First, although the phase structure is intuitively appealing, no scientific evidence was presented the HSRG for existence of the phases. Second, while we agree that conservation of populations at perilously low abundance may require prioritization of demographic over genetic concerns, we are concerned that high pHOS/low PNI regimes imposed on small recovering populations may prevent them from advancing to higher recovery phases[21]. A WDFW scientific panel reviewing HSRG principles and guidelines reached the same conclusion (Anderson et al. 2020). In response, the HSRG in issued revised guidance for the preservation and recolonization phases (HSRG 2020):

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

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

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

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

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

A good example is a system of genetically linked hatchery programs, an integrated program in which in which returnees from a (typically smaller) integrated hatchery program are used as broodstock for a larger segregated program, and both programs contribute to pHOS (Figure 6). It seems logical that this would result in less impact on the natural population than if the segregated program used only its own returnees as broodstock, but because the two-population implementation of the Ford model did not apply, there was no way to calculate PNI for this system.

Extending Ford's recursion equations (equations 5 and 6) to three populations allowed us to calculate PNI for a system of this type. We successfully applied this approach to link two spring Chinook salmon hatchery programs: Winthrop NFH (segregated) and Methow FH (integrated). By using some level of Methow returnees as broodstock for the Winthrop program, PNI for the natural population could be increased significantly[22](Busack 2015). We have since used the multi-population PNI model in numerous hatchery program consultations in Puget Sound and the Columbia basin, and have extended to it to include as many as ten hatchery programs and natural production areas.

[22] Such programs can lower the effective size of the system, but the model of Tufto (Section 1.2.1.4) can easily be applied to estimate this impact.

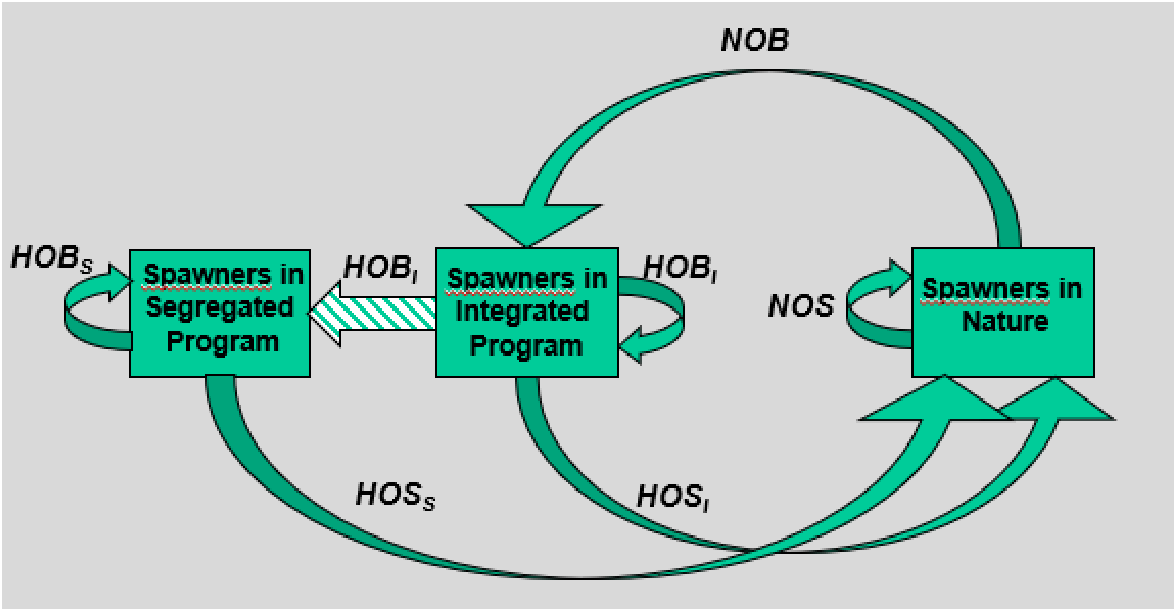

Figure 6. Example of genetically linked hatchery programs. The natural population is influenced by hatchery-origin spawners from an integrated (HOS_I) and a segregated program (HOS_S). The integrated program uses a mix of natural-origin (NOB) and its own returnees (HOB_I) as broodstock, but the segregated uses returnees from the integrated program (HOB_I above striped arrow) as all or part of its broodstock, genetically linking the two programs. The system illustrated here is functionally equivalent to the HSRG's *(HSRG 2014)* "stepping stone" concept.

5.2.1.4.4. California HSRG

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

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

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

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

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

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

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

The added spawner density resulting from hatchery-origin fish spawning in the wild can have negative consequences, such as increased competition, and potential for redd superimposition. Although males compete for access to females, female spawners compete for spawning sites. Essington, Quinn and Ewert (2000) found that aggression of both sexes increases with spawner density, and is most intense with conspecifics. However, females tended to act aggressively towards heterospecifics as well. In particular, when there is spatial overlap between natural-and hatchery-origin spawners, the potential exists for hatchery-derived fish to superimpose or destroy the eggs and embryos of ESA-listed species. Redd superimposition has been shown to be a cause of egg loss in pink salmon and other species (e.g., Fukushima, Quinn and Smoker 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. 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 (Revised June 1, 2020)

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

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 (SIWG 1984). Natural-origin fish may be competitively displaced by hatchery fish early in life, especially when hatchery fish are more numerous, are of equal or greater size, take up residency before natural-origin fry emerge from redds, and residualize. Hatchery fish might alter natural-origin salmon behavioral patterns and habitat use, making natural-origin fish more susceptible to predators (Hillman and Mullan 1989; Steward and Bjornn 1990). Hatchery-origin fish may also alter natural-origin salmonid migratory responses or movement patterns, leading to a decrease in foraging success by the natural-origin fish (Hillman and Mullan 1989; Steward and Bjornn 1990). Actual impacts on natural-origin fish thus depend on the degree of dietary overlap, food availability, size-related differences in prey selection, foraging tactics, and differences in microhabitat use (Steward and Bjornn 1990).

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

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

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

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

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

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

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

Critical information for analyzing competition risk is quality and quantity of spawning and rearing habitat in the action area,[23] 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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

5.3.3. Disease

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

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

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

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

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

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

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

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

Several state, federal, and tribal fish health policies, in some cases combined with state law, limit the disease risks associated with hatchery programs (IHOT 1995; ODFW 2003; USFWS 2004; NWIFC and WDFW 2006). Specifically, the policies govern the transfer of fish, eggs, carcasses, and water to prevent the spread of exotic and endemic pathogens. For example, the policy for Washington (NWIFC and WDFW 2006) divides the state into 14 Fish Health Management Zones[24] (FHMZs), and specifies requirements for transfers within and across FHMZs. Washington state law lists pathogens for which monitoring and reporting is required (regulated pathogens), and the Washington Department of Fish and Wildlife typically requires monitoring and reporting for additional pathogens. Reportable pathogen occurrence at a Washington hatchery is communicated to the state veterinarian, but also to fish health personnel at a variety of levels: local, tribal, state, and federal.

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

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

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

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

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

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

5.3.4. Ecological Modeling

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

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

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

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

5.3.5. Acclimation

One factor that can affect hatchery fish distribution and the potential to spatially overlap with natural-origin spawners, and thus the potential for genetic and ecological impacts, is the acclimation (the process of allowing fish to adjust to the environment in which they will be released) of hatchery juveniles before release. Acclimation of hatchery juveniles before release increases the probability that hatchery adults will 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 (Quinn 1997; Dunnigan 1999; YKFP 2008).

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

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

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

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

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

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

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

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

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

5.4.1. Observing

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

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

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; 2008d) that have been incorporated as terms and conditions into section 7 opinions and section 10 permits for research and enhancement. Additional monitoring principles for supplementation programs have been developed by Galbreath et al. (2008).

5.4.3. Fin clipping and tagging

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

In addition to fin clipping, two commonly available tags are available to differentially mark fish: passive integrated transponder (PIT) tags, and coded-wire tags (CWTs). PIT tags consist of small radio transponders that transmit an ID number when interrogated by a reader device.[25] CWTs are small pieces of wire that are detected magnetically and may contain codes[26] that can be read visually once the tag is excised from the fish.

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

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

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

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.

CWTs are made of magnetized, stainless-steel wire and are injected into the nasal cartilage of a salmon and thus cause little direct tissue damage (Bergman et al. 1968; Bordner et al. 1990). The conditions under which CWTs should be inserted are similar to those required for PIT tags. A major advantage to using CWTs is that they have a negligible effect on the biological condition or response of tagged salmon (Vander Haegen et al. 2005); however, if the tag is placed too deeply in the snout of a fish, it may kill the fish, reduce its growth, or damage olfactory tissue (Fletcher, Haw and Bergman 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 as a result of misidentification in status evaluations. 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:

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 2005d). In any event, fisheries must be carefully evaluated and monitored based on the take, including catch and release effects, of ESA-listed species.

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