Science, Service, Stewardship

2022 5-Year Review: Summary & Evaluation of **Snake River Fall-Run Chinook Salmon**

National Marine Fisheries Service
West Coast Region

5-Year Review: Snake River Fall-Run Chinook Salmon

Species Reviewed	Evolutionarily Significant Unit(s) or Distinct Population Segment
Chinook Salmon (*O. tshawytscha*)	*Snake River Fall-Run Chinook Salmon*

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1. General Information

1.1 Introduction

Many West Coast salmon and steelhead (*Oncorhynchus* spp.) stocks have declined substantially from their historical numbers and now are at a fraction of their historical abundance. Several factors contribute to these declines, including overfishing, loss and degradation of freshwater and estuarine habitat, hydropower development, poor ocean conditions, and hatchery practices. These factors collectively led to the National Marine Fisheries Service's (NMFS) listing of 28 salmon and steelhead stocks in California, Idaho, Oregon, and Washington under the Federal Endangered Species Act (ESA).

The ESA, under section 4(c)(2), directs the Secretary of Commerce to review the listing classification of threatened and endangered species at least once every 5 years. A 5-year review is a periodic analysis of a species' status conducted to ensure that the listing classification of a species as threatened or endangered on the List of Endangered and Threatened Wildlife and Plants (List) (50 CFR 17.11 – 17.12; 50 CFR 223.102, 224.101) is accurate (USFWS and NMFS 2006; NMFS 2020). After completing this review, the Secretary must determine if any species should be: (1) removed from the list; (2) have its status changed from endangered to threatened; or (3) have its status changed from threatened to endangered. The most recent 5-year status review for salmon and steelhead occurred in 2016 (NMFS 2016a). This document describes the results of the agency's 2022 5-year review for ESA-listed Snake River (SR) fall-run Chinook salmon.

A 5-year review is:

- A summary and analysis of available information on a given species;
- The tracking of a species' progress toward recovery;
- The recording of the deliberative process used to make a recommendation on whether or not to reclassify a species; and
- A recommendation on whether reclassification of the species is indicated.

A 5-year review is not:

- A re-listing or justification of the original (or any subsequent) listing action;
- A process that requires acceleration of ongoing or planned surveys, research, or modeling;
- A petition process; and
- A rulemaking.

1.1.1 Background on Salmonid Listing Determinations

The ESA defines species to include subspecies and distinct population segments (DPSs) of vertebrate species. A species may be listed as threatened or endangered. To identify taxonomically recognized species of Pacific salmon we apply the "Policy on Applying the Definition of Species under the ESA to Pacific Salmon" (56 FR 58612). Under this policy, we identify population groups that are "evolutionarily significant units" (ESUs) within taxonomically recognized species. We consider a group of populations to be an ESU if it is substantially reproductively isolated from other populations within the taxonomically recognized species and represents an important component in the evolutionary legacy of the species. We consider an ESU as constituting a DPS and therefore a species under the ESA.

Artificial propagation programs (hatcheries) are common throughout the range of ESA-listed West Coast salmon and steelhead. Prior to 2005, our policy was to include in the listed ESU or DPS only those hatchery fish deemed "essential for conservation" of the species. We revised that approach in response to a court decision and, on June 28, 2005, announced a final policy addressing the role of artificially propagated Pacific salmon and steelhead in listing determinations under the ESA (70 FR 37204, Hatchery Listing Policy).[1] This policy establishes criteria for including hatchery stocks in ESUs and DPSs. In addition, it: (1) provides direction for considering hatchery fish in extinction risk assessments of ESUs and DPSs; (2) requires that hatchery fish determined to be part of an ESU or DPS be included in any listing of the ESU or DPS; (3) affirms our commitment to conserving natural salmon and steelhead populations and the ecosystems upon which they depend; and (4) affirms our commitment to fulfilling trust and treaty obligations with regard to the harvest of some Pacific salmon and steelhead populations, consistent with the conservation and recovery of listed salmon ESUs and steelhead DPSs.

To determine whether a hatchery program is part of an ESU or DPS, and therefore must be included in the listing, we consider the origins of the hatchery stock, where the hatchery fish are released, and the extent to which the hatchery stock has diverged genetically from the donor stock. We include within the ESU or DPS (and therefore within the listing) hatchery fish that are derived from the population in the area where they are released and that are no more than moderately diverged from the local population.

SR fall-run Chinook salmon were first listed as threatened on April 22, 1992 (57 FR 14653). Because the revised Hatchery Listing Policy changed the way we considered hatchery fish in ESA listing determinations, we completed new status reviews and ESA listing determinations for West Coast salmon ESUs on June 28, 2005 (70 FR 37159), and for steelhead DPSs on January 5, 2006 (71 FR 834). On August 15, 2011, we published our status reviews and listing determinations for 11 ESUs of Pacific salmon and 6 DPSs of steelhead from the Pacific Northwest (76 FR 50448). On May 26, 2016, we published our status reviews and listing

[1] Policy on the Consideration of Hatchery-Origin Fish in Endangered Species Act Listing Determinations for Pacific Salmon and Steelhead.

determinations for 17 ESUs of Pacific salmon, 10 DPSs of steelhead, and the southern DPS of eulachon (*Thaleichthys pacificus*) (81 FR 33468), including reaffirming threatened status for SR fall-run Chinook salmon.

1.2 Methodology Used to Complete the Review

On October 4, 2019, we announced the initiation of 5-year reviews for 17 ESUs of salmon and 11 DPSs of steelhead in Oregon, California, Idaho, and Washington (84 FR 53117). We requested that the public submit new information on these species that has become available since our 2016 5-year reviews. In response to our request, we received information from Federal and state agencies, Native American tribes, conservation groups, fishing groups, and individuals. We considered this information, as well as information routinely collected by our agency, to complete these 5-year reviews.

To complete the reviews, we first asked scientists from our Northwest and Southwest Fisheries Science Centers to collect and analyze new information about ESU and DPS viability. To evaluate viability, our scientists used the Viable Salmonid Population (VSP) concept developed by McElhany et al. (2000). The VSP concept evaluates four criteria – abundance, productivity, spatial structure, and diversity – to assess species viability. Through the application of this concept, the Science Centers considered new information on the four population viability criteria for the salmon and steelhead species. They also considered any new information available on the composition of the ESUs and DPS. At the end of this process, the science teams prepared reports detailing the results of their analyses (Ford 2022).

To further inform the reviews, we also asked our West Coast Region salmon management biologists familiar with hatchery programs to consider new information available since the previous listing determinations. Among other things, they considered whether any hatchery programs have ended, whether new hatchery programs have started, any changes in the operation of existing programs, and scientific data relevant to the degree of divergence of hatchery fish from naturally spawning fish in the same area. Finally, we consulted salmon management biologists from the West Coast Region who are familiar with habitat conditions, hydropower operations, and harvest management. In a series of structured meetings, by geographic area, these biologists identified relevant information and provided their insights on the degree to which circumstances have changed for each listed entity.

In preparing this report for SR fall-fun Chinook salmon, we considered the best available information, including the work of the Northwest Fisheries Science Center (Ford 2022); the report of the regional biologists regarding hatchery programs; the SR fall-run Chinook salmon recovery plan (NMFS 2017); technical reports prepared in support of the recovery plan for SR fall-run Chinook salmon (e.g., appendices A and B to NMFS 2017); the listing record (including designation of critical habitat and adoption of protective regulations); recent biological opinions issued for ESA-listed Snake River basin salmon and steelhead; information submitted by the public, tribes, and government agencies; numerous recovery actions completed in the species domain; and the information and views provided by the geographically based salmon conservation partners. The present report describes the agency's findings based on consideration of all the above-mentioned information.

1.3 Background – Summary of Previous Reviews, Statutory and Regulatory Actions, and Recovery Planning

1.3.1 Federal Register Notice Announcing Initiation of this Review

84 FR 53117, October 4, 2019.

1.3.2 Listing History

In 1992, NMFS listed SR fall-run Chinook salmon as threatened under the ESA (Table 1).

Table 1. Summary of the listing history under the Endangered Species Act for SR fall-run Chinook salmon.

Salmonid Species	ESU/DPS Name	Original Listing	Revised Listing(s)
Chinook Salmon (*O. tshawytscha*)	Snake River Fall-Run Chinook Salmon	**FR Notice:** 57 FR 14653 **Date:** 4/22/1992 **Classification:** Threatened	**FR Notice:** 70 FR 37159 **Date:** 6/28/2005 **Classification:** Threatened

1.3.3 Associated Rulemakings

The ESA requires NMFS to designate critical habitat, to the maximum extent prudent and determinable, for species it lists under the ESA. Critical habitat is defined as: (1) specific areas within the geographical area occupied by the species at the time of listing, that contain physical or biological features essential to conservation, that may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by the species at the time of listing that are essential for the conservation of the species. We designated critical habitat for SR fall-run Chinook salmon in 1993 (Table 2).

Section 9 of the ESA prohibits the take of species listed as endangered. The ESA defines take to mean harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct. For threatened species, the ESA does not automatically prohibit take, but instead authorizes the agency to adopt regulations it deems necessary and advisable for species conservation and to apply the take prohibitions of Section 9(a)(1) through ESA section 4(d). In 2000, NMFS adopted 4(d) regulations for threatened salmonids that prohibit take except in specific circumstances. On July 10, 2000, we applied these 4(d) regulations to SR fall-run Chinook salmon (65 FR 42421). In 2005, we revised our 4(d) regulations for consistency between ESUs and DPSs and to take into account our Hatchery Listing Policy (70 FR 37159) (Table 2).

Table 2. Summary of rulemaking for 4(d) protective regulations and critical habitat for the SR fall-run Chinook salmon ESU**.**

Salmonid Species	ESU/DPS Name	4(d) Protective Regulations	Critical Habitat Designations
Chinook Salmon (*O. tshawytscha*)	Snake River Fall-Run Chinook Salmon	**FR Notice:** 65 FR 42421 **Date:** 7/10/2000 **Revised:** 6/28/2005 (70 FR 37159)	**FR Notice:** 58 FR 68543 **Date:** 12/28/1993

1.3.4 Review History

Table 3 lists the numerous scientific assessments of the status of SR fall-run Chinook salmon. These assessments include the viability analyses and status reviews conducted by our Northwest Fisheries Science Center and technical reports prepared in support of recovery planning for this species.

Table 3. Summary of previous technical scientific assessments for the SR fall-run Chinook salmon ESU.

Salmonid Species	ESU/DPS Name	Document Citation
Chinook Salmon (*O. tshawytscha*)	Snake River Fall-Run Chinook Salmon	Ford 2022 Appendix A of NMFS 2017 NWFSC 2015 Ford et al. 2011 ICTRT 2010 ICTRT 2007 ICTRT and Zabel 2007 Good et al. 2005 McClure et al. 2003 ICTRT 2003 NMFS 1999 Waples et al. 1991

1.3.5 Species' Recovery Priority Number at Start of 5-year Review Process

On April 30, 2019, NMFS issued new guidelines (84 FR 18243) for assigning listing and recovery priorities. Under these guidelines, we assign each species a recovery priority number ranging from 1 (high) to 11 (low). This priority number reflects the species' demographic risk (based on the listing status and species' condition in terms of its productivity, spatial distribution, diversity, abundance, and trends) and recovery potential (major threats understood, management actions exist under United States (U.S.) authority or influence to abate major threats, and certainty that actions will be effective). Additionally, if the listed species is in conflict with construction or other development projects or other forms of economic activity, then they are assigned a 'C' and are given a higher priority over those species that are not in conflict. Table 4 lists the recovery priority number for SR fall-run Chinook salmon ESU that was in effect at the time this 5-year review began (NMFS 2019a). In January 2022, NMFS issued a new biennial report with updated recovery priority numbers. The priority number for SR fall-run Chinook salmon ESU remained unchanged (NMFS 2022).

1.3.6 Recovery Plan or Outline

Table 4. Recovery Priority Number (NMFS 2019a) and Endangered Species Act Recovery Plan for the SR fall-run Chinook salmon ESU.

Salmonid Species	ESU/DPS Name	Recovery Priority Number	Recovery Plans/Outline
Chinook Salmon (*O. tshawytscha*)	Snake River Fall-Run Chinook Salmon	5C	**Title:** Recovery Plan for Snake River Fall Chinook Salmon (NMFS 2017) Available at: https://www.fisheries.noaa.gov/resource/document/recovery-plan-snake-river-fall-chinook-salmon

2. Review Analysis

In this section, we review new information to determine whether the SR fall-run Chinook salmon ESU delineation remains appropriate.

2.1 Delineation of Species under the Endangered Species Act

Is the species under review a vertebrate?

ESU/DPS Name	YES	NO
Snake River Fall-Run Chinook Salmon	X	

Is the species under review listed as an ESU/DPS?

ESU/DPS Name	YES	NO
Snake River Fall-Run Chinook Salmon	X	

Was the ESU/DPS listed prior to 1996?

ESU/DPS Name	YES	NO	Date Listed if Prior to 1996
Snake River Fall-Run Chinook Salmon	X		04/22/1992

Prior to this 5-year review, was the ESU/DPS classification reviewed to ensure it meets the 1996 DPS policy standards?

In 1991, NMFS issued a policy explaining how the agency would apply the definition of "species" in evaluating Pacific salmon stocks for listing consideration under the Endangered Species Act (ESA) (56 FR 58612). Under this policy a group of Pacific salmon populations is considered a "species" under the ESA if it represents an "evolutionarily significant unit" (ESU) which meets the two criteria of being substantially reproductively isolated from other con-specific populations, and it represents an important component in the evolutionary legacy of the biological species. The 1996 joint NMFS-Fish and Wildlife Service (FWS) "distinct population segment" (DPS) policy (61 FR 4722) affirmed that a stock (or stocks) of Pacific salmon is considered a DPS if it represents an ESU of a biological species.

2.1.1 Summary of Relevant New Information Regarding the Delineation of the Snake River Fall-run Chinook Salmon ESU

ESU Delineation

This section provides a summary of information presented in Ford 2022: *Biological viability assessment update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest.*

We found no new information since the 2016 5-year status review (NMFS 2016a) that would justify a change in the composition of the SR fall-run Chinook salmon ESU (Ford 2022).[2]

Membership of Hatchery Programs

For West Coast salmon and steelhead, many of the ESU and DPS descriptions include fish originating from specific artificial propagation programs (e.g., hatcheries) that, along with their naturally produced counterparts, are included as part of the listed species. NMFS' Hatchery Listing Policy (70 FR 37204) guides our analysis of whether individual hatchery programs should be included as part of the listed species. The Hatchery Listing Policy states that hatchery programs will be considered part of an ESU/DPS if they exhibit a level of genetic divergence relative to the local natural population(s) that is not more than what occurs within the ESU/DPS.

In preparing this report, our hatchery management biologists reviewed the best available information regarding hatchery membership of this ESU. They considered any changes in hatchery programs that occurred since the 2016 5-year status review (e.g., whether any programs have been terminated, or are new) and made recommendations about the inclusion or exclusion of specific programs. They also noted any errors and omissions in the existing descriptions of hatchery program membership. NMFS intends to address any needed changes and corrections via separate rulemaking subsequent to the completion of the 5-year review process and prior to any official change in hatchery membership.

In the 2016 5-year status review (NMFS 2016a), the extant SR fall-run Chinook salmon ESU was defined as including naturally spawned fall-run Chinook salmon originating from the mainstem Snake River below Hells Canyon Dam and from the Tucannon River, Grande Ronde River, Imnaha River, Salmon River, and Clearwater River subbasins. Also included were fall-run Chinook salmon from four artificial propagation programs: the Lyons Ferry Hatchery Program, the Fall Chinook Acclimation Ponds Program, the Nez Perce Tribal Hatchery Program, and the Oxbow Hatchery Program (70 FR 37159). Since 2016, we changed the name of the Oxbow Hatchery Program to the Idaho Power Program (85 FR 81822).

[2] Since the 2016 review of SR fall-run Chinook salmon was both a 5-year review and a status review (i.e., response to a delisting petition), we refer to it in this document as the "2016 5-year status review."

The addition or removal of an artificial propagation program from an ESU does not necessarily affect the listing status of the ESU, but rather is a revision to the ESU's composition to reflect the best available scientific information as considered under our Hatchery Listing Policy. Addition of an artificial propagation program to an ESU represents our determination that the artificially propagated stock is no more divergent relative to the local natural population(s) than what would be expected between closely related natural populations within the ESU (70 FR 37204). We relied on the Hatchery Listing Policy in our 2020 Final Rule on Revisions to Hatchery Programs as Part of Pacific Salmon and Steelhead Species Listed under the Endangered Species Act (85 FR 81822).

2.2 Recovery Criteria

The ESA requires that recovery plans be developed for each listed species unless the Secretary finds a recovery plan would not promote the conservation of the species. Recovery plans must contain, to the maximum extent practicable, objective measurable criteria for delisting the species, site-specific management actions necessary to recover the species, and time and cost estimates for implementing the recovery plans.

Evaluating a species for potential changes in ESA listing requires an explicit analysis of population or demographic parameters (the biological criteria) and also of threats under the five ESA listing factors in ESA section 4(a)(1) (listing factor [threats] criteria). Together these make up the objective, measurable criteria‖ required under section 4(f)(1)(B).

For Pacific salmon, Technical Recovery Teams (TRTs), appointed by NMFS, define criteria to assess biological viability for each listed species. NMFS develops criteria to assess progress toward alleviating the relevant threats (listing factor criteria).

NMFS adopts the TRT's viability criteria as the biological criteria for a recovery plan, based on best available scientific information and other considerations as appropriate. For the Snake River Fall Chinook Salmon Recovery Plan (NMFS 2017), NMFS adopted the viability criteria metrics defined by the Interior Columbia Technical Recovery Team (ICTRT 2007) as the biological recovery criteria for the threatened Snake River fall Chinook salmon ESU.

As the recovery plan is implemented, additional information becomes available along with new scientific analyses that can increase certainty about whether the threats have been abated, whether improvements in population biological viability have occurred for fall Chinook salmon, and whether linkages between threats and changes in salmon biological viability are understood. NMFS assesses these biological recovery criteria and the delisting criteria through the adaptive management program for the plan during the ESA 5-Year Review (USFWS and NMFS 2006; NMFS 2020).

2.2.1 Does the Species Have a Final, Approved Recovery Plan Containing Objective, Measurable Criteria?

ESU/DPS Name	YES	NO
Snake River Fall-Run Chinook Salmon	X	

2.2.2 Adequacy of Recovery Criteria

Based on new information considered during this review, are the recovery criteria still appropriate?

ESU/DPS Name	YES	NO
Snake River Fall-Run Chinook Salmon	X	

Are all of the listing factors that are relevant to the species addressed in the recovery criteria?

ESU/DPS Name	YES	NO
Snake River Fall-Run Chinook Salmon	X	

2.2.3 List the Biological Recovery Criteria as They Appear in the Recovery Plans

NMFS adopted the ESA Recovery Plan for Snake River Fall Chinook Salmon in November 2017 (NMFS 2017).

For the purposes of reproduction, salmon and steelhead typically exhibit a metapopulation structure (McElhany et al. 2000; Schtickzelle and Quinn 2007). Rather than interbreeding as one large aggregation, ESUs and DPSs function as a group of demographically independent populations separated by areas of unsuitable spawning habitat. For conservation and management purposes, it is important to identify the independent populations that make up an ESU or DPS.

McElhany et al. (2000) defined an independent population as: "a group of fish of the same species that spawns in a particular lake or stream (or portion thereof) at a particular season and which, to a substantial degree, does not interbreed with fish from any other group spawning in a different place or in the same place at a different season". For our purposes, not interbreeding to a "substantial degree" means that two groups are considered to be independent populations if they are isolated to such an extent that exchanges of individuals among the populations do not substantially affect the population dynamics or extinction risk of the independent populations over a 100-year time frame (McElhany et al. 2000). Independent populations exhibit different population attributes that influence their abundance, productivity, spatial structure and diversity. Independent populations are the units that are combined to form alternative recovery scenarios for multiple similar population groupings and ESU viability.

The viable salmonid population (VSP) concept (McElhany et al. 2000) is based on the biological parameters of abundance, productivity, spatial structure, and diversity for an independent salmonid population to have a negligible risk of extinction over a 100-year time frame. The VSP concept identifies the attributes, provides guidance for determining the conservation status of populations and larger-scale groupings of Pacific salmonids, and describes a general framework for how many and which populations within an ESU/DPS should be at a particular status for the ESU/DPS to have an acceptably low risk of extinction. The ICTRT (2007) developed combined VSP criteria metrics that describe the probability of population extinction risk in 100 years (Figure 1). NMFS color coded the risk assessment to assist readers to more easily distinguish the various risk categories.

		VSP Criteria Metrics			
		Spatial Structure/Diversity Risk			
		Very Low	Low	Moderate	High
Abundance/ Productivity Risk	Very Low (<1%)	Very Low Risk (Highly Viable)	Very Low Risk (Highly Viable)	Low Risk (Viable)	Moderate Risk
	Low (<5%)	Low Risk (Viable)	Low Risk (Viable)	Low Risk (Viable)	Moderate Risk
	Moderate (<25%)	Moderate Risk	Moderate Risk	Moderate Risk	High Risk
	High (>25%)	High Risk	High Risk	High Risk	High Risk

Figure 1. Viable Salmonid Population (VSP) Criteria Metrics.

For the purposes of recovery planning and development of biological recovery criteria, the Interior Columbia Technical Recovery Team (ICTRT) identified independent populations for each ESA-listed salmon and steelhead species in the interior Columbia River basin and then grouped them together into genetically similar major population groups (MPGs) (ICTRT 2003). These independent populations are the units that are combined to form alternative recovery scenarios for multiple population groupings and ESUs.

The ICTRT also developed species biological viability criteria for applications at the ESU/DPS, MPG and independent population scales (ICTRT 2007). The viability criteria are based on the VSP concept described above. Recovery scenarios outlined in the ICTRT viability criteria report (ICTRT 2007) are targeted to achieve, at a minimum, the ICTRT's biological viability criteria for each major population grouping. Accordingly, the criteria are designed "[t]o have all major population groups at viable (low risk) status with representation of all the major life history strategies present historically, and with the abundance, productivity, spatial structure, and diversity attributes required for long-term persistence."

The SR fall-run Chinook salmon ESU includes all natural-origin fall-run Chinook salmon originating from the mainstem Snake River below Hells Canyon Dam and from the Tucannon River, Grande Ronde River, Imnaha River, Salmon River, and Clearwater River subbasins. It also includes fall-run Chinook salmon from the following artificial propagation programs: The Lyons Ferry Hatchery Program; Fall Chinook Acclimation Ponds Program; Nez Perce Tribal Hatchery Program; and the Idaho Power Program (70 FR 37159; 85 FR 81822).

There is only one MPG in the ESU, and only one extant population: the Lower Snake River population (Figure 1). Historically, fall Chinook salmon also spawned in the middle mainstem Snake River and its tributaries, upstream from the current site of Hells Canyon Dam (ICTRT 2005, 2010). In 2005, the ICTRT identified three historical populations within the single SR fall-run Chinook salmon MPG: the extant Lower Snake River population and two extirpated populations (Marsing Reach and Salmon Falls), which spawned above the current site of Hells Canyon Dam (ICTRT 2005). Based on information submitted to NMFS by the U.S. Fish and Wildlife Service (Connor et al. 2015) as part of the 2016 5-year status review, NMFS determined that the two spawning aggregations above the current Hells Canyon Dam were more likely part of a single population – the Middle Mainstem Snake River population (NWFSC 2015; NMFS 2016a, 2017).

The area upstream of Hells Canyon supported the majority of SR fall-run Chinook salmon production until it became inaccessible due to dam construction. Construction of Swan Falls Dam in 1901 blocked access to 157 miles of historically productive fall Chinook salmon habitat in the middle Snake River downstream of Shoshone Falls, a natural barrier to upstream migration. Construction of the three-dam Hells Canyon Complex, completed in 1967, blocked access to the remaining spawning areas in the middle mainstem reach. The loss of this upstream habitat, habitat loss in lower segments of the larger tributaries, and inundation of spawning areas in the lower mainstem Snake River by reservoirs associated with the four lower Snake River dams has reduced spawning habitat for SR fall-run Chinook salmon to approximately 20 percent of the habitat that was historically available (NMFS 2017).

A basic application of the ICTRT's recommended viability criteria (ICTRT 2007) would require two populations to meet criteria for high viability for the SR fall-run Chinook salmon ESU to be at low risk of extinction. This would require achieving highly viable status for the extant population and re-establishing the extirpated population above Hells Canyon to highly viable status. The ICTRT recognized that there were significant difficulties in reestablishing fall Chinook salmon above the Hells Canyon Complex and recommended that initial efforts be focused on recovery of the extant population while creating the potential for re-establishing an additional population. The ICTRT also acknowledged that a recovery scenario that differs from the basic approach might be appropriate in cases where "well documented and justified circumstances exist," and noted that "different scenarios of ESU recovery may reflect alternative combinations of viable populations and specific policy choices regarding acceptable levels of risk" (ICTRT 2007).

Consistent with the ICTRT's line of reasoning, the recovery plan contains three recovery scenarios, each consistent with the basic set of viability objectives developed by the ICTRT and each representing a potential pathway to achieving low risk for the ESU. Scenario A would achieve ESU viability with two populations, while Scenarios B and C describe alternative approaches for achieving viability with the single extant Lower Snake River population. Each scenario includes specific criteria and potential metrics for measuring viability characteristics (NMFS 2017). The scenarios are summarized briefly below:

- ***Scenario A – two populations, one highly viable and the other viable***: This scenario would achieve ESU viability by improving the extant Lower Snake River population to highly viable status and reestablishing the extirpated Middle Snake River population above the Hells Canyon Dam Complex to viable status. It reflects a simple, modified application of the ICTRT's general MPG-level viability criteria (which would require that both historical populations achieve highly viable status). NMFS determined that this variation on the ICTRTs general criteria was appropriate given the spatial and life-history diversity of the extant Lower Snake River population and in recognition of the complexities involved in reestablishing the extirpated Middle Snake River population.

- ***Scenario B – single population measured in the aggregate*****:** Scenario B is based on an alternative application of the ICTRT's criteria. It would achieve ESU viability by improving the status of the extant Lower Snake River population to highly viable with a high degree of certainty. VSP characteristics would be evaluated in the aggregate (i.e., population-wide), across all natural-origin adult spawners. The requirement for a high degree of certainty that the population is highly viable would reduce the inherent increased risk associated with a single-population ESU. The spatial complexity and associated ability to support life history diversity of the Lower Snake River population provide opportunities to achieve the basic ICTRT viability objectives for protection against demographic and catastrophic risk and to provide for expression of diversity and within-population adaptation to environmental variation.

- ***Scenario C – single population with natural production emphasis areas*****:** Like Scenario B, Scenario C would achieve ESU viability by achieving high confidence of highly viable status for the Lower Snake River population. In this scenario, however, rather than evaluating population status in the aggregate, as under Scenario B, population status would be evaluated based on having a substantial amount of natural production for the ESU come from one or two of the five major spawning areas. These Natural Production Emphasis Areas (NPEAs) would be managed to have a low percentage of hatchery-origin spawners and to support significant levels of natural-origin spawners (other major spawning areas could have higher acceptable levels of hatchery-origin spawners). The NPEAs would make it possible to directly evaluate the productivity of the natural population and ensure that a substantial proportion of the population is subject to natural selection rather than hatchery processes.

The recovery plan (NMFS 2017) includes potential criteria and metrics for measuring viability characteristics relative to each of the potential recovery scenarios. It also notes that each scenario has attendant uncertainties and tradeoffs. Under Scenario A, there are uncertainties related to the feasibility of reestablishing a viable population above the Hells Canyon Complex, and the scenario would take many decades to achieve. Under Scenario B, hatchery production would need to be significantly reduced to make it possible to determine the underlying productivity of the population, and this would affect the ability to meet Tribal treaty and trust obligations regarding harvest and hatchery mitigation goals. Under Scenario C, hatchery production could be maintained, and recovery could be achieved in a shorter timeframe than under Scenario A, but there are uncertainties regarding whether dispersal rates of hatchery-origin spawners will be low enough to allow natural selective processes to dominate in the NPEAs, whether we can identify methods and metrics to evaluate natural production in the NPEAs, and what the effect on natural production will be of reducing hatchery-origin spawners. Because available information indicates that it is reasonable to pursue Scenario C and because it provides the fastest potential route to ESA recovery and allows for meeting hatchery mitigation goals, NMFS noted in the recovery plan that it considers Scenario C the most likely pathway to ESA recovery (NMFS 2017).

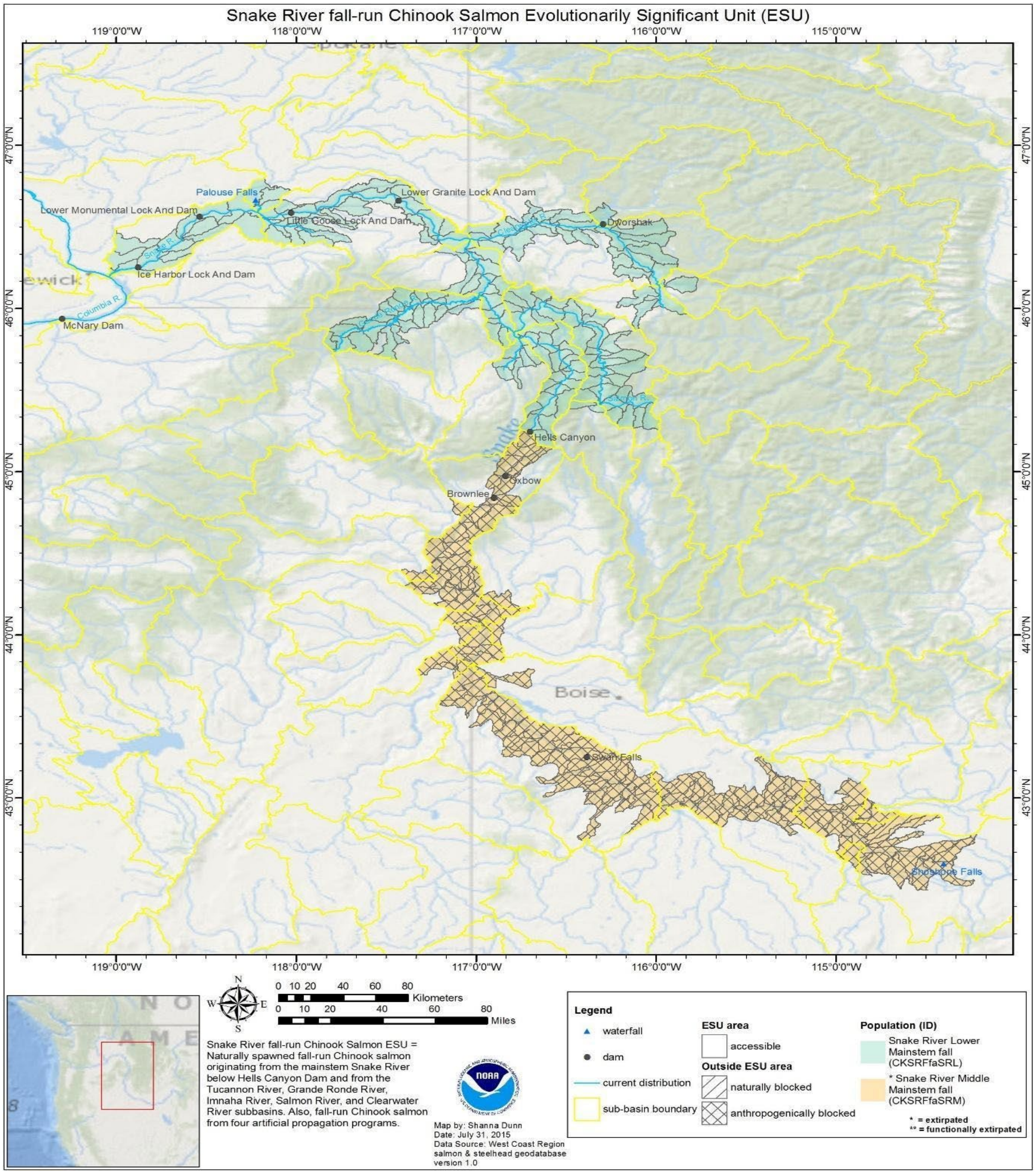

Figure 2. Snake River Fall-Run Chinook Salmon ESU population structure.[3]

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[3] The map above generally shows the accessible and historically accessible areas for Snake River fall-run Chinook salmon. The area displayed is consistent with the regulatory description of the range of the Snake River fall-run Chinook salmon ESU found at 50 CFR17.11, 223.102, and 224.102. Actions outside the areas shown can affect this ESU. Therefore, these areas do not delimit the entire area that could warrant consideration in recovery planning or determining if an action may affect this ESU for the purposes of the ESA.

2.3 Updated Information and Current Species' Status

Information provided in this section is summarized from the Northwest Fisheries Science Center's Biological Viability Assessment Update for Pacific Salmon and Steelhead Listed under the Endangered Species Act: Pacific Northwest (Ford 2022).

2.3.1 Analysis of Viable Salmonid Population (VSP) Status

Updated Biological Risk Summary

The overall current risk rating for the extant Lower Mainstem Snake River fall Chinook salmon population is viable (i.e., low risk). This risk rating is based on a low risk rating for abundance/productivity and a moderate risk rating for spatial structure/diversity (Ford 2022) and remains unchanged from the 2016 5-year status review. All three potential delisting scenarios in the recovery plan would require the extant population to meet requirements for highly viable status, or very low risk (NMFS 2017). The two-population scenario (Scenario A) would require at least a 50 percent certainty that the Lower Mainstem Snake River population is highly viable (and the same level of certainty that a re-established Middle Snake River population was viable). The two single-population scenarios (Scenarios B and C) would require at least an 80 percent certainty that the extant Lower Mainstem Snake River population is highly viable. All three scenarios would also require at least a low risk rating for spatial structure/diversity (NWFSC 2015; NMFS 2017).

Abundance/Productivity: Supplementation and other measures since listing led to large increases in natural-origin returns, and in 2013, adult spawner abundance reached over 20,000 fish. From 2012 to 2015, natural-origin returns were over 10,000 adults per year. Since 2016, spawner abundance has declined. This decline is evidenced in a 36 percent decrease in abundance between the two most recent 5-year geomeans: 2010 to 2014 (11,254 natural-origin adults) and 2015 to 2019 (7,252 natural-origin adults). While the population has not maintained the higher returns it achieved in 2010 and 2013 to 2015, it has maintained abundance at or above the ICTRT-defined minimum abundance threshold (3,000) during climate challenges in the ocean and rivers. In addition, the 10-year trend, across more than one brood cycle, shows an increase. The 10-year geometric mean for the years 2010 to 2019 (9,034 natural-origin adults) is higher than for the years 2005 to 2014 (6,418 natural-origin adults). The 15-year trend has also remained above the minimum abundance threshold, despite climate challenges (Ford 2022).

Productivity, as seen in brood-year returns per spawner, has been below replacement (i.e., below a 1:1 spawner: spawner ratio) in recent years, and a longer-term, 20-year geometric mean intrinsic productivity for brood years 1995 through 2014 (returns through 2019) is 0.63 (Ford 2022). This most recent 20-year geometric mean intrinsic productivity, however, is not directly comparable to the value of 1.5 reported for the years 1990 to 2009 in the 2016 5-year status review (NWFSC 2015; NMFS 2016a).

Productivity is defined in the ICTRT viability criteria report as the expected replacement rate at low to moderate abundance relative to a population's minimum abundance threshold, and is a key measure of the potential resilience of a natural population to annual environmentally driven fluctuations in survival (ICTRT 2007). Under a simple method proposed by the ICTRT, productivity is measured as the geometric mean of the annual spawner-to-spawner natural return rate estimated at low to moderate parental spawner abundance within the most recent 20 years. Because the productivity criterion is intended to evaluate resiliency at low abundance, the ICTRT recommended that only recruits per spawner (R/S) values for years where the number of spawners is below 2,250 (i.e., 75 percent of the minimum abundance threshold of 3,000) be used in calculating the geometric mean. The geometric mean intrinsic productivity for the years 1990 to 2009 (as reported in the 2016 5-year status review) was based on only 5 data points (i.e., there were only 5 years when returning spawners numbered less than 75 percent of the minimum abundance threshold) (Appendix A of NMFS 2017). However, for the 20-year geometric mean intrinsic productivity of 0.63 reported here, returns have been above the minimum abundance threshold in every year. Under the ICTRT methods, all these years would have been excluded (since all were >75 percent of the MAT), so this is an underestimate of intrinsic productivity. In accordance with the ICTRT methods, survival at all life stages is accounted for by calculating productivity at the spawning ground, which includes ocean, downstream and upstream passage, and freshwater survivals.

The ICTRT noted that alternatives to simple average return per spawner metrics might be needed to estimate intrinsic productivity if parent escapement levels consistently exceed minimum abundance targets (ICTRT 2007). Since that has been the case, it may be important to explore alternative methods to estimate intrinsic productivity, including those suggested by the ICTRT, and to develop metrics that account for harvest and hatchery operations.

Metrics identified in the recovery plan for Scenario B call for a most recent 10-year geometric mean abundance > 4,200 natural-origin spawners and a most recent 20-year geometric mean intrinsic productivity > 1.7. For Scenario C, population-level abundance metrics would need to be higher than under Scenario B to accommodate meeting the NPEA requirements. (The recovery plan notes that metrics will vary depending on the proportion of natural production coming from NPEAs and the level of hatchery influence remaining in the NPEAs.) Population-level productivity metrics for Scenario B would also apply to Scenario A: most recent 20-year geometric mean intrinsic productivity > 1.7 (NMFS 2017).

The most recent 10-year geometric mean natural-origin abundance, as in the 2016 5-year status review, exceeds the metric identified in the recovery plan; however, the associated 20-year productivity estimate of 0.63 is below the recovery plan metric of 1.7. The current low risk rating for abundance/productivity continues to reflect uncertainty about whether recent increases in abundance can be sustained over the long term, as well as recent evidence for density dependence within the available spawning habitat (Ford 2022).

Spatial Structure and Diversity: Annual redd surveys show that SR fall Chinook salmon spawning occurs in all five of the historical MaSAs. The fraction of natural-origin fish on the spawning grounds has remained relatively stable for the last 10 years, with 5-year means of 31 percent (2010 to 2014) and 33 percent (2015 to 2019) (Ford 2022).

To achieve highly viable status with a high degree of certainty, the recovery plan also calls for the spatial structure/diversity rating to be low risk. Spatial structure and diversity were evaluated for this 5-year review using the ICTRT framework organized around two main goals: maintaining natural patterns for spatially mediated processes and maintaining natural levels of variation. The Lower Mainstem Snake River fall Chinook salmon population was rated at low risk for the first goal and at moderate risk for the second, resulting in an overall rating of moderate risk for spatial structure/diversity. In particular, the rating reflects the relatively high proportion of within-population hatchery spawners (70 percent) in all major spawning areas (Ford 2022).

ESU Summary: The Lower Mainstem Snake River fall Chinook salmon population is the only extant population in an ESU that historically also included a population upstream of the current location of the Hells Canyon Dam Complex. The status of this extant population has clearly improved since the time of listing. The extant population is currently meeting the criteria for “viable,” as developed by the ICTRT, but the ESU as a whole is not meeting the recovery goals described in the recovery plan, which require the single population to be “highly viable with high certainty” and/or will require reintroduction of a viable population above the Hells Canyon Dam complex (NMFS 2017; Ford 2022).

The rating of viable is based on ratings of low risk for abundance/productivity and moderate risk for spatial structure/diversity, as summarized above. The rating reflects ongoing uncertainty regarding the population’s productivity, and whether recent increases in natural-origin abundance can be sustained over the long term. It also reflects concerns with the high levels of hatchery-origin spawners in natural spawning areas (Ford 2022).

2.3.2 ESA Listing Factor Analysis

Section 4(a)(1) of the ESA directs us to determine whether any species is threatened or endangered because of any of the following factors: (A) the present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; or (E) other natural or man-made factors affecting its continued existence. Section 4(b)(1)(A) requires us to make listing determinations after conducting a review of the status of the species and taking into account efforts to protect such species. Below we discuss new information relating to each of the five factors as well as efforts being made to protect the species.

Listing Factor A: Present or Threatened Destruction, Modification, or Curtailment of its Habitat or Range

Significant actions have been implemented to improve the degraded mainstem and tributary habitat conditions and fish passage issues described in the SR fall-run Chinook salmon recovery plan (NMFS 2017). SR fall-run Chinook salmon spawn primarily in the mainstem Snake River, and the suite of actions implemented since listing that affects this mainstem habitat are believed to have contributed to the improved status of this species. Tributary habitat limiting factors are less well understood, and the focus of the discussion below is on the mainstem areas that provide the primary spawning and rearing, as well as migratory, habitats for this ESU.

Current Status and Trends in Habitat

Below, we summarize information on the **current status and trends in habitat** conditions for SR fall-run Chinook salmon since our 2016 5-year status review. We specifically address:

> **(1)** the **key emergent or ongoing habitat concerns** (threats or limiting factors) focusing on the top concerns that potentially have the biggest impact on independent population viability;
>
> **(2)** the **population-specific geographic areas** (e.g., independent population major/minor spawning areas) where key emergent or ongoing concerns about this habitat condition remain;
>
> **(3) population-specific key protective measures and major restoration actions taken since the 2016 5-year status review** toward achieving the recovery plan viability criteria established by the ICTRT (2007) and adopted by NMFS in the ESA Recovery Plan for Snake River Fall Chinook Salmon (NMFS 2017) as efforts that substantially address a key concern noted in **above #1 and # 2**, or, that represent a noteworthy conservation strategy;
>
> **(4) key regulatory measures that are either adequate, or, inadequate** and contributing substantially to the key concerns summarized above; and
>
> **(5) recommended future recovery actions over the next 5 years toward achieving population viability**, including: key near-term restoration actions that would address the key concerns summarized above; projects to address monitoring and research gaps; fixes or initiatives to address inadequate regulatory mechanisms, and addressing priority habitat areas when sequencing priority habitat restoration actions.

SR fall-run Chinook salmon are primarily mainstem, rather than tributary, spawners. Most spawn in the mainstem reach of the Snake River from below Hells Canyon Dam to the mouth of the Salmon River (RM 247 to RM 188). River flow and volume in this reach are dominated by the outflow of the Hells Canyon Dam Complex. Some additional spawning takes place in the lower mainstem reaches of the Clearwater River (and lower reaches of tributaries to the Clearwater), the lower reaches of the Grande Ronde River (and some of its tributaries), and in the lower

Tucannon, Imnaha, and Salmon Rivers (NMFS 2017).[4] This discussion of listing factor A therefore focuses on the mainstem spawning and rearing reach, the mainstem migratory corridor, and, to a lesser extent, on the lower reaches of the tributaries used by SR fall-run Chinook salmon. The Columbia River estuary also provides important habitat where juvenile SR fall-run Chinook salmon feed and complete the process of acclimating to salt water while avoiding predators. Habitat conditions and improvement efforts in the estuary are described in more detail below, under Listing Factor E.

1) Population-Specific Key Emergent or Ongoing Habitat Concerns Since the 2016 5-Year Status Review

For the single extant Lower Mainstem Snake River population that comprises the single MPG of the SR fall-run Chinook Salmon ESU, the primary habitat concerns continue to be those identified in the recovery plan (NMFS 2017):

Habitat Loss Due to Hydropower Dams

SR fall-run Chinook salmon spawning habitat is limited to approximately 20 percent of the area available historically. The majority of SR fall-run Chinook salmon spawned historically in the middle mainstem Snake River, upstream of the site of Hells Canyon Dam and below Shoshone Falls (a natural barrier to upstream migration). Construction of Swan Falls Dam in 1901 blocked access to 157 miles of habitat in the middle mainstem Snake River, and construction of the three-dam Hells Canyon Complex, completed in 1967, blocked access to remaining spawning areas in the middle mainstem reach. As a result, one of the two historical populations (the Middle Mainstem population) was extirpated (NMFS 2017).

Some spawning and rearing habitat in the lower mainstem Snake River, where the single extant population spawns, has also been lost. Impoundment from Lower Granite Dam eliminated 6.2 miles of mainstem spawning and rearing habitat. Some additional spawning and rearing habitat was also inundated by the contiguous reservoirs formed by Little Goose, Lower Monumental, and Ice Harbor Dams (NMFS 2017).

Operational Effects of the Hells Canyon Dam Complex

In addition to blocking major portions of historical spawning habitat, operation of the Hells Canyon Dam Complex has downstream effects on spawning habitat in the lower mainstem Snake River, the primary spawning area for the extant Lower Snake River population. These effects include: (1) exposure to low dissolved oxygen levels in the late summer and early fall in the reach immediately downstream of Hells Canyon Dam, which could negatively affect adult

[4] Starting in 2018, the release site for 1 million juvenile hatchery fish was moved from the upper Hells Canyon reach to the lower Salmon River (consistent with a recovery action to reduce the proportion of hatchery-origin fish in the Hells Canyon reach). The initial indication (based on 2-salt spawners returning in 2020) is that adults from these releases are successfully spawning in the lower Salmon River (Brink 2021). While it is too early to tell if the juveniles from the Salmon River will successfully return to spawn, these early results are encouraging, and the proportion of fish spawning in the Salmon River is likely to increase.

migrants and gamete viability in the reach immediately downstream of Hells Canyon Dam; (2) elevated TDG levels in winter and spring, which could cause gas bubble disease in juveniles; (3) altered flows (on a seasonal, daily, and hourly basis), which could result in altered migration patterns and juvenile fish stranding; and (4) entrapment of sediment, which could result in reduced turbidity, higher predation, and diminished amount and quality of juvenile rearing habitat, especially in the reach between Hells Canyon Dam and the mouth of the Salmon River (NMFS 2017).

Operational Effects of the Mainstem Lower Snake and Columbia River Dams

Both adult and juvenile SR fall-run Chinook salmon are subject to passage effects at mainstem Lower Snake and Columbia River dams. For adults, these effects include reduced survival during migration, migration delay as fish search for fishway entrances and navigate through fishways, and fallback (i.e., adult fish that fall back over a dam once they have passed it). For juveniles, effects include delayed downstream passage and increased direct and indirect mortality compared to a free-flowing river reach (NMFS 2017).

Mainstem Temperatures

The thermal regime in the mainstem spawning reach is likely more productive for fall Chinook salmon today than it was historically, as a result of the moderating effects of the Hells Canyon Complex. In addition, the U.S. Army Corps of Engineers draws cooler water from Dworshak Reservoir, on the North Fork Clearwater River, during summer months to cool water in the lower mainstem Snake River. However, water temperatures in this reach are higher than they were historically. While there is uncertainty regarding the effects of this increase on both adult and juvenile fall Chinook salmon (NMFS 2017), it is a concern, particularly in the face of ongoing climate change, since continued rising mainstem temperatures could diminish the mitigating effects of Hells Canyon Complex and Dworshak water management.

Tributary Habitat Degradation

Limiting factors for SR fall-run Chinook salmon in tributary spawning and rearing areas are less well understood than those in mainstem areas. Potential impairments include loss of side channel habitats, excess sediment, degraded riparian conditions, low summer flows, high water temperatures, and other water quality impairments (NMFS 2017). The 2016 5-year status review also noted that with the large increases in numbers of fall Chinook salmon seen prior to that review, adults appeared to be expanding upstream in the larger rivers (Selway, Lochsa, and South Fork Clearwater Rivers) and into some of the lower reaches of tributaries to those rivers, such as the Potlatch River and Lapwai Creek. Habitat conditions for fall Chinook salmon are marginal in many of these expansion areas due to reduced stream flows from water withdrawals and alteration of channels and floodplains to accommodate developments (NMFS 2016a). In addition, with the relocation of hatchery juvenile releases from the upper Hells Canyon reach to the lower Salmon River, numbers of fish spawning in the lower Salmon River will likely increase.

2) Population-Specific Geographic Areas of Concern Since the 2016 5-Year Status Review

There are no additional population-specific geographic areas of concern identified beyond the areas enumerated above under key emergent and ongoing habitat concerns.

3) Population-Specific Key Protective Measures and Major Restoration Actions Taken Since the 2016 5-Year Status Review

Continuation of Ongoing Priority Actions

The foundation of the recovery strategy for SR fall-run Chinook salmon is to continue ongoing recovery actions that have contributed to the large improvements in abundance since listing (NMFS 2017). The 2016 5-year status review (NMFS 2016a) highlighted the importance of continuing the following four key habitat-related recovery actions:

- *Implementation of Idaho Power Company's SR fall Chinook salmon spawning program to enhance and maintain suitable spawning and incubation conditions.*

  The Idaho Power Company, which operates the Hells Canyon Complex, has continued the operations it began in 1991 to provide stable flows for spawning fall Chinook salmon from mid-October to early December, minimum flows through the winter and early spring to protect incubating eggs and emerging fry, and measures to reduce entrapment (NMFS 2017).

- *Implementation of the Columbia River System biological opinions, including hydrosystem operations such as cool-water releases from Dworshak Dam; summer flow augmentation and summer spill at multiple projects; and operations at Lower Granite Dam to address adult passage delays caused by warm surface waters entering the fish ladders.*

  Implementation of the 2008 FCRPS biological opinion (and its 2010 and 2014 supplemental biological opinions) continued through March 29, 2019, when NMFS issued a new biological opinion for operation of the Columbia River System (CRS, formerly referred to as the FCRPS) (NMFS 2008a, 2010, 2014a, 2019b). On July 31, 2020, NMFS issued another CRS biological opinion (NMFS 2020), this one on the preferred alternative in the Columbia River System Operations final environmental impact statement issued by the U.S. Army Corps of Engineers, Bonneville Power Administration, and Bureau of Reclamation on the same date (NMFS 2020).

  The 2019 and 2020 biological opinions continued, for the most part, the suite of actions from the 2008 biological opinion, including:

  - Cool water releases at Dworshak Dam in August to help keep temperatures at the Lower Granite Dam tailrace monitoring site below 68°F, which helps to maintain adequate SR fall-run Chinook migration and rearing conditions in the lower Snake River;

  - Operating storage projects (Libby, Hungry Horse, Grand Coulee, and Dworshak Dams) to provide sufficient water to meet spring and summer flow objectives, when water supply permits. In particular, refilling Dworshak Reservoir by about June 30 and then drafting Dworshak to its September 30 elevation target supports summer flow augmentation for juvenile SR fall-run Chinook salmon migration;
  - Operations at Lower Granite Dam to address adult passage delays caused by warm surface waters entering the fish ladders (see below).

  In addition, the 2019 and 2020 biological opinions implemented a new spill operation involving a flexible approach to providing additional spring spill. This spill regime is intended to improve the survival of spring-migrating juvenile salmon and steelhead, while also addressing Action Agency objectives for power generation and transmission and recognizing operational constraints in the hydrosystem (NMFS 2019b, 2020).

  The flexible spring spill operation will potentially increase survival of juvenile SR fall-run Chinook salmon. Juvenile SR fall-run Chinook salmon migrating during enhanced spring spill (i.e., between April 10 and June 21) should see reduced travel times and improved survival as a result of more fish migrating through spillways (versus bypass systems); those migrating after June 21 will not see this benefit. These potential survival improvements would affect both yearlings (mostly Clearwater-reared fish) and subyearlings (mostly Snake River-reared fish). The effects of the higher spill levels are not expected to benefit adult SR fall-run Chinook salmon, since their migration timing does not overlap with the higher spill levels. To the extent that latent mortality might be improved by reduced powerhouse passage as a result of increased spring spill, there is potential for additional increased productivity of SR fall-run Chinook salmon (NMFS 2020). We are unable to predict the scale of these benefits at this time.

- *Implementation of Lower Snake River Programmatic Sediment Management Plan (PSMP) measures to reduce impacts of reservoir and river channel dredging and disposal on SR fall-run Chinook salmon.*

  The U.S. Army Corps of Engineers maintains a navigation channel to enable barges and other large vessels to travel upstream in the Snake River from Ice Harbor Dam to Lewiston, Idaho. The navigation channel affects SR fall-run Chinook salmon through the effects of barges and the dredging needed to maintain the channel. The PSMP was developed to guide sediment management for this navigation channel, and in 2014, NMFS signed a biological opinion on the PSMP. The proposed action included specific actions to protect SR fall-run Chinook salmon – for example, requirements to conduct underwater surveys for redds and implement appropriate protective measures before dredging and to use dredged material to construct shallow water habitat for out-migrating juvenile fall Chinook salmon. The opinion evaluated the effects of the PSMP on SR fall-run Chinook salmon, including effects of suspended sediment, contaminants, dredging equipment, and sediment disposal and effects to SR fall-run Chinook salmon behavior patterns, habitat, and food (NMFS 2014b).

- *Implementation of recovery plan actions in tributary lower mainstem habitats to maintain and improve spawning and rearing potential for SR fall-run Chinook salmon.*

  Numerous tributary habitat protection and restoration efforts have been implemented in recent years through the combined efforts of local recovery planning groups, Federal and state agencies, Tribal governments, local governments, conservation groups, private landowners, and other entities. While these actions have focused primarily on upstream segments of basins used by spawning and rearing spring/summer Chinook salmon and steelhead, some small, incremental benefit (e.g., improved flows, reduced sediment, etc.) from these actions would be expected to translate to the lower river reaches of the Tucannon, Grande Ronde, and Clearwater Rivers, which are three of the five major spawning areas used by SR fall-run Chinook salmon (NMFS 2017, 2020). Degraded tributary habitat conditions likely continue to negatively affect SR fall-run Chinook salmon to some extent. While mainstem Snake River reaches contain most of the current and potential spawning habitat for the extant SR fall-run Chinook salmon population, some opportunities exist to expand natural production in the tributary spawning areas used by the population (NMFS 2017, 2020).

Implementation of Recovery Actions Identified in 2016 5-Year Status Review

A second fundamental component of the recovery strategy for SR fall-run Chinook salmon is to strategically identify additional recovery actions that would contribute to improvements for the ESU. The 2016 5-year status review (NMFS 2016a) recommended implementation of the following 10 habitat-related actions:[5]

- *Installation of fish ladder cooling systems at Lower Granite and Little Goose Dams to reduce adult migration delay caused by high water temperatures and excessive ladder temperature differentials in summer months.*

  In June 2013, elevated water temperatures (>68°F) began to occur in Columbia and Snake river mainstem reaches due to relatively low flows and unusually hot weather. At the Lower Granite Dam fish ladder, longer-duration elevated water temperatures began to form a thermal barrier to upstream migrating salmon and steelhead, slowing adult fish migration upstream. In response, the U.S. Army Corps of Engineers developed an interim solution to the thermal barrier in 2014 through 2015, and installed permanent cooling systems at Lower Granite Dam in 2016 and at Little Goose Dam in 2017.

[5] While not all of these actions are strictly habitat-related, we have grouped them together to maintain consistency with the recommended future actions identified under Listing Factor A in the 2016 5-year status review, and because some do not fit neatly into any of the other listing factors.

The permanent cooling system consists of large, vertical intake structures bolted to the upstream face of the dam on the upstream end of the fish ladder where adult fish normally continue their upstream migration into the forebay in the reservoir. The intake structures draw cooler water from deep in the reservoir to supply the fish ladders at Lower Granite and Little Goose dams (as well as the adult trap at Lower Granite Dam) during hot summer months.

Evaluation of the effects of the cooling structures using tagged fish and temperature sensors in the ladder and forebay confirmed that the intake chimneys cooled the ladder, reduced temperature differentials within the ladder, and helped adult salmon and steelhead migrate more expediently through the fish ladders and into the reservoirs above the dams (Anchor QEA 2017). The Corps will continue to monitor the effectiveness of the ladder cooling structures and evaluate whether new structures are needed at other dams.

- *Modifications to the U.S. Army Corps of Engineers' juvenile fish transportation program to enhance adult returns of migrating juvenile salmon.*

A study designed to assess the response of SR fall-run Chinook salmon to two management strategies – transport with spill and bypass with spill – was completed in 2018 (Smith et al. 2018). The study found that transport may be somewhat detrimental to early migrating SR fall-run Chinook salmon smolts and beneficial to later migrating SR fall-run Chinook salmon smolts. Early in the season (from May to early June), transported fish often had lower smolt-to-adult returns (SARs) than bypassed fish; for the rest of June and sometimes into early July, transported and bypassed fish had roughly equal SARs; then, after the first or second week in July, SARs of the transported fish tended to exceed those of bypassed fish. In contrast, transport in May to June has been shown to be beneficial for SR spring/summer Chinook salmon and Snake River basin steelhead.

Under the 2020 CRS biological opinion (NMFS 2020), transport is proposed to end on June 20, when the flexible spring spill operations ends, and resume sometime between July 1 and August 15 (with the exact date determined annually based on discussions with co-managers). Transport will continue through September 30 at Lower Monumental Dam and through October 31 at Lower Granite and Little Goose Dams.

Based on the findings of Smith et al. (2018), eliminating transport from June 21 until August 15 would have a slight negative effect on SR fall-run Chinook salmon, because transport was shown to be slightly beneficial to SR fall-run Chinook salmon migrating during that time. However, the vast majority of SR fall-run Chinook salmon migrate prior to July or after August, so only a small fraction of juveniles would be affected by lack of transport during the period when it was shown to be beneficial. Thus, the overall effect on the ESU would range from zero to a small negative effect depending upon the date that is selected by regional co-managers to resume transport. This conclusion is based on average findings. In any given year, inter-annual variability will influence the timing and magnitude of the response, and even whether the effects on SARS are positive or negative for a given transport year.

In addition, higher spring spill levels (up to 125 percent of the total dissolved gas [TDG] limit) being implemented under the 2020 biological opinion at the three Snake River collector dams are expected to substantially reduce the proportion of subyearling fall Chinook salmon transported during the spring migration period (through June 20). Because this is the period when transported SR fall-run Chinook salmon had lower SARs than bypassed fish, reduced transport during this time is expected to result in increased adult returns (Smith et al. 2018). For example, in 2020 (the first year in which spill to 125 percent TDG was implemented), transport rates for spring migrants were among the lowest on record. Zabel (2020) estimated that only 24 percent of wild and 15.7 percent of hatchery Chinook salmon that passed during transport operations were collected and transported. These collection rates are less than half of those for 2018 or 2019.

In summary, the change in transport dates is expected to have a neutral to slightly negative effect at the ESU-scale, with the effect in any given year dependent on the specific dates chosen and in-river conditions. The decrease in proportion of juveniles transported before June 21 is expected to have a positive effect on SARs. The overall effect of changes in transport, coupled with higher spill rates, is expected to be slightly positive for SR fall-run Chinook salmon.

- *Installation of a passive integrated transponder (PIT) tag detector in the removable spillway weir at Lower Granite Dam to enhance understanding of smolt-to-adult returns and the contributions of alternative life history strategies.*

  In December 2019, a PIT-tag detector was installed in the removable spillway weir at Lower Granite Dam. This detector, which represents a huge technological advance, enables the detection of PIT-tagged fish passing through the spillway (whereas previously only fish going through the bypass system were able to be detected). The technological challenge was to embed low-frequency antennas in the concrete spillway of Lower Granite Dam that could detect tags in juvenile salmon and steelhead passing by in water moving at speeds of roughly 50 miles an hour. This will make it possible to detect fish going through the spillway, in addition to the fish that were previously able to be tracked through the bypass system

  Having information on fish passing through both spill and bypass systems will help answer critical uncertainties about downstream survival, hypothesized juvenile bypass system effects, latent mortality, and smolt-to-adult-returns of fish passing through the different routes. Since 2020 is the first year of operations of the spillway PIT-tag detector, it will be some time before these questions are answered.

- *Prioritize and fill monitoring gaps based on information in Appendix B (Research, Monitoring & Evaluation for Adaptive Management) of the ESA Recovery Plan for Snake River Fall Chinook Salmon.*

  The SR fall Chinook salmon recovery plan (NMFS 2017) emphasized the importance of prioritizing and sequencing RME activities that would inform critical uncertainties and help detect whether the ESU is meeting its recovery objectives. Appendix B of the recovery plan identified two core RME questions, 15 related RME objectives, specific RME questions associated with each objective, types of monitoring needed to address each question, and gaps in existing monitoring.

  While an organized process has not been convened to prioritize the monitoring needed, several of the actions implemented since the 2016 5-year status review will inform some of the critical uncertainties. Primarily, these are actions implemented in hatcheries that will inform our understanding of the productivity and genetic diversity of the natural component of the extant population – these actions are discussed below under Listing Factor E (hatcheries). Additionally, the installation of the PIT-tag detector in the Lower Granite Dam spillway has the potential to inform critical uncertainties regarding juvenile survival under different downstream passage routes.

- *Evaluate and prioritize opportunities to restore tributary side channel rearing habitats to increase natural production capacity for SR fall-run Chinook salmon in all major spawning areas and associated tributary spawning areas.*

  This action, which focuses on tributary spawning areas used by SR fall-run Chinook salmon, has not been implemented in a systematic manner. As noted above, numerous tributary habitat protection and restoration efforts have been implemented in recent years, focused primarily on upstream areas used by spawning and rearing spring/summer Chinook salmon and steelhead. Some small, incremental benefit from these actions would be expected to translate to the lower river reaches of the Tucannon, Grande Ronde, and Clearwater Rivers (three of the five major spawning areas used by SR fall-run Chinook salmon) (NMFS 2017).

- *Evaluate the potential to improve survival of juvenile fall Chinook salmon passing Lower Granite Dam in late fall and early spring and implementing appropriate modifications to configurations.*

  This action has not been implemented in a systematic manner. While many SR fall-run Chinook salmon juveniles from the Clearwater River spawning aggregate overwinter in the lower Snake River reservoirs, only a relatively small fraction of those fish actually pass over dams in the late fall and early spring, so any actions that might be implemented to improve survival of those fish would likely have a relatively small benefit.

  The proposed action for the 2020 CRS biological opinion includes a provision that, between October 15 and February 28, when power market conditions warrant and when river conditions make it feasible, power generation at Snake River projects may cease and water may be stored, most commonly between 2300 and 0500 hours, when demand for power is lowest or when other renewable resources are generating surplus power (or both). This will allow operators to save water in low demand periods to use for power generation during higher demand periods. This operation could conceivably have a small negative effect on SR fall-run Chinook salmon juveniles. These negative effects, however, would likely be offset by benefits of ancillary adult overshoot spill that was incorporated into the Terms and Conditions of the 2020 CRS biological opinion (NMFS 2020). Designed to provide better passage for downstream migrating adult steelhead, the 4-hour blocks of spill will occur 3 times each week at each of the Snake River dams from October 1 until November 15 in the fall and from March 1 to March 30 in the spring. This operation will occur when SR fall-run Chinook salmon juveniles are overwintering and would provide a downstream passage route for any juveniles attempting to pass downstream during this period. PIT-tag detections at the Lower Granite spillway detector should provide some additional information regarding these operational changes in the future.

- *Implement actions to improve the quality of water discharged from the Hells Canyon Complex (dissolved oxygen, total dissolved gas) - as called for in NMFS' recommendations for the Hells Canyon Federal Energy Regulatory Commission (FERC) relicensing.*

  Idaho Power Company (IPC) has recently taken several voluntary actions that should somewhat improve the quality of water exiting the Hells Canyon Complex. First, when IPC must spill water at Brownlee Dam (typically between December and July as a result of high flows), IPC is preferentially using the upper spill gates, which generate less total dissolved gas than the lower spill gates. Second, IPC recently upgraded units 1 through 4 (of 5) at Brownlee Dam with distributed aeration systems, which will add as much additional dissolved oxygen (DO) as possible to Brownlee powerhouse outflows in the late summer and fall, when low DO levels have been documented (Idaho Power Company 2020).[6]

- *Complete and implement TMDLs to improve water quality in tributary habitats that affect SR fall-run Chinook salmon spawning and rearing habitats.*

  Total maximum daily load (TMDL) implementation plans have been completed within the range of SR fall-run Chinook salmon in Idaho for many tributaries to the Clearwater River, as well as for the Lower Salmon River, the Lower Snake/Asotin, and the Snake River/Hells Canyon subbasins.[7] A draft TMDL for the lower mainstem Clearwater is

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[6] IPC has proposed to implement additional enhancement measures to improve total dissolved gas and dissolved oxygen levels in project outflows as part of their license application. However, it is not yet clear when the relicensing process is likely to be completed.

[7] https://www.deq.idaho.gov/water-quality/surface-water/total-maximum-daily-loads/ (accessed 3/10/2021).

under review.[8] In Oregon, a TMDL has been completed for the Lower Grande Ronde River subbasin (including the Imnaha River).[9] In Washington, a temperature TMDL has been completed for the Tucannon River subbasin (WA DOE 2010). Implementation of these plans will improve the targeted water quality parameters.

- *Target high priority opportunities to restore October spawning life history patterns, e.g., by evaluating potential spawning and rearing habitats in the lower reaches of the Selway, Lochsa, and South Fork Clearwater Rivers.*

  The Nez Perce Tribe has an effort underway to restore an early-spawning fall Chinook salmon component in the Clearwater River (where it had been historically observed), using SR fall-run Chinook hatchery stock (using adults returning to the South Fork Clearwater and/or earlier egg takes to promote early spawn timing). Restoring this life-history pattern in the Clearwater River would increase diversity and spatial structure for the ESU. To date, redd abundance in the SF Clearwater has not reached the trigger (134 redds) the Tribe established for installing a weir and collecting fish for broodstock.

- *Develop and conduct life-cycle modeling to gain a better understanding of the relative and combined effects of different limiting factors and targeted actions on species viability.*

  A life-cycle model has been developed by the U.S. Geological Survey (USGS) in coordination with the Northwest Fisheries Science Center (NWFSC) (Tiffan and Perry 2020). NMFS used the model to assess the effect of proposed hydropower system operations, continuing hatchery production, and recent, seasonally variable increases in sea lion predation in the lower Columbia River from the mouth to Bonneville Dam as part of its analysis for the 2020 CRS biological opinion (NMFS 2020). The model has not yet been used for the full scope of analyses envisioned in the recovery plan.

In addition, the following recovery action, while not specifically called for in the 2016 5-year status review, has been implemented and is significant for SR fall-run Chinook salmon:

- *Identify locations of seasonal use of cold-water refugia and research reasons for loss of fish using these cold-water refugia sites. Based on research, identify actions to protect and restore cold-water refugia to improve survival of fish using this habitat.*

  Cold water refuges (CWR) are locations that migrating adult salmon and steelhead temporarily use to escape warm summer river temperatures. They serve an increasingly important role to some salmon species, as the lower Columbia River has warmed over the past 50 years and will likely continue to warm in the future. The U.S. Environmental Protection Agency (EPA) has completed a Columbia River Cold Water Refuge Plan (EPA 2021) as part of compliance with the reasonable and prudent alternative in NMFS's

[8] http://nptwaterresources.org/tmdl/ (accessed 3/12/2021).
[9] https://www.oregon.gov/deq/wq/tmdls/Pages/TMDLs-Basin-Grande-Ronde.aspx (accessed 3/10/2021).

2015 biological opinion (NMFS 2015) on EPA's approval of Oregon's temperature water quality standards.

EPA estimated that approximately 5,000 fall Chinook salmon use CWRs during the last week of August and the first two weeks of September in an average year (2008 through 2017), and that in warmer years, a higher proportion of fall Chinook salmon will use CWRs. In 2013, for example, 20,000 to 40,000 fall Chinook salmon are estimated to have been in the Bonneville reservoir CWR in the latter part of August through mid-September (EPA 2021).

The CWR plan recommends implementation of actions in existing programs, plans, and regulations that would help to improve fish habitat and reduce river temperatures to help maintain CWRs in light of predicted tributary warming due to climate change. To address identified uncertainties, this Plan recommends future studies to track fish use of CWR, to assess the benefits of CWR use, and to assess density effects and the carrying capacity of CWR.

4) Key Regulatory Measures Since the 2016 5-Year Status Review

Various Federal, state, and county regulatory mechanisms are in place to minimize or avoid habitat degradation caused by human use and development. New information available since the 2016 5-year status review indicates that the adequacy of regulatory mechanisms has stayed the same on average, with some mechanisms showing the potential for some improvement whereas others have made it more challenging to protect and recover our species. See *Listing Factor D: Inadequacy of Regulatory Mechanisms* in this document for details.

5) Recommended Habitat Actions Over the Next 5 Years Toward Achieving Population Viability

- *Continue implementing the following ongoing actions, described above in more detail, which are considered to have contributed to the improved status of the ESU.*
    - Implementation of Idaho Power Company's SR fall-run Chinook salmon spawning program to enhance and maintain suitable spawning and incubation conditions, including recent voluntary actions to improve the quality of water exiting the Hells Canyon Complex.

    - Implementation of the Columbia River System biological opinions, including hydrosystem operations such as cool-water releases from Dworshak Dam; summer flow augmentation and summer spill at multiple projects; operations at fish ladder cooling stations at Lower Granite and Little Goose Dams to address adult passage delays caused by warm surface waters entering the fish ladders; flexible spring spill and evaluation of its effects; juvenile fish transportation program as outlined in the 2020 biological opinion; and operation of the PIT-tag detector in the removable spillway weir at Lower Granite Dam and use of the data obtained to inform critical uncertainties. In addition, continue use of regional coordination to address and adaptively manage any new issues associated with the implementation of Columbia River System operations.

- Implementation of Lower Snake River Programmatic Sediment Management Plan (PSMP) measures to reduce impacts of reservoir and river channel dredging and disposal on SR fall-run Chinook salmon.

- Completion and implementation of TMDLs and tributary habitat improvement actions (primarily to benefit SR spring/summer Chinook salmon and steelhead but with ancillary benefits to SR fall-run Chinook salmon).

- Efforts to restore an early-spawning fall Chinook salmon component in the Clearwater River.

- *Convene a group to provide coordination for additional validation and development of the SR fall-run Chinook salmon life-cycle model so that it can be used to assess potential response of SR fall-run Chinook salmon to alternative management strategies and actions under alternative climate scenarios, and to determine the best opportunities for closing the gap between the species' current status and its ESA recovery objectives.*[10]

  As noted above, a life-cycle model has been developed by the USGS in coordination with the NWFSC (Tiffan and Perry 2020). NMFS used the model to assess the effect of proposed hydropower system operations, continuing hatchery production, and recent, seasonally variable increases in sea lion predation in the lower Columbia River from the mouth to Bonneville Dam as part of its analysis for the 2020 CRS biological opinion (NMFS 2020). The model has not yet been used for the full scope of analyses envisioned in the recovery plan. Additional validation and development of the model will allow an expanded range of uses that may inform recovery actions.

- *Protect and continue to study the benefits of CWRs, as outlined in the Columbia River Cold Water Refuge Plan, discussed above (EPA 2021).*

  The CWR plan recommends implementation of actions in existing programs, plans, and regulations that would help to improve fish habitat and reduce river temperatures to help maintain CWRs in light of predicted tributary warming due to climate change. To address identified uncertainties, the Plan recommends future studies to track fish use of CWRs, to assess the benefits of CWR use, and to assess density effects and the carrying capacity of CWRs.

Listing Factor A Conclusion

New information available since the 2016 5-year status review indicates that tributary and mainstem spawning, rearing, and migration conditions have likely improved slightly, and

[10] Note that this recommended action is cross-cutting across multiple listing factors.

therefore the risk to the species' persistence because of habitat destruction or modification has been reduced slightly since the 2016 5-year status review. However, habitat concerns remain with regard to both mainstem and tributary habitats, and there is a need to more systematically evaluate what actions might offer the greatest benefits in terms of improved viability. Ongoing actions should continue and needed new actions are identified above.

This conclusion for Listing Factor A applies to tributary and mainstem Snake River spawning and rearing habitat for this ESU, which spawns primarily in the lower Snake River mainstem. It also addresses some mainstem migratory habitat conditions resulting from flow and transport operations under the 2020 CRS biological opinion. We provide additional, more general discussion and evaluation of current migration corridor habitat, including estuary habitat, under *Listing Factor C (Disease and Predation)* and *Listing Factor D (Inadequacy of Regulatory Mechanisms: Columbia River System).* We discuss threats from climate change under *Listing Factor E (Other Natural or Manmade Factors).*

Listing Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Harvest

Systematic improvements in fisheries management since the last 5-year status review include:

- Implementation of a newly negotiated 2019 Pacific Salmon Treaty, which will reduce impacts to fall-run Chinook salmon in fisheries that occur north of the U.S./Canada border beginning in 2020. Impacts will be reduced by 7.5 and 12.5 percent for Alaska and British Columbia, respectively. This is in addition to reductions that started in 2009 of 15 and 30 percent for Alaska and British Columbia, respectively. There has not been an increase in the rate of salmon fishing in northern areas of the Pacific West Coast for the past 20 years.
- Implementation of a new *U.S. v. Oregon* Management Agreement for years 2018 through 2027, which replaces the previous 10-year agreement. This new agreement maintains the limits and reductions in harvest impacts for the listed ESUs/DPSs that were secured in previous agreements (NMFS 2018a).

SR fall-run Chinook salmon are encountered in fisheries in the ocean, in the mainstem Columbia River, and in some tributaries. Natural-origin fall Chinook salmon are caught incidentally in these fisheries, and these fisheries are managed to limit impacts on natural-origin SR fall-run Chinook salmon and other ESA-listed species. SR fall-run Chinook salmon contribute to ocean fisheries in Alaska and Canada, with minor contributions to ocean fisheries off Washington and Oregon (NMFS 2019c). Since 1996, ocean fisheries have been required to achieve a 30 percent reduction from the average exploitation rate observed during a base period of 1988 to 1993 (NMFS 1996).

Fisheries in the Columbia River are limited to an incidental take of 21.5 to 45 percent (depending on run size) of SR fall-run Chinook salmon returning to the Columbia River mouth (NMFS

2018a). Actual incidental take in the Columbia River has increased by one percent since the 2016 5-year status review and averaged 33.3 percent for the years 2014 to 2019 (TAC 2015, 2016, 2017, 2018, 2019, 2020). Additional harvest impacts to SR fall-run Chinook salmon occur in fisheries in the mainstem Snake River above Lower Granite Dam and in lower reaches of the associated tributaries, but these are limited primarily to incidental catch that occurs in fisheries directed at steelhead.

Figure 3 shows total exploitation rates and ocean exploitation rates and indicates that both have declined substantially since listing and have been relatively stable since the 2016 5-year status review.

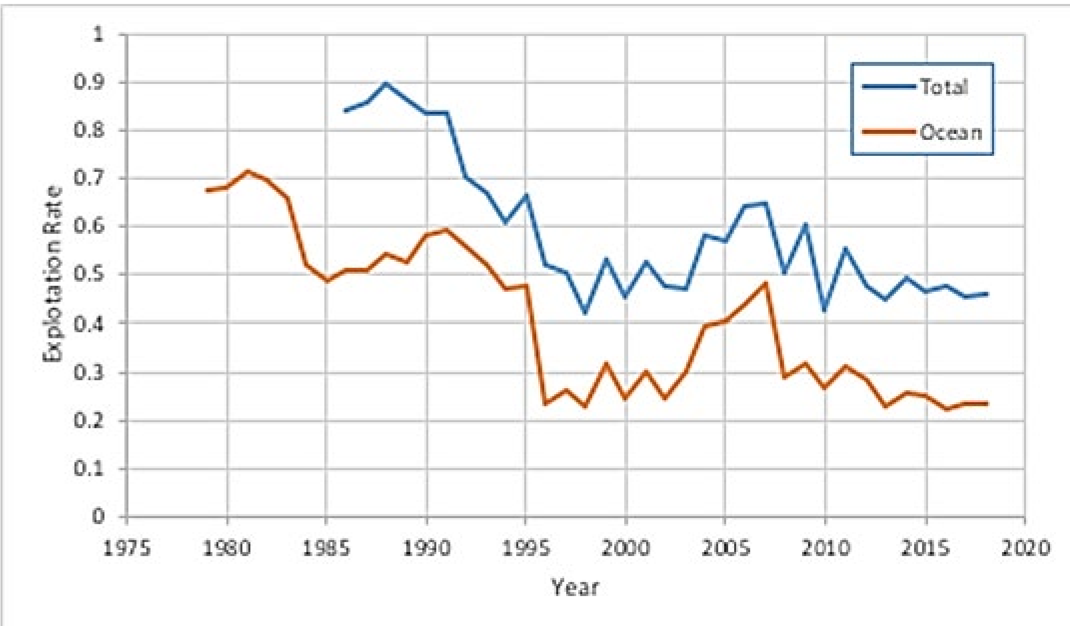

Figure 3. Total and ocean exploitation rates for SR fall-run Chinook salmon (from Ford 2022).

Research and Monitoring

The quantity of take authorized under ESA sections 10(a)(1)(A) and 4(d) for scientific research and monitoring for all ESA-listed SR salmon and steelhead species remains low in comparison to their abundance, and much of the work being conducted is done for the purpose of fulfilling state and Federal agency obligations under the ESA to ascertain the species' status. Authorized mortality rates associated with scientific research and monitoring are generally capped at 0.5 percent across the NMFS West Coast Region for all listed salmonid ESUs and DPSs. As a result, the mortality levels that research causes are very low throughout the region. In addition, and as with all other listed salmonids, the effects of research on Snake River salmonids are spread out over various reaches, tributaries, and areas across all of their ranges, and thus no area or population is likely to experience a disproportionate amount of loss. Therefore, the research program, as a whole, has only a very small impact on overall population abundance, a similarly small impact on productivity, and no measurable effect on spatial structure or diversity for SR fall-run Chinook salmon.

Any time we seek to issue a permit for scientific research, we consult on the effects that the proposed work would have on each listed species' natural- and hatchery-origin components. However, because research has never been identified as a threat or a limiting factor for any listed species, and because most hatchery fish are considered excess to their species' recovery needs, examining the quantity of hatchery fish taken for scientific research would not inform our analysis of the threats to a species' recovery. Therefore, we only discuss the research-associated take of naturally produced fish in these sections.

From 2015 through 2019, researchers were approved to take a yearly average of fewer than 3,100 SR fall-run Chinook salmon juveniles (<151 lethally). For adult salmonids during this same period, researchers were approved to take a yearly average of fewer than 640 SR fall-run Chinook salmon (<22 lethally) per year (NMFS APPS database; https://apps.nmfs.noaa.gov/).

For the vast majority of scientific research actions, history has shown that researchers generally take far fewer salmonids than are authorized every year. Reporting from 2015 through 2019 indicates that over those 5 years, the average actual yearly total take for naturally produced juveniles or adults was less than 1.5 percent of the amount authorized for SR fall-run Chinook salmon. The actual lethal take was also low over the same 5-year period: average yearly lethal take of juveniles was only 3.5 percent of the average amount authorized per year, and average yearly lethal take of adults was less than 6 percent (5.6 percent) of the average amount authorized per year.

The majority of the requested take for naturally produced juveniles has primarily been (and is expected to continue to be) capture via electrofishing units, beach seines, and minnow traps, with smaller numbers collected as a result of hand or dip netting, weirs, other seines, trawling, hook and line sampling, screw traps, and those intentionally sacrificed. Adult take has primarily been (and is expected to continue to be) capture via weirs or fish ladders, trawls, and hook and line angling, with smaller numbers getting unintentionally captured by screw traps, seining, and other methods that target juveniles (NMFS APPS database; https://apps.nmfs.noaa.gov/). Our records indicate that mortality rates for screw traps are typically less than 1 percent and for backpack electrofishing are typically less than 3 percent. Unintentional mortality rates from seining, dip netting, minnow traps, weirs, and hook and line methods are also limited to no more than 3 percent.

The quantity of take authorized over the past 5 years (2015 to 2019) has decreased for SR fall-run Chinook salmon compared to the prior 5 years (2010 to 2014). Between those two time periods, total authorized take decreased by 59 percent, authorized lethal take decreased by 30 percent, reported total take decreased by 97 percent, and reported lethal take decreased by 55 percent between the same two time periods.

Overall, research impacts remain minimal due to the low mortality rates authorized under research permits and the fact that research is spread out geographically throughout the Snake River basin. Therefore, the overall effect on listed populations has not changed substantially, and we conclude that the risk to the species' persistence because of utilization related to scientific studies has changed little since the 2016 5-year status review (NMFS 2016a).

Listing Factor B Conclusion

New information available since the 2016 5-year status review indicates that the overall effect of harvest on the SR fall-run Chinook salmon ESU has not changed substantially since that review (NMFS 2016a). Research impacts remain minimal due to the low mortality rates authorized under research permits. Therefore, the overall effect on SR fall-run Chinook salmon has not changed substantially since the 2016 5-year status review. We conclude that the risk to the species' persistence because of harvest or utilization related to scientific studies has changed little since the 2016 5-year status review. No additional actions for listing factor B are recommended at this time. Ongoing actions should continue.

Listing Factor C: Disease and Predation

Disease

Disease rates over the past 5 years (including in fish transported at Snake River collector projects) are believed to be consistent with the previous review period. Climate change impacts such as increasing temperature likely increase susceptibility to diseases. For the 2016 5-year status review, we reported that the spread of a new strain of infectious hematopoietic necrosis virus (IHNV) along the Pacific coast that may increase disease-related concerns for Snake River salmon and steelhead in the future (NMFS 2016a). No new information on disease-related concerns for SR fall-run Chinook salmon was available at the time of this review.

Avian Predation

Avian Predation in the Columbia River Estuary

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, have had a significant impact on the survival of juvenile salmonids in the Columbia River. Caspian terns on Rice Island, an artificial dredged-material disposal island in the estuary, consumed about 5.4 to 14.2 million juveniles per year in 1997 and 1998 (up to 15 percent of all the smolts reaching the estuary; Roby et al. 2017). Efforts to move the tern colony closer to the ocean at East Sand Island, where they would diversify their diet to include marine forage fish, began in 1999. During the next 15 years, smolt consumption was about 59 percent less than when the colony was on Rice Island. The U.S. Army Corps of Engineers has further reduced smolt consumption by reducing the amount of bare sand available on East Sand Island for nesting from 6 acres to 1 acre. Combined with harassment (kleptoparasitism) by bald eagles, and egg and chick predation by gulls, the number of nesting pairs has dropped from more than 10,000 in 2008 to fewer than 5,000 in 2018 and 2019 (Roby et al. 2021).

Based on PIT-tag recoveries at East Sand Island, average annual tern and cormorant predation rates for SR fall-run Chinook salmon were about 2.9 and 2.7 percent, respectively, before efforts to manage the size of these colonies (Roby et al. 2021).[11] Tern predation rates have decreased to 1.0 percent since 2007, a statistically significant difference (Roby et al. 2021). This improvement was offset to an unknown degree by about 1,000 terns trying to nest on Rice Island in 2017 (Evans et al. 2018) and smaller numbers roosting or trying to nest on Rice, Miller, and Pillar Islands in 2018 and 2019 (Harper and Collis 2018; USACE 2019).

The U.S. Army Corps of Engineers has also reduced the size of the double-crested cormorant colony on East Sand Island, although efforts to reduce predation rates have not been successful. The pressures of lethal take and non-lethal hazing under the Corps' management plan (USACE 2015), combined with harassment by bald eagles, moved thousands of nesting pairs from the island to the Astoria-Megler Bridge. Because the colony on the bridge is 9 miles further up-river than East Sand Island, these birds are likely to be consuming more juvenile salmonids per capita than when they were foraging further downstream with access to marine forage fish (Lawes et al. 2021). Researchers cannot estimate predation rates for birds nesting on the bridge because PIT tags cannot be detected or recovered if they fall into the water. Although predation rates for East Sand Island cormorants on subyearling SR fall-run Chinook salmon decreased from 2.7 percent to 0.9 percent when birds moved to the bridge, they may have increased for the estuary as a whole.

Avian Predation in the Mainstem Columbia River

Juvenile SR fall-run Chinook salmon also have been vulnerable to predation by terns nesting in the interior Columbia plateau, including islands in McNary Reservoir and the Hanford Reach. The U.S. Army Corps of Engineers has successfully prevented terns from nesting on Crescent Island since 2015. However, because terns moved from this site, and from Goose Island in Reclamation's Potholes Reservoir, to the Blalock Islands in John Day Reservoir, predation rates on subyearling SR fall-run Chinook salmon did not change. To improve survival for this and other salmonids, the Corps has proposed to raise the elevation of John Day Reservoir during the spring smolt migration starting in 2021, inundating the Blalock Islands to prevent its use by terns (BPA et al. 2020; NMFS 2020).

The 2008 FCRPS biological opinion (NMFS 2008a) first required that the Action Agencies implement avian predation control measures at mainstem dams in the lower Snake and Columbia Rivers. Since then, each of the CRS projects has used hazing and passive deterrence, including wire arrays across tailraces, spike strips along the edge of the concrete, water sprinklers at juvenile bypass outfalls, pyrotechnics, propane cannons, and limited amounts of lethal take. These measures have reduced the number of smolts consumed by birds at the dams and will continue to be implemented, with improvements as new techniques become available. Until recently, predation by gulls was not considered to warrant management actions. However, Cramer et al. (2021) reported that annual predation rates by gulls nesting on Miller Rocks in

[11] While most SR fall-run Chinook salmon migrate as sub-yearlings, a substantial proportion also migrate as yearlings. We do not have estimates of differential rates of predation on the two life-history types.

John Day Reservoir averaged 2.0 percent of available SR fall-run Chinook salmon during the last decade. There are no management plans to reduce the size of the Miller Rocks colony at this time, in part because ownership of the property is unclear.

Overall, avian predation on SR fall-run Chinook salmon may have decreased slightly since the 2016 5-year status review, although those decreases may be offset by the movement of cormorants from East Sand Island to the Astoria-Megler Bridge; avian predation impacts to SR fall-run Chinook salmon remain relatively low.

Marine Mammal Predation

Recent research suggests that predation pressure on ESA-listed salmon and steelhead from pinnipeds (seals and sea lions) and from killer whales has been increasing in the northeastern Pacific over the past few decades (Chasco et al. 2017a, 2017b). Killer whales are known to selectively prey on Chinook salmon, including SR fall-run Chinook salmon (Hanson et al. 2021).

The three main seal and sea lion predators of ESA-listed salmonids in the eastern Pacific Ocean are harbor seals, California sea lions, and Steller sea lions. With the passing of the Marine Mammal Protection Act (MMPA) in 1972, these pinniped stocks along the West Coast of the United States have steadily increased in abundance (Carretta et al. 2019). With their increasing numbers and expanded geographic range, pinnipeds are consuming more Pacific salmon and steelhead, and some are having an adverse impact on some ESA-listed species (Marshall et al. 2016; Chasco et al. 2017a; Thomas et al. 2017).

California sea lions, Steller sea lions, and harbor seals all consume salmonids from the mouth of the Columbia River and its tributaries up to the tailrace of Bonneville Dam. The Oregon Department of Fish and Wildlife counted the number of individual California sea lions hauling out in the Columbia River mouth at the East Mooring Basin in Astoria, Oregon, from 1997 through 2017. Individual pinniped counts at East Mooring Basin have steadily increased since the inception of the observation program, with rapid increases within the last decade. Within the Columbia River, the abundance of pinnipeds peaks in the spring and thus does not overlap with the timing of SR fall-run Chinook salmon adult migration. Pinniped counts at the mooring basin during September and October, when SR fall-run Chinook salmon adults are migrating, have increased, however, from an average of 269 from 2008 to 2014 to an average of 914 in 2015 and 2016 (Wright 2018). Rub et al. (2019) found strong evidence that the recent increases in Chinook salmon loss estimates were a function of the large increase in pinnipeds in the Columbia River.

Within the Columbia River, adult salmonid losses due to pinniped predation are greatest directly downstream of Bonneville Dam (Rub et al 2019). The dam provides a predation advantage, as fish congregate in search of ladder entrances; this can concentrate fish, making them more vulnerable to predation (Stansell 2004). Biologists have been estimating consumption by pinnipeds directly below Bonneville dam since 2002 (Tidwell et al. 2020), and they monitored predation in the fall and winter months in 2017 and 2018 in response to increases in Steller sea lion presence in the last decade, especially outside of the traditional spring monitoring period.

Between July 21 and December 31, 2017, Tidwell et al. (2018) documented an average of 14.5 Steller sea lions at Bonneville Dam, and an average of 21.1 Steller sea lions were recorded in 2018 (Tidwell et al. 2020). They estimated that pinnipeds consumed 0.7 percent of the fall Chinook salmon run in 2017 and 0.6 percent in 2018. This serves as a reasonable estimate for the percentage of SR fall-run Chinook salmon consumed directly below Bonneville Dam. During those same months in 2019, Tidwell et al. (2020) documented an average of 31.8 Steller sea lions with a peak of 53 individuals. A small number (range 0 to 5) of California sea lions have been observed in Bonneville Reservoir in recent years.

Management actions intended to reduce pinniped predation in the Columbia River are discussed in Listing Factor D (Inadequacy of Regulatory Mechanisms).

Overall, pinniped predation on SR fall-run Chinook salmon has not changed substantially since the last 5-year review, although uncertainty remains about total impacts throughout the estuary. Pinniped populations in Oregon and Washington have continued to increase over the past 5 years, and recent research provides evidence that adult salmonids with run timing that overlaps with increased sea lion presence have decreased survival rates when migrating through the lower Columbia River and estuary (Rub et al 2019; Sorel et al 2020). While there are management efforts underway to reduce pinniped predation on Pacific salmon and steelhead in select areas of the Columbia River basin (see Listing Factor D), these management efforts alone may be insufficient to reduce the severity that pinniped predation poses to the species' recovery.

Northern Pikeminnow Predation

A sport fishing reward program was implemented in 1990 to reduce the numbers of Northern pikeminnow in the Columbia basin (NMFS 2010). The program continues to meet expected targets, which may reduce predation on smolts of all salmon and steelhead species in the mainstem Columbia River. The sport reward fishery removed an average of 188,708 piscivorous pikeminnow per year during 2015 to 2019 in the Columbia and Snake Rivers (Williams et al. 2015, 2016, 2017, 2018; Winter et al. 2019). The program has not changed during the past 5 years though, and thus the program's benefit to the ESU is the same as during our 2016 5-year status review.

Aquatic Invasive Species

Non-indigenous fishes affect salmon and their ecosystems through many mechanisms. A number of studies have concluded that many established non-indigenous species (including smallmouth bass, channel catfish, walleye, and American shad) pose a threat to the recovery of ESA-listed Pacific salmon. Threats are not restricted to direct predation; non-indigenous species compete directly and indirectly for resources, significantly altering food webs and trophic structure, and potentially altering evolutionary trajectories (Sanderson et al. 2009; NMFS 2010).

Recent research indicates that consumption of SR fall-run Chinook salmon by smallmouth bass is significantly higher than it was in the past (Connor et al. 2015; NMFS 2017; Erhardt et al. 2018). The increase corresponds to large increases in the abundance of both hatchery- and natural-origin juvenile fall Chinook salmon in reaches above Lower Granite Dam. It is not known if the increased consumption levels reflect a higher proportional mortality rate on juvenile fall Chinook salmon. Walleye, the largest member of the perch family, also prey on fall Chinook salmon, and in the Columbia River basin are most abundant in dam tailraces, where the potential for impacts on juvenile salmonids is high (NMFS 2017).

Fishing regulations in Oregon and Washington were modified in 2016 to eliminate size and daily limits on the catch of smallmouth bass and walleye in the Columbia and Snake Rivers. This could potentially help control non-native fish predator populations.

Thermal conditions may influence current and future spatial and temporal overlap with smallmouth and largemouth bass, which ultimately drives the potential for species interactions, including predation (Rubenson and Olden 2016, 2019, 2020; Hawkins et al. 2020). Elevated water temperatures are likely increasing overlap with non-indigenous species and likely to continue to do so in the future. Non-native and highly predatory Northern pike (*Esox lucius*), currently located upstream of Grand Coulee Dam, may pose an additional predation threat if they establish populations further downstream.

Listing Factor C Conclusion

New information available since the 2016 5-year status review indicates that predation impacts on SR fall-run Chinook salmon have remained relatively stable since the 2016 5-year status review. At this time, we do not have information available that would allow us to quantify the change in extinction risk due to predation. Therefore, we conclude that the risk to the species' persistence because of predation has remained relatively static since the 2016 5-year status review. Disease rates have continued to fluctuate within the range observed in past review periods and are not expected to affect the extinction risk of the ESU. Ongoing actions to reduce avian, pinniped, northern pikeminnow, and non-native fish predation should continue.

Listing Factor D: Inadequacy of Regulatory Mechanisms

One factor affecting habitat conditions across all land or water ownerships is climate change, the effects of which are discussed under *Listing Factor E (Other natural or manmade factors affecting its continued existence*). We reviewed summaries of national and international regulations and agreements governing greenhouse gas emissions, which indicate that while the number and efficacy of such mechanisms have increased in recent years there has not yet been a substantial deviation in global emissions from the past trend, and upscaling and acceleration of far-reaching, multilevel, and cross-sectoral climate mitigation will be needed to reduce future climate-related risks (IPCC 2014, 2018). These findings suggest that current regulatory mechanisms, both in the U.S. and internationally, are not currently adequate to address the rate at which climate change is negatively impacting habitat conditions for many ESA-listed salmon and steelhead.

Most of the land in the Snake River basin is managed by the Federal government (about 64 percent), including the U.S. Forest Service (USFS), U.S. Bureau of Land Management (BLM), and the U.S. Department of Energy. The U.S. Bureau of Reclamation, along with other state and Federal agencies and private groups, manages the water resources for the Columbia River's many, and sometimes competing, uses. Starting in the 1890s, fifteen major dams have been built on the Snake River to generate hydroelectricity, enhance navigation, and provide water for irrigation. Dams on the Snake and Columbia Rivers affect water quality and quantity of tributaries and mainstem rivers.[12]

Regulatory Mechanisms Resulting in Adequate or Improved Protection

New information available since the 2016 5-year status review indicates that the adequacy of some regulatory mechanisms has improved and has increased protection of SR fall-run Chinook salmon, as described below:

1. Endangered Species Act Section 7 Biological Opinions

1.1 Columbia River System

Implementation of the 2008 FCRPS biological opinion (and its 2010 and 2014 supplemental biological opinions) continued through March 29, 2019, when NMFS issued a new biological opinion for operation of the Columbia River System (CRS, formerly referred to as the FCRPS) (NMFS 2008a, 2010, 2014a, 2019b). On July 31, 2020, NMFS issued another CRS biological opinion (NMFS 2020), this one on the preferred alternative in the Columbia River System Operations final environmental impact statement issued by the U.S. Army Corps of Engineers, Bonneville Power Administration, and Bureau of Reclamation on the same date (NMFS 2020). The 2019 and 2020 biological opinions continued many actions from the 2008 biological opinion that were beneficial to SR fall-run Chinook salmon. In addition, the 2019 and 2020 biological opinions implemented a new spill operation involving a flexible approach to providing additional spring spill. This spill regime is intended to improve the survival of spring-migrating juvenile salmon and steelhead, while also addressing Action Agency objectives for power generation and transmission and recognizing operational constraints in the hydrosystem (NMFS 2019b, 2020).

The flexible spring spill operation will potentially increase survival of juvenile SR fall-run Chinook salmon. Juvenile SR fall-run Chinook salmon migrating during enhanced spring spill (i.e., between April 10 and June 21) should see reduced travel times and improved survival as a result of more fish migrating through spillways (versus bypass systems); those migrating after June 21 will not see this benefit. These potential survival improvements would affect both yearlings (mostly Clearwater-reared fish) and subyearlings (mostly Snake River-reared fish). The effects of the higher spill levels are not expected to benefit adult SR fall-run Chinook salmon, since their migration timing does not overlap with the higher spill levels. To the extent that latent mortality might be improved by reduced powerhouse passage as a result of increased spring spill,

[12] https://www.nwcouncil.org/reports/columbia-river-history/damshistory. Accessed 5/27/21.

there is potential for additional increased productivity of SR fall-run Chinook salmon (NMFS 2020). We are unable to predict the scale of these benefits at this time.

In addition, changes in juvenile fish transport under the 2020 biological opinion are expected to have a slightly positive effect for SR fall-run Chinook salmon. See Listing Factor A, above, for more detailed discussion of CRS effects on SR fall-run Chinook salmon spawning, rearing, and migratory habitat.

2. Federal Power Act

As part of the re-authorization process for the Hells Canyon Complex of dams (i.e., Brownlee, Oxbow, and Hells Canyon Dams), FERC has issued annual operating licenses for each project since the original 50-year licenses expired in 2005. In May 2019, the Oregon Department of Environmental Quality and Idaho Department of Environmental Quality issued Clean Water Act Section 401 certifications for the project, an important component of a complete license application (IDEQ 2019; ODEQ 2019). Most notably, the 401 certifications require a substantial commitment to reduce the temperature of water exiting Hells Canyon Dam in the late summer and fall and improve water quality in the Snake River. This is expected to be accomplished primarily through habitat restoration activities upstream of the Hells Canyon Complex (both in the mainstem Snake River and in several tributaries), which will address return flows from irrigation projects, narrow the channel width, and restore more normative river processes between Swan Falls Dam and the upper end of Brownlee reservoir. The 401 certifications should also improve dissolved oxygen levels below Hells Canyon Dam in late summer and fall and reduce total dissolved gas levels downstream of Hells Canyon Dam in winter and spring.

In 2020, the Idaho Power Company amended its license application and provided FERC with a biological evaluation assessing the impacts of the dam complex. As of July 2021, FERC had not indicated how it intended to proceed with relicensing of the Hells Canyon Complex. While aspects of future Hells Canyon Complex license requirements have become somewhat clearer as a result of the 401 certifications issued in 2019, substantial uncertainty regarding future operations and other protective measures will remain until a new license is issued (and a formal ESA section 7 consultation is completed), and the required measures are implemented.

3. Clean Water Act

3.1 Clean Water Act Section 123 Columbia River Basin Restoration Funding

The United States Congress (Congress) amended the Clean Water Act in 2016 by adding Section 123 (33 U.S.C. § 1275), which required EPA to establish a Columbia River Basin Restoration Program. Section 123 directs EPA to develop a voluntary, competitive grant program for environmental protection and restoration programs throughout the basin. The grant program offers funding assistance to eligible entities on a competitive basis. In October 2019, EPA Region 8 and Region 10 launched the first request for applications for a competitive grant program. In September 2020, EPA announced the award of $2 million in 14 grants to tribal, state, and local governments; non-profits; and community groups throughout the Columbia River basin. These projects will increase agricultural best practices, green infrastructure, and monitoring and assessment; promote pollution prevention; and increase citizen education and involvement. These inaugural year projects will serve as models for toxics reduction and assessment throughout the basin.

3.2 Columbia and Lower Snake River Draft Temperature TMDL

In December 2019, the Ninth Circuit Court of Appeals issued an opinion requiring the EPA to identify a temperature TMDL for the Columbia River, as neither the state of Washington nor the state of Oregon had provided one. On May 18, 2020, EPA issued a draft TMDL for temperature on the Columbia and Lower Snake Rivers for public review and comment (EPA 2020a). The TMDL addresses portions of the Columbia and lower Snake Rivers that have been identified by the states of Washington and Oregon as impaired due to temperatures that exceed those states' water quality standards. After considering comments, EPA may make modifications, as appropriate, and then transmit the TMDL to Oregon and Washington for incorporation into their current water quality management plans. Implementation of the TMDL will likely benefit SR fall-run Chinook salmon through improved thermal conditions in the migratory corridor.

3.3 Protection for Cold Water Refuges

EPA released its final Columbia River Cold Water Refuges Plan in January 2021 (EPA 2021). The plan focuses on the lower 325 miles of the Columbia River from the Snake River to the ocean. Cold water refuges serve an increasingly important role to some salmon and steelhead species as the lower Columbia River has warmed over the past 50 years and will likely continue to warm in the future due to climate change. The Columbia River Cold Water Refuges Plan is a scientific document with recommendations to protect and restore cold water refuges. EPA issued this plan in response to a consultation under section 7 of the ESA associated with its approval of Oregon’s temperature standards for the Columbia River (NMFS 2015). This plan also serves as a reference for EPA’s Columbia and Snake Rivers Temperature TMDL.

4. Improved Columbia River Harvest Management

Pursuant to a September 1, 1983, order of the U.S. District Court, the allocation of harvest in the Columbia River was established under the Columbia River Fish Management Plan and implemented in 1988 by the parties to *U.S. v. Oregon*. Since 2008, 10-year management agreements have been negotiated through *U.S. v. Oregon* (NMFS 2008b, 2018a). Harvest impacts on ESA-listed species in Columbia River commercial, recreational, and treaty fisheries are currently managed under the 2018 to 2027 *U.S. v. Oregon* Management Agreement (NMFS 2018a). The parties to the agreement are the United States; the states of Oregon, Washington, and Idaho; and the Columbia River Treaty Tribes (the Warm Springs, Yakama, Nez Perce, Umatilla, and Shoshone-Bannock Tribes). The agreement sets harvest rate limits on fisheries that impact ESA-listed species, and these harvest limits are managed annually by the fisheries co-managers (TAC 2015, 2016, 2017, 2018, 2019, 2020). The current *U.S. v. Oregon* Management

Agreement has, on average, maintained reduced impacts of fisheries on the Snake River species (TAC 2015, 2016, 2017, 2018, 2019, 2020), and we expect that to continue with the abundance-based framework incorporated into the regulatory regime.

5. Improved Hatchery Management

The recent proposed action from the *U.S. v. Oregon* biological opinion (NMFS 2018a), as well as a new site-specific SR fall-run Chinook salmon hatchery biological opinion (NMFS 2018b), included the movement of 1 million fall Chinook salmon hatchery releases from the Hells Canyon reach into the Salmon River. We expect this action to decrease genetic risk from the hatchery programs above the Salmon River, although there is considerable uncertainty about this risk reduction (Cleary et al. 2017). The relocation of releases also offers potential benefits in terms of better understanding the extant SR fall-run Chinook salmon population and providing critical information on the consequences of large-scale perturbations in hatchery/natural dynamics. In addition, the population now has a much higher PNI level than it did previously, as a result of management measures that have been implemented.

The change in release locations is also consistent with a central aspect of the potential recovery scenario that NMFS considered the most likely pathway to achieving ESA recovery goals for the species. This scenario (Scenario C) would achieve high certainty of highly viable status for the Lower Snake River population by evaluating status based on one or more Natural Production Emphasis Areas (NPEA), an area of greatly reduced hatchery influence compared to other spawning areas. Recent homing fidelity information (Cleary et al. 2017) suggests that it may be possible to create an NPEA in the upper Hells Canyon reach of the Snake River by moving hatchery releases from the upper Hells Canyon reach to alternative release locations.

6. Marine Mammal Protection Act (MMPA) Removal Actions

Congress amended the MMPA in 1994 to include a new section, section 120 – Pinniped Removal Authority. This section provides an exception to the MMPA "take" moratorium and authorizes the Secretary of Commerce to authorize the intentional lethal taking of individually identifiable pinnipeds that are having a significant negative impact on the decline or recovery of salmonid fishery stocks. In 2018, Congress amended section 120(f) of the MMPA, which expanded the removal authority for removing predatory sea lions in the Columbia River and tributaries.

To address the severity of pinniped predation in the Columbia River Basin, NMFS has issued six MMPA section 120 authorizations (2008, 2011, 2012, 2016, 2018, and 2019) and one section 120(f) permit (2020). Under these authorizations, as of May 13, 2022, the states have removed (transferred and killed) 278 California sea lions and 52 Steller sea lions.

Continued management action under the MMPA is expected to reduce sea lion predation on adult salmon and steelhead in the Columbia River. Given the logistical challenges of removing sea lions and other uncertainties, the magnitude of this expected reduction in sea lion predation is uncertain.

Regulatory Mechanisms Resulting in Inadequate or Decreased Protection

We remain concerned about the adequacy of certain regulatory mechanisms in terms of their ability to support the recovery of SR fall-run Chinook salmon. These include:

1. Lack of a Long-term FERC License for the Hells Canyon Complex

The original 50-year license for the Hells Canyon Dam Complex expired in 2005. Since then, FERC has issued annual operating licenses for each project. In May 2019, Oregon and Idaho issued Clear Water Act Section 401 Water Quality Certifications, a step that is required before a new license can be issued by FERC. FERC has yet to determine how to move forward with its National Environmental Policy Act compliance for a new license. As a result of the lack of a long-term license for the Complex, there is uncertainty regarding future operations and other protective measures.

2. Changes to the Clean Water Act

2.1 Definition of Waters of the United States

The current Navigable Waters Protection Rule, which defines Waters of the United States, went into effect on June 22, 2020 (85 FR 22250). This rule has deleterious effects on SR fall-run Chinook salmon, because the regulatory nexus for consulting on potentially harmful actions was redefined and reduced. The redefined language and increased exemptions reduce the ability to utilize the ESA and essential fish habitat (EFH) to avoid, minimize, and mitigate effects that impact listed species and their designated critical habitats. However, on December 7, 2021, the EPA and U.S. Army Corps of Engineers published a proposed rule to revise the definition of "Waters of the United States" (86 FR 69372). The agencies propose to put back into place the pre-2015 definition of "Waters of the United States," updated to reflect consideration of Supreme Court decisions. This familiar approach would support a stable implementation of "Water of the United States" while the agencies continue to consult with states, Tribes, local governments, and a broad array of stakeholders in implementing the Waters of the United States rule and future regulatory actions.

Additionally, in 2021, the U.S. Army Corps of Engineers finalized the reissuance of existing Nationwide Permits with modifications (86 FR 2744; 86 FR 73522). These modifications will allow an increase in the amount of fill and destruction of habitat for frequently used nationwide permits throughout the range of SR fall-run Chinook salmon. Although regional permit conditions may address some of these issues, there has not yet been any indication that regional permit conditions will be developed to address the impacts to listed species and their designated critical habitat.

2.2 Clean Water Act Section 404 Permit Exemptions

CWA 404 permit exemptions, particularly ones affecting agricultural and transportation activities, continue to promulgate degraded tributary and mainstem habitat conditions. Incorporating measures incentivizing habitat and floodplain functional improvements could provide meaningful habitat improvement for this ESU that are not provided for in the current exemptions.

3. Inconsistent State and Local Land Use Planning Regulations

City, county, and state land use planning regulations remain inconsistent across the species' range and resulting in growth and development practices that often prevent attaining desired watershed and riparian functions. Development in floodplains continues to be a regional concern as it frequently results in stream bank alteration, stream bank armoring, and stream channel alteration projects to protect private property that do not allow streams to function properly and result in degraded aquatic habitat.

The National Flood Insurance Program (NFIP) is a Federal benefits program that extends access to Federal monies or other benefits, such as flood disaster funds, and subsidized flood insurance, in exchange for communities adopting local land use and development criteria consistent with federally established minimum standards. Development proceeding in compliance with NFIP minimum standards ultimately results in impacts to floodplain connectivity, flood storage/inundation, hydrology, and to habitat forming processes. Consequences of levees, stream bank armoring, stream channel alteration, and floodplain fill combine to prevent streams from functioning properly and result in degraded habitat. Most communities (counties, towns, cities) in Washington, Idaho, and Oregon are NFIP participating communities, applying the NFIP minimum standards. For this reason, it is important to note that, where it has been analyzed for effects on salmonids, floodplain development that occurs consistent with the NFIP's minimum criteria has been found to jeopardize 18 listed species of salmon and steelhead (Chinook salmon, steelhead, chum salmon, coho salmon, sockeye salmon) (NMFS 2008c, 2016b). The Reasonable and Prudent Alternative provided in NMFS 2016b, including Columbia River basin species, has not yet been implemented.

4. Toxic Contaminants

In 2014, NMFS issued a jeopardy biological opinion on Idaho standards for toxic substances (NMFS 2014c). The reasonable and prudent alternatives calling for the adoption of new criteria for mercury and arsenic and calling for the removal of the hardness floor remain to be implemented in Idaho.

Toxics-impaired waters are broadly distributed throughout the Columbia River basin. The mainstem Columbia River is impaired sporadically in Washington, and nearly the entire reach from McNary Dam to the mouth of the estuary is impaired for one or more toxic pollutants (EPA 2020b). The mainstem Snake River has multiple segments with identified category 5 impairments (waters that have been identified as category 5 impaired require a TMDL or water pollution control plan), including the entire reach that forms the border between Oregon and Idaho. In total, 31 TMDL documents that address at least one toxic pollutant have been developed in the basin. Every state has developed at least one TMDL for toxic pollutants: Idaho (5), Oregon (4), Washington (9), and EPA developed a basin-wide Dioxin TMDL that covers the lower mainstem Columbia River (EPA 2020b). The role that toxic-impaired waters play in juvenile and adult survival is a large gap in our current knowledge.

Listing Factor D Conclusion

The NMFS Recovery Plan (NMFS 2017) and the 2016 5-year status review (NMFS 2016a) identified inadequate regulatory mechanisms as a priority issue affecting SR fall-run Chinook salmon recovery. While the adequacy of some regulatory mechanisms within the Snake River has improved since the 2016 5-year status review, there have also been regulatory changes that make species preservation more challenging and some programs continue that do not adequately support the persistence of SR fall-run Chinook salmon. In addition, the lack of a long-term license for the Hells Canyon Dam Complex creates uncertainty regarding future operations and other protective measures. Overall, we conclude that based on information available since the 2016 5-year status review on regulations in the Snake River basin and the Columbia River migratory corridor, we conclude that the risk to the species' persistence because of the adequacy of existing regulatory mechanisms has improved slightly since our previous review.

Listing Factor E: Other Natural or Manmade Factors Affecting Its Continued Existence

Other natural or manmade factors affecting the continued existence of this species include:

- Climate change, ocean conditions, and marine survival.
- Rearing and migration habitat conditions in the Columbia River estuary.
- Hatcheries.

Climate Change, Ocean Conditions, and Marine Survival

Climate change is affecting and will continue to affect the range-wide status of SR fall-run Chinook salmon and its aquatic habitat. The five warmest years in the 1880 to 2019 record have all occurred since 2015, while 9 of the 10 warmest years have occurred since 2005 (Lindsey and Dahlman 2020). The year 2020 was another hot year in national and global temperatures; it was the second hottest year in the 141-year record of global land and sea measurements, and capped off the warmest decade on record (http://www.ncdc.noaa.gov/sotc/global202013). Events such as the 2013 to 2016 marine heatwave (Jacox et al. 2018), have been attributed directly to anthropogenic warming in the annual special issue of the *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. These two factors are often examined in isolation, but likely have interacting effects on ecosystem function (Siegel and Crozier 2019).

Climate change has negative implications for Columbia River basin salmon survival and recovery, and for their designated critical habitat (Climate Impacts Group 2004; Scheuerell and Williams 2005; Zabel et al. 2006; ISAB 2007). These negative implications have been characterized by the Independent Scientific Advisory Board (ISAB) as follows:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a smaller snowpack, watersheds will see their runoff diminished earlier in the season, resulting in lower stream-flows in June through September. Peak river flows, and river flows in general, are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures are expected to rise, especially during the summer months when lower stream-flows co-occur with warmer air temperatures. Islam et al. (2019) found that air temperature accounted for about 80 percent of the variation in stream temperatures in the Fraser River, thus tightening the link between increased air and water temperatures.

These changes will not be spatially homogeneous across the entire Pacific Northwest. Low-lying areas are likely to be more affected. Climate change may have long-term effects that include, but are not limited to, depletion of important cold-water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, earlier emergence of fry, and increased competition among species.

Range of Effects Caused by a Changing Climate

Climate change is predicted to cause a variety of impacts to Pacific salmon and their ecosystems (Mote et al. 2003; Crozier et al. 2008a; Martins et al. 2012; Wainwright and Weitkamp 2013; OCCRI 2019, 2021). The complex life cycles of anadromous fishes, including salmon, rely on productive freshwater, estuarine, and marine habitats for growth and survival, making them particularly vulnerable to environmental variation. Ultimately, the effects of climate change on salmon and steelhead across the Pacific Northwest will be determined by the specific nature, level, and rate of change and the synergy among interconnected terrestrial/freshwater, estuarine, nearshore, and ocean environments. Climate change and anthropogenic factors will continue to reduce adaptive capacity in Pacific salmon, to alter life history characteristics, and to simplify population structure.

The primary effects of climate change on Pacific Northwest salmon and steelhead are (Crozier 2016; Crozier et al. 2021):

- Direct effects of increased water temperatures alter fish physiology and increase susceptibility to disease.
- Temperature-induced changes to stream-flow patterns can block fish migration, trap fish in dewatered sections, dewater redds, introduce non-native fish, and degrade water quality.

- Alterations to freshwater, estuarine, and marine food webs alter the availability and timing of food resources.
- Changes in estuarine and ocean productivity change the abundance and productivity of fish resources.

The ESA Recovery Plan for Snake River Fall Chinook Salmon (NMFS 2017) identified the following potential effects of climate change in mainstem and tributary Snake River habitat:

- Increased water temperatures in the lower Snake River could cause migrating adult SR fall-run Chinook salmon to delay passage or to fail to enter fish ladders. This situation occurred at Lower Granite Dam in late July and early August 2013, when higher than average water temperatures and associated tailrace hydraulic conditions slowed the upstream movement of adult SR fall-run Chinook salmon. (Since then, as described above under Listing Factor A, fish ladder cooling systems have been installed at Lower Granite and Little Goose Dams to reduce adult migration delay caused by high water temperatures and excessive ladder temperature differentials in summer months.)
- In addition to the delay in migration described above, higher water temperatures during adult migration could also lead to increased pre-spawning mortality or reduced spawning success, increased fallback at dams, loss of energy reserves due to increased metabolic demand, or increased susceptibility to disease and pathogens.
- A delay in adult migration and spawn timing could then trigger a delay in fry emergence and dispersal. If delays in emergence timing occur and are long (i.e., weeks), then timing of smolt migration could be altered such that there is a mismatch with ocean conditions and predators. It is uncertain, however, whether delays in adult run timing would result in delayed fry emergence and dispersal since, as explained below, warmer winter temperatures would also increase incubation rates.
- Increased water temperatures could also accelerate the rate of egg development and lead to earlier fry emergence and dispersal. Research by Connor et al. (2002, 2003b, 2005) indicated that warmer water temperatures during the incubation period of fall Chinook salmon eggs also shifted the timing of emergence, parr, and smolt life stages earlier. This shift could be either beneficial or detrimental, depending upon spawning location and prey availability. If juvenile fall Chinook salmon were to move out of protected, shallow, nearshore habitats earlier, and potentially at a smaller size, their exposure and vulnerability to predators could be increased.
- If water temperatures in the lower Snake River became so warm during spring, summer, and fall that cold-water releases from Dworshak Reservoir could not maintain temperatures suitable for salmon, then the yearling life-history pattern of the SR fall-run Chinook population could be diminished or lost. Juvenile SR fall-run Chinook salmon that exhibit a yearling life history would be particularly susceptible to the increased temperatures in the river reach and reservoirs because they generally outmigrate later in the summer than subyearlings.

- SR fall-run Chinook salmon use of some tributary habitats might increase if winter water temperatures increase. Currently, it appears that fall Chinook salmon production in some tributary areas may be limited by low winter water temperatures. These areas could be more conducive to spawning and rearing if water temperatures rise.
- Sublethal thermal stress could increase vulnerability to predation (ISAB 2007). Increases in water temperatures in Snake and Columbia River reservoirs could increase consumption rates and growth rates of predators and, hence, predation-related mortality of juvenile fall Chinook salmon. Consumption of juvenile salmonids by northern pikeminnow, walleye, and smallmouth bass in Columbia and lower Snake River reservoirs is highest in July, concurrent with maximum availability of salmonid prey and high temperature (Vigg et al. 1991). Maximum daily consumption of juvenile salmonids by northern pikeminnow has also been shown to increase exponentially as a function of temperature (Vigg and Burley 1991).
- The higher temperatures could increase competition for food and/or result in changes in the food web. Warmer temperatures would increase juvenile salmonid metabolism, but would also favor food competitors of juvenile fall-run Chinook salmon, such as American shad, in late July or August. Larval and juvenile shad are suspected to reduce the abundance and size of *Daphnia* spp. (water fleas) in Columbia River reservoirs. This could reduce the amount of food available for yearling fall-run Chinook salmon that prefer *Daphnia* spp. and rear in the reservoirs (Rondorf et al. 1990; ISAB 2007); however, some juvenile fall Chinook salmon prey on young shad when they are available and this predation may increase.
- Reduced flow in late spring and summer could lead to delayed migration of juvenile fall Chinook salmon and higher mortality passing dams. However, it is also possible that the juvenile outmigrants could adjust their migration timing accordingly.

Effects Caused by Changing Flows and Temperatures

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. 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, the rate of change, and the unique life history characteristics of different natural populations (Crozier et al. 2008b). For example, a few weeks' difference in migration timing can have large differences in the thermal regime experienced by migrating fish (Martins et al. 2011).

Like most fishes, salmon are poikilotherms (cold-blooded animals); therefore, increasing temperatures in all habitats can have pronounced effects on their physiology, growth, and development rates (see review by Whitney et al. 2016). Increases in water temperatures beyond their thermal optima will likely be detrimental through a variety of processes, including increased metabolic rates (and therefore food demand), decreased disease resistance, increased physiological stress, and reduced reproductive success. All of these processes are likely to reduce the fitness of salmonids, including SR fall-run Chinook salmon (Beechie et al. 2013; Wainwright and Weitkamp 2013; Whitney et al. 2016).

By contrast, increased temperatures at ranges well below thermal optima (i.e., when the water is cold) can increase growth and development rates. Examples of this include accelerated emergence timing during egg incubation stages, or increased growth rates during fry stages (Crozier et al. 2008a; Martins et al. 2011). Temperature is also an important behavioral cue for migration (Sykes et al. 2009), and elevated temperatures may result in earlier-than-normal migration timing. While there are situations or stocks where this acceleration in processes or behaviors is beneficial, there are others where it is detrimental (Sykes et al. 2009; Whitney et al. 2016).

Climate change is predicted to increase the intensity of storms, reduce winter snowpack at low and middle elevations, and increase snowpack at high elevations in northern areas. Middle and lower-elevation streams will have larger fall/winter flood events and lower late-summer flows, while higher elevations may have higher minimum flows. How these changes will affect freshwater ecosystems largely depends on their specific characteristics and location (Crozier et al. 2008b; Martins et al. 2012). For example, within a relatively small geographic area (the Salmon River basin in Idaho), survival of some Chinook salmon populations was shown to be determined largely by temperature, while in other areas it was determined by flow (Crozier and Zabel 2006). Certain salmon populations inhabiting regions that are already near or exceeding thermal maxima will be most affected by further increases in temperature and, perhaps, the rate of the increases, while the effects of altered flow are less clear and likely to be basin-specific (Crozier et al. 2008b; Beechie et al. 2013). However, river flow is likely to become more variable in many rivers and is believed to negatively affect anadromous fish survival more than other environmental parameters (Ward et al. 2015). This increasingly variable flow will likely be detrimental to salmon populations in the Columbia River basin.

The effects of climate change on stream ecosystems are difficult to predict (Lynch et al. 2016). Changes in stream temperature and flow regimes are likely to lead to shifts in the distributions of native species and facilitate the establishment of exotic species. This will result in novel species interactions, including predator-prey dynamics, where juvenile native species may be either predators or prey (Lynch et al. 2016; Rehage and Blanchard 2016). How juvenile native species will fare as part of "hybrid food webs," which are constructed from a mixture of native and invasive species, is difficult to predict (Naiman et al. 2012).

New Climate Change Information

The 2016 5-year status review (NMFS 2016a) summarized the best available science on how climate change is predicted to impact freshwater environments, estuarine and plume environments, marine conditions and marine survival, the consequences of marine conditions, and drought management. The current best available science supports that previous analysis. The discussion below updates new information as it relates to how climate change is currently impacting and predicted to impact SR fall-run Chinook salmon in the future.

Marine Effects

Siegel and Crozier (2020) summarized new science published in 2019, with a number of publications describing the anomalous conditions of the marine heatwave that led to an onshore and northward movement of warm stratified waters into the California Current ecosystem off of the west coast of the United States. Brodeur et al. (2019) described the response of the plankton community composition and structure, suggesting that forage fish diets had to shift in response to food resources that are considerably less nutritionally dense. This was supported by the work of Morgan et al. (2019), who stated that it was unclear whether these observations represented an anomaly or were a permanent change in the Northern California Current.

Crozier et al. (2019) asserted in their vulnerability analysis (see below) that sea surface temperature and ocean acidification (as well as freshwater stream temperatures) were the most broadly identified climate-related stressors likely to impact salmon populations.

Groundwater Effects

The effect of climate change on groundwater availability is likely to be uneven. Sridhar et al. (2018) coupled a surface-flow model with a ground-flow model to improve predictions of surface water availability with climate change in the Snake River basin. Combining the VIC and MODFLOW models (VIC-MF), they predicted flow for 1986 through 2042. Comparisons with historical data show improved performance of the combined model over the VIC model alone. Projections using RCP 4.5 and 8.5 emission scenarios suggested an increase in water table heights in downstream areas of the basin and a decrease in upstream areas. Such assessments will help stakeholders manage water supplies more sustainably, but ultimately will likely make it more challenging for adult fall Chinook returning to spawn in late summer and early fall. In support of that idea, Leach and Moore (2019) found that groundwater may only make streams resistant to change in the short term as groundwater sources will be impacted on longer time scales.

Freshwater Effects

As cited in Siegel and Crozier (2019), Isaak et al. (2018) examined recent trends in stream temperature across the western United States using a large regional dataset. Stream warming trends paralleled changes in air temperature and were pervasive during the low-water warm seasons of 1996 to 2015 (0.18 to 0.35°C/decade) and 1976 to 2015 (0.14 to 0.27°C/decade). These results show how continued warming will likely affect the cumulative temperature exposure of migrating fall Chinook salmon. Isaak et al. (2018) concluded that most stream habitats will likely remain suitable for salmonids in the near future, with some becoming too warm, but many of the locations for the gages cited by Isaak et al. (2018) are on small tributaries not used by SR fall-run Chinook salmon. Migrating adults may be the most vulnerable life stage for this ESU; Connor et al. (2019) found significant challenges in the upstream migration stage through the Columbia River basin under projected climate change scenarios for SR fall-run Chinook salmon. Krosby et al. (2018) looked at temperature refugia and found that flat lowland areas, which commonly contain migration corridors, were generally least resilient to changes in air temperature, and thus should be prioritized for conservation and restoration.

Chittaro et al. (2019) examined habitat use and life history strategies of juvenile SR fall-run Chinook using otolith microchemistry collected from adults. They found that the majority of fish exhibited the yearling (versus sub-yearling) migratory strategy and that the mainstem Snake River provided important rearing grounds for both life-history strategies. These results described spatiotemporal patterns in juvenile habitat use and may help inform the management and conservation of these populations.

Marine Survival

Variation in marine productivity and prey quality can greatly impact the marine survival of salmon populations. The specific ocean habitat use of different salmon populations is poorly defined. Recent work by Espinasse et al. (2019) used carbon and nitrogen stable isotopes derived from an extensive time-series of salmon scales to examine aspects of the marine environment used by Rivers Inlet (British Columbia) sockeye salmon. The authors were able to identify likely rearing areas before sampling. This work as well as other research cited in Siegel and Crozier (2020) are improving our understanding of how marine productivity impacts salmon growth and survival, particularly during the early marine period.

While we understand that sea surface temperature is tightly linked to marine survival, we do not yet understand the mechanism involved. The work described above is important in our evolving understanding.

Siegel and Crozier (2019) observe that changes in marine temperature are likely to have a number of physiological consequences on fishes themselves. For example, in a study of small planktivorous fish, Gliwicz et al. (2018) found that higher ambient temperatures increased the distance at which fish reacted to prey. Numerous fish species (including many tuna and sharks) demonstrate regional endothermy, which in many cases augments eyesight by warming the retinas. However, Gliwicz et al. (2018) suggest that ambient temperatures can have a similar effect on fish that do not demonstrate this trait. Climate change is likely to reduce the availability of biologically essential omega-3 fatty acids produced by phytoplankton in marine ecosystems. Loss of these lipids may induce cascading trophic effects, with distinct impacts on different species depending on compensatory mechanisms (Gourtay et al. 2018). Reproduction rates of many marine fish species are also likely to be altered with temperature (Veilleux et al. 2018). The ecological consequences of these effects and their interactions add complexity to predictions of climate change impacts in marine ecosystems.

Climate Vulnerability Assessment

Crozier et al. (2019) recently completed a climate vulnerability assessment for Pacific salmon and steelhead, including SR fall-run Chinook salmon. The assessment was based on three components of vulnerability: (1) biological sensitivity, which is a function of individual species characteristics; (2) climate exposure, which is a function of geographical location and projected future climate conditions; and (3) adaptive capacity, which describes the ability of a DPS to adapt to rapidly changing environmental conditions. Objectives were to characterize the relative degree of threat posed by each component of vulnerability across DPSs and to describe landscape-level patterns in specific threats and cumulative vulnerability at the DPS level. Crozier et al. (2019) provides more information on the methodology used to calculate climate vulnerability for each ESU or DPS.

Crozier et al. (2019) concluded that SR fall-run Chinook salmon have high vulnerability to the effects of climate change, based on high biological sensitivity (which is a function of individual species characteristics), high exposure to climate effects, and high adaptive capacity.

Analysis of biological sensitivity included life-stage specific metrics that reflect the biological characteristics and geographic range of each DPS. Adult SR fall-run Chinook salmon migrate upstream from mid-August through October (Connor et al. 2019), and returning adults are exposed to temperatures exceeding 68°F (20°C), with cumulative exposures highest for early-returning adults (Keefer and Caudill 2015). Although models suggest that future migrants may experience lower migration and spawning success due to rising temperatures (Connor et al. 2019), Crozier et al. (2019) ranked vulnerability of this ESU during the adult freshwater stage as moderate, because most adults migrate after temperatures have peaked and spawn after temperatures have declined in the fall.

SR fall-run Chinook salmon eggs incubate in stream gravel through the winter, and fry emerge from early April (in the Hells Canyon reach of the Snake River, where most individuals return to spawn) to late May (in the Grande Ronde and Imnaha Rivers) (Connor et al. 2003b). Low winter temperatures may extend incubation times or limit the suitability of egg incubation in some locations (Connor et al. 2003b), so rising stream temperature during incubation is of less concern for this DPS. Juvenile emergence, growth, and migration occur earlier in warmer than in cooler spawning and rearing areas, and certain areas not used as spawning habitat appear to be too cold (Connor and Burge 2003; Connor et al. 2003a, b). Juveniles have been observed to tolerate constant temperatures of 22°C and fluctuating temperatures up to 27°C (Geist et al. 2010) and to grow well in these conditions, even at reduced rations (Geist et al. 2011). During the predominantly subyearling migration of this ESU, rapid growth and thermoregulatory behavior (Tiffan et al. 2009) allow fish to avoid thermal stress, despite generally warm summer temperatures in the lower Snake River (Connor and Burge 2003). Juveniles rearing in cooler reaches of the Clearwater River have shown a yearling life history, and hence adaptability to a wide temperature range. Thus Crozier et al. (2019) ranked sensitivity to climate change at the early life history and juvenile freshwater stage low for SR fall-run Chinook salmon.

The extent of estuary use and residence by SR fall-run Chinook salmon juveniles is not well known, but individuals are present in the estuary during summer and early fall (Teel et al. 2014). The ESU exhibits a wide distribution across the eastern Pacific Ocean, ranging from coastal British Columbia to California and Oregon. A moderate relationship has been reported between survival of subyearlings and the Pacific Decadal Oscillation, and between the northern copepod anomaly index and survival of Columbia River fall Chinook salmon (Peterson et al. 2014). Thus for the marine stage, Crozier et al. (2019) considered SR fall-run Chinook to have moderate risk.

SR fall-run Chinook salmon production is dominated by hatcheries, and Crozier et al. (2019) gave the ESU a very high score for hatchery influence on climate resilience, indicating a concern about the loss of phenotypic diversity and less ability to adapt to a changing climate in the future. Extrinsic factors in lower reaches of the Snake and Columbia Rivers range from an increasing proliferation of non-native species to a growing list of contaminants. Mainstem dams on the Snake and Columbia Rivers present challenges for both juvenile and adult migration. These factors were reflected in a high sensitivity score for other stressors (Crozier et al. 2019).

The exposure score for SR fall-run Chinook salmon was high based on exposure to warmer temperatures and changing hydrology in the freshwater portion of their life cycle, and higher sea surface temperatures and increased ocean acidification in the marine phase.

The adaptive capacity score was intended to capture perceived potential for behavioral, physiological, or other adaptive response to ameliorate climate stress. Despite considerable hatchery influence, the SR fall-run Chinook ESU has extensive opportunity for habitat shift and flexibility in age at juvenile migration (e.g., opportunities for an overwintering life history strategy), resulting in overall high adaptive capacity (Crozier et al. 2019).

Rearing and Migration Habitat Conditions in the Columbia River Estuary

The Columbia River estuary provides important habitat where juvenile SR fall Chinook salmon feed and complete the process of acclimating to salt water while avoiding predators. Juveniles from this ESU enter the estuary in two timing peaks each year. The first, likely made up of yearling migrants, passes Bonneville Dam during early to mid-May; the second (subyearlings) between late June and early July. Individuals of both life-history types generally spend less than a week in the estuary. Small numbers of subyearlings have been caught or detected in shallow water habitat along the margins of the estuary, including the larger “distributory” channels that provide access to floodplain wetland (NMFS 2017).

Since the late 1800s, 68 to 74 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening combined with flow regulation and other modifications (Kukulka and Jay 2003; Bottom et al. 2005; Marcoe and Pilson 2017; Brophy et al. 2019). Disconnection of tidal wetlands and floodplains has eliminated much of the historical rearing habitat for smaller subyearling Chinook salmon and reduced the production of wetland macrodetritus supporting salmonid food webs (Simenstad et al. 1990; Maier and

Simenstad 2009), both in shallow water and for larger juveniles, including subyearling SR fall Chinook salmon, migrating in the mainstem (PNNL and NMFS 2020).

Restoration actions in the estuary have improved habitat quality and fish access to floodplain forests and wetlands. From 2007 through 2019, the Bonneville Power Administration and U.S. Army Corps of Engineers implemented 64 projects that included dike and levee breaching or lowering, tide-gate removal, and tide-gate upgrades. These projects have reconnected over 6,100 acres of the historical floodplain to the mainstem Columbia River and another 2,000 acres of floodplain lakes (Karnezis 2019; BPA et al. 2020). This represents more than a 2.5 percent net increase in the connectivity of habitats that produce prey used by yearling Chinook salmon (Johnson et al. 2018). In addition to this extensive reconnection effort, the Bonneville Power Administration and Corps have acquired conservation easements to protect about 2,500 acres of currently functioning floodplain habitat from development. Numerous other project sponsors have completed floodplain protection and restoration projects in the lower Columbia River.

Floodplain habitat restoration can benefit juvenile salmonids whether they move onto the floodplain or stay in the mainstem. Wetland food production supports foraging and growth within the wetland (Johnson et al. 2018), but these prey items (primarily chironomid insects) (PNNL and NMFS 2018, 2020) are also exported to the mainstem and off-channel habitats behind islands and other landforms, where they become available to salmon and steelhead migrating in these locations. Thus, while most of the smolts produced by Snake River Chinook and sockeye salmon and steelhead populations may not enter a tidal wetland channel, they still derive benefits from wetland habitats. Continuing to grow during estuary transit may be part of a strategy to escape predation during the ocean life stage through larger body size.

Hatchery Effects

The effects of hatchery fish on the status of an ESU or DPS depend upon which of the four key attributes – abundance, productivity, spatial structure, and diversity – are currently limiting the ESU/DPS, and how the hatchery fish within the ESU/DPS affect each of the attributes (70 FR 37204). Hatchery programs can provide short-term demographic benefits, such as increases in abundance during periods of low natural abundance. They also can help preserve genetic resources until limiting factors can be addressed. However, the long-term use of artificial propagation may pose risks to natural productivity and diversity. The magnitude and type of the risk depends on the status of affected populations and on specific practices in the hatchery program.

Fall Chinook salmon are produced in four hatchery programs, all of which are part of the SR fall-run Chinook salmon ESU and funded as mitigation for fish production lost through construction and operation of hydropower dams in the Columbia and Snake River basins: the Lyons Ferry Hatchery Program, the Fall Chinook Acclimation Ponds Program, the Nez Perce Tribal Hatchery Program, and the Idaho Power Program (70 FR 37159). Releases of hatchery fish from these programs provide fish for harvest, but some releases are also intended to return hatchery fish to spawn naturally to increase the abundance of the naturally spawning population. Table 5 shows the ESA listing status and the status of ESA section 7 consultations on hatchery and genetics management plans (HGMPs) for SR fall-run Chinook salmon hatchery programs.

Table 5. ESA Status of Hatchery Programs within the SR Fall-Run Chinook Salmon ESU. HGMP = Hatchery and Genetic Management Plan, TRMP = Tribal Resource Management Plan; C = Review under the ESA is complete.

Program Stock Origin	Program	Run	Watershed Location of Release (State)	Currently Listed?	HGMP/ TRMP Status
Snake River Basin	Lyons Ferry Hatchery Program	Fall	Snake River (ID)	Yes	C
	Fall Chinook Acclimation Ponds Program	Fall	Snake River (ID)	Yes	C
	Nez Perce Tribal Hatchery Program	Fall	Snake and Clearwater rivers (ID)	Yes	C
	Idaho Power Program	Fall	Snake River (OR, ID)	Yes	C

In a 2012 biological opinion on the SR fall-run Chinook salmon hatchery programs, NMFS concluded that the proportion of hatchery-origin fish spawning naturally (pHOS), coupled with the presumed proportion of natural-origin fish in the broodstocks (pNOB), led to a proportionate natural influence (PNI) that was considerably lower than the 67 percent recommended for a population of high conservation concern, [13] and that these programs therefore posed a fitness risk through hatchery-influenced selection (NMFS 2012). While recognizing these risks, we also considered that although, in theory, the presence of so many hatchery-origin fish on the spawning grounds should cause fitness to decline, natural production in the population was increasing. Given that the hatchery program was also increasing in size, it was possible that the increase in natural production was caused by spawning of an increasing number of hatchery-origin fish, but it could not be ruled out that intrinsic productivity had increased. Based on this hypothesis and the relatively short number of generations the population had been subjected to hatchery influence, NMFS concluded that issuing an ESA Section 10 permit to continue operation of the programs through broodstock collection, without attempting to reduce hatchery influence, posed low risk to the survival or recovery of the population and thus the SR fall-run Chinook salmon ESU (NMFS 2012).

[13] Impacts of hatchery-origin fish spawning in natural production areas are often described based on the proportionate natural influence (PNI). PNI is a function of the proportion of hatchery origin spawners (pHOS) and the proportion of natural-origin fish in the hatchery broodstock (pNOB).

Hatchery programs, while undoubtedly having the ability to increase abundance, may pose genetic risks to natural populations. In particular, hatchery-influenced selection continues to pose a risk to SR fall-run Chinook salmon due to high pHOS and low PNI. NMFS calculated PNI levels to be 7 percent on average when the 2012 Biological Opinion was completed (NMFS 2012). However, PNI has, on average, improved in recent years due to management strategies outlined in the 2012 Biological Opinion. PNI has recently averaged 26 percent, and while still far below the 67 percent PNI recommendation, this is an impressive improvement. While pHOS levels above and below Lower Granite Dam remain around 70 percent, PNI has improved due to improved identification of natural-origin fish, selective use of older unmarked/untagged fish for broodstock, and limited reuse of known hatchery-origin males. These factors allowed for higher pNOB values (NMFS 2018b).

The recent proposed action from the *U.S. v. Oregon* biological opinion (NMFS 2018a), as well as a new site-specific SR fall-run Chinook salmon hatchery biological opinion (NMFS 2018b), included the movement of the 1 million fall Chinook salmon that Idaho Power Company released from the Hells Canyon reach into the Salmon River. Based on our current understanding of homing fidelity of SR fall-run Chinook salmon, the reprogramming of the Idaho Power Company releases should lessen the effects of the hatchery programs in the upper Snake River area (above the Salmon River) (Cleary et al. 2017). While we anticipate that this change will substantially reduce genetic risk from current levels, considerable uncertainty remains. However, it also potentially offers large benefits in terms of better understanding the productivity of the natural-origin population, as well as providing critical information on the consequences of large-scale perturbations in hatchery/natural dynamics. In addition, the population now has a much higher PNI level than it did previously. Although the hatchery programs continue to pose a risk, the level of risk is considerably reduced from previous levels, and at this point the programs do not appear to pose a risk to the survival or recovery of SR fall-run Chinook salmon (NMFS 2018b).

The SR fall Chinook salmon recovery plan (NMFS 2017) outlines the following three potential recovery scenarios: (A) achieve highly viable status for the extant Lower Snake River population and viable status for the currently extirpated Middle Snake River population; (B) achieve high certainty of highly viable status for the Lower Snake River population with the status of the population evaluated in the aggregate; and (C) achieve high certainty of highly viable status for the Lower Snake River population by evaluating status based on one or more Natural Production Emphasis Areas (NPEA). An NPEA is a region of greatly reduced hatchery influence compared to other spawning areas. In the recovery plan, NMFS acknowledged the uncertainties regarding the feasibility of Scenario C and the need to maintain opportunities to pursue other recovery scenarios if needed, but also noted that achieving recovery under Scenario C could be faster than under Scenario A, and that, unlike under Scenario B, existing levels of hatchery production could be maintained under Scenario C (NMFS 2017). Updated homing fidelity information presented at the Snake River Fall Chinook Symposium (Cleary et al. 2017) informed the preliminary feasibility of the NPEA and suggested that it may be possible to create such a scenario if the Idaho Power Company moved their hatchery releases from the upper Hells Canyon reach of the

Snake River to the Salmon River. Juvenile releases were moved from the upper Hells Canyon reach to the lower Salmon River beginning in 2018. The initial indication (2-salt spawners returning in 2020) is that adults from these releases are successfully spawning in the lower Salmon River (Brink 2021). It is too early to tell if the juveniles from this "new" production area will successfully return to spawn themselves, but upon initial review of data, the proportion of hatchery fish appears to have dropped slightly in the upper Hells Canyon reach as planned.

Listing Factor E Conclusion

Climate Change

Climate change affects the range-wide status of SR fall-run salmon and aquatic habitat. In their climate vulnerability analysis for Pacific salmon and steelhead, Crozier et al. (2019) rated SR fall-run Chinook salmon as having high vulnerability to the effects of climate change, based on high biological sensitivity (which is a function of individual species characteristics), high exposure to climate effects, and high adaptive capacity.

Migrating adults may be the most vulnerable life stage for this ESU. Connor et al. (2019) found significant challenges in the upstream migration stage through the Columbia River basin under projected climate change scenarios for SR fall-run Chinook salmon. Because most adults migrate after temperatures have peaked and spawn after temperatures have declined in the fall, however, Crozier et al. (2019) ranked vulnerability of this ESU during the adult freshwater stage as moderate. They rated sensitivity to climate change at the early life history and juvenile freshwater stage low for SR fall-run Chinook salmon, and for the marine stage, they considered SR fall-run Chinook to have moderate risk (Crozier et al. 2019). SR fall-run Chinook salmon production is dominated by hatcheries, and Crozier et al. (2019) gave the ESU a very high score for hatchery influence on climate resilience, indicating a concern about the loss of phenotypic diversity and less ability to adapt to a changing climate in the future.

Rearing and Migration Habitat Conditions in the Columbia River Estuary

Restoration actions in some areas of the Columbia River estuary have improved salmon habitat quality and juvenile access to floodplain wetlands and likely resulted in a small net improvement in conditions for juvenile outmigrants, including SR fall-run Chinook salmon. However, about 70 percent of the vegetated tidal wetlands of the Columbia River estuary have been lost to diking, filling, and bank hardening, combined with flow regulation and other modifications.

Hatchery Effects

In general, hatchery programs can provide short-term demographic benefits to salmon and steelhead, such as increases in abundance during periods of low natural abundance. They also can help preserve genetic resources until limiting factors can be addressed. However, the long-term use of artificial propagation may pose risks to natural productivity and diversity. The magnitude and type of risk depends on the status of affected populations and on specific practices in the hatchery program. Hatchery programs can affect naturally produced populations of salmon and steelhead in a variety of ways, including competition (for spawning sites and food) and predation effects, disease effects, genetic effects (e.g., outbreeding depression, hatchery-influenced selection), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge) (NMFS 2018a).

The hatchery programs that affect the SR fall-run Chinook salmon ESU have changed over time, and these changes have likely reduced adverse genetic effects on ESA-listed species. In particular, the recent proposed action from the *U.S. v. Oregon* biological opinion (NMFS 2018a), as well as a new SR fall-run Chinook salmon hatchery biological opinion (NMFS 2018b), included the movement of the 1 million fall Chinook salmon that Idaho Power Company released from the Hells Canyon reach into the Salmon River. This action was consistent with the recovery plan strategy to evaluate and adapt SR fall-run Chinook salmon hatchery programs to address uncertainties regarding the effect of hatchery fish on productivity of natural fish and to enhance our understanding of the status of the natural-origin population (NMFS 2017). Specifically, the change in juvenile release locations may also make it possible to implement Recovery Scenario C, which focused on creating one or more NPEAs to make it possible to directly evaluate the productivity of the natural population and ensure that a substantial proportion of the population is subject to natural selection rather than hatchery processes. While there are uncertainties about the feasibility of establishing an NPEA (and while it remains important to maintain opportunities to pursue any of the potential recovery scenarios), updated homing fidelity information (Cleary et al. 2017) suggests that it may be possible to create such a scenario under the Idaho Power Company's plan to move hatchery releases from Hells Canyon to the Salmon River, and the reprogramming of the Idaho Power Company releases should lessen the genetic effects of the hatchery programs in the upper Snake River area (above the confluence of the Salmon River) (NMFS 2018b). While we anticipate that this change will substantially reduce genetic risk from current levels, considerable uncertainty remains. In addition, the population is now being managed at a much higher PNI level than it was previously. Although the hatchery programs continue to pose a risk, the level is considerably reduced from previous levels and at this point does not appear to pose a risk to the survival or recovery of SR fall-run Chinook salmon (NMFS 2018b).

Recommended Future Actions

NMFS should ensure continued implementation of the 2018 biological opinion on SR fall-run Chinook salmon hatchery programs (NMFS 2018b). In addition, NMFS should convene a group to evaluate questions related to the relocation of hatchery fish releases from Hells Canyon to the Salmon River. The recovery plan explicitly highlighted hatchery management actions as a key component of the recovery strategy, given their potential to inform key questions about the species productivity and to improve diversity (NMFS 2017). One of these core actions is now being implemented, as described above, by working through the *U.S. v. Oregon* co-manager forum to relocate hatchery releases from Hells Canyon to the Salmon River. As also described in the recovery plan, there is a need to develop approaches to evaluate the effects of this relocation and to clarify delisting criteria under Recovery Plan Scenario C. For example, the recovery plan identified the following actions:

- Identify data gaps that limit assessment of feasibility of NPEA management frameworks and implement appropriate RME measures to fill the gaps.
- Develop appropriate metrics for evaluation of VSP status in NPEAs and other major spawning areas.
    - Develop methods/indices for the estimation of the relative contribution of naturally spawning hatchery SR fall-run Chinook salmon across major spawning areas to productivity and diversity.
- Identify and implement additional methods to measure effects of high levels of hatchery-origin spawners on the natural population of Snake River fall Chinook salmon productivity, diversity, and response to natural-selective processes.

2.4 Synthesis

The ESA defines an endangered species as one that is in danger of extinction throughout all or a significant portion of its range, and a threatened species as one that is likely to become an endangered species in the foreseeable future throughout all or a significant portion of its range. Under ESA section 4(c)(2), we must review the listing classification of all listed species at least once every 5 years. While conducting these reviews, we apply the provisions of ESA section 4(a)(1) and NMFS's implementing regulations at 50 CFR part 424.

To determine if a reclassification is warranted, we review the status of the species and evaluate the five factors, as identified in ESA section 4(a)(1): (1) the present or threatened destruction, modification, or curtailment of its habitat or range; (2) overutilization for commercial, recreational, scientific, or educational purposes; (3) disease or predation; (4) inadequacy of existing regulatory mechanisms; and (5) other natural or man-made factors affecting a species continued existence. We then make a determination based solely on the best available scientific and commercial information, taking into account efforts by states and foreign governments to protect the species.

We conclude:

- *Updated biological risk summary:* Our Northwest Fisheries Science Center completed an updated biological viability assessment for the ESU (Ford 2022). They concluded that the extant SR fall-run Chinook salmon population is meeting the criteria for "viable," but the population and the ESU as a whole are not meeting the recovery goals described in the recovery plan, which require the single population to be "highly viable with high certainty" and/or will require reintroduction of a viable population above the Hells Canyon Dam complex (NMFS 2017; Ford 2022).

- *Listing Factor A (Habitat):* We conclude that tributary and mainstem spawning, rearing, and migration conditions have likely improved slightly for SR fall-run Chinook salmon as a result of actions implemented to improve mainstem (and, to a lesser extent, tributary) habitats used by this ESU, and therefore the risk to the species' persistence because of habitat destruction or modification has been reduced slightly since the 2016 5-year status review. However, habitat concerns remain with regard to both mainstem and tributary habitats, and there is a need to more systematically evaluate what actions might offer the greatest benefits in terms of improved viability.
- *Listing Factor B (Overutilization):* We conclude that the risk to the species' persistence because of harvest or utilization related to scientific studies has changed little since the 2016 5-year status review, and is not currently considered a major risk factor for the species because of sustained systematic improvements to harvest management, and low mortality rates authorized for research and monitoring.
- *Listing Factor C (Disease and Predation*): We conclude that the risk to the species' persistence because of disease and predation has not changed since the 2016 5-year review, since: (1) predation impacts on SR fall-run Chinook salmon have remained relatively stable; and (2) disease rates have continued to fluctuate within the range observed in past review periods and are not expected to affect the extinction risk of the ESU.
- *Listing Factor D (Regulatory Mechanisms*): We conclude that since the 2016 5-year status review, the risk to persistence of SR fall-run Chinook salmon because of the inadequacy of regulatory mechanisms has decreased slightly.
- *Listing Factor E (Other Natural and Manmade Factors*): We conclude that since the last 5-year review, the overall risk to SR fall-run Chinook salmon because of other natural and manmade factors remains high as a result of high biological sensitivity, high risk for climate exposure, and low capacity to adapt (Crozier et al. 2019), and continued risk from hatchery programs.

After considering the biological viability of the SR fall-run Chinook salmon ESU and the current status of the ESA section 4(a)(1) factors, we conclude that the overall low risk rating for the ESU remains unchanged from that reported in the 2016 5-year status review. As also reported in the 2016 5-year status review, while the extinction risk status of the ESU has improved since it was listed in 1992, and while the ESU is at low risk, it is still not meeting its recovery goals (NMFS 2016a, 2017). The implementation of sound management actions to address hydropower, habitat, hatcheries, harvest, and predation remain essential to the recovery of this ESU. The ESA Snake River Fall Chinook Salmon Recovery Plan (NMFS 2017) will be the primary guide for identifying future actions to target and address limiting factors and threats for this ESU.

2.4.1 Snake River Fall-Run Chinook Salmon ESU Delineation and Hatchery Membership

The Northwest Fisheries Science Center's review (Ford 2022) found that no new information has become available that would justify a change in the delineation of the SR fall-run Chinook Salmon ESU.

The West Coast Region's 2022 review of new information since the previous 2016 5-year status review regarding the ESU/DPS membership status of various hatchery programs indicates no changes in the SR fall-run Chinook salmon ESU are warranted.

2.4.2 ESU/DPS Viability and Statutory Listing Factors

- The Northwest Fisheries Science Center's review of updated information (Ford 2022) does not indicate a change in the biological risk category for the SR fall-run Chinook salmon ESU since the time of the 2016 5-year status review (NWFSC 2015).
- Our analysis of ESA 4(a)(1) factors indicates that the risk to the SR fall-run Chinook salmon ESU's persistence has not changed significantly since our 2016 5-year status review (NMFS 2016a). The overall level of concern remains the same.

3. Results

3.1 Classification

Listing Status

Based on the information provided above, we recommend that the SR fall-run Chinook salmon ESU should remain listed as threatened.

ESU/DPS Delineation

No changes in the delineation of the SR fall-run Chinook Salmon ESU are warranted.

Hatchery Membership

We do not recommend any changes to hatchery program membership for the SR fall-run Chinook salmon ESU.

3.2 New Recovery Priority Number

Since the 2016 5-year status review, NMFS revised the recovery priority number guidelines and twice evaluated the numbers (NMFS 2019a, 2022). Table 4 indicates the number in place for the SR fall-run Chinook salmon ESU at the beginning of the current review (5C). In January 2022, the number remained unchanged.

As part of this 5-year review we reevaluated the number based on the best available information, including the new viability assessment (Ford 2022). We concluded that the current recovery priority number remains 5C.

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4. Recommendations for Future Actions

In our review of the listing factors, we identified several actions critical to maintaining and improving the status of the SR fall-run Chinook salmon ESU. These include implementing the 2017 Recovery Plan (NMFS 2017), the Idaho Power Company's SR fall-run Chinook salmon spawning program, the 2020 Columbia River System biological opinion (NMFS 2020), the Programmatic Sediment Management Plan, the current *U.S. v. Oregon* Management Agreement (NMFS 2018a), and the biological opinion on hatchery operations within the ESU (NMFS 2018b).

Recommended actions affecting Listing Factor A:

- *Continue the ongoing actions described above under Listing Factor A and considered to have contributed to the improved status of this ESU.*
    - Implementation of Idaho Power Company's SR fall-run Chinook salmon spawning program to enhance and maintain suitable spawning and incubation conditions, including recent voluntary actions to improve the quality of water exiting the Hells Canyon Complex.
    - Implementation of the Columbia River System biological opinion (including cool water releases from Dworshak Dam; summer flow augmentation and summer spill at multiple projects; operations at fish ladder cooling systems at Lower Granite Dam and Little Goose Dams; flexible spring spill and evaluation of its effects; juvenile fish transportation program as outlined in the 2020 biological opinion; operation of the PIT-tag detector in the removable spillway weir at Lower Granite Dam and use of the data obtained to inform critical uncertainties). In addition, continue the use of regional coordination to address and adaptively manage any new issues associated with the implementation of Columbia River System operations.
    - Implementation of Lower Snake River PSMP measures to reduce impacts of reservoir and river channel dredging and disposal on SR fall-run Chinook salmon.
    - Implementation of TMDLs and tributary habitat improvement actions (primarily to benefit SR spring/summer Chinook salmon and steelhead but with ancillary benefits to SR fall-run Chinook salmon).
    - Efforts to restore an early-spawning fall Chinook salmon component in the Clearwater River.
- *Convene a group to provide coordination for additional validation and development of the SR fall-run Chinook salmon life-cycle model so that it can be used to assess potential response of SR fall-run Chinook salmon to alternative management strategies and actions under*

alternative climate scenarios, and to determine the best opportunities for closing the gap between the species' current status and its ESA recovery objectives.[14]

- *Protect CWRs, as outlined in the Columbia River Cold Water Refuge Plan, discussed above (EPA 2021).*

Recommended actions affecting Listing Factor B:

- Continue implementation of the *U.S. v. Oregon* Management Agreement.

Recommended actions affecting Listing Factor C:

- Continue ongoing predation control and monitoring actions.

Recommended actions affecting Listing Factor D:

- Continue implementation of improved regulatory mechanisms.

Recommended actions affecting Listing Factor E:

- Continue implementation of the 2018 biological opinion on SR fall-run Chinook salmon hatchery programs (NMFS 2018b).
- Convene a group to evaluate questions related to the relocation of hatchery fish releases from Hells Canyon to the Salmon River, including approaches to evaluate the effects of this relocation and to clarify delisting criteria under Recovery Plan Scenario C. For example, the recovery plan identified a need for the following actions:
    - Identify data gaps that limit assessment of feasibility of NPEA management frameworks and implement appropriate RME measures to fill the gaps.
    - Develop appropriate metrics for evaluation of VSP status in NPEAs and other major spawning areas.
    - Develop methods/indices for the estimation of the relative contribution of naturally spawning hatchery SR fall-run Chinook salmon across major spawning areas to productivity and diversity.
    - Identify and implement additional methods to measure effects of high levels of hatchery-origin spawners on the natural population of Snake River fall Chinook salmon productivity, diversity, and response to natural-selective processes.

Additional recommendations:

- The ESA Recovery Plan for Snake River Fall Chinook Salmon (NMFS 2017) noted that as the plan was implemented, new information might become available that could improve our

[14] Note that this recommended action is cross-cutting across multiple listing factors.

understanding of the status of the ESU as well as of threats, their impacts, and the extent to which they have been ameliorated. The recovery plan also noted that details of how to evaluate the status of SR fall-run Chinook salmon under Recovery Scenario C needed to be further developed, and the ICTRT signaled that there might be a need to explore alternative methods to estimating intrinsic productivity. NMFS should review its understanding of how to evaluate SR fall-run Chinook salmon population status, particularly productivity, as well as evaluate whether any new information on the status of the species, threats to the species, or other factors warrants a review of the delisting criteria proposed in the plan.

- Continue to explore opportunities for reintroduction above the Hells Canyon Complex in case a reestablished Middle Snake River population is needed for ESA recovery.

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NATIONAL MARINE FISHERIES SERVICE
5-YEAR REVIEW

Oncorhynchus tshawytscha: Snake River Fall-Run Chinook Salmon

Current Classification: Threatened

Recommendation resulting from the 5-Year Review

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_**X**__No change needed

Review Conducted By: West Coast Region Snake River Fall-run Chinook Salmon ESU Evaluation Team

REGIONAL OFFICE APPROVAL:

Scott M. Rumsey, Ph.D., West Coast Region

Acting Regional Administrator, NOAA Fisheries

Approve____ Date: ________

HEADQUARTERS APPROVAL:

Assistant Administrator, NOAA Fisheries

I concur. ____ Date_______
Signature

I do not concur. ____ Date _______
Signature

NATIONAL MARINE FISHERIES SERVICE
5-YEAR REVIEW

Oncorhynchus tshawytscha: Snake River F

Current Classification: Threatened

Recommendation resulting from the 5-Year Review

- [ ] Downlist to Threatened
- [ ] Uplist to Endangered
- [ ] Delist
- [x] No change is needed

Review Conducted By (Name and Office):

West Coast Region Snake River Fall-run Chinook Salmon ESU Evaluation Team

REGIONAL OFFICE APPROVAL:

Lead Regional Administrator, NOAA Fisheries

Approve Korie Ann Schaeffer Date: 06/30/2022
For Scott M. Rumsey, Ph.D., Acting Regional Administrator

Cooperating Regional Administrator, NOAA Fisheries

[ ] Concur [ ] Do Not Concur [x] N/A

Signature__________________________ Date: _______

HEADQUARTERS APPROVAL:

Assistant Administrator, NOAA Fisheries

[x] Concur [ ] Do Not Concur

Signature RAUCH.SAMUEL.D.III.1365850948 Digitally signed by RAUCH.SAMUEL.D.III.1365850948 Date: 2022.08.05 16:10:14 -04'00' Date: _______