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

Recreational and Tribal Treaty Steelhead Fisheries in the Snake River Basin

NMFS Consultation Number: WCR-2018-10283

Action Agency: National Marine Fisheries Service (NMFS)

Affected Species and Determinations:

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

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

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

Issued By:

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Sustainable Fisheries Division

Date: March 14, 2019

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1. INTRODUCTION

1.1. Background

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

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

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

1.2. Consultation History

NMFS has issued four previous section 10(a)(1)(B) permits to the Idaho Department of Fish and Game (IDFG) for their recreational fisheries since first listing Snake River sockeye salmon as endangered (November 20, 1991, 56 FR 58619). In 1993, the IDFG applied for a permit, and NMFS subsequently issued permit 844 that same year after completion of a biological opinion (NMFS 1993). Permit 844 expired December 31, 1998, and IDFG was issued permit 1150 on May 28, 1999, which expired at the end of 1999. The IDFG's next application was accompanied by a conservation plan that detailed how fisheries were conducted, and permit 1233 was issued on May 26, 2000. The IDFG submitted a request on February 25, 2004 (with amendments on March 4, 2004), to renew the ESA coverage. In response, NMFS issued permit 1481.

IDFG submitted a new Fishery Management and Evaluation Plan (FMEP) for all fisheries in 2009 prior to the expiration of permit 1481, and requested a one year permit extension. NMFS granted the extension request, and approved fisheries for resident fish and spring/summer Chinook salmon, but NMFS did not act on the FMEP for steelhead/fall Chinook salmon. IDFG and NMFS resumed discussion of these fisheries in March of 2018 and IDFG submitted a revised FMEP on November 1, 2018 (IDFG 2018). Recreational selective steelhead fisheries addressed under this 4(d) authorization are the same as those addressed by permits 844, 1150, 1233, and 1481, and continue to be similar in time and location to the activities assessed in the earlier permits.

The Oregon Department of Fish and Wildlife (ODFW) submitted a FMEP on their recreational steelhead fisheries in the Grande Ronde, Imnaha and Snake rivers to NMFS first in 1998 and again in 2009. In response to recent discussion with NMFS, ODFW has submitted a revised FMEP on February 21, 2019 for these steelhead fisheries to NMFS for evaluation under limit 4 of the 4(d) Rule (ODFW 2019).

The Washington Department of Fish and Wildlife's (WDFW) recreational selective steelhead fishery in the Tucannon and Grande Ronde Rivers, and Snake River mainstem was previously authorized by NMFS on April 18, 2011 (NMFS 2011b). Based on renewed discussion with other fishery managers since March of 2018, the incidental take coverage for the recreational selective steelhead fishery authorized during that consultation will be superseded with this opinion.

The Nez Perce Tribe (NPT) conducts annual Treaty fisheries for steelhead and other anadromous fish consistent with their reserved fishing rights under the Treaty of 1855 (12 Stat. 957). The NPT's treaty steelhead fisheries in the Clearwater River Subbasin were described in previous *United States v. Oregon* biological assessments and associated biological opinions. The NPT treaty steelhead fisheries in the Snake Basin were also described in plans provided to NMFS in 2006, 2007 and 2014. The Tribe provided an updated and revised plan to NMFS on November 21, 2018 for evaluation under the 4(d) Tribal rule (Nez Perce Tribe 2018).

At this time, the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), and the Shoshone-Bannock Tribes (SBT) have decided not to submit a TRMP for a steelhead fishery. However, both the CTUIR and the SBT may choose to submit one in the future in coordination with the other fishery managers.

Since March of 2018, NMFS and the six fishery managers in the Snake River Basin have worked to create a basin-wide framework that limits impacts to ESA-listed steelhead. Monthly meetings with all fishery managers have been held to discuss the framework, provide feedback on fishery plans, identify next steps, and review draft documents. In addition numerous phone conversations and e-mail correspondence with all fishery managers has occurred between the monthly meetings to maintain momentum. The Proposed Action description below summarizes the outcome of these discussions.

1.3. Proposed Federal Action

NMFS proposes to issue a determination that the Snake River steelhead FMEPs submitted by IDFG and ODFW meet the criteria required by limit 4 of the 4(d) Rule. NMFS also proposes to issue a determination that the Snake River steelhead TRMP submitted by the NPT meets the requirements of the Tribal 4(d) Rule. This Proposed Action encompasses fair sharing of harvestable fish between tribal and non-tribal fisheries in accordance with Treaty fishing rights standards, which is the intent of *US v. Oregon*. In addition, the Proposed Action supports the Federal government's tribal trust and fiduciary responsibilities1.

[1] The Tribal steelhead fishery harvest has been limited (or minimal) and the levels of harvest of these fish will increase over time to allow for meaningful exercise of their treaty fishing rights. This depends on having sufficient access to fish at all "usual and accustomed" fishing places to catch the treaty harvest share.

1.3.1. Fishery Descriptions

The information in this section is based on the FMEPs submitted by IDFG, ODFW, and WDFW, and the TRMP submitted by the NPT (IDFG 2018; Nez Perce Tribe 2018; ODFW 2019; WDFW 2009).

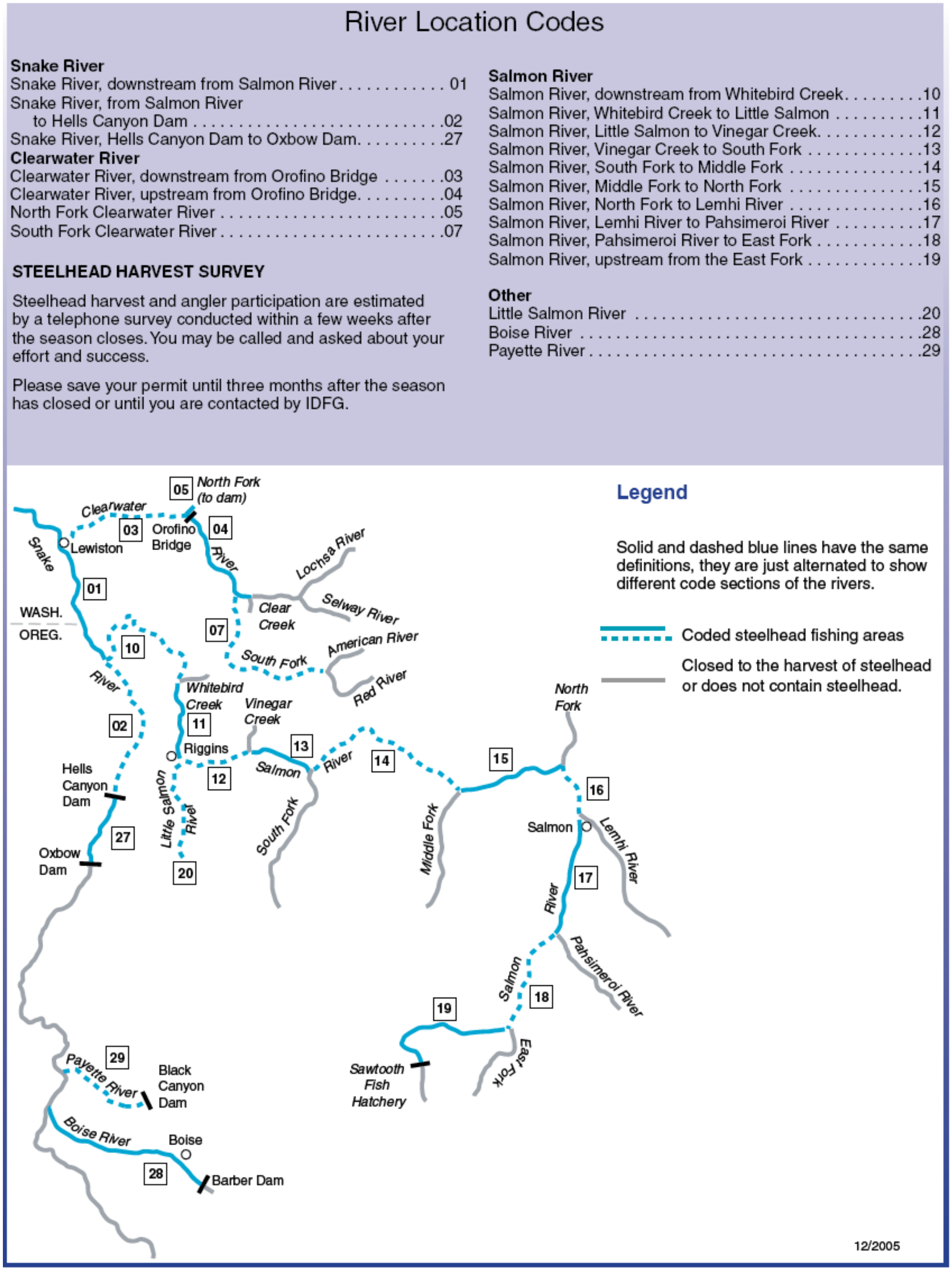
Table 1. Proposed Steelhead Fisheries

Fishery	Manager	Location (river sections)[3]	Timing	Gear
Recreational mark-selective steelhead[1, 2]	IDFG	Mainstem Snake River (1, and 2)	August 1-April 30	Barbless hook; bait, lure, jig
		Lower Mainstem Clearwater River (lower 3)	July 1-April 30	
		Mainstem and middle fork Clearwater River (upper 3, and 4)	July 1-April 30	
		North Fork Clearwater River (5)	July 1-April 30	
		South fork Clearwater River (7)	July 1-April 30	
		Lower mainstem Salmon River (10, 11, lower 12)	August 1-April 30	
		Middle mainstem Salmon River (upper 12, 13, 14)	August 1-March 31	
		Upper mainstem Salmon River (15-19)	August 1-April 30	
		Little Salmon River (20)	August 1-May 15	
		Non-anadromous waters; upstream of Hells Canyon Dam, and Boise and Payette Rivers	October 15-May 30	
Recreational mark-selective steelhead	ODFW	Grande Ronde and Imnaha Rivers	September 1-April 30	Barbed and barbless hook: bait, lure, jig
		Mainstem Snake River	September 1-April 30	
Recreational mark-selective steelhead	WDFW	Mainstem Snake River (640, 642, 644, 646, 648, 650)	August 1-March 31	Barbless hook; bait, lure, jig
		Palouse, and Tucannon Rivers (652, 653)	August 1-April 15	
		Grande Ronde River (592)	August 1-April 15	
Treaty steelhead	NPT	Clearwater, Salmon, Grande Ronde, Imnaha and Tucannon River Subbasins and Snake River mainstem	Late August-April	Hook, gillnet, spear, seine, weir, dipnet, gaff, other traditional gear

[1] For IDFG's steelhead fishery this period covers both catch-and-release and ad-clipped (hatchery) retention fishing.

[2] Only hatchery-origin steelhead, with a clipped adipose fin as evidence by a healed scar may be harvested during open steelhead seasons. Steelhead without a clipped adipose fin as evidenced by a healed scar must be immediately released unharmed.

[3] The river sections identified within parentheses correlate with the numbered river locations identified in Figure 1 and Figure 2.



River Location Codes

Snake River
Snake River, downstream from Salmon River 01
Snake River, from Salmon River to Hells Canyon Dam 02
Snake River, Hells Canyon Dam to Oxbow Dam. 27

Clearwater River
Clearwater River, downstream from Orofino Bridge 03
Clearwater River, upstream from Orofino Bridge. 04
North Fork Clearwater River 05
South Fork Clearwater River 07

STEELHEAD HARVEST SURVEY

Steelhead harvest and angler participation are estimated by a telephone survey conducted within a few weeks after the season closes. You may be called and asked about your effort and success.

Please save your permit until three months after the season has closed or until you are contacted by IDFG.

Salmon River
Salmon River, downstream from Whitebird Creek. 10
Salmon River, Whitebird Creek to Little Salmon 11
Salmon River, Little Salmon to Vinegar Creek. 12
Salmon River, Vinegar Creek to South Fork 13
Salmon River, South Fork to Middle Fork 14
Salmon River, Middle Fork to North Fork 15
Salmon River, North Fork to Lemhi River 16
Salmon River, Lemhi River to Pahsimeroi River 17
Salmon River, Pahsimeroi River to East Fork 18
Salmon River, upstream from the East Fork 19

Other
Little Salmon River 20
Boise River 28
Payette River 29

Figure 1. Areas in Idaho open to state-managed recreational steelhead fisheries.

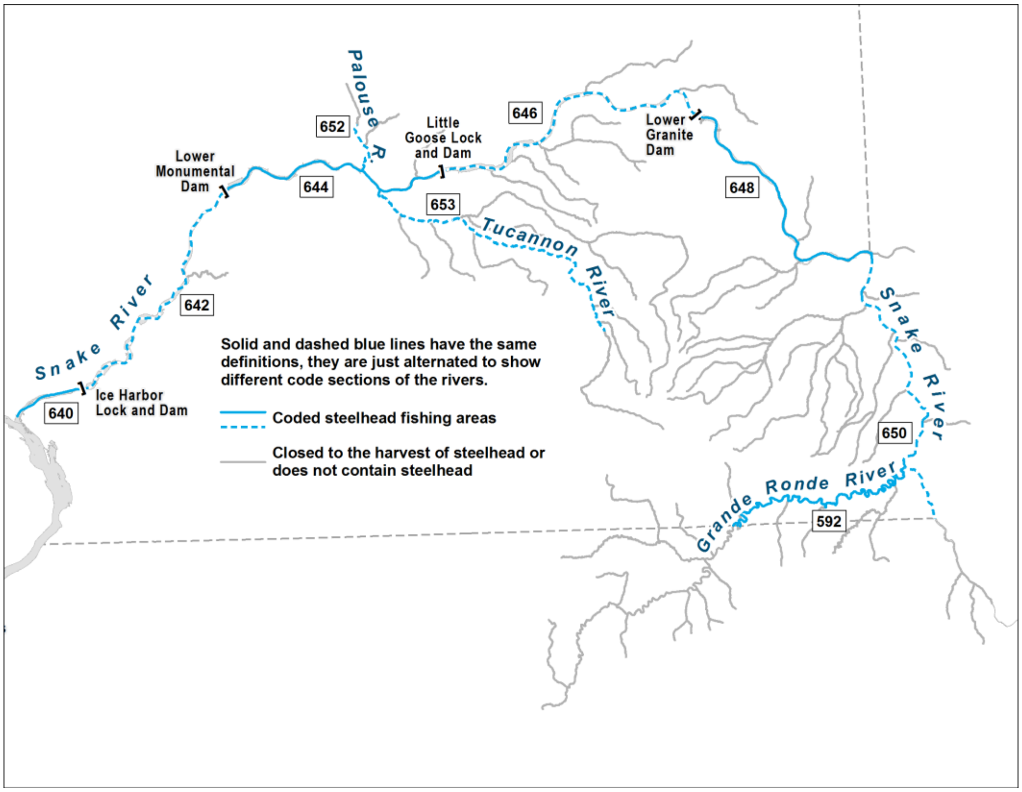


Figure 2. The mainstem Snake, Tucannon, and Grande Ronde River areas within southeast Washington open for recreational steelhead fisheries.

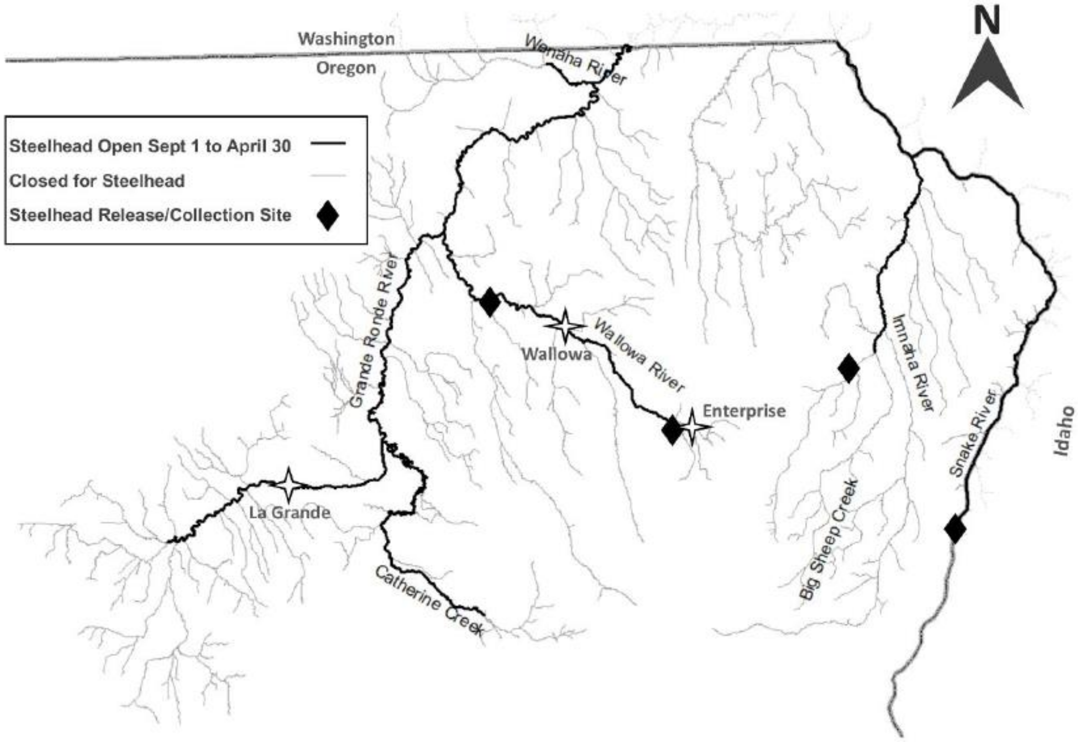


Figure 3. Areas in Northeast Oregon open to state-managed steelhead recreational fishing.

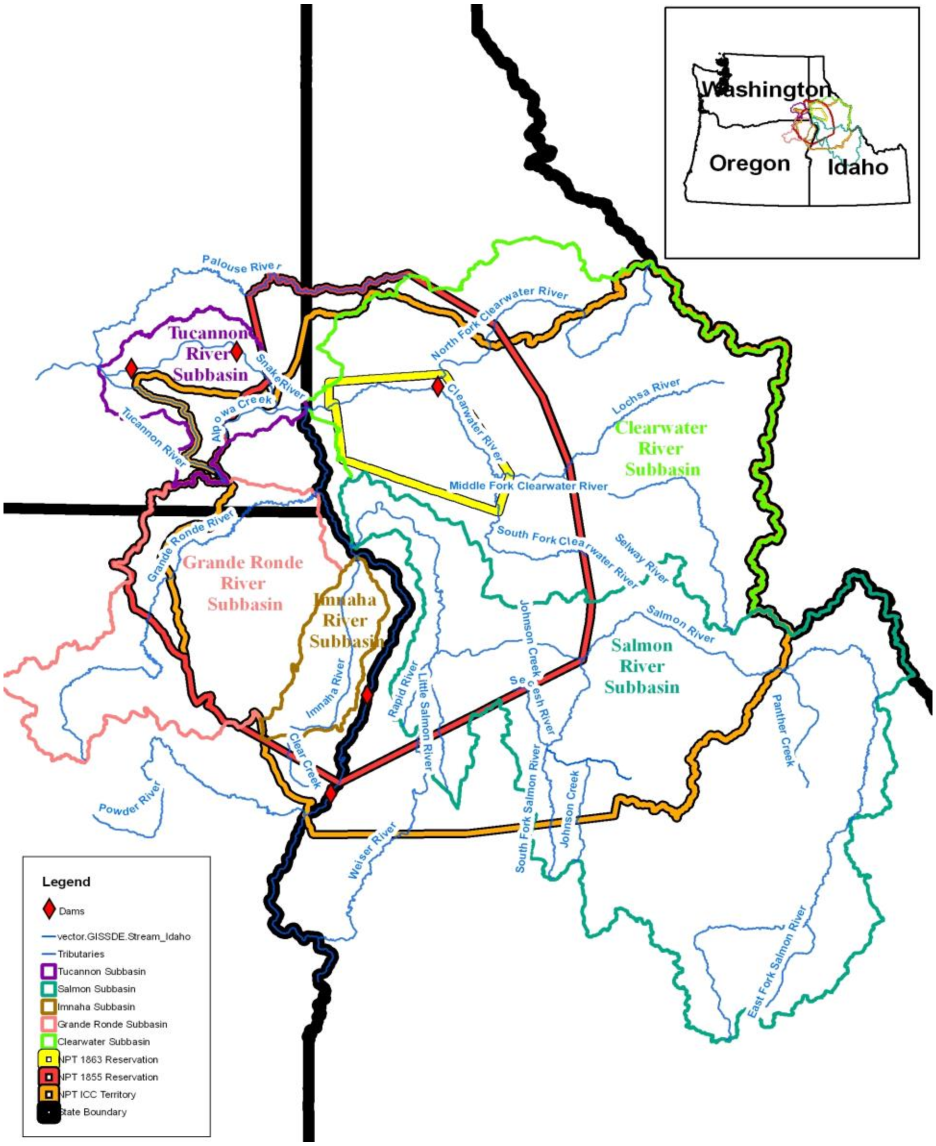


Figure 4. The Snake River Basin and its harvest areas as they relate to the Nez Perce Tribe's 1855 Reservation and usual and accustomed fishing areas.

1.3.2. Proposed Impact Rates and Calculation Methodology

Steelhead

The submitted FMEPs propose to maintain status quo steelhead fisheries in Oregon, Washington, and Idaho portions of the Snake River Basin. However, the proposed TRMP includes proposed changes to the allowable tribal harvest rates. The TRMP and ODFW's FMEP also propose a refined methodology that would be used by the fishery managers to determine impact rates on Snake River steelhead. Previously, fishery impacts were reported at the distinct population segment (DPS) level for most fisheries occurring in the mainstem Snake River, Clearwater, and Salmon River basins. In contrast, they were reported as impacts on the major population group

(MPG[2]) level for the Grande Ronde and Imnaha Rivers, and at the population level for Tucannon River (NMFS 2005b; NMFS 2011b). Because there is now more refined steelhead escapement data using genetic stock identification (GSI), the fishery managers are now able to determine natural-origin impacts by MPG for the entire Snake River steelhead DPS.

Identifying harvest rates by MPG allows the fishery managers to manage their fisheries more effectively. That is, they can change their regulations to limit impacts on MPGs with low abundance while allowing the continuation of fisheries that only affect MPGs with higher abundance levels. A more in depth discussion of the role of MPGs within a DPS can be found in Section 2.2.1

The TRMP also sets forth a framework for jointly managing impacts to each MPG. ODFW, WDFW, and IDFG support the proposed framework as depicted in Table 2, and would manage their fisheries jointly with the Nez Perce Tribe to meet the MPG goals identified in the framework (Hebdon 2019; ODFW 2019). Impact rates under the proposed framework are defined in Table 2. It is expected that tribal and state fishery managers would determine allocation of the total impact rates reflected in Table 3 between treaty and non-treaty fisheries. Furthermore, maintaining status quo recreational fisheries may continue to affect the tribal fishery by limiting access to the river in time and space to catch treaty share of the harvest. In the proposed management framework, any incidental impacts on adult steelhead during fisheries for fall Chinook salmon, spring/summer Chinook salmon, coho salmon, and resident trout in the action area would also be included in the impact rates described in Table 2[3].

Table 2. Proposed maximum allowable impact rates for ESA-listed natural-origin steelhead from fisheries in the Snake River Basin. Rates are expressed as the percent of adults which passed above Ice Harbor Dam by Major Population Group (MPG).

MPG	Proposed natural-origin lethal impact rate of steelhead that pass Ice Harbor Dam (%)
Lower Snake	5
Clearwater	10
Grande Ronde	10
Imnaha	5
Salmon	10

If MPG abundances at Ice Harbor Dam are predicted to fall below their aggregated (excluding extirpated populations) critical abundance threshold (CAT) as defined in Table 3 based on the preseason forecast, fishery managers will work with NOAA to determine what management

[2] MPGs are sets of populations that share genetic, geographic (hydrographic), and habitat characteristics within the DPS.

[3] Fisheries in the Snake River Basin that target spring/summer Chinook salmon and resident trout were evaluated by NMFS in 2011 and 2013 (NMFS 2011, NMFS 2013). NMFS is in the process of conducting a 5-year review of these authorizations. NMFS is also in the process of evaluating the effects of Snake River Basin fisheries that target fall Chinook and coho salmon; we expect to complete a biological opinion on these fisheries in 2019.

measures will be implemented to reduce encounters of wild steelhead. The degree of management change will depend on how many consecutive years of low abundance have been observed/and or are forecasted. For example, in the first year of forecasted low abundance, fishery managers may institute a change such as a decrease in bag limits, but in the second consecutive year of forecasted low abundance, fishery managers may decrease bag limits and prohibit fishing in certain areas.

Table 3. Critical abundance thresholds for ESA-listed natural-origin steelhead used for management of fisheries in the Snake River Basin. Thresholds are measured in terms of adult passage above Ice Harbor Dam by Major Population Group (MPG).

MPG	Critical-Abundance Threshold[1]
Lower Snake	450
Clearwater	1500
Grande Ronde	1200
Imnaha	300
Salmon	2850

[1] The CAT for each MPG is 30% of the aggregated (excluding extirpated populations) MPG minimum abundance threshold (MAT) value, as apportioned for each MPG determined by the average GSI proportions from the most recent five years available at Lower Granite Dam.

Fall Chinook Salmon

The fishery managers propose to manage steelhead fisheries to limit incidental mortality on natural-origin Snake River fall Chinook adults to 6% or less (as a percentage of adult passage past Lower Granite Dam, plus the Tucannon River).

Spring/Summer Chinook Salmon

The applicants propose to manage their steelhead fisheries to limit impacts on Snake River spring/summer Chinook salmon to 40 encounters and up to 4 incidental deaths.

Sockeye Salmon

The applicants propose to manage their steelhead fisheries to limit impacts on Snake River sockeye salmon to 10 encounters and up to 1 incidental death.

1.3.3. Fishery Monitoring and Reporting

For adult steelhead fisheries, all fishery managers will use the agreed-to preseason forecast of steelhead abundance at Ice Harbor Dam at the MPG level for fishery planning purposes. Although sampling of Snake River steelhead is focused at Lower Granite Dam, the forecasted returns of adults to Ice Harbor Dam must be used in order to include all Snake River steelhead (e.g., Lower Snake MPG). However, the run reconstruction effort uses information at Lower Granite Dam to inform estimates at Ice Harbor Dam. The fishery managers will then coordinate all fisheries on allocation and to not exceed the proposed impact rates at the MPG level in Table 3. Steelhead returns at Bonneville Dam are monitored throughout the season and some in-season data (e.g., PIT-tagged hatchery returns) can be used to adjust the preseason forecast and make in-season management changes such as bag, season, or fishing area limits. Post-season, dam counts and GSI will be used to estimate the abundance of steelhead by MPG.

Each year, fishery managers will supply harvest and impact data for the Steelhead Run Reconstruction model by January 31 of the year after the fishery ends. However, due to the time lag in obtaining coded-wire tag (CWT) and catch record card (CRC) data from ODFW and WDFW, it is necessary for fishery managers to submit a preliminary post-season report to NMFS by March 15 following the year the fishery ends using a rough estimate of catch rate indexes on natural-origin steelhead expanded by angler effort. Fishery managers will then submit a finalized post-season report by December 31 when the CWT and CRC data is available. For example, for the 2018-2019 season ending May 30th 2019, data would be supplied for the model by January 31, 2020, the preliminary report would be submitted to NMFS by March 15, 2020, and the final report would be submitted to NMFS by December 31, 2020.

State Recreational Steelhead Fisheries

The ODFW and WDFW assess steelhead impacts using creel surveys to determine natural-origin fish encounters. This index area information is combined with CRC information where needed, to determine the total number of natural-fish encountered. A 5% catch-and-release mortality rate is then applied to the natural-origin encounter rate to determine lethal impacts attributable to fisheries (Flesher et al. 2017; WDFW 2009).

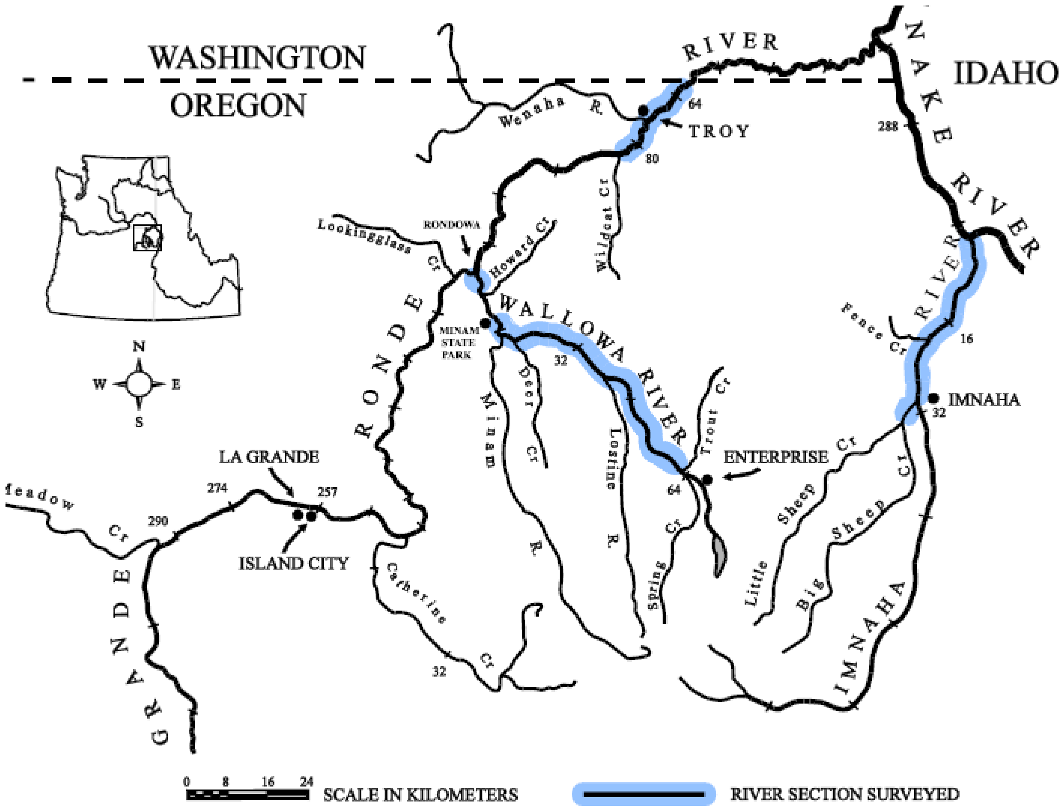


Figure 4. Map of northeastern Oregon showing where summer steelhead creel surveys were conducted in the Grande Ronde and Imnaha river basins during the 2014-15 run year.

Idaho's estimation method is different in that during creel surveys, surveyors collect data on the number of hatchery fish harvested and the total number of fish caught and released. Hatchery fish data is used instead of natural-fish encountered because the creel was designed to sample for biological data making it limited in scale, but the phone survey can be used to extrapolate over the entire fishery. A hatchery fish encounter rate is estimated by applying the proportion of fish caught and kept in the fishery (as determined through the creel survey). To the total number of hatchery fish harvested (as determined by the telephone survey). The telephone survey questions a subsample of licensed individuals on the number of hatchery fish harvested and then scales up to all participants in the fishery. IDFG assumes the natural-origin encounter rate is the same as hatchery-origin encounter rate (Kiefer 2007). This is IDFG's best approximation of natural-origin encounter rates based on the data collected, nonetheless IDFG has committed to investigating alternative methods for estimating encounter rates of natural-origin fish (IDFG 2018).

The IDFG then applies the same 5% catch-and-release mortality rate to determine lethal impacts. The rationale for using a 5% catch-and-release mortality rate is described in Section 2.5.1. The IDFG will be conducting a study in collaboration with the University of Idaho to further validate the encounter rates and catch-and-release mortality rates used to calculate impacts prior to the 5-year check-in. This study is not part of the proposed action considered in this biological opinion, and impacts to ESA-listed species as a result of this catch-and release mortality study are covered under IDFG's state 4(d) research authorization (Approval number 22514; NMFS 2018c).

Tribal Treaty Fisheries

The NPT also has a monitoring program in place to determine the amount of clipped, unclipped hatchery and natural-origin steelhead harvested during their fisheries. The NPT conducts creel surveys in two main areas to estimate steelhead harvested in their treaty fisheries; the North Fork Clearwater and mainstem reaches of the Snake and Clearwater rivers. The NPT also conducts post-season surveys to determine where fishing is taking place and what was caught for other locations not sampled on an in-season basis.

1.4. Interrelated and Interdependent Actions

Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration. NMFS has identified angler access and wading, and boat operation as interdependent or interrelated activities associated with the Proposed Action.

Hatcheries are not part of this Proposed Action. Although fisheries target hatchery-origin returns, harvest frameworks are managed separately from specific hatchery programs, and are not solely tied to production numbers. However, this Opinion accounts for the effects of hatcheries and other fisheries not included in the Proposed Action, including *U.S. v Oregon* fisheries, as part of the species status, baseline, and cumulative effects discussions.

2. Endangered Species Act: Biological Opinion and Incidental Take Statement

2.1. Analytical Approach

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

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

The designations of critical habitat for the species considered in this opinion use the terms primary constituent element (PCE) or essential features. The new critical habitat regulations (81

FR 7414, February 11, 2016) replace this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. We use the term PCE as equivalent to PBF or essential feature, due to the description of such features in applicable recovery planning documents.

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

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

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

- *Analyze the effects of the proposed action on both the species and their habitat*
  Section 2.5 first describes the various pathways by which proposed fisheries can affect ESA-listed salmon and steelhead, then applies that concept to the specific programs considered here.

- *Cumulative effects*
  Cumulative effects, as defined in NMFS' implementing regulations (50 CFR 402.02), are the effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area. Future Federal actions that are unrelated to the proposed action are not considered because they require separate section 7 consultation. Cumulative effects are considered in Section 2.6 of this opinion.

- *Integration and synthesize the above factors by:* (1) Reviewing the status of the species and critical habitat; and (2) adding the effects of the action, the environmental baseline, and cumulative effects to assess the risk that the proposed action poses to species and critical habitat (Section 2.7).

- *Reach a conclusion about whether species are jeopardized or critical habitat is adversely modified*. These conclusions (Section 2.8) flow from the logic and rationale presented in the Integration and Synthesis Section (2.7).

- *If necessary, suggest a RPA to the proposed action.* If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat, we must identify a reasonable and prudent alternative (RPA) to the action in Section 2.8. The RPA must not be likely to jeopardize the continued existence of listed species nor adversely modify their designated critical habitat and it must meet other regulatory requirements.

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

This opinion examines the status of each species and designated critical habitat that would be affected by the Proposed Action (Table 4). Status of the species is tied to the level of risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and ESA listing determinations. This informs the description of the species' likelihood of both survival and recovery. The species status section helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the current function of the essential PBFs that help to form that conservation value.

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

Species	Listing Status	Critical Habitat	Protective Regulations
Chinook salmon *(Oncorhynchus tshawytscha)*			
Snake River spring/summer	Threatened, 79 FR 20802, April 14, 2014	64 FR 57399, October 25, 1999	70 FR 37160, June 28, 2005

Snake River fall	Threatened, 79 FR 20802, April 14, 2014	58 FR 68543, December 28, 1993	70 FR 37160, June 28, 2005
Steelhead *(O. mykiss)*			
Snake River	Threatened, 79 FR 20802, April 14, 2014	70 FR 52769, September 2, 2005	70 FR 37160, June 28, 2005
Mid-Columbia River	Threatened, 79 FR 20802, April 14, 2014	70 FR 52769, September 2, 2005	70 FR 37160, June 28, 2005
Sockeye salmon (*O. nerka*)			
Snake River	Endangered, 79 FR 20802, April 14, 2014	70 FR 52769, September 2, 2005	Issued under ESA Section 9

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

2.2.1. Status of Listed Species

As described in Section 2.1, Analytical Approach, for Pacific salmon and steelhead, NMFS commonly uses four parameters to assess the viability of the populations that, together, constitute the species status: abundance, productivity, spatial structure, and diversity (McElhany et al. 2000). These VSP criteria therefore encompass the species' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. When data from these parameters are collected at appropriate levels, they inform a population's capacity to adapt to various environmental conditions and allow it to sustain itself in the natural environment. These parameters or attributes are substantially influenced by habitat and other environmental conditions.

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

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

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

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

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

In order to describe a species' status, it is first necessary to define what the term "species" means in this context. In addition to defining "species" as including an entire taxonomic species or subspecies of animals or plants, the ESA also recognizes listing units that are a subset of the species as a whole. As described above, the ESA allows a DPS (or in the case of salmon, an ESU) of a species to be listed as threatened or endangered. In terms of determining the status of a species, the Willamette Lower Columbia TRT (WLC TRT) developed a hierarchical approach for determining ESU-level viability criteria (Figure 5) that represents best available science and is used for the purposes of this opinion.

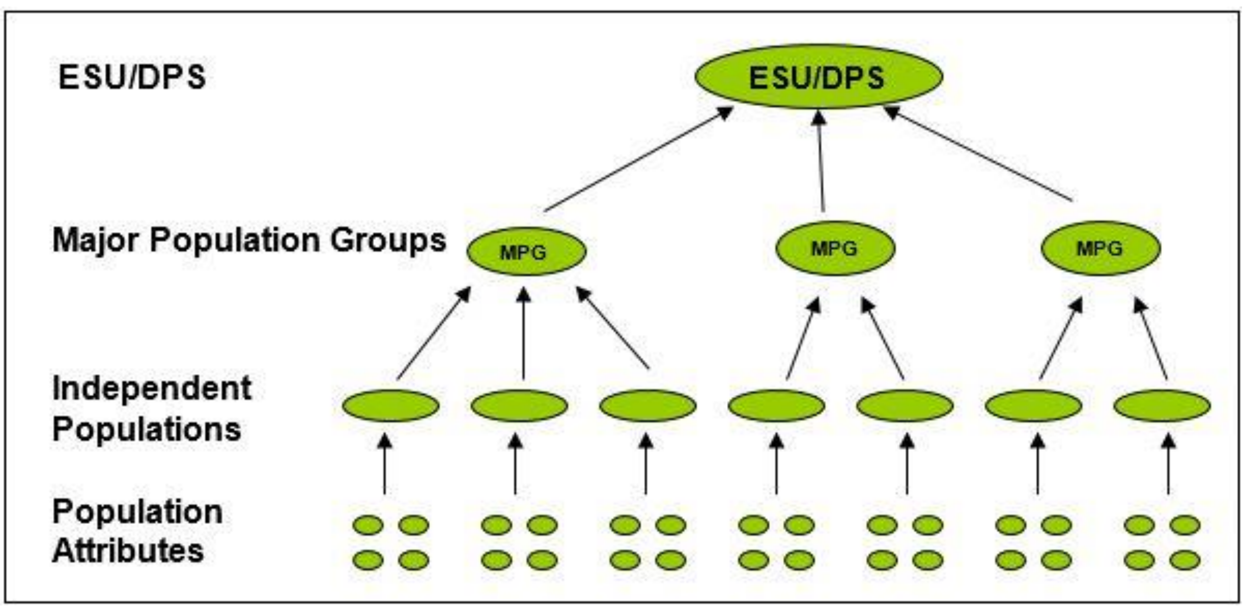


Figure 5. Hierarchical approach to ESU viability criteria.

Briefly, an ESU or DPS is divided into natural populations (McElhany et al. 2000). The risk of extinction of each population is evaluated, taking into account population-specific measures of abundance, productivity, spatial structure, and diversity. Natural populations are then grouped into ecologically and geographically similar *strata* (referred to as major population groups (MPG)) which are evaluated on the basis of population status. In order to be considered viable, an MPG generally must have at least half of its historically present natural populations meeting their population-level viability criteria (McElhany et al. 2006). A viable salmonid ESU or DPS, requires all extant MPGs to be viable, and is naturally self-sustaining, with a high probability of persistence over a 100-year period.

In assessing status, we consider the hierarchical approach described above in combination with the information used in its most recent ESA status review for the salmon and steelhead species considered in this opinion, and if applicable, consider more recent data, that are relevant to the species' rangewide status. Many times, this information exists in ESA recovery plans. Recent information from recovery plans, where they are developed for a species, is often relevant and is used to supplement the overall review of the species' status. This step of the analysis tells us how well the species is doing over its entire range in terms of trends in abundance and productivity, spatial distribution, and diversity. It also identifies the causes for the species' decline.

The status review starts with a description of the general life history characteristics and the population structure of the ESU or DPS including the MPGs where they occur. We review VSP information that is available including abundance, productivity and trends (information on trends supplements the assessment of abundance and productivity parameters), and spatial structure and diversity. We also summarize available estimates of extinction risk that are used to characterize the viability of each natural population leading-up to a risk assessment for the ESU or DPS, and the limiting factors and threats. This Section concludes by examining the status of critical habitat.

Recovery plans are an important source of information that describe, among other things, the status of the species and its component populations, limiting factors, recovery goals and actions that the plan recommends to address limiting factors. Recovery plans are not regulatory documents and the recommended actions are not assured of happening. Consistency of a proposed action with a recovery plan, therefore, does not by itself provide the basis for determining that an action does not jeopardize the species. However, recovery plans do provide a perspective encompassing all human impacts that is important when assessing the effects of an action. Information from existing recovery plans for each respective ESA-listed salmon and steelhead is discussed where it applies in various sections of this opinion.

2.2.1.1. Snake River Steelhead

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

The Snake River Basin Steelhead DPS includes all naturally spawned anadromous *O. mykiss* originating below natural and manmade impassable barriers in streams in the Snake River Basin of southeast Washington, northeast Oregon, and Idaho (Figure 6) (NWFSC 2015). This DPS consists of A-Index steelhead, which primarily return to spawning areas beginning in the summer, and the B-Index steelhead, which exhibit a larger body size and begin their migration in the fall (NMFS 2011a). Twenty-six historical populations within six MGPs comprise the Snake River Basin Steelhead DPS. Inside the geographic range of the DPS, 12 hatchery steelhead programs are currently operational. Five of these artificial programs are included in the DPS (Table 5) (Jones Jr. 2015). Genetic resources can be housed in a hatchery program, but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS see NMFS (2005d).

Table 5. Snake River Basin Steelhead DPS description and MPGs (Jones Jr. 2015; NMFS 2012b; NWFSC 2015).

DPS Description	
Threatened	Listed under ESA as threatened in 1997; updated in 2014.
6 major population groups	26 historical populations (2 extirpated)
Major Population Group	***Populations***
Grande Ronde	Joseph Creek, Upper Mainstem, Lower Mainstem, Wallowa River
Imnaha River	Imnaha River
Clearwater	Lower Mainstem River, North Fork Clearwater (extirpated), Lolo Creek, Lochsa River, Selway River, South Fork Clearwater
Salmon River	Little Salmon/Rapid, Chamberlain Creek, Secesh River, South Fork Salmon, Panther Creek, Lower MF, Upper MF, North Fork, Lemhi River, Pahsimeroi River, East Fork Salmon, Upper Mainstem
Lower Snake	Tucannon River, Asotin Creek
Hells Canyon Tributaries	Wild Horse/Powder River (extirpated)
Artificial production	
Hatchery programs included in DPS (6)	Tucannon River summer, Little Sheep Creek summer, EF Salmon River Natural A, Dworshak NFH B, SF Clearwater (Clearwater Hatchery) B, Salmon River B
Hatchery programs not included in DPS (7)	Lyons Ferry NFH summer, Wallowa Hatchery summer, Hells Canyon A, Pahsimeroi Hatchery A, Upper Salmon River A, Streamside Incubator Project A and B, Little Salmon River A

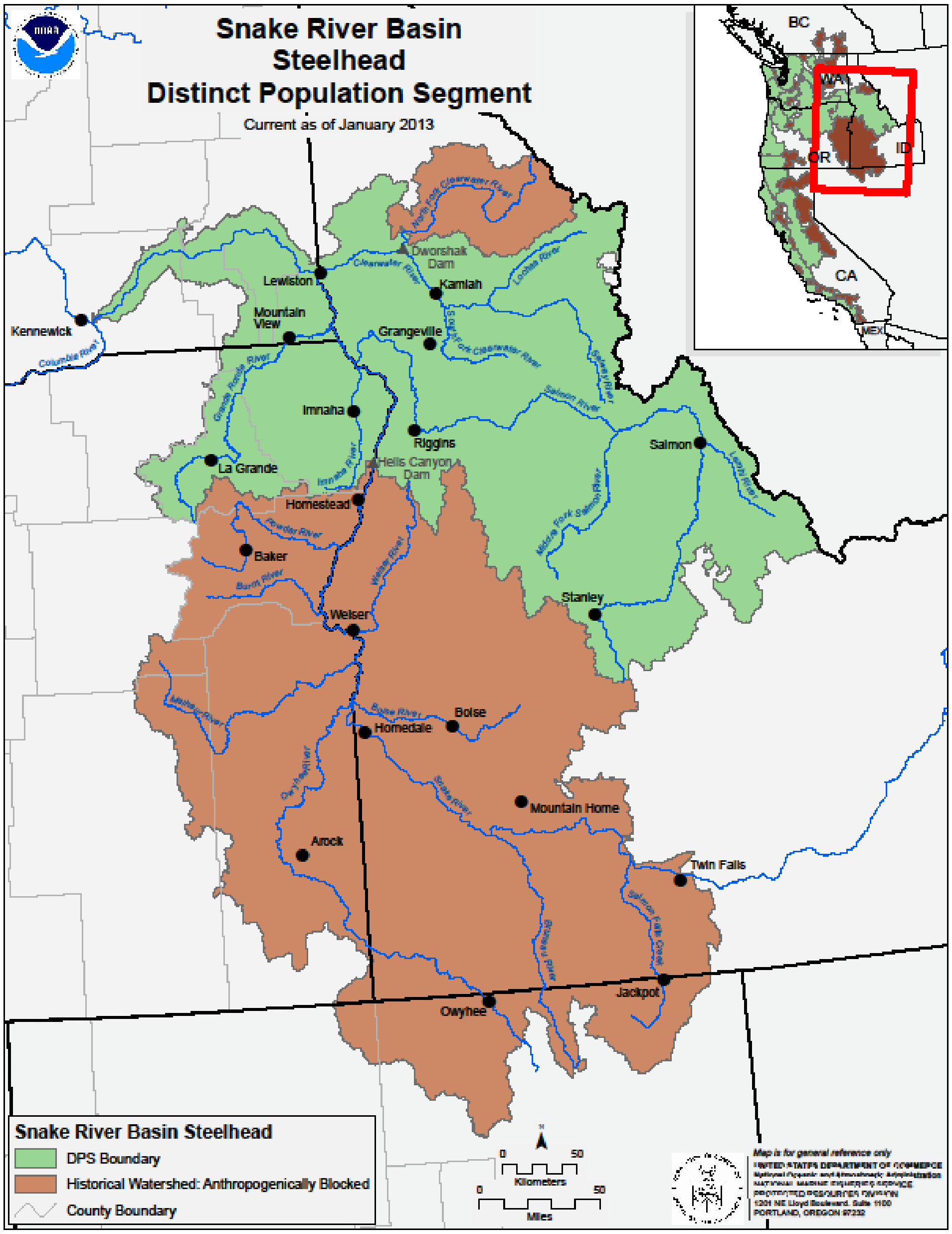


Figure 6. Map of the Snake River Basin Steelhead DPS's spawning and rearing areas.

Snake River Basin steelhead exhibit two distinct morphological forms, identified as "A-Index" and "B-Index" fish, which are distinguished by differences in body size, run timing, and length of ocean residence. B-Index fish predominantly reside in the ocean for 2 years, while A-Index steelhead typically reside in the ocean for 1-year (NMFS 2017e). Because of different ocean residence times, B-Index steelhead are generally larger than A-Index fish. The smaller size of A-Index adults allows them to spawn in smaller headwater streams and tributaries. The differences in the two fish forms represent an important component of phenotypic and genetic diversity of the Snake River Basin Steelhead DPS through the asynchronous timing of ocean residence, segregation of spawning in larger and smaller streams, and possible differences in the habitats of the fish in the ocean (NMFS 2012b).

Like all salmonid species, steelhead are cold-water fish (Magnuson et al. 1979) that survive in a relatively narrow range of temperatures, which limits the species distribution in fresh water to northern latitudes and higher elevations. Snake River Basin steelhead migrate a substantial distance from the ocean (up to 930 miles) and occupy habitat that is considerably warmer and drier (on an annual basis) than steelhead of other DPSs. Adult Snake River Basin steelhead return to the Snake River Basin from late summer through fall, where they hold in larger rivers for several months before moving upstream into smaller tributaries, and are generally classified as summer-run (NMFS 2012b; NMFS 2013b). A small component returns in the following spring, just prior to spawning.

Steelhead live primarily off stored energy during the holding period, with little or no active feeding (Laufle et al. 1986; Shapovalov and Taft 1954). Adult dispersal toward spawning areas varies with elevation, with the majority of adults dispersing into tributaries from March through May, with earlier dispersal at lower elevations, and later dispersal at higher elevations. Spawning begins shortly after fish reach spawning areas, which is typically during a rising hydrograph and prior to peak flows (NMFS 2012b; Thurow 1987).

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the Snake River Basin Steelhead DPS ranges from moderate to high risk and remains at threatened status. A great deal of uncertainty remains regarding the relative proportion of hatchery-origin fish in natural spawning areas near major hatchery release sites.

Direct counts of steelhead abundance by population are generally not available for Snake River steelhead due to difficulties conducting surveys in much of their range when steelhead move into their spawning tributaries. However, most populations are thought to be maintained, meaning they exist at levels providing ecological and evolutionary function to the DPS as a whole (ICTRT 2007; NWFSC 2015). Information on the distribution of natural returns among stock groups and populations indicates that differences in abundance/productivity status among populations may be more related to habitat conditions such as geography or elevation rather than the morphological forms of A-run versus B-run (NWFSC 2015).

For those populations where information is known, productivity is above replacement (i.e., when the number of offspring are equivalent to the number of parents, or 1) and abundance is close to or exceeds the MAT values, which are the values required for the population to meet the full range of criteria for a viable salmonid population (Table 6). These values were derived by assuming a replacement rate of 1, and considering available spawning habitat (ICTRT 2007). Recently, steelhead abundance for this DPS has been low. One possible explanation is the warm -water “Blob” that formed in the Pacific Ocean off the coast of the Pacific Northwest in 2014. Over the last several years, these ocean conditions have led to poor survival of young salmon and steelhead while they were in the ocean. The Blob has dissipated, but it is still impacting the number of adult salmon and steelhead that are returning the Columbia River Basin. However, recent samples taken by scientists at NMFS’ Northwest Fisheries Science Center have indicated that marine conditions are improving.

The ICTRT viability criteria adopted in the Snake River Management Unit Recovery Plans include spatial explicit criteria and metrics for both spatial structure and diversity. With one exception, spatial structure ratings for all of the Snake River Basin steelhead populations were low or very low risk, given the evidence for distribution of natural production with populations. The exception was the Panther Creek population, which was given a high risk rating for spatial structure based on the lack of spawning in the upper sections. No new information was provided for the 2015 status update that would change those ratings (NWFSC 2015).

Updated information is available for two important factors that contribute to rating diversity risk under the ICTRT approach: hatchery spawner fractions and the life history diversity. Hatchery straying appears to be relatively low. At present, direct estimates of hatchery returns based on PBT analysis are available for the run assessed at Lower Granite Dam and at the hatchery rack (IDFG 2015). Furthermore, information from the Genetic Stock Identification (GSI) assessment sampling provide an opportunity to evaluate the relative contribution of B-Index returns within each stock group. No population fell exclusively into the B-Index size category, although there were clear differences among population groups in the relative contributions of the larger B-Index life history type (NWFSC 2015).

Table 6. Risk levels and viability ratings for Snake River steelhead Major Population Groups (MPGs) (NWFSC 2015). Data are from 2004-2015. ICTRT = Interior Columbia Technical Recovery Team. Current abundance and productivity estimates expressed as 10-year geometric means (standard error).

MPG	Population	ICTRT minimum threshold	Natural spawning abundance	Productivity	Abundance and productivity risk[1]	Spatial structure and diversity risk[1]	Overall risk viability rating[1]
Clearwater River	Lower Main	1500	2099 (0.15)	2.36 (0.16)	Moderate	Low	Maintained
	South Fork	1000	Insufficient data		High	Moderate	Maintained/High
	Lolo Creek	500	Insufficient data		High	Moderate	Maintained/High
	Selway River	1000	1650 (0.17)	2.33 (0.18)	Moderate	Low	Maintained
	Lochsa River	1000			Moderate	Low	Maintained
Salmon River	Little Salmon River	500	Insufficient data		Moderate	Moderate	Maintained
	South Fork	1000	1028 (0.17)	1.8 (0.15)	Moderate	Low	Maintained
	Secesh River	500			Moderate	Low	Maintained
	Chamberlain Creek	500			Moderate	Low	Maintained
	Lower Middle Fork	1000	2213 (0.16)	2.38 (0.10)	Moderate	Low	Maintained
	Upper Middle Fork	1000			Moderate	Low	Maintained
	Panther Creek	500	Insufficient data		Moderate	High	High
	North Fork	500	Insufficient data		Moderate	Moderate	Maintained
	Pahsimeroi River	1000	Insufficient data		Moderate	Moderate	Maintained
	East Fork	1000	Insufficient data		Moderate	Moderate	Maintained
	Upper Main	1000	Insufficient data		Moderate	Moderate	Maintained
	Lemhi	1000	Insufficient data		Moderate	Moderate	Maintained
Imnaha	Imnaha River	1000	Insufficient data		Moderate	Moderate	Maintained
Grande Ronde River	Lower Grande Ronde	1000	Insufficient data		Moderate	Moderate	Maintained
	Joseph Creek	500	1839	1.86	Very Low	Low	Low
	Upper Grande Ronde	1500	1649	3.15	Moderate	Moderate	Low
	Wallowa River	1000	Insufficient data		High	Moderate	Maintained
Lower Snake River	Tucannon River	1000	Insufficient data		High	Moderate	High
	Asotin Creek	500	Insufficient data		Moderate	Moderate	High

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

Limiting Factors

One of the necessary steps in recovery and consideration for delisting the species is to ensure that the underlying limiting factors and threats have been addressed. There are many factors that affect the abundance, productivity, spatial structure, and diversity of the Snake River Basin Steelhead DPS. Factors that limit the DPS have been, and continue to be (NMFS 2017e):

- Mainstem Columbia River hydropower-related adverse effects,
- Impaired tributary fish passage,
- Degraded, including degradation in floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream flow, and water quality as a result of cumulative impacts of agriculture, forestry, and development,
- Impaired water quality and increased water temperature,
- Related harvest effects, particularly for B-Index steelhead,
- Predation, and
- Genetic diversity effects from out-of-population hatchery releases

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

2.2.1.2. Middle Columbia River Steelhead

On March 25, 1999, NMFS listed the MCR Steelhead DPS as a threatened species (64 FR 14517). The threatened status was reaffirmed in 2006 and most recently on April 14, 2014 (79 FR 20802). Critical habitat for the MCR steelhead was designated on September 2, 2005 (70 FR 52808).

The MCR Steelhead DPS includes naturally spawned anadromous *O. mykiss* originating from below natural and manmade impassable barriers from the Columbia River and its tributaries upstream of the Wind River (Washington) and Hood River (Oregon) to and including the Yakima River, excluding the Upper Columbia River tributaries (upstream of Priest Rapids Dam) and the Snake River. Four MPGs, composed of 20 historical populations (3 extirpated), comprise the MCR Steelhead DPS. Inside the geographic range of the DPS, 10 hatchery steelhead programs are currently operational. Seven of these artificial programs are included in the DPS (Table 7). As explained by NMFS (2005d), genetic resources can be housed in a hatchery program, but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS, see NMFS (2005d).

Table 7. MCR Steelhead DPS description and MPGs (Jones Jr. 2015; NWFSC 2015).

DPS Description	
Threatened	Listed under ESA as threatened in 1999; updated in 2014
4 major population groups	20 historical populations (3 extirpated)
Major Population Group	***Populations***
Cascades Eastern Slope Tributaries	Deschutes River Eastside, Deschutes River Westside, Fifteenmile Creek*, Klickitat River*, Rock Creek*, Crooked River (extirpated), White Salmon River (extirpated)
John Day River	John Day River Lower Mainstem Tributaries, John Day River Upper Mainstem Tributaries, MF John Day River, NF John Day River, SF John Day River
Yakima River	Naches River, Satus Creek, Toppenish Creek, Yakima River Upstream Mainstem
Umatilla/Walla Walla Rivers	Touchet River, Umatilla River, Walla Walla River, Willow Creek (extirpated)
Artificial production	
Hatchery programs included in DPS (7)	Touchet River Endemic summer, Yakima River Kelt Reconditioning summer (in Satus Creek, Toppenish Creek, Naches River, and Upper Yakima River), Umatilla River summer, Deschutes River summer
Hatchery programs not included in DPS (3)	Lyons Ferry NFH summer (on-station and Walla Walla River releases), Skamania summer, Skamania winter

* These populations are winter steelhead populations. All other populations are summer steelhead populations.

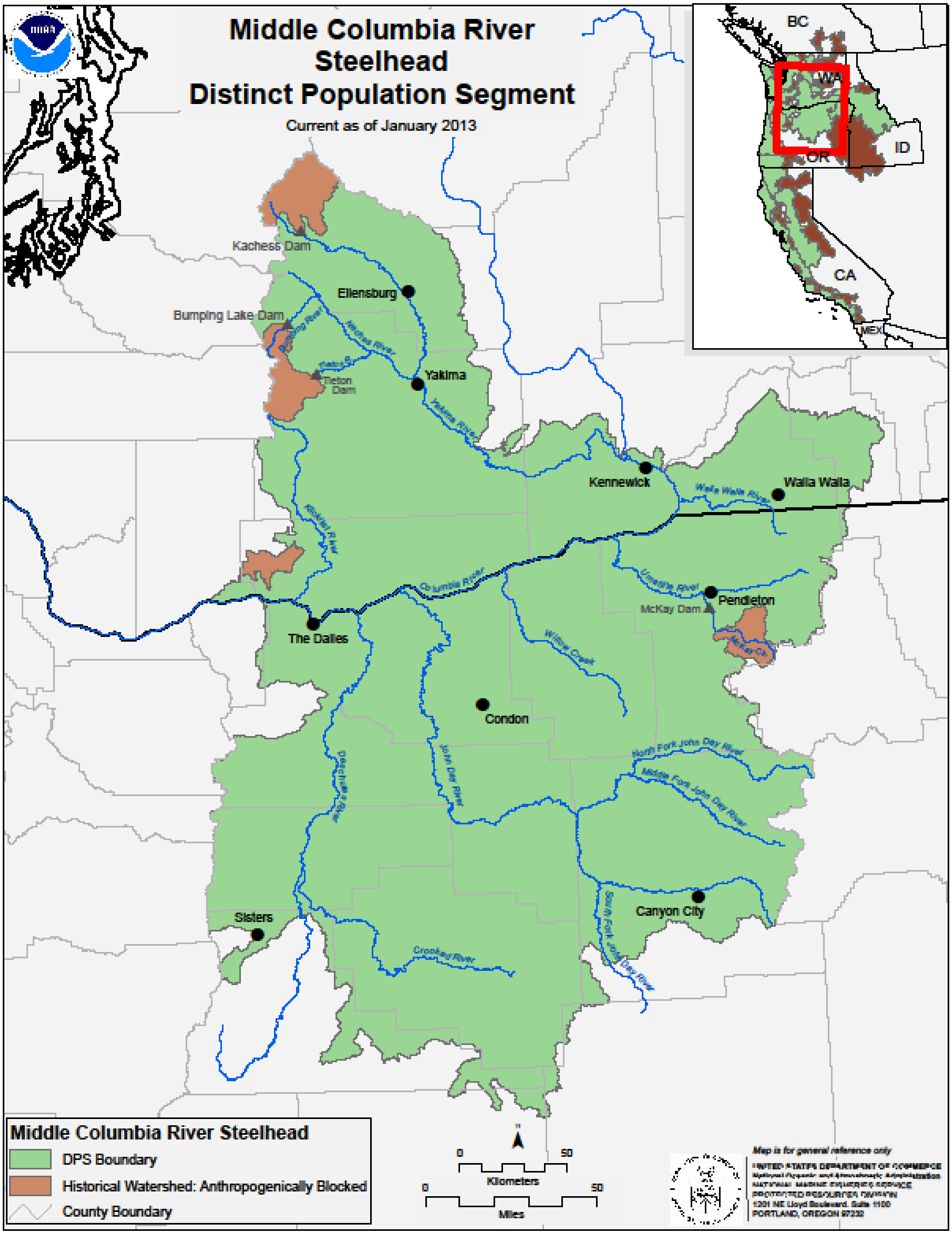


Figure 7. Map of the MCR Steelhead DPS's spawning and rearing areas.

Steelhead exhibit more complex life history traits than other Pacific salmonid species as discussed in previous steelhead specific DPS sections above. While MCR steelhead share these general life history traits, it is worth noting they typically reside in marine waters for two to three years before returning to their natal stream to spawn at four or five years of age (NMFS 2011e). In addition, the MCR Steelhead DPS includes the only populations of inland winter steelhead in the Columbia River. Variations in the migration timing exist between populations: in the Pacific Northwest, summer steelhead enter freshwater between May and October, and winter steelhead enter freshwater between November and April (NMFS 2011e).

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the MCR Steelhead DPS, is at moderate risk and remains at threatened status. The most recent status update (NWFSC 2015) used updated abundance and hatchery contribution estimates provided by regional fishery managers to inform the analysis on this DPS. However, this DPS has been noted as difficult to evaluate in several of the reviews for reasons such as: the wide variation in abundance for individual natural populations across the DPS, chronically high levels of hatchery strays into the Deschutes River, and a lack of consistent information on annual spawning escapements in some tributaries (NWFSC 2015).

The Mid-Columbia Recovery Plan identifies a set of most likely scenarios to meet the ICTRT recommendations for low risk populations at the MPG level. In addition, the management unit plans generally call for achieving moderate risk ratings (maintained status) across the remaining extant populations in each MPG. **Error! Reference source not found.**Table 8 shows the most recent abundance, productivity, spatial structure, and diversity metrics for the 17 extant populations in the DPS. Overall viability ratings for the populations in the MCR Steelhead DPS remained generally unchanged from the prior five year review. One population, Fifteenmile Creek, shifted downward from viable to maintained status as a result of a decrease in natural-origin abundance to below its MAT. The Toppenish River population (in the Yakima MPG) dropped in both estimated abundance and productivity, but the combination remained above the 5% viability curve, and, therefore, its overall rating remained as viable. Although the majority of the populations showed increases in estimates of productivity (NWFSC 2015), the majority of the population level viability ratings remained unchanged from prior reviews for each MPG within the DPS.

Table 8. Risk levels and viability ratings for Middle Columbia steelhead populations (NWFSC 2015); ICTRT = Interior Columbia Technical Recovery Team. Data are from 2005-2014. Abundance and productivity estimates expressed as geometric means (standard error).

MPG	Population	ICTRT minimum threshold	Natural spawning abundance	Proportion natural-origin spawners	Productivity	Abundance and productivity risk	Spatial structure and diversity risk	Overall risk viability rating
Umatilla/Walla Walla	Touchet River	1000	382 (0.12)	0.80	1.25 (0.11)	High	Moderate	High risk
	Walla Walla River	1000	877 (0.13)	0.97	1.65 (0.11)	Moderate	Moderate	Moderate
	Umatilla River	1500	2379 (0.11)	0.82	1.2 (0.32)	Moderate	Moderate	Moderate
	Willow Creek	500			Extirpated			
Eastern Cascades	Fifteen Mile Creek	500	356 (0.16)	0.96	1.84 (0.19)	Moderate	Low	Maintained
	Deschutes (Westside)	1500	634 (0.13)	0.94	1.16 (0.15)	High	Moderate	High risk
	Deschutes (Eastside)	1000	1749 (0.05)	0.86	2.52 (0.24)	Low	Moderate	Viable
	Klickitat River	1000		Insufficient data		Moderate	Moderate	Maintained
	Rock Creek	500		Insufficient data		Insufficient data	Moderate	High risk
	Crooked River	2000			Extirpated			
	White River	500			Extirpated			
Yakima River	Status Creek	1000	1127 (0.17)	0.98	1.93 (0.12)	Low	High	Viable
	Toppenish Creek	500	516 (0.14)	0.98	2.52 (0.19)	Low	Moderate	Viable
	Naches River	1500	1244 (0.16)	0.97	1.83 (0.10)	Moderate	Moderate	Moderate
	Upper Yakima River	1500	246 (0.18)	0.95	1.87 (0.10)	Moderate	Moderate	High risk
John Day River	Lower John Day	2250	1270 (0.22)	0.85	2.67 (0.19)	Moderate	Moderate	Maintained
	MF John Day	1000	1736 (0.41)	0.98	3.66 (0.26)	Low	Moderate	Viable
	NF John Day	1000	1896 (0.19)	0.98	2.48 (0.23)	Very low	Low	Highly viable
	SF John Day	500	697 (0.27)	0.98	2.01 (0.21)	Low	Moderate	Viable
	Upper John Day	1000	641 (0.21)	0.98	1.32 (0.18)	Moderate	Moderate	Maintained

Limiting Factors

Understanding the limiting factors and threats that affect the MCR Steelhead DPS provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting the species is to ensure that the underlying limiting factors and threats have been addressed. There are many factors that affect the abundance, productivity, spatial structure, and diversity of the MCR Steelhead DPS. Factors that limit the DPS have been, and continue to be, loss and degradation of spawning and rearing habitat, impacts of mainstem hydropower dams on upstream access and downstream habitats, and the legacy effects of historical harvest; together, these factors have reduced the viability of natural population in the MCR Steelhead DPS. Historically, extensive beaver activity, dynamic patterns of channel migration in floodplains, human settlement and activities, and loss of rearing habitat quality and floodplain channel connectivity in the lower reaches of major tributaries, all impacted the MCR Steelhead DPS populations (NWFSC 2015).

The recovery plan (NMFS 2009) summarizes information from four regional management unit plans covering the range of tributary habitats associated with the DPS in Washington and Oregon. Each of the management unit plans are incorporated as appendices to the recovery plan, along with modules for the mainstem Columbia hydropower system and the estuary, where conditions affect the survival of steelhead production from all of the tributary populations comprising the DPS. The recovery objectives defined in the recovery plan are all based on the biological viability criteria developed by the ICTRT (NMFS 2011e).

The recovery plan also provides a detailed discussion of limiting factors and threats and describes strategies for addressing each of them. Chapter 6 of the recovery plan describes the limiting factors on a regional scale and how they affect the populations in the MCR Steelhead DPS (NMFS 2009). Chapter 7 of the recovery plan addresses the recovery strategy for the entire DPS and more specific plans for individual MPGs within the DPS (NMFS 2009). The recovery plan addresses the topics of:

- Tributary habitat conditions,
- Columbia River mainstem conditions,
- Impaired fish passage,
- Water temperature and thermal refuges,
- Hatchery-related adverse effects,
- Predation, competition, and /disease,
- Degradation of estuarine and nearshore marine habitat, and
- Climate change.

Rather than repeating this extensive discussion from the recovery plan, it is incorporated here by reference. The complete recovery plan may be read or downloaded from our website[4].

[4] MCR Steelhead Recovery Plan

2.2.1.3. Snake River Fall Chinook salmon

On June 3, 1992, NMFS listed the Snake River fall-run Chinook Salmon ESU as a threatened species (57 FR 23458). More recently, the threatened status was reaffirmed on June 28, 2005 (70 FR 37160) and on April 14, 2014 (79 FR 20802). Critical habitat was designated on December 28, 1993 (58 FR 68543).

The Snake River fall-run Chinook Salmon ESU includes naturally spawned fish in the lower mainstem of the Snake River and the lower reaches of several of the associated major tributaries including the Tucannon, Grande Ronde, Clearwater, Salmon, and Imnaha Rivers, along with 4 artificial propagation programs (Jones Jr. 2015; NWFSC 2015). None of the hatchery programs are excluded from the ESU. As explained above by NMFS (2005d), genetic resources can be housed in a hatchery program but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS, see (NMFS 2005d). Table 9 lists the natural and hatchery populations included in the ESU.

Table 9. Snake River Fall-Run Chinook Salmon ESU description and MPGs (Jones Jr. 2015; NWFSC 2015).

ESU Description	
Threatened	Listed under ESA in 1992; updated in 2014
1 major population group	2 historical populations (1 extirpated)
Major Population Group	***Population***
Snake River	Lower Snake River, Middle Snake River (extirpated)
Artificial production	
Hatchery programs included in ESU (4)	Lyons Ferry NFH fall, Acclimation Ponds Program fall, Nez Perce Tribal Hatchery fall, Idaho Power fall
Hatchery programs not included in ESU (0)	Not applicable

Two historical populations (1 extirpated) within one MPG comprise the Snake River fall-run Chinook Salmon ESU (Figure 8). The extant natural population spawns and rears in the mainstem Snake River and its tributaries below Hells Canyon Dam. The decline of this ESU was due to heavy fishing pressure beginning in the 1890s and loss of habitat with the construction of the various mainstem Columbia and Snake River dams, which extirpated one of the historical populations. Hatcheries mitigating for losses caused by the dams have played a major role in the production of Snake River fall-run Chinook salmon since the 1980s (NMFS 2012b). Since the species were originally listed in 1992, fishery impacts have been reduced in both ocean and river fisheries. Total exploitation rate has been relatively stable in the range of 40% to 50% since the mid-1990s (NWFSC 2015).

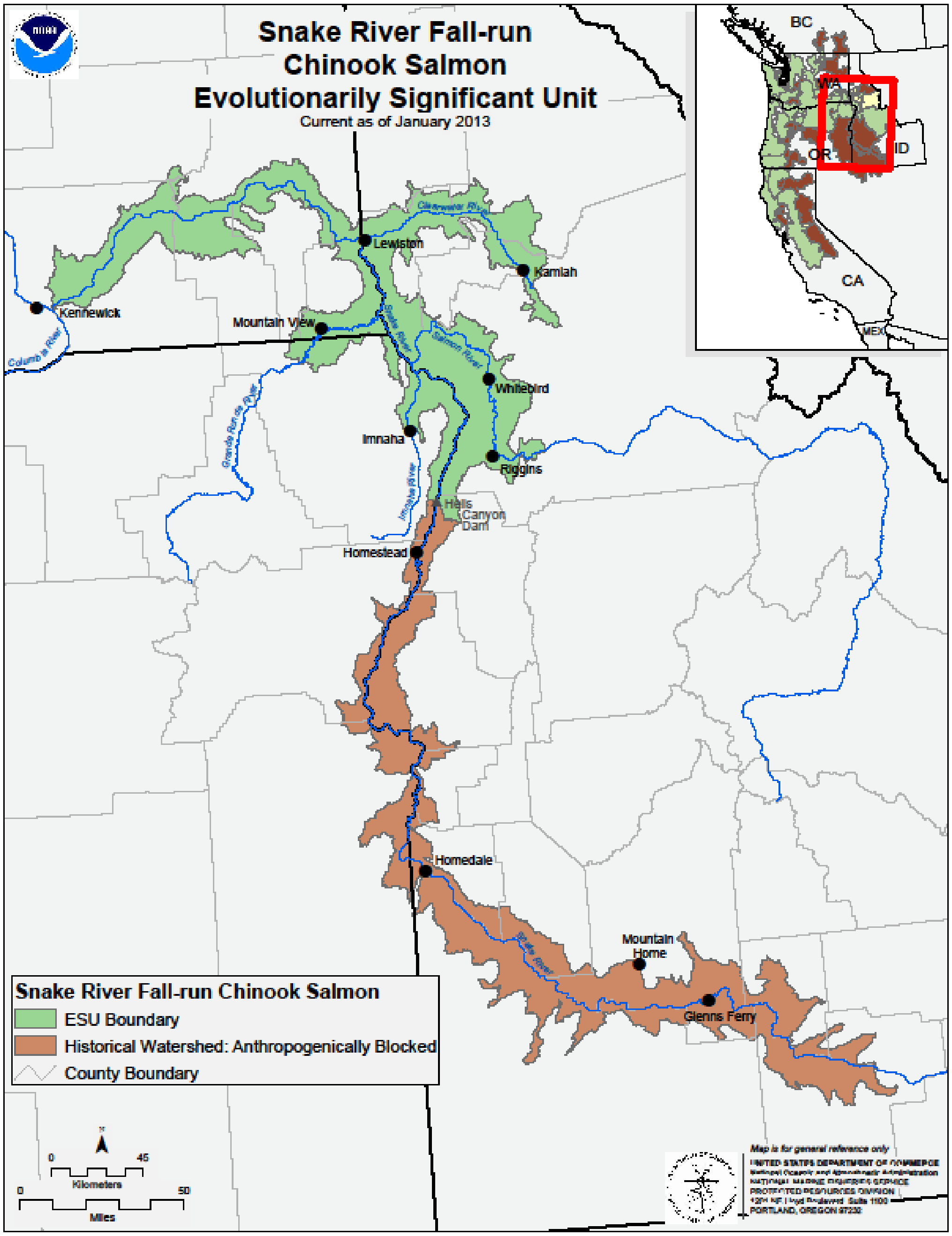


Figure 8. Map of the Snake River Fall-Run Chinook Salmon ESU's spawning and rearing areas.

Snake River fall-run Chinook salmon spawning and rearing occurs primarily in larger mainstem rivers, such as the Salmon, Snake, and Clearwater Rivers. Historically, the primary fall-run Chinook salmon spawning areas were located on the upper mainstem Snake River (Connor et al. 2005). Now, a series of Snake River mainstem dams block access to the Upper Snake River and about 85% of ESU's spawning and rearing habitat. Swan Falls Dam, constructed in 1901, was the first barrier to upstream migration in the Snake River, followed by the Hells Canyon Complex beginning with Brownlee Dam in 1958, Oxbow Dam in 1961, and Hells Canyon Dam in 1967. Natural spawning is currently limited to the Snake River from the upper end of Lower

Granite Dam to Hells Canyon Dam; the lower reaches of the Imnaha, Grande Ronde, Clearwater, Salmon, and Tucannon rivers; and small areas in the tailraces of the Lower Snake River hydroelectric dams (Good et al. 2005).

Some fall-run Chinook salmon also spawn in smaller streams such as the Potlatch River, and Asotin and Alpowa Creeks and they may be spawning elsewhere. The vast majority of spawning today occurs upstream of Lower Granite Dam, with the largest concentration of spawning sites in the mainstem Snake River (about 60%) and in the Clearwater River, downstream from Lolo Creek (about 30%) (NMFS 2012b).

Abundance, Productivity, Spatial Structure, and Diversity

The recently released NMFS Snake River fall-run Chinook Recovery Plan (NMFS 2017d) proposes that a single population viability scenario could be possible given the unique spatial complexity of the Lower Mainstem Snake River fall-run Chinook salmon population; the recovery plan notes that such a scenario could be possible if major spawning areas supporting the bulk of natural returns are operating consistent with long-term diversity objectives in the proposed plan. Under this single population scenario, the requirements for a sufficient combination of natural abundance and productivity could be based on a combination of total population natural abundance and relatively high production from one or more major spawning areas with relatively low hatchery contributions to spawning, i.e., low hatchery influence for at least one major natural spawning production area.

The overall current risk rating for the Lower Snake River fall-run Chinook salmon population is viable. This is based on a low risk rating for abundance/productivity (A/P) and a moderate risk rating for spatial structure/diversity (SS/D). For abundance/productivity, the rating reflects remaining uncertainty that current increases in abundance can be sustained over the long run. The geometric mean natural-origin fish abundance obtained from the most recent 10 years of annual spawner escapement estimates is 6,418 fish. The most recent status review used the ICTRT simple 20-year recruits per spawner (R/S) method to estimate the current productivity for this population (1990-2009 brood years) and determined it was 1.5. Given remaining uncertainty and the current level of variability, the point estimate of current productivity would need to meet or exceed 1.70, which is the present potential metric for the population to be rated at very low risk. While natural-origin spawning levels are above the minimum abundance threshold of 4,200, and estimated productivity is also high, neither measure is high enough to achieve the very low risk rating necessary to buffer against significant remaining uncertainty (NWFSC 2015).

For spatial structure/diversity, the moderate risk rating was driven by changes in major life-history patterns, shifts in phenotypic traits, and high levels of genetic homogeneity detected in samples from natural-origin returns. In particular, the rating reflects the relatively high proportion of within-population hatchery spawners in all major spawning areas and the lingering effects of previous high levels of out-of-ESU strays. In addition, the potential for selective pressure imposed by current hydropower operations and cumulative harvest impacts contribute to the current rating level (NWFSC 2015).

Limiting Factors

Understanding the limiting factors and threats that affect the Snake River fall-run Chinook Salmon ESU provides important information and perspective regarding the status of a species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. This ESU has been reduced to a single remnant population with a narrow range of available habitat. However, the overall adult abundance has been increasing from the mid-1990s, with substantial growth since the year 2000 (NMFS 2017d).

There are many factors that affect the abundance, productivity, spatial structure, and diversity of the Snake River fall-run Chinook Salmon ESU. Factors that limit the ESU have been, and continue to be, hydropower projects, predation, harvest, degraded estuary habitat, and degraded mainstem and tributary habitat (Ford et al. 2011). Ocean conditions have also affected the status of this ESU. Ocean conditions affecting the survival of Snake River fall-run Chinook salmon were generally poor during the early part of the last 20 years (NMFS 2017d).

The recovery plan (NMFS 2017d) provides a detailed discussion of limiting factors and threats and describes strategies for addressing each of them. Rather than repeating this extensive discussion from the recovery plan, it is incorporated here by reference. Section 3.3 of the plan provides criteria for addressing the underlying causes of decline. Furthermore, Section 4.1.2 B.4. of the plan (NMFS 2017d) describes the changes in current impacts on Snake River fall-run Chinook salmon. These changes include:

- Hydropower systems,
- Juvenile migration timing,
- Adult migration timing,
- Harvest,
- Age-at-return,
- Selection caused by non-random removals of fish for hatchery broodstock, and
- Habitat

Overall, the status of Snake River fall-run Chinook salmon has clearly improved compared to the time of listing and since the time of prior status reviews. The single extant population in the ESU is currently meeting the criteria for a rating of viable developed by the ICTRT, but the ESU as a whole is not meeting the recovery goals described in the recovery plan for the species, which require the single population to be “highly viable with high certainty” and/or will require reintroduction of a viable population above the Hells Canyon Dam complex (NWFSC 2015).

2.2.1.4. Snake River spring/summer Chinook salmon

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

The Snake River spring/summer-run Chinook Salmon ESU includes all naturally spawned populations of spring/summer-run Chinook salmon in the mainstem Snake River and the Tucannon River, Grande Ronde River, Imnaha River, and Salmon River subbasins, as well as 10 artificial propagation programs (Jones Jr. 2015; NWFSC 2015). However, inside the geographic range of the ESU, there are a total of 19 hatchery spring/summer-run Chinook salmon programs currently operational (Jones Jr. 2015). As explained above, genetic resources can be housed in a hatchery program but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS, see NMFS (2005d). Table 10 lists the natural and hatchery populations included (or excluded) in the ESU.

Table 10. Snake River spring/summer-run Chinook Salmon ESU description and MPGs (Jones Jr. 2015; NWFSC 2015).

ESU Description	
Threatened	Listed under ESA in 1992; updated in 2014.
5 major population groups	32 historical populations (4 extirpated)
Major Population Group	***Populations***
Lower Snake River	Tucannon River, Asotin Creek (extirpated)
Grande Ronde/Imnaha River	Wenaha, Lostine/Wallowa, Minam, Catherine Creek, Upper Grande Ronde, Imnaha, Big Sheep Creek (extirpated), Lookingglass Creek (extirpated)
South Fork Salmon River	Secesh, East Fork/Johnson Creek, South Fork Salmon River Mainstem, Little Salmon River
Middle Fork	Bear Valley, Marsh Creek, Sulphur Creek, Loon Creek, Camas Creek, Big Creek, Chamberlain Creek, Lower Middle Fork (MF) Salmon, Upper MF Salmon
Upper Salmon	Lower Salmon Mainstem, Lemhi River, Pahsimeroi River, Upper Salmon Mainstem, East Fork Salmon, Valley Creek, Yankee Fork, North Fork Salmon, Panther Creek (extirpated)
Artificial production	
Hatchery programs included in ESU (10)	Tucannon River Spr/Sum, Lostine River Spr/Sum, Catherine Creek Spr/Sum, Lookingglass Hatchery Reintroduction Spr/Sum, Upper Grande Ronde Spr/Sum, Imnaha River Spr/Sum, McCall Hatchery summer, Johnson Creek Artificial Propagation Enhancement summer, Pahsimeroi Hatchery summer, Sawtooth Hatchery spring.
Hatchery programs not included in ESU (8)	South Fork Chinook Eggbox spring, Panther Creek summer, Yankee Fork SBT spring, Rapid River Hatchery spring, Dworshak NFH spring, Kooskia spring, Clearwater Hatchery spring, Nez Perce Tribal Hatchery spring.

Thirty-two historical populations (four extirpated) within five MPGs comprise the Snake River spring/summer-run Chinook Salmon ESU. The natural populations are aggregated into the five extant MPGs based on genetic, environmental, and life-history characteristics. Figure 9 shows a map of the current ESU and the MPGs within the ESU.

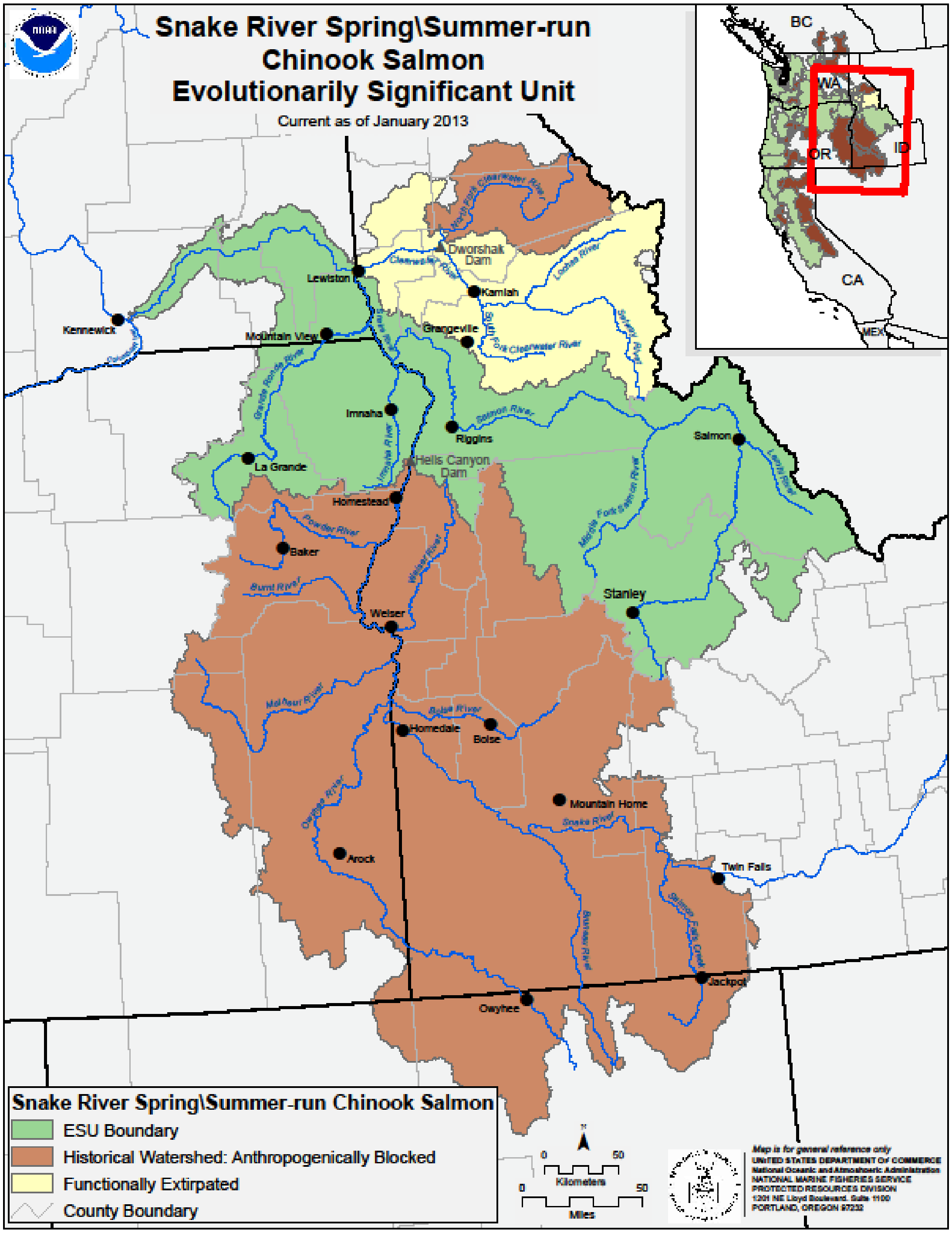


Figure 9. Snake River spring/summer-run Chinook Salmon ESU spawning and rearing areas

Chinook salmon have a wide variety of life-history patterns that include: variation in age at seaward migration; length of freshwater, estuarine, and oceanic residence; ocean distribution;

ocean migratory patterns; and age and season of spawning migration. The Snake River spring/summer-run Chinook Salmon ESU consists of "stream-type" Chinook salmon, which spend two to three years in ocean waters and exhibit extensive offshore ocean migrations (Myers et al. 1998). For a general review of stream-type Chinook salmon, see the UWR Chinook Salmon ESU life-history and status description. In general, Chinook salmon tend to occupy streams with lower gradients than steelhead, but there is considerable overlap between the distributions of the two species (NMFS 2012b).

Abundance, Productivity, Spatial Structure, and Diversity

Natural-origin abundance has increased over the levels reported in the prior review (Ford et al. 2011) for most populations in this ESU, although the increases were not substantial enough to change viability ratings (Table 11). Relatively high ocean survivals in recent years were a major factor in recent abundance patterns. Ten natural populations increased in both abundance and productivity, seven increased in abundance while their updated productivity estimates decreased, and two populations decreased in abundance and increased in productivity. One population, Loon Creek in the MF MPG, decreased in both abundance and productivity. Overall, all but one population in this ESU remains at high risk for abundance and productivity and there is a considerable range in the relative improvements to life cycle survivals or limiting life stage capacities required to attain viable status (NWFSC 2015).

Spatial structure ratings remain unchanged or stable with low or moderate risk levels for the majority of the populations in the ESU. Four populations from three MPGs (Catherine Creek and Upper Grande Ronde of the Grande Ronde/Imnaha MPG, Lemhi River of the Upper Salmon River MPG, and Lower MF Mainstem of the MF MPG) remain at high risk for spatial structure loss. Three of the four extant MPGs in this ESU have populations that are undergoing active supplementation with local broodstock hatchery programs. In most cases, those programs evolved from mitigation efforts and include some form of sliding scale management guidelines that limit hatchery contribution to natural spawning based on the abundance of natural-origin fish returning to spawn – the more natural-origin fish that return the fewer hatchery fish that are needed to spawn naturally. Sliding-scale management is designed to maximize hatchery benefits in low abundance years and reduce hatchery risks at higher spawning levels. Efforts to evaluate key assumptions and impacts are underway for several programs (NWFSC 2015).

Table 11. Risk levels and viability ratings for Snake River spring/summer Chinook salmon populations (NWFSC 2015); ICTRT = Interior Columbia Technical Recovery Team; MPG = Major Population Group. Data are from 2005-2014. Abundance and productivity estimates expressed as geometric means (standard error).

MPG	Population	ICTRT minimum threshold	Natural spawning abundance	Proportion natural-origin spawners	Productivity	Abundance and productivity risk	Spatial structure and diversity risk	Overall rating
Lower Snake	Tucannon River	750	267 (0.19)	0.67	0.69 (0.23)	High	Moderate	High risk
	Asotin Creek	500	Extirpated					
Grande Ronde/ Imnaha	Wenaha River	750	399 (0.12)	0.76	0.93 (0.21)	High	Moderate	High risk
	Lostine/Wallowa River	1000	332 (0.24)	0.45	0.98 (0.12)	High	Moderate	High risk
	Lookingglass Creek	500	Extirpated					
	Minam River	750	475 (0.12)	0.89	0.94 (0.18)	High	Moderate	High risk
	Catherine Creek	1000	110 (0.31)	0.45	0.95 (0.15)	High	Moderate	High risk
	Upper Grande Ronde	1000	43 (0.26)	0.18	0.59 (0.28)	High	High	High risk
	Imnaha River	750	328 (0.21)	0.35	1.2 (0.09)	High	Moderate	High risk
	Big Sheep Creek	500	Extirpated					
South Fork (SF)	SF Mainstem	1000	791 (0.18)	0.77	1.21 (0.2)	High	Moderate	High
	Secesh River	750	472 (0.18)	0.98	1.25 (0.2)	High	Low	High
	EF/Johnson Creek	1000	208 (0.24)	0.61	1.15 (0.2)	High	Low	High
	Little Salmon River	750	Insufficient data				Low	High
Middle Fork (MF)	Chamberlain Creek	750	641 (0.17)	1.0	2.26 (0.45)	Moderate	Low	Maintained
	Big Creek	1000	154 (0.23)	1.0	1.1 (0.21)	High	Moderate	High
	Loon Creek	500	54 (0.1)	1.0	0.98 (0.4)	High	Moderate	High
	Camas Creek	500	38 (0.2)	1.0	0.8 (0.29)	High	Moderate	High
	Lower mainstem MF	500	Insufficient data				Moderate	High
	Upper mainstem MF	750	71 (0.18)	1.0	0.5 (0.72)	High	Moderate	High
	Sulphur Creek	500	67 (0.99)	1.0	0.92 (0.26)	High	Moderate	High
	Marsh Creek	500	253 (0.27)	1.0	1.21 (0.24)	High	Low	High
	Bear Valley Creek	750	474 (0.27)	1.0	1.37 (0.17)	High	Low	High
Upper Salmon River	Salmon Lower main	2000	108 (0.18)	1.0	1.18 (0.17)	High	Low	High
	Salmon upper main	1000	411 (0.18)	0.7	1.22 (0.19)	High	Low	High
	Pahsimeroi River	1000	267 (0.24)	0.93	1.37 (0.2)	High	High	High
	Lemhi River	2000	143 (0.18)	1.0	1.3 (0.23)	High	High	High
	Valley Creek	500	121 (0.18)	1.0	1.45 (0.15)	High	Moderate	High
	Salmon EF	1000	347 (0.24)	1.0	1.08 (0.28)	High	High	High
	Yankee Fork	500	44 (0.18)	0.39	0.72 (0.39)	High	High	High
	North Fork	500	Insufficient data				Low	High
	Panther Creek	750	Extirpated					

Limiting Factors

Understanding the limiting factors and threats that affect the Snake River spring/summer-run Chinook Salmon ESU provides important information and perspective regarding the status of a species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. The abundance of spring/summer-run Chinook salmon had already began to decline by the 1950s, and it continued declining through the 1970s. In 1995, only 1,797 spring/summer-run Chinook salmon total adults (both hatchery and natural-origins combined) returned to the Snake River (NMFS 2017e).

There are many factors that affect the abundance, productivity, spatial structure, and diversity of the Snake River spring/summer-run Chinook Salmon ESU. Factors that limit the ESU have been, and continue to be, survival through the Federal Columbia River Power System (FCRPS); the degradation and loss of estuarine areas that help the fish survive the transition between fresh and marine waters, spawning and rearing areas that have lost deep pools, cover, side-channel refuge areas, and high quality spawning gravels; and interbreeding and competition with hatchery fish that far outnumber fish of natural-origin.

2.2.1.5. Snake River Sockeye Salmon

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

The ESU includes naturally spawned anadromous and residual sockeye salmon originating from the Snake River Basin in Idaho, as well as artificially propagated sockeye salmon from the Redfish Lake captive propagation program (Jones Jr. 2015) (Table 12). The MPG contains one extant population (Redfish Lake) and two to four historical populations (Alturas, Petit, Stanley, and Yellowbelly Lakes) (NMFS 2015) (Figure 10). At the time of listing in 1991, the only confirmed extant population included in this ESU was the beach-spawning population of sockeye salmon from Redfish Lake, with about 10 fish returning per year (NMFS 2015). Historical records indicate that sockeye salmon once occurred in several other lakes in the Stanley Basin, but no adults were observed in these lakes for many decades. Once residual sockeye salmon were observed in Redfish Lake, their relationship to the Redfish Lake anadromous population was uncertain (McClure et al. 2005). Since ESA-listing, progeny of the Redfish Lake sockeye salmon population have been outplanted to Pettit and Alturas lakes within the Sawtooth Valley for recolonization purposes (NMFS 2011a).

Table 12. Snake River Sockeye Salmon ESU description and MPG (Jones Jr. 2015; NMFS 2015).

ESU Description	
Threatened	Listed under ESA in 1991; updated in 2014.
1 major population group	5 historical populations (4 extirpated)
Major Population Group	***Extant Population***
Sawtooth Valley Sockeye	Redfish Lake
Artificial production	
Hatchery programs included in ESU (1)	Redfish Lake Captive Broodstock
Hatchery programs not included in ESU (0)	Not applicable

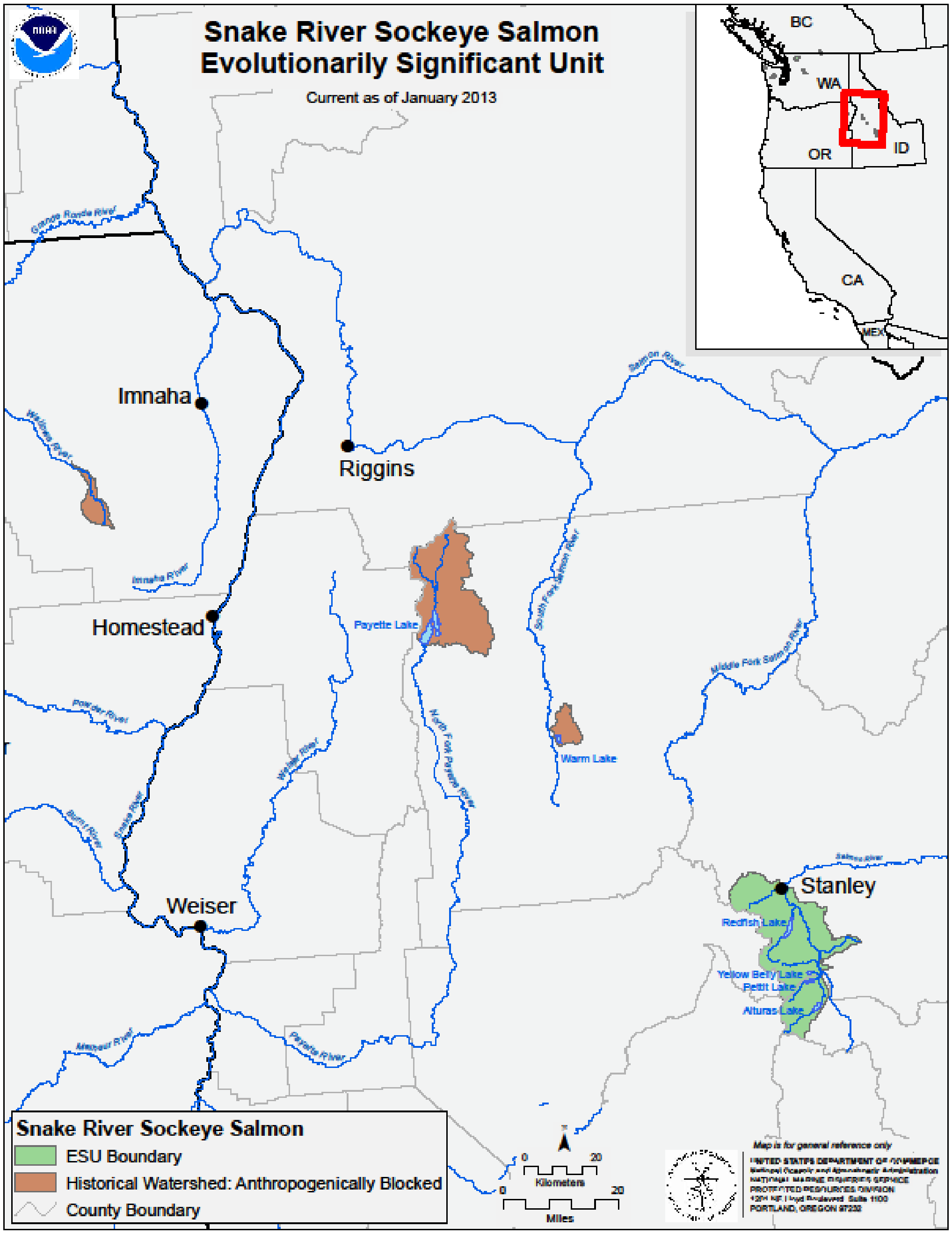


Figure 10. Map of the Snake River Sockeye Salmon ESU's spawning and rearing areas.

While there are very few sockeye salmon currently following an anadromous life cycle in the Snake River, the small remnant run of the historic population migrates 900 miles downstream from the Sawtooth Valley through the Salmon, Snake, and Columbia Rivers to the ocean (Figure 10). After one to three years in the ocean, they return to the Sawtooth Valley as adults, passing once again through these mainstem rivers and through eight major federal dams, four on the Columbia River and four on the lower Snake River. Anadromous sockeye salmon returning to Redfish Lake in Idaho's Sawtooth Valley travel a greater distance from the sea, 900 miles, to a higher elevation (6,500 ft.) than any other sockeye salmon population. They are the southernmost population of sockeye salmon in the world (NMFS 2015).

Abundance, Productivity, Spatial Structure, and Diversity

Best available information indicates that the Snake River Sockeye Salmon ESU is at high risk and remains at endangered status. Annual returns of sockeye salmon through 2018 show that more fish are returning than before initiation of the captive broodstock program, which began soon after the initial ESA listing (Table 13). Between 1999 and 2007, more than 355 adults returned from the ocean from captive brood releases – almost 20 times the number of natural-origin fish that returned in the 1990s. Though this total is primarily due to large returns in the year 2000. Adult returns in the last six years have ranged from a high of 1,579 fish in 2014 (including 453 natural-origin fish) to a low of 91 adults in 2015 (including 14 natural-origin fish). Sockeye salmon returns to Alturas Lake ranged from one fish in 2002 to 14 fish in 2010 (NWFSC 2015).

Table 13. Hatchery- and natural-origin sockeye salmon returns to Sawtooth Valley, 1999-2018 (Christine Kozfkay, IDFG, personal communication, March 4, 2018; NMFS 2015).

Return Year	Total Return	Natural Return	Hatchery Return	Alturas Returns[1]	Observed Not Trapped
1999	7	0	7	0	0
2000	257	10	233	0	14
2001	26	4	19	0	3
2002	22	6	9	1	7
2003	3	0	2	0	1
2004	27	4	20	0	3
2005	6	2	4	0	0
2006	3	1	2	0	0
2007	4	3	1	0	0
2008	646	140	456	1	50
2009	832	86	730	2	16
2010	1,355	178	1,144	14	33
2011	1,117	145	954	2	18
2012	257	52	190	0	15
2013	272	79	191	0	2
2014	1,579	453	1,062	0	63
2015[2]	91	14	77	0	0
2016	596	33	539	0	24
2017	176	11	151	0	14
2018	114	13	100	0	1

[1] These fish were assigned as sockeye salmon returns to Alturas Lake and are included in the natural return numbers.
[2] In 2015, 56 fish naturally migrated and 35 Snake Basin origin fish were transported from Granite.

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

Furthermore, there is evidence that the historical Snake River Sockeye Salmon ESU included a range of life history patterns, with spawning populations present in several of the small lakes in the Sawtooth Basin (NMFS 2015). Historical production from Redfish Lake was likely associated with a lake shoal spawning life history pattern although there may have also been some level of spawning in Fishhook Creek (NMFS 2015; NWFSC 2015). In NMFS' 2011 status review update for Pacific salmon and steelhead listed under the ESA (Ford et al. 2011), it was not possible to quantify the viability ratings for Snake River sockeye salmon. Ford et al. (2011) determined that the Snake River sockeye salmon captive broodstock-based program has made substantial progress in reducing extinction risk, but that natural production levels of anadromous returns remain extremely low for this species (NMFS 2012b).

In the most recent 2015 status update, NMFS determined that at this stage of the recovery efforts, the ESU remains at high risk for both spatial structure and diversity (NWFSC 2015). At present, anadromous returns are dominated by production from the captive spawning component. The ongoing reintroduction program is still in the phase of building sufficient returns to allow for large scale reintroduction into Redfish Lake, the initial target for restoring natural spawning (NMFS 2015). There is some evidence of very low levels of early timed returns in some recent years from out-migrating naturally produced Alturas Lake smolts. At this stage of the recovery efforts, the ESU remains rated at high risk for spatial structure, diversity, abundance, and productivity (NWFSC 2015).

Limiting Factors

Factors that limit the ESU have been, and continue to be the result of impaired mainstream and tributary passage, fisheries, chemical treatment of Sawtooth Valley lakes in the 1950s and 1960s, poor ocean conditions, Snake and Columbia River hydropower system, and reduced tributary stream flows and high temperatures. These combined factors reduced the number of sockeye salmon that make it back to spawning areas in the Sawtooth Valley to the single digits, and in some years, zero. The decline in abundance itself has become a major limiting factor, making the remaining population vulnerable to catastrophic loss and posing significant risks to genetic diversity (NMFS 2015; NWFSC 2015).

Today, some threats that contributed to the original listing of Snake River sockeye salmon now present little harm to the ESU, while others continue to threaten viability. Fisheries are now better regulated through ESA constraints and management agreements, significantly reducing harvest-related mortality. Potential habitat-related threats to the fish, especially in the Sawtooth Valley, pose limited concern since most passage barriers have been removed and much of the natal lake area and headwaters remain protected. Hatchery-related concerns have also been reduced through improved management actions (NMFS 2015).

The recovery plan (NMFS 2015) provides a detailed discussion of limiting factors and threats and describes strategies and actions for addressing each of them. Rather than repeating this extensive discussion from the recovery plan, it is incorporated here by reference. Overall, the recovery strategy aims to reintroduce and support adaptation of naturally self-sustaining sockeye salmon populations in the Sawtooth Valley lakes. An important first step towards that objective has been the successful establishment of anadromous returns from the remnant Redfish Lake stock gained through a captive broodstock program. The long-term strategy is for the naturally produced population to achieve escapement goals in a manner that is self-sustaining and without the reproductive contribution of hatchery spawners (NMFS 2015).

2.2.2. Critical Habitat

NMFS determines the range-wide status of critical habitat by examining the condition of its physical and biological features (PBFs) that were identified when critical habitat was designated. These features are essential to the conservation of the listed species because they support one or more of the species' life stages. An example of some PBFs are listed below. These are often similar among listed salmon and steelhead; specific differences can be found in the critical habitat designation for each species (Table 4).

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

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

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

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

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

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

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

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

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

2.2.3. Climate Change

One factor affecting the rangewide status of species and aquatic habitat at large is climate change. The U.S. Global Change Research Program (USGCRP)[5], mandated by Congress in the Global Change Research Act of 1990, reports average warming of about 1.3ºF from 1895 to 2011 and projects an increase in average annual temperature of 3.3ºF to 9.7ºF by 2070 to 2099 (CCSP 2014). Climate change has negative implications for designated critical habitats in the Pacific Northwest (Climate Impacts Group 2004; ISAB 2007; Scheuerell and Williams 2005; Zabel et al. 2006). According to the Independent Scientific Advisory Board (ISAB)[6], these effects pose the following impacts into the future:

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[5] http://www.globalchange.gov

[6] The Independent Scientific Advisory Board (ISAB) serves the National Marine Fisheries Service (NOAA Fisheries), Columbia River Indian Tribes, and Northwest Power and Conservation Council by providing independent scientific advice and recommendations regarding scientific issues that relate to the respective agencies' fish and wildlife programs.

- 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, these watersheds will see their runoff diminished earlier in the season, resulting in lower stream-flows in the June through September period. River flows in general and peak river flows are likely to increase during the winter due to more precipitation falling as rain rather than snow.
- Water temperatures are expected to rise, especially during the summer months when lower stream-flows co-occur with warmer air 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, premature emergence of fry, and increased competition among species.

Climate change is predicted to cause a variety of impacts to Pacific salmon and their ecosystems (Crozier et al. 2008a; Martins et al. 2012; Mote et al. 2003; Wainwright and Weitkamp 2013). The complex life cycles of anadromous fishes including salmon rely on productive freshwater, estuarine, and marine habitats for growth and survival, making them particularly vulnerable to environmental variation (Morrison et al. 2016). Ultimately, the effect of climate change on salmon and steelhead across the Pacific Northwest will be determined by the specific nature, level, and rate of change and the synergy between interconnected terrestrial/freshwater, estuarine, nearshore and ocean environments.

The primary effects of climate change on Pacific Northwest salmon and steelhead are:

- direct effects of increased water temperatures of fish physiology
- temperature-induced changes to stream flow patterns
- alterations to freshwater, estuarine, and marine food webs
- changes in estuarine and ocean productivity

While all habitats used by Pacific salmon will be affected, the impacts and certainty of the change vary by habitat type. Some effects (e.g., increasing temperature) affect salmon at all life stages in all habitats, while others are habitat specific, such as stream flow variation in freshwater, sea level rise in estuaries, and upwelling in the ocean. How climate change will affect each stock or population of salmon also varies widely depending on the level or extent of change and the rate of change and the unique life history characteristics of different natural populations (Crozier 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). This occurred in 2015 on Upriver Sockeye in the Columbia River when over 475,000 sockeye entered the River but only 2% of sockeye counted at Bonneville Dam survived to their spawning grounds. Most died in the Columbia River beginning in June when the water warmed to above 68°F, the temperature at which salmon begin to die. It got up to 73°F in July, due to elevated temperatures associated with lower snow pack from the previous winter and drought conditions and may be exacerbated due to increased occurrences of warm weather patterns.

Temperature Effects

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 survival (Beechie et al. 2013; Wainwright and Weitkamp 2013; Whitney et al. 2016). As examples of this, high mortality rates for adult sockeye salmon in the Columbia River have recently been attributed to higher water temperatures and likewise in the Fraser River, as increasing temperatures during adult upstream migration are expected to result in increased mortality of sockeye salmon adults by 9 to 16% by century's end (Martins et al. 2011). Juvenile parr-to-smolt survival of Snake River Chinook salmon are predicted to decrease by 31 to 47% due to increased summer temperatures (Crozier et al. 2008b).

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 also others where it is detrimental (Martins et al. 2012; Whitney et al. 2016).

Freshwater Effects

As described previously, climate change is predicted to increase the intensity of storms, reduce winter snow pack 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, which vary at fine spatial scales (Crozier et al. 2008b; Martins et al. 2012). For example, within a relatively small geographic area (Salmon River Basin, Idaho), survival of some Chinook salmon populations was shown to be determined largely by temperature, while others were 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 (Beechie et al. 2013; Crozier et al. 2008b). However, river flow is already becoming more variable in many rivers, and is believed to negatively affect anadromous fish survival more than other environmental parameters (Ward et al. 2015). It is likely this increasingly variable flow is detrimental to multiple salmon and steelhead populations, and likely multiple other freshwater fish species in the Columbia River Basin as well.

Stream ecosystems will likely change in response to climate change in ways that are difficult to predict (Lynch et al. 2016). Changes in stream temperature and flow regimes will likely lead to shifts in the distributions of native species and provide "invasion opportunities" for 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 natives, native invaders, and exotic species, is difficult to predict (Naiman et al. 2012).

Estuarine Effects

In estuarine environments, the two big concerns associated with climate change are rates of sea level rise and temperature warming (Limburg et al. 2016; Wainwright and Weitkamp 2013). Estuaries will be affected directly by sea-level rise: as sea level rises, terrestrial habitats will be flooded and tidal wetlands will be submerged (Kirwan et al. 2010; Limburg et al. 2016; Wainwright and Weitkamp 2013). The net effect on wetland habitats depends on whether rates of sea-level rise are sufficiently slow that the rates of marsh plant growth and sedimentation can compensate (Kirwan et al. 2010).

Due to subsidence, sea level rise will affect some areas more than others, with the largest effects expected for the lowlands, like southern Vancouver Island and central Washington coastal areas (Lemmen et al. 2016; Verdonck 2006). The widespread presence of dikes in Pacific Northwest estuaries will restrict upward estuary expansion as sea levels rise, likely resulting in a near-term loss of wetland habitats for salmon (Wainwright and Weitkamp 2013). Sea level rise will also result in greater intrusion of marine water into estuaries, resulting in an overall increase in salinity, which will also contribute to changes in estuarine floral and faunal communities (Kennedy 1990). While not all anadromous fish species are generally highly reliant on estuaries for rearing, extended estuarine use may be important in some populations (Jones et al. 2014), especially if stream habitats are degraded and become less productive.

Marine Impacts

In marine waters, increasing temperatures are associated with observed and predicted poleward range expansions of fish and invertebrates in both the Atlantic and Pacific oceans (Asch 2015; Cheung et al. 2015; Lucey and Nye 2010). Rapid poleward species shifts in distribution in response to anomalously warm ocean temperatures have been well documented in recent years, confirming this expectation at short time scales. Range extensions were documented in many species from southern California to Alaska during unusually warm water associated with "The Blob" in 2014 and 2015 (Bond et al. 2015; Di Lorenzo and Mantua 2016), and past strong El Niño events (Fisher et al. 2015; Pearcy 2002).

Exotic species benefit from these extreme conditions to increase their distributions. Green crab (*Carcinus maenas*) recruitment increased in Washington and Oregon waters during winters with warm surface waters, including 2014 (Yamada et al. 2015). Similarly, Humboldt squid (*Dosidicus gigas*) dramatically expanded their range during warm years of 2004-2009 (Litz et al. 2011). The frequency of extreme conditions, such as those associated with El Niño events or "blobs" are predicted to increase in the future (Di Lorenzo and Mantua 2016). This is likely to occur to some degree over the next ten years, but at a similar rate as the last ten years.

As with changes to stream ecosystems, expected changes to marine ecosystems due to increased temperature, altered productivity, or acidification, will have large ecological implications through mismatches of co-evolved species and unpredictable trophic effects (Cheung et al. 2015; Rehage and Blanchard 2016). These effects will certainly occur, but predicting the composition or outcomes of future trophic interactions is not possible with the tools available at this time.

Pacific Northwest anadromous fish inhabit as many as three marine ecosystems during their ocean residence period: the Salish Sea, the California Current, and the Gulf of Alaska (Brodeur et al. 1992; Morris et al. 2007; Weitkamp and Neely 2002). The response of these ecosystems to climate change is expected to differ, although there is considerable uncertainty in all predictions. It is also unclear whether overall marine survival of anadromous fish in a given year depends on conditions experienced in one versus multiple marine ecosystems. Several are important to Columbia River Basin species, including the California Current and Gulf of Alaska.

Wind-driven upwelling is responsible for the extremely high productivity in the California Current ecosystem (Bograd et al. 2009; Peterson et al. 2014). Minor changes to the timing, intensity, or duration of upwelling, or the depth of water column stratification, can have dramatic effects on the productivity of the ecosystem (Black et al. 2014; Peterson et al. 2014). Current projections for changes to upwelling are mixed: some climate models show upwelling unchanged, but others predict that upwelling will be delayed in spring, and more intense during summer (Rykaczewski et al. 2015). Should the timing and intensity of upwelling change in the future, it may result in a mismatch between the onset of spring ecosystem productivity and the timing of salmon entering the ocean, and a shift towards food webs with a strong sub-tropical component (Bakun et al. 2015).

Columbia River anadromous fish also use coastal areas of British Columbia and Alaska, and mid-ocean marine habitats in the Gulf of Alaska, although their fine-scale distribution and marine ecology during this period are poorly understood (Morris et al. 2007; Pearcy and McKinnell 2007). Increases in temperature in Alaskan marine waters have generally been associated with increases in productivity and salmon survival (Mantua et al. 1997; Martins et al. 2012), thought to result from temperatures that have been below thermal optima (Gargett 1997). Warm ocean temperatures in the Gulf of Alaska are also associated with intensified down welling and increased coastal stratification, which may result in increased food availability to juvenile salmon along the coast (Hollowed et al. 2009; Martins et al. 2012). Predicted increases in freshwater discharge in British Columbia and Alaska may influence coastal current patterns (Foreman et al. 2014), but the effects on coastal ecosystems are poorly understood.

In addition to becoming warmer, the world's oceans are becoming more acidic as increased atmospheric CO_2 is absorbed by water. The North Pacific is already acidic compared to other oceans, making it particularly susceptible to further increases in acidification (Lemmen et al. 2016). Laboratory and field studies of ocean acidification show it has the greatest effects on invertebrates with calcium-carbonate shells and relatively little direct influence on finfish (see reviews by Haigh et al. (2015) and Mathis et al. (2015). Consequently, the largest impact of ocean acidification on salmon will likely be its influence on marine food webs, especially its effects on lower trophic levels, which are largely composed of invertebrates (Haigh et al. 2015; Mathis et al. 2015).

Uncertainty in Climate Predictions

There is considerable uncertainty in the predicted effects of climate change on the globe as a whole, and on Pacific Northwest in particular and there is also the question of indirect effects of climate change and whether human "climate refugees" will move into the range of salmon and steelhead, increasing stresses on their respective habitats (Dalton et al. 2013; Poesch et al. 2016).

Many of the effects of climate change (e.g., increased temperature, altered flow, coastal productivity, etc.) will have direct impacts on the food webs that species examined in this analysis rely on in freshwater, estuarine, and marine habitats to grow and survive. Such ecological effects are extremely difficult to predict even in fairly simple systems, and minor differences in life history characteristics among stocks of salmon may lead to large differences in their response (e.g., Crozier et al. (2008b); Martins et al. (2011); Martins et al. (2012). This means it is likely that there will be "winners and losers" meaning some salmon populations may enjoy different degrees or levels of benefit from climate change while others will suffer varying levels of harm.

Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depend both on characteristics of each individual population and on the level and rate of change. They should be able to adapt to some changes, but others are beyond their adaptive capacity (Crozier et al. 2008a; Waples et al. 2009). With their complex life cycles, it is also unclear how conditions experienced in one life stage are carried over to subsequent life stages, including changes to the timing of migration between habitats. Systems already stressed due to human disturbance are less resilient to predicted changes than those that are less stressed, leading to additional uncertainty in predictions (Bottom et al. 2011; Naiman et al. 2012; Whitney et al. 2016).

Climate change is expected to impact anadromous fish during all stages of their complex life cycle. In addition to the direct effects of rising temperatures, indirect effects include alterations in stream flow patterns in freshwater and changes to food webs in freshwater, estuarine and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty.

2.3. Action Area

The "action area" means all areas to be affected directly or indirectly by the Proposed Action, in which the effects of the action can be meaningfully detected, measured, and evaluated (50 CFR 402.02). The action area resulting from this analysis includes all water accessible to anadromous fish in the entire Snake Basin above Ice Harbor Dam, including the Tucannon, Clearwater, Salmon, Grande Ronde, and Imnaha River Subbasins.

2.4. Environmental Baseline

Under the Environmental Baseline, NMFS describes what is affecting listed species and designated critical habitat before including any effects resulting from the Proposed Action. The "environmental baseline" includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed

Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process (50 CFR 402.02).

2.4.1. Habitat and Hydropower

A discussion of the baseline condition of habitat and hydropower throughout the Columbia River Basin occurs in our Biological Opinion on the Mitchell Act Hatchery programs (NMFS 2017c) and in our Biological Opinion on the 2018 *U.S. v. Oregon* Management Agreement (NMFS 2018b). Here we summarize some of the key impacts on salmon and steelhead habitat, primarily in the Snake River Basin because it encompasses the Action Area for this Opinion.

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

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

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

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

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

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

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

The PACFISH/INFISH Biological Opinion monitoring program on Federal lands (PIBO) that began in 1998 has generally shown improvements in fish habitat in watersheds managed under the Northwest Forest Plan (NFP) Aquatic and Riparian Conservation Strategy (ARCS) and PACFISH. The PIBO summary report (Meredith et al. 2012), found improving trends in managed watershed for five of seven stream habitat characteristics , and declining trends in two characteristics. Many BLM Management Areas and National Forests in the Interior Columbia River Basin have revised their land management plans in recent years and replaced NFP ARCS and PACFISH measures with a variety of different approaches that differ in the level of protection provided by previous plans. The generally positive trend in fish habitat characteristics that has occurred in recent decades on Federal lands may change under revised plans that follow different rules. A continued trend in habitat improvements is uncertain due to changes in protective measures combined with environmental changes associated with climate change (e.g., Crozier et al. 2016)

2.4.2. Climate Change

In Section 2.2.3, we describe the on-going and anticipated temperature, freshwater, and marine effects of climate change. Because the impacts of climate change are ongoing, these present impacts are reflected in the most recent status of the species, which NMFS recently re-evaluated in 2015 (NWFSC 2015) and was summarized in relevant ESU or DPS specific sections of Section 2.2 of this opinion. Climate change effects are also considered in the Cumulative Effects section (2.6) of this opinion, regarding future potential impacts.

2.4.3. Hatcheries

Included in the Environmental Baseline are the ongoing effects of hatchery programs or facilities that have undergone Federal review under the ESA, as well as past and present effects of programs that have not undergone review. Table 14 details the list of all hatchery programs in the action area; all have undergone ESA review, and were initiated under the LSRCP, Hells Canyon Settlement Agreement or the BPAs Fish and Wildlife Program to mitigate for the construction and operation of the four lower Snake River dams, the Hells Canyon Complex, and the Federal Columbia River Power System on salmon and steelhead in the Snake River Basin.

The history and evolution of hatcheries are important factors in analyzing their past and present effects. From their origin more than 100 years ago, hatchery programs have been tasked to compensate for factors that limit anadromous salmonid viability. The first hatcheries, beginning in the late 19th century, provided fish to supplement harvest levels, as human development and harvest impacted naturally produced salmon and steelhead populations. As development of the Columbia River Basin proceeded (e.g., dam construction as part of the FCRPS between 1939 and 1975), hatcheries were used to mitigate for lost salmon and steelhead harvest attributable to reduced salmon and steelhead survival and habitat degradation. Since that time, most hatchery programs have been tasked to maintain fishable returns of adult salmon and steelhead, usually for cultural, social, recreational, or economic purposes, as the capacity of natural habitat to produce salmon and steelhead has been reduced.

A new role for hatcheries emerged during the 1980s and 1990s after naturally produced salmon and steelhead populations declined to unprecedented low levels. Because genetic resources that represent the ecological and genetic diversity of a species can reside in fish spawned in a hatchery, as well as in fish that spawn in the wild, hatcheries began to be used for conservation purposes (e.g., Snake River sockeye salmon). Such hatchery programs are designed to preserve the salmonid genetic resources until the factors limiting salmon and steelhead viability are addressed. In this role, hatchery programs reduce the risk of extinction (Ford et al. 2011; NMFS 2005d). However, hatchery programs that conserve vital genetic resources are not without risk to the natural salmonid populations because the manner in which these programs are implemented can affect the genetic structure and evolutionary trajectory of the target population (i.e., natural population that the hatchery program aims to conserve) by reducing genetic and phenotypic variability and patterns of local adaptation (HSRG 2014; NMFS 2014). A full description how hatchery programs can affect ESA-listed salmon and steelhead can be found in Appendix A.

Population viability and reductions in threats are key measures for salmon and steelhead recovery (NMFS 2013c). Beside their role in conserving genetic resources, hatchery programs also are a tool that can be used to help improve viability (i.e., supplementation of natural population abundance through hatchery production). In general, these hatchery programs increase the number and spatial distribution of naturally spawning fish by increasing the natural production with returning hatchery adults. These programs are not, however, a proven technology for achieving sustained increases in adult production (ISAB 2003), and the long-term benefits and risks of hatchery supplementation remain untested (Christie et al. 2014).

Because most hatchery programs are ongoing, the effects of these hatchery program are reflected in the most recent status of the species, which NMFS recently re-evaluated in 2015 (NWFSC 2015) and was summarized in relevant ESU or DPS specific sections of Section 2.2 of this opinion.

The following sections describe the anticipated effects of hatchery programs that have completed ESA Section 7 consultation. As discussed in detail in the site-specific consultations for each hatchery program, hatcheries generally pose risks to the naturally-spawning salmon and steelhead populations (See Appendix A). These risks include genetic risks, competition and predation on natural-origin fish, disease, and broodstock collection and facility effects. However, as described below and in the referenced hatchery program consultations, in many cases steps are being taken to reduce the associated impacts and risks. Thus, while in our assessment of effects we include the continued negative impacts of the hatcheries, we also consider the extent to which implementation of new measures will reduce their effects.

Table 14. Hatchery programs in the Snake River Basin.

Hatchery Programs in Action Area	Biological Opinion Signature Date	Citation
Lyons Ferry NFH Snake River fall Chinook	October 9, 2012	NMFS (2018a)
Fall Chinook salmon Acclimation program		
Idaho Power Company fall Chinook		
Nez Perce Tribal Hatchery Snake River fall Chinook		
Snake River sockeye Salmon Hatchery Program	September 28, 2013	NMFS (2013b)
Catherine Creek spring/summer Chinook	June 24, 2016	NMFS (2016)
Upper Grande Ronde spring/summer Chinook		
Imnaha River spring/summer Chinook		
Lookingglass Creek spring Chinook		
Lostine spring/summer Chinook		
Tucannon River spring/summer Chinook		
Clearwater River coho restoration project	January 15, 2017	NMFS (2017c)
Lostine River coho restoration project;		
Grande Ronde Basin summer steelhead	July 11, 2017	NMFS (2017b)
Little Sheep Creek summer steelhead		
Tucannon River summer steelhead		
Lyons Ferry NFH summer steelhead		
Rapid River spring Chinook	November 27, 2017	NMFS (2017f)
Hells Canyon spring Chinook		
South Fork Salmon River summer Chinook		
Johnson Creek Artificial Propagation and Enhancement Project summer Chinook		

Hatchery Programs in Action Area	Biological Opinion Signature Date	Citation
South Fork Chinook Eggbox Project summer Chinook		
Kooskia spring Chinook	December 12, 2017	NMFS (2017g)
Clearwater Fish Hatchery spring/summer Chinook		
Nez Perce Tribal Hatchery spring/summer Chinook		
Dworshak spring Chinook		
Clearwater River coho (at Dworshak and Kooskia)		
Steelhead Streamside Incubator (SSI) Project	December 12, 2017	NMFS (2017h)
Dworshak National Fish Hatchery B-Run Steelhead		
East Fork Salmon Natural A-run Steelhead		
Hells Canyon Snake River A-run Summer Steelhead		
Little Salmon River A-run Summer Steelhead		
Pahsimeroi A-run Summer Steelhead		
South Fork Clearwater (Clearwater Hatchery) B-Run Steelhead		
Upper Salmon River A-Run Steelhead		
Salmon River B-Run		
Snake River Kelt Reconditioning		
Yankee Fork spring Chinook	December 26, 2017	NMFS (2017a)
Panther Creek summer Chinook		
Panther Creek summer Chinook egg box		
Upper Salmon River spring Chinook		
Pahsimeroi summer Chinook		

Middle Columbia River Steelhead DPS

The hatchery programs that affect the Middle Columbia River DPS have changed over time and reduced adverse effects on ESA-listed species. For example, the Walla Walla summer steelhead hatchery program (Wallowa stock) has been modified over time to reduce the genetic effects of releasing a non-endemic stock. In addition, the operators are evaluating the feasibility of using an endemic summer steelhead broodstock (Touchet stock), which would further reduce genetic risk of the hatchery program on the MCR Steelhead DPS.

Snake River Fall-Run Chinook Salmon ESU

The recently completed Snake River fall Chinook salmon recovery plan (NMFS 2017d) includes one recovery scenario that deals with genetic risk in an innovative way with the creation of natural production emphasis areas (NPEA). An NPEA is essentially a region of greatly reduced hatchery influence relative to other spawning areas, which benefits the species by having a portion of the population with very low genetic risk. Modeling based on homing fidelity studies available at that time indicated this approach was feasible. Updated homing fidelity information (USFWS 2017) supported the preliminary feasibility of the NPEA, implemented by moving at least the Hells Canyon and Pittsburgh Landing releases to the Salmon River.

Considerations of the uncertainties regarding survival rates, homing to the Salmon River, and response of natural production to a large scale change from the present configuration of releases led to the operators making changes to reduce hatchery effects through an NPEA approach in a phased manner. Under the phased approach, the hatchery operators would change one of their release locations: moving the release of 1,000,000 subyearling fall Chinook salmon from Hells Canyon to a site (of equivalent distance to Lower Granite Dam) on the lower Salmon River. This effects of this action were considered as part of the *U.S. v Oregon* 2018 Management Agreement Biological Opinion (NMFS 2018b) as well as a site-specific consultation on NMFS issuance of a new section 10 permit for the Snake River fall Chinook hatchery programs (NMFS 2018a). This management change is expected to reduce genetic risk to the ESU.

Snake River Spring/Summer-run Chinook ESU

There are 18 spring/summer Chinook salmon hatchery programs in the Snake River Basin. Most of these programs release hatchery fish into rivers with ESA-listed natural-origin spring/summer-run Chinook salmon. However, some of these hatchery programs release fish into the Clearwater River, where spring/summer-run Chinook salmon are not listed under the ESA.

Over the years, hatchery programs in the Salmon River have made improvements to their hatchery programs. In particular, program managers have better integrated natural-origin fish into their broodstock, thereby creating integrated components of their hatchery programs. The South Fork Salmon River summer Chinook salmon hatchery program out of McCall Fish Hatchery created an integrated component and now has two components (segregated and integrated) with a recently implemented genetic relationship between them. In other words, a percentage of returning fish from the integrated component will be used as broodstock in the segregated component. This type of genetic linkage is sometimes referred to as a “stepping stone” system (HSRG 2014). Initial analysis by NMFS of programs connected this way shows that these linked programs pose considerably less risk of hatchery-influenced selection than solely segregated programs because they maintain a genetic linkage with the naturally spawning population (Busack 2015).

In this case, the presence of returning segregated hatchery-origin adults on the South Fork Salmon River spawning grounds poses little additional risk compared to integrated hatchery-origin adults. The South Fork Salmon River summer Chinook salmon hatchery program also contributes eyed-eggs to the South Fork Chinook eggbox program, meaning segregated hatchery fish produced with this program are also genetically linked, which is an improvement from when this program operated as the “Dollar Creek Eggbox Program”. According to NMFS’ site-specific biological opinion (NMFS 2017f), genetic analyses using a PNI model indicate that, depending on natural-origin returns, the PNI will range from 5% to 67% on any given year in the South Fork Salmon River population. NMFS considers this to be a considerable improvement to the genetic structure of the population, compared to when these components were not genetically linked.

The Rapid River and Hells Canyon programs are segregated and for harvest purposes. In the most recent biological opinion, these programs have developed new strategies to limit straying and ecological interactions between hatchery and ESA-listed natural-origin fish (NMFS 2017f). The Johnson Creek Artificial Propagation Enhancement program has always used 100% natural-origin fish in their broodstock, so there are only minor genetic risks associated with this program, and this program will continue to operate with these same conservation considerations and standards. The Sawtooth hatchery program in the Upper Salmon River has also recently employed a genetically linked aspect to their integrated and segregated program components, reducing genetic risk to the ESU. In addition, the proposed Panther Creek hatchery program may reduce risk to the ESU by re-establishing a natural-origin population. There is also a commitment for this future hatchery program to adhere to PNI values according to the sliding scale management objectives described in the biological opinion (NMFS 2017a). The Pahsimeroi and Yankee Fork hatchery programs have implemented sliding scale management strategies to manage genetic interactions between hatchery-origin fish with natural-origin fish on spawning grounds. The hatchery programs in the Upper Salmon River have also committed to strategies to limit hatchery straying and ecological interactions with ESA-listed natural-origin fish.

There have also been some improvements in recent years to hatchery programs located in northeast Oregon. The Catherine Creek, Imnaha, and Lostine hatchery programs use sliding scales sensitive to population abundance (NMFS 2016). Under the sliding scales, the programs allow some hatchery-origin fish to spawn in the wild at all abundance levels, but reduce proportions as natural-origin abundance increases. Outplanting of adults is in addition to the pHOS determined by the sliding scales. This strategy attempts to balance the risk of extinction (low natural-origin abundance) with the risk of hatchery influence.

The Clearwater hatchery programs operate where ESA-listed Snake River spring/summer-run Chinook salmon are not present. Furthermore, according to NMFS site-specific biological opinion (NMFS 2017g) these hatchery programs have implemented new strategies to limit straying of program fish into areas where ESA-listed fish are present.

Snake River Sockeye ESU

The purpose of the Snake River sockeye hatchery program is to restore sockeye salmon runs to Stanley Basin waters leading, eventually, to sockeye salmon recovery and Indian and non-Indian harvest opportunity. The hatchery program was initiated in 1991, and the Snake River Sockeye Salmon ESU might now be extinct if not for the hatchery program (NMFS 2013b). The hatchery program is expected to accelerate recovery of the Snake River Sockeye Salmon ESU by increasing the number of natural-origin spawners faster than what may occur naturally (NMFS 2013b). In addition, the sockeye salmon hatchery program will continue to provide a genetic reserve for the Snake River Sockeye Salmon ESU to prevent the loss of unique traits due to catastrophes.

The Snake River sockeye hatchery program is using a three-phase approach:

- Phase 1: increase genetic resources and the number of adult sockeye returns (captive brood)
- Phase 2: incorporate more natural-origin returns into hatchery spawning designs and increase natural spawning escapement (population re-colonization phase)
- Phase 3: move towards the development of an integrated program that meets proportionate natural influence (PNI) goals established by the Columbia River Hatchery Scientific Review Group (HSRG) (local adaptation phase). During Phase 3, no hatchery-origin sockeye salmon would be released into Pettit or Alturas Lake.

Growth of sockeye salmon in the Stanley Basin lakes is often density-dependent and related to zooplankton density (NMFS 2013b). Juvenile sockeye salmon rear one or two years in the lakes before emigrating to the ocean, and, during their stay in the lakes, sockeye juveniles feed almost entirely on certain assemblages of zooplankton (Burgner 1987). The Stanley Basin lakes' zooplankton communities declined drastically after the sockeye populations declined and other fish (e.g., trout and non-native kokanee) were introduced (NMFS 2013b), and the types of zooplankton available changed to assemblages less supportive of sockeye salmon (Koenings and Kyle 1997). The Snake River sockeye salmon hatchery program is expected to help sockeye salmon reestablish their biological niche and may result in an increase in zooplankton levels as kokanee abundance declines. This change would be expected to increase the growth rate of juvenile sockeye salmon and improve their survival during the long seaward migration from their nursery lakes. However, in the short-term, increasing the number of juvenile sockeye salmon in the lakes may increase competition for food. Therefore, ongoing studies to determine the carrying capacity of the lakes will continue and allow permit holders to adjust release levels if needed.

Snake River Steelhead DPS

There are 13 steelhead hatchery programs in the Snake River Basin and one kelt reconditioning program. Typically, shortly after spawning, a kelt is in fairly poor condition, and its chances of surviving the downstream migration may be low. The objective of kelt reconditioning is to improve the condition of kelts by feeding and treating any disease in a hatchery environment, so that the kelts can be returned to the river in a healthier state (Hatch et al. 2017).

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

Most of the steelhead hatchery programs are operated to augment harvest of A-run and B-run steelhead, but three programs are for supplementation. Hatchery-origin fish from all of the steelhead programs are identifiable through the use of parental-based tagging. This allows any fish encountered to be identified to the program level. NMFS concluded in its site-specific biological opinions that straying is low for all of the segregated harvest steelhead programs in the Snake River Basin, and is not expected to affect the abundance, productivity, diversity or spatial structure of the DPS because of the low potential for interbreeding and competition for spawning space between hatchery and natural-origin steelhead (NMFS 2017b). Genetic effects of the three integrated programs (East Fork Salmon River Natural, Tucannon, and Little Sheep Creek) are limited by the use of natural-origin broodstock and proportionate natural influence targets[7] that meet or exceed current estimates. In addition, all three programs are likely to benefit the DPS through increased abundance and potentially productivity for their respective populations.

[7] For East Fork and Little Sheep Creek this is > 0.5. The Tucannon steelhead program's PNI should more than double within the next five years once hatchery program changes are realized, but the low abundance of natural-origin fish means that demographic concerns outweigh genetic risks at the present time.

2.4.4. Harvest

Spring/Summer Chinook Salmon

The spring/summer Chinook fisheries in the Snake basin typically occur from late April through mid-August. The non-tribal fisheries selectively target hatchery fish with a clipped adipose fin, while tribal fisheries retain both hatchery and natural-origin fish. These fisheries operate using abundance-based management; as the natural-origin population increases, so does the impact on natural-origin spring/Summer Chinook salmon. These fisheries have been evaluated previously by NMFS throughout the Snake Basin and were found to not jeopardize the continued existence of ESA-listed spring/summer Chinook salmon, nor destroy or adversely modify their designated critical habitat (NMFS 2011d; NMFS 2013a).

Fisheries for steelhead and fall Chinook salmon are unlikely to encounter more than a few adult spring/summer Chinook salmon, due to limited spatial and temporal overlap. Resident trout fisheries may encounter juvenile natural-origin spring/summer Chinook salmon, but due to the use of lures, hook size specifications, and timing of these fisheries in rearing areas (May 4-October 31), the number of juveniles encountered is estimated to have resulted in a few adult equivalents annually, probably fewer than ten, though information is incomplete.

Fall Chinook Salmon

The fall Chinook salmon fisheries in the Snake River Basin typically take place from August through November. Similar to spring/summer Chinook salmon, the non-tribal fisheries have selectively targeted hatchery fish with a clipped adipose fin. Tribal fisheries retain both hatchery and natural-origin fish regardless of external marking. Table 15, below, shows that an average of ~ 4.3 % of the Snake River Fall Chinook Salmon ESU that returns to Lower Granite Dam have typically been killed during fall Chinook salmon fisheries in the Snake River Basin.

There are few incidental encounters or mortality of fall Chinook salmon from spring/summer Chinook salmon fisheries because the fisheries close prior to the arrival of fall Chinook salmon in the Snake Basin. However, the timing of the fall Chinook salmon fishery overlaps with steelhead fisheries, which results in the mortality of ~ 6% of the natural-origin fall Chinook salmon that return to Lower Granite Dam (Table 21). Resident trout fisheries are unlikely to encounter fall Chinook salmon because the majority of salmon migrate out of rearing areas as subyearlings prior to the opening of resident trout fisheries. The reservoir-type fall Chinook salmon life history smolts are too small (~ 4 inches) to be hooked with legal trout-sized hooks.

Table 15. Number of ESA-listed natural-origin fall Chinook salmon killed (catch and release mortality for state fisheries is estimated at 10 percent of those caught) in fall Chinook salmon fisheries from 2011-2016: LGR; Lower Granite Dam.

Fishery Manager	Average mortality	Average natural-origin escapement above LGR	% Average natural-origin mortality
WDFW[1]	116	12,535	0.9

IDFG and ODFW	93	12,534	0.7
NPT	333	12,534	2.7

Sources: (Table 15 in this opinion; IDFG 2014; IDFG 2016; IDFG 2017; Oatman 2017; Petrosky 2012; Petrosky 2013; Petrosky 2014)
[1]This includes fall Chinook salmon caught both incidental to the mark-selective fall Chinook and steelhead fisheries.

Sockeye Salmon

There are no fisheries in the Snake River Basin that target hatchery or natural sockeye salmon. However, the spring/summer Chinook salmon fisheries and resident fish fisheries in Idaho, especially those in the Salmon River Basin, may incidentally encounter an estimated 22 sockeye salmon, with a catch-and-release mortality rate of 10 percent (NMFS 2011d). For Idaho steelhead fisheries, no sockeye salmon encounters have been reported since the 1970s (IDFG 2018).

Steelhead

The past and present effects of recreational and tribal treaty fisheries (i.e., spring/summer Chinook, fall Chinook and coho salmon, and resident fish fisheries) on ESA-listed steelhead in the Snake River Basin are described in conjunction with the effects of the Proposed Action, see Effects of the Proposed Action, Section 2.5.1. In brief, these fisheries have been ongoing for decades. Since the advent of mass-marking, recreational fisheries have been selective, so impacts have likely decreased from historical impacts over the last decade. In addition, the reduction in rainbow trout stocking by the states has likely decreased angler effort, and the more widespread use of barbless hooks in state recreational fisheries may have contributed to lower incidental mortality rates as compared to historical fishery impacts on natural-origin steelhead.

2.5. Effects of the Action

Under the ESA, “effects of the action” means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur. This section describes the effects of the Proposed Action, independent of the Environmental Baseline and Cumulative Effects. The Proposed Action, the status of ESA-protected species and designated critical habitat, the Environmental Baseline, and the Cumulative Effects are considered together later in this document (see Section 2.7, Integration and Synthesis) to determine whether the Proposed Action is likely to appreciably reduce the likelihood of survival and recovery of ESA protected species or result in the destruction or adverse modification of their designated critical habitat.

2.5.1. Effects on Steelhead

2.5.1.1. Catch and release mortality rate in recreational steelhead fisheries

The available information assessing hook and release mortality of adult steelhead suggests that hook and release mortality is low. Hooton (1987) found catch and release mortality of adult winter steelhead averaged 5.1% for all gear types out of 336 steelhead angled in the study. Natural bait had slightly higher mortality (5.6%) than did artificial lures (3.8%), and barbed hooks (7.3%) had higher mortality than barbless hooks (2.9%). Another study by Nelson et al. (2005) found an average incidental mortality of 3.6% out of the 226 steelhead included in the study, which were primarily caught using bait and barbless hooks. NMFS and NOAA (1999) cited Hooton (1987) as the basis for suggesting a 5 percent incidental mortality on natural-origin steelhead for selective fisheries. This rate was reaffirmed as the best estimate available at the time in NMFS and NOAA (2000).

For now, a review of current literature supports the continued use of 5% as applied to the proposed fisheries. The median mortality rate reported in available research (Table 16) is 4.2%. The two studies that might suggest an increase of the catch and release mortality rate assumption above 5% are Mongillo (1984), and Taylor and Barnhart (2010). However, caveats exist for both studies that help explain the higher mortality rates. First, Mongillo (1984) reported mortality rates of 11% for steelhead collected for broodstock in Washington. However, Hooton (2001) noted the steelhead in Mongillo's study were tethered through the gills before transport to the hatchery, which likely resulted in critical injuries that would not be representative of catch and release mortality in Idaho fisheries. In addition, the Mongillo study could not differentiate holding mortality from hooking mortality. Second, Taylor and Barnhart (2010) reported a catch and reelase mortality rate of 8.7% in California's Mad and Trinity Rivers, but higher mortality rates were associated with warmer water temperatures (above 19°C). When temperature was below 19° C, mortality was less than 5%.

While the Twardek et al. (2018) study does discuss higher catch and release mortality rates when overwintering and tag retention are considered, we believe that the 4.5% 3-day handling mortality is the best estimate of catch and release mortality for that study. This is because the 3-day mortality rate following study handling (4.5%) is similar to other studies that have found that the majority of mortality from angling occurs within 24-48 hours of the catch event (Meka 2004; Mongillo 1984; Muoneke and Childress 1994; Wood et al. 1983). As to the 15% overwinter mortality rate identified in the Twardek study, winter generally has the highest rate of natural mortality of any season for salmonids (see review by Brown et al. 2011). In addition, Twardek et al. (2018) did not have data on overwinter mortality for fish that were not caught and released, which would allow separation of mortality into overwintering and catch and release components. The Twardek study also assumed that no fish lost their tags during this seven-month period, acknowledging that any tag loss would inflate their estimate of overwinter mortality. Tag loss is possible, but is uncommon (i.e., 1-2% of those that are tagged).

Table 16. Reported steelhead catch and release mortality rates in literature (IDFG 2019).

Citation	Location	Type of Study	Sample Size	Mortality Rate
Lough (1980)	Skeena River	C & R for radio-tagging	181	3.9%
Hooten (1987)	Vancouver Island, BC	C & R for broodstock	3,715	3.4%
Hooten (1987)	Keogh River	C&R	336	5.1%
Mongillo (1984)	WA streams	C & R for broodstock	390	11.0%
Thomas (1995)	Skeena River	C&R	21	4.6%
Nelson et al. 2005	Vedder-Chilliwack River, BC	C&R for radio-tagging	226	3.6%
Twardek (unpublished data)*	Bulkley River, BC	C&R	N/A	3.0%
Taylor and Barnhart (1997)	Trinity River, Mad River, CA	C&R	126	8.7%
Whitney et al. (in press)	South Fork Clearwater River, ID	C & R for broodstock	1148	3.0%
Twardek et al. (2018)	Bulkley River, BC	C&R	129	4.5%

*available at www.psmfc.org/steelhead/2018/Twardek_PSMFC.pdf

There is the possibility that fish caught and released multiple times may have a higher mortality rate. However, the literature does not support this idea. Nelson et al. (2005) have found no difference in survival of fish captured and released multiple times. Likewise Bartholomew and Bohnsack (2005) “found no studies of cumulative mortality from multiple catch-and-release events for individual fish”, and provided a predictive model of survival rates, (to date unsubstantiated). Richard et al. (2013) did not directly address reproductive success for re-captured adults but did note that two Atlantic salmon were caught multiple times and successfully spawned and produced many juveniles. Ultimately, catch rates of individual fish may increase with certain traits (citing shyness and domestication as well as aggressiveness; Ruzzante 1994) or may decrease as a result of learning hook avoidance (Askey et al. 2006). There is no evidence to suggest that hooking mortality increases with capture rates.

An important distinction in some of the more recent hooking mortality studies is that some studies are angling steelhead for use in hatchery program broodstock. This is worth noting because the method of collection may lead to different factors that influence the resulting mortality. For example, angling for broodstock collection is likely to be conducted with more experienced anglers, but increased handling compared to recreational fisheries. After collection, the fish are transported back to a hatchery and held for months before spawning, during which time they may be given prophylactic treatments for pathogens, which could reduce mortality. In a study conducted by ODFW at Wallowa Hatchery in October of 2004 to 2007, 410 steelhead were collected via angling using a variety of gear (i.e., bait, lure, jig, fly). Of those, 7 died (1.7%) within a couple of days post-collection and before any prophylactic treatments could be administered (Yanke 2018). IDFG (Whitney et al. 2019) evaluated pre-spawn mortality of steelhead broodstock collected in the SF Clearwater River via angling, and compared rates to those that voluntarily returned to Dworshak National Fish Hatchery. The authors found that mortality due to angling, holding on-site in fish tubes, transfer to a fish truck, and transportation to Dworshak National Fish Hatchery (a minimum of one-hour drive time from the fishery) was less than 3% for the 1,148 steelhead included in the study.

Other factors including time played and time out of water can potentially influence incidental mortality rates. Reingold (1975) showed that adult steelhead hooked, played to exhaustion, and then released returned to their target spawning stream at the same rate as steelhead not hooked and played to exhaustion. Chiaramonte et al. (2018) also found that air exposure and fight times likely result in negligible incidental mortality rates of steelhead and Chinook salmon when air exposure (< 30 seconds) and fight times (1-2 minutes) are representative of angler behaviors. These angler behaviors are detailed by Lamansky Jr. and Meyer (2016), who found that for Idaho trout anglers (N = 280), fight time averaged 53 seconds and total air exposure averaged 29 seconds. A subsequent study in Idaho confirmed similar fight times (mean = 40 seconds) and air exposure times (mean = 19 seconds) by anglers in other trout fisheries (Roth et al. 2018). Ferguson and Tufts (1992) found that mortality was increased the longer hatchery rainbow trout were exposed to air, but this was confounded by other stressors during the experiment. For example, the authors exhaustively exercised hatchery rainbow trout to the point that fish could no longer respond to further stimulation. Fish were then exposed to air for 0, 30, and 60 seconds, and experienced mortality rates of 12, 38, and 72%, respectively. However, these fish were the subject of repeated blood sampling during the experiment. The mortality rates were likely elevated as a result of the extreme conditions the fish encountered, as evidenced by the 12% mortality rate for fish not even exposed to air.

Chiaramonte et al. (2018) also observed deep hooking rates of < 1% regardless of the type of fishing gear used, which is lower than rates reported in other studies (8, 13 and 3% respectively, in Fritts et al. 2016; Lindsay et al. 2004; Twardek et al. 2018). This is important because deep hooking is more likely to result in hooking of vital organs (i.e., gills, esophagus/stomach) that can lead to higher mortality rates. Still other handling factors common in catch-and-release mortality rate studies—such as if fish had blood drawn or had PIT tags or radio tags inserted—could influence mortality rates, likely increasing mortality above the average angler.

Evidence regarding relative aggressiveness of natural versus hatchery-origin steelhead is inconclusive. Seals and French (2009), the lone study to directly address the question, described anglers encountering natural steelhead in the Deschutes River in greater proportions than those observed at the Sherars Falls collection facility upstream of the fishery. The authors stated that they do not have a good explanation for the discrepancy, but referenced a range of potentially valid explanations for the reported difference: (1) wild fish may be more aggressive, (2) anglers may be over-reporting the number of hooked wild fish, or (3) the proportions of hatchery and natural fish above the fishery reported in the study may differ from those below the collection facility susceptible to angling. In support of point 2, studies have shown angler bias and misreporting of catch and release events (McCormick et al. 2015; Sullivan 2003). To point 3, there may be differences in spatial distributions of hatchery and natural fish within a system as hatchery fish tend to home back to their release locations (Ludwig 1995; Nelson et al. 2005). Finally, because many of the steelhead caught in the Deschutes River fishery are from other drainages (Hess et al. 2016), natural: hatchery proportions available to the fishery downstream of Sherars Falls may be higher than those at Sherars Falls. Therefore, NMFS cannot assume a different encounter probability between hatchery- and natural-origin fish.

Environmental factors may also play a role in catch and release mortality outcomes. Mortality of steelhead is likely to be higher if the fishery occurs during warm water conditions as was demonstrated in Taylor and Barnhart (2010). Based upon the findings of this paper, IDFG examined the fishery across space and time to determine when and where a 19 °C threshold may be observed (IDFG 2019). IDFG found that exceedance of this temperature threshold occurred primarily from July through September. In addition, by September 1, a low percentage (11%) of steelhead have crossed Lower Granite Dam into Idaho waters, with about a 2% estimated encounter rate. Furthermore, catch and release mortality may be mediated in warmer water in several ways: (1) steelhead may seek out cooler areas to reside, and (2) catch rates may decline as water temperatures increase because fish have moved to cooler water or reduced activity of the fish themselves (Höök et al. 2004). Based on this analysis, temperature may not be playing an important role in current fisheries, but may become more important in the future with climate change.

Based on all of the factors above that can influence catch and release mortality from the peer reviewed literature, we conclude that the 5% catch and release mortality rate estimate used by the state fishery managers in the Snake Basin is supported by the best available science. NMFS will consider any new information that becomes available suggesting a different value may be more appropriate.

2.5.1.2. Sublethal effects of catch and release fisheries

Aside from mortality, fish that are caught and then released could suffer sublethal effects. Some scientific authors have hypothesized sublethal detrimental effects such as altered behavior, negative physiological response, or increased risk of disease or predation. There are currently no conclusive data to indicate that sublethal effects have a population-level impact on wild steelhead reproduction.

Few studies have directly assessed the reproductive success of fish that are caught and then released. The results of these studies suggest that individual fish show no meaningful long-term effects on reproduction. Most recently, Whitney et al. (2019) found that fight duration and air exposure did not reduce survival to the free-swimming stage for progeny of hatchery steelhead. Other studies of gamete viability (i.e., fertilization rates after spawning) have shown no differences between angled and non-angled steelhead (Hooton 1987; Pettit 1977) or Atlantic salmon (Booth et al. 1995; Davidson et al. 1994). Richard et al. (2013) studied the reproductive success of Atlantic salmon captured by anglers as they traveled upstream to spawn. They reported that it was unclear whether 5 of the 40 fish did not reach the spawning location because they died or because they were "dip-ins" that went back to the ocean. With the five fish of unknown fates excluded, Richard et al. (2013) reported that angled Atlantic Salmon had the same probability of reproduction as the uncaught salmon.

With these five fish included as presumed mortalities, the study found some relationship between fishing mortality and reproductive success, but only for larger fish. There was overlap in the standard errors around the estimates, indicating that this relationship was weak. Study fish of 65 cm produced ~15 offspring, fish of 100 cm produced ~12 offspring; the two fish caught multiple times produced 16 and 25 offspring, respectively. Richard et al. (2013) hypothesized that larger fish may be played to exhaustion at a greater rate, but also recognized that other studies investigating fish size and hooking mortalities have inconclusive results. When the authors looked at the interaction of angling, air exposure and water temperature, they found that fish exposed to air when water temperatures were below 17°C had reduced reproductive success, but also found those exposed to air when water temperature was warmer than 17°C had *increased* reproductive success. These counterintuitive findings might be a result of small sample size.

Several studies observing behavioral movements after being caught and then released found no effect on the ability of fish to spawn. In Idaho, Reingold (1975) removed steelhead from a trap, hooked and played them to exhaustion, and tagged and released them downstream along with a control group that was transported and released without simulated angling. Reingold (1975) reported no difference in return rates between the two groups. Twardek et al. (2018) evaluated physiological and behavioral responses in steelhead from catch and release and reported no difference in fish movement two weeks after capture and no long term behavioral impairments. While there appeared to be an initial stress response from angling, survival to winter was reported as 94%, suggesting adequate recovery subsequent to angling.

For Atlantic salmon, Richard et al. (2014) reported some differences in behavior of fish that were caught and released, but stated that "the observed influence of catch and release on the migratory behavior of Atlantic salmon likely has little or no impact on salmon fitness in terms of survival and reproductive success." Lennox et al. (2015) used radio-telemetry to compare the migration of 27 Atlantic salmon that were caught and released to a control group. The authors concluded that fish that were caught and released migrated shorter distances than the control fish, but noted that this difference may not lead to an effect on reproduction as all the fish were observed in the spawning areas at spawning time. Thorstad et al. (2007) used radio-tracking to evaluate survival and migration of Atlantic salmon that were caught and released in Norway. They found that fish that were caught and released displayed an unusual downstream movement and a delay in upstream migration. The authors stated that the importance of this finding is uncertain because if the fish arrive on the spawning grounds in time for spawning season, then there should be no effect on reproductive success. They did not further evaluate spawning or reproductive success.

Therefore, based on the available scientific literature on the sublethal effects of catch and release fisheries, NMFS concludes that catch and release fisheries are unlikely to result in decreased reproductive success of fish that are caught and released. Some short-term effects on behavior could occur, but these are also unlikely to result in reduced reproductive success.

2.5.1.3. Spatial limitation on recreational steelhead fisheries

Of the 4,500 miles of river and stream occupied by listed steelhead in Idaho, 683 miles (approximately 15%) are open to harvest of steelhead. The open waters are located in the main stems of the largest rivers and downstream from fish hatcheries where hatchery produced fish are known to return. The most important spawning streams for listed, naturally reproducing steelhead are closed to harvest and managed as natural fish refugia. The Middle Fork, and South Fork, of the Salmon River along with tributaries to the main Salmon River, the Lochsa and Selway Rivers and tributaries are all managed as wild fish refugia. Only limited catch-and-release fishing may be allowed in these areas.

Although natural-origin listed steelhead are mixed with unlisted hatchery fish when migrating through the open fishing areas, they are protected from all fishing impacts when they arrive in the spawning streams. In addition, the proportion of hatchery to natural fish passing over Lower Granite Dam in most years is typically 3 times (Hebdon 2018b). This likely limits encounter rates of natural-origin steelhead because anglers tend to concentrate in areas where hatchery-origin fish return. The most heavily fished areas for steelhead are section 3 in the Clearwater River below Dworshak Hatchery (Stacy Feeken, University of Idaho, personal communication, August 31, 2018), and section 15 of the main Salmon River downstream of Pahsimeroi and Sawtooth hatcheries (Hebdon 2018a).

A similar approach to harvest management occurs in the Grande Ronde and Imnaha Rivers, where only 202 of the 1,996 (approximately 10%) miles occupied by listed steelhead is open to steelhead fishing (Jeff Yanke, ODFW, personal communication, May 21, 2018). Only the mainstem portions of each river are open to fishing, with the exception of a portion of the Wenaha River, and the Wallowa River up to Wallowa hatchery; both are tributaries to the Grande Ronde River. Limiting recreational fishery harvest to areas where hatchery fish are most common and providing sanctuary areas that are closed to harvest where natural fish predominate (e.g., Joseph Creek, Minam River), limits the encounter and impact rates on natural-origin fish in the fisheries.

2.5.1.4. Evaluating natural-origin impacts

Information on impacts to natural-origin steelhead, whether caught incidentally in mark-selective steelhead fisheries managed by the states or in non-selective tribal fisheries is detailed in Table 17. All of the Snake Basin co-managers participate in annually supplying fishery harvest and natural-origin mortality data for the Snake Basin Steelhead Run Reconstruction modeling effort. In summary, this model uses abundances at Lower Granite Dam because of the intensive sampling program operating on adult steelhead as an anchor point. Disposition of these fish within the Snake River Basin is estimated by applying survival and movement probabilities. Escapement and loss to fisheries between Ice Harbor Dam and Lower Granite Dam was estimated by moving fish downstream to Ice Harbor Dam using a conversion rate and then estimating fisheries and natural losses within that reach. Escapement and losses upstream of Lower Granite Dam are estimated by moving fish upstream according to how many are known to be harvested, return to the hatchery rack, and are detected at various PIT tag arrays (Stark et al. 2016).

This effort represents the best information available for assessing mortality of steelhead attributable to fisheries at the MPG level. This group generates an annual report that estimates the mortality of steelhead due to fisheries in each reach of the Snake River and its tributaries (Figure 11). We totaled the number of steelhead harvested in all reaches by MPG to assess the total mortality of steelhead by MPG attributable to Snake Basin fisheries. This assessment of mortality at the MPG level has only been possible since 2011 when GSI at Lower Granite Dam began, but is not currently possible at the population level.

To evaluate the risk of the proposed impact rates by MPG, we compared the current impacts and the proposed impacts applied to data from 2011-2016 to two thresholds: the aggregated minimum abundance threshold (MAT; i.e., viability) values for each MPG developed by the ICTRT, and the aggregated critical abundance thresholds (CAT; 30% of MAT) developed by the fishery managers (Figure 12). The CAT value is used as an indicator of low abundance. Management changes would be implemented when abundances fall below this critical abundance threshold. The CAT was derived from a Biological Requirements Workgroup Progress Report that developed thresholds for spring/summer Chinook salmon populations (BRWG 1994) that informed survival and recovery. The Workgroup determined that all populations should have no fewer than 150 adults annually because of strong concerns about genetic and demographic risk (e.g., difficulty finding a mate). For larger populations this value was doubled to 300 due to increased uncertainties for larger populations that typically occupy larger geographic areas. The fishery managers took this one step further and tripled the value to establish a CAT of 450 for larger steelhead populations as designated by the ICTRT. This larger value is appropriate because fishery managers will be using abundance as projected at Ice Harbor Dam, as opposed to spawners, to determine when additional conservation measures need to be implemented.

Management changes designed to limit impacts will likely increase in severity if low abundances occur in multiple consecutive years. A single year of dipping below the CAT is unlikely to reduce the potential for the populations to survive and recover long-term because steelhead life history allows for repeat spawning, a variety of ages at return, and some productivity from resident *O. mykiss* parents (Table 2 and Figure 11 in Camacho et al. 2017; Flesher et al. 2017). However, multiple years below CAT values may indicate a drop in productivity.

Under the Proposed Action, allowable impacts are tailored to each MPG. MPGs comprised of a higher number of populations are allowed a higher level of impact on natural-origin steelhead than MPGs comprised of lower numbers of populations. That is because not all populations in larger MPGs need to attain viable or highly viable status. As an example, the Salmon River MPG has 12 populations. Of those populations, half need to meet viability standards to achieve the minimum level of recovery, and one needs to be highly viable (NMFS 2017e). This leaves as many as six to meet maintained population standards, with abundances that could be lower than MAT without undermining the chances of recovery. In contrast, the Imnaha MPG has only a single population. That population must achieve high viability for that MPG to be considered viable, which requires, in part, obtaining the MAT value with a high level of certainty.

Although we are unable to assess impacts of the proposed fisheries on individual populations, these impacts are unlikely to be uniform across all populations within an MPG because of the time and space over which fisheries occur. For example, in the Salmon MPG, fisheries only occur in the mainstem Salmon River and those populations that originate furthest upstream are likely to accumulate more impacts than those closer to the River mouth. Under the current recovery scenario, four out of the six upper Salmon River populations can be maintained with two targeted for high viability and none targeted for high viability (NMFS 2017e). Thus, recovery is still possible without all populations meeting MAT values.

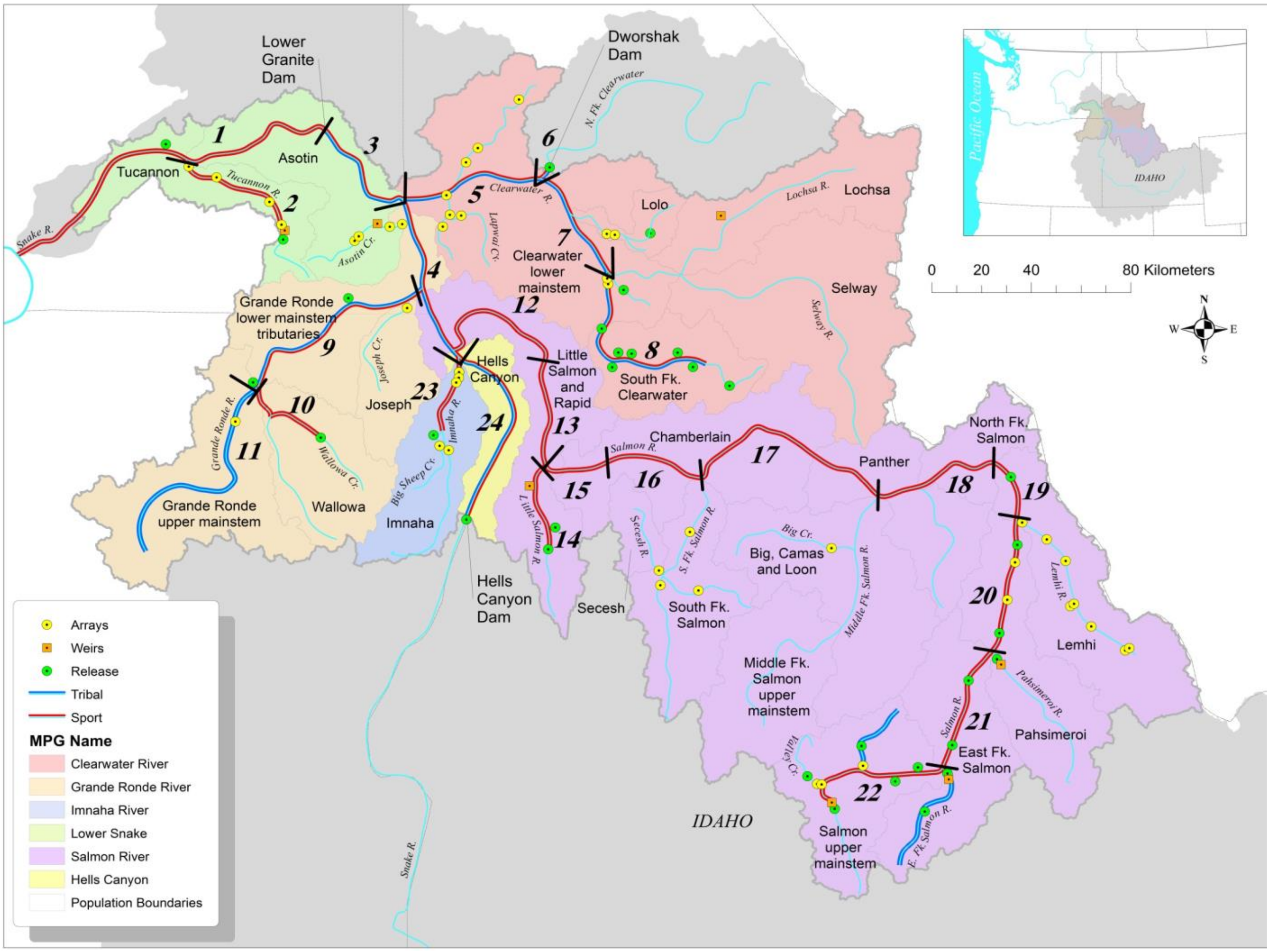

Figure 11. River reaches as used for the Steelhead Run Reconstruction Model (courtesy of Eric Stark, IDFG).

Our analysis using the Steelhead Run Reconstruction Model estimates that over the last six years, current fisheries have not caused a decrease in the abundance of steelhead from each MPG measured at Ice Harbor Dam below the aggregated MAT value (Figure 12). After applying the *proposed* MPG impact rates to the last six years of data, abundances would still not have been decreased below the aggregated MAT value for 3 of the 5 MPGs; the Clearwater and Salmon MPGs were the only MPGs for which harvest drove abundance below the MAT, but abundance was still well above the CAT (Table 17).

The Steelhead Run Reconstruction model runs for estimating impacts for spawn years 2017-2019 have not been completed, and thus we could not perform an analysis for these years as we have done for previous years in Table 17. Because the modeling has not been completed, the estimates described in Table 18 do not include all of the pertinent information necessary to calculate abundance of the Lower Snake MPG, because the Tucannon population is below Lower Granite Dam. Applying the most recent five-year average percent breakdown of each MPG this would lead to the Salmon MPG dropping below CAT in two of the last three years (Table 18).

Even with the proposed impact rates that include expansion of tribal fisheries into their Usual and Accustomed (U&A) fishing areas over time, we anticipate that steelhead fisheries will not decrease the abundance or productivity of natural-origin Snake River steelhead to a level that would undermine recovery or survival because MPG returns are infrequently at or below aggregated CAT values (only the Salmon MPG in 2018 and 2019; Table 18). Furthermore, at current impact levels, productivity for Snake Basin steelhead populations for which it can be measured (Table 6) is well above replacement (i.e., 2-3 versus a replacement rate of 1; NWFSC 2015), which is where each adult spawner has a single offspring that survives to adulthood. If multiple years of low abundances were to occur, which would be a sign that productivity may have decreased, the CAT would ensure that modifications to fisheries would be made to reduce impacts, and limit further productivity declines.

Into the future, NMFS anticipates refinements will be made to the Steelhead Run Reconstruction Model. The fishery managers already have plans to help resolve genetic signatures at the stock group level, and ultimately for each MPG to better predict the origin of natural-origin fish. For example, estimates of abundance for the Lower Snake River MPG are confounded by the presence of fish from the Mid-Columbia Steelhead DPS, which are genetically similar using the current genetic markers. Fallback/reascension rates for the Lower Snake MPG are also likely underestimated. Both of these estimates contribute to an overestimation in the abundance of steelhead from this MPG estimated to pass over Ice Harbor Dam. In addition, IDFG plans to refine their natural-origin encounter rate estimates during steelhead fishing to improve estimation of impact rates.

Table 17. Estimated current impacts and proposed maximum impacts on natural-origin Snake River steelhead from Snake River Basin fisheries as measured at Ice Harbor Dam (ICH).

Spawn Year	MPG	Number return to ICH	Current			Proposed		
			Number killed during fisheries	MPG impact (%)	Post-fishery MPG abundance	Number killed during fisheries	MPG impact (%)	Po M ab
2011	Lower Snake	16227	142	0.9	16085	811	5	15
2012		13228	181	1.4	13047	661	5	12
2013		3787	63	1.7	3724	189	5	35
2014		3573	103	2.9	3470	179	5	33
2015		6603	106	1.6	6497	330	5	62
2016		4691	88	1.9	4603	235	5	44
2011	Clearwater	11096	836	7.5	10260	1110	10	99
2012		7657	338	4.4	7319	766	10	68
2013		5849	157	2.7	5692	585	10	52
2014		5764	172	3.0	5592	576	10	51
2015		10641	259	2.4	10382	1064	10	95
2016		9405	268	2.8	9137	941	10	84
2011	Grande Ronde	7354	269	3.7	7085	735	10	66
2012		7643	422	5.5	7221	764	10	68
2013		6067	375	6.2	5692	607	10	54
2014		6819	194	2.8	6625	682	10	61
2015		12405	248	2.0	12157	1241	10	11
2016		9094	339	3.7	8752	909	10	81
2011	Imnaha	2477	262	10.6	2215	124	5	23
2012		2555	240	9.4	2315	128	5	24
2013		2270	47	2.1	2223	114	5	21
2014		1918	46	2.4	1872	96	5	18
2015		3503	52	1.5	3451	175	5	33
2016		2783	46	1.7	2737	139	5	26
2011	Salmon	14872	450	3.0	14422	1487	10	13
2012		13667	330	2.4	13337	1367	10	12
2013		8122	308	3.8	7814	812	10	73
2014		9277	401	4.3	8876	928	10	83
2015		16737	454	2.7	16283	1674	10	15
2016		10544	376	3.6	10168	1054	10	94

Source: (Hurst 2018; Stark 2018a)

Table 18. Comparison of Returns to Ice Harbor Dam (ICH) from 2017-2019 by MPG to critical abundance thresholds.

MPG	2017 Spawn Year[1]	2018 Spawn Year[1]	2019 Spawn Year[2]	Critical Abundance Threshold
Lower Snake River	3335	3294	1559	450
Clearwater River	4434	1746	2015	1500
Grande Ronde River	5391	4150	2134	1200
Salmon River	2979	2153	2453	2850
Imnaha River	1033	736	630	300

Sources: Lance Hebdon, IDFG, personal communication, March 13, 2019.
[1] Preliminary report based on GSI and PIT tag conversion rates.
[2] An in-season estimate based on most recent 5-year average run timing, GSI stock composition, and PIT tag

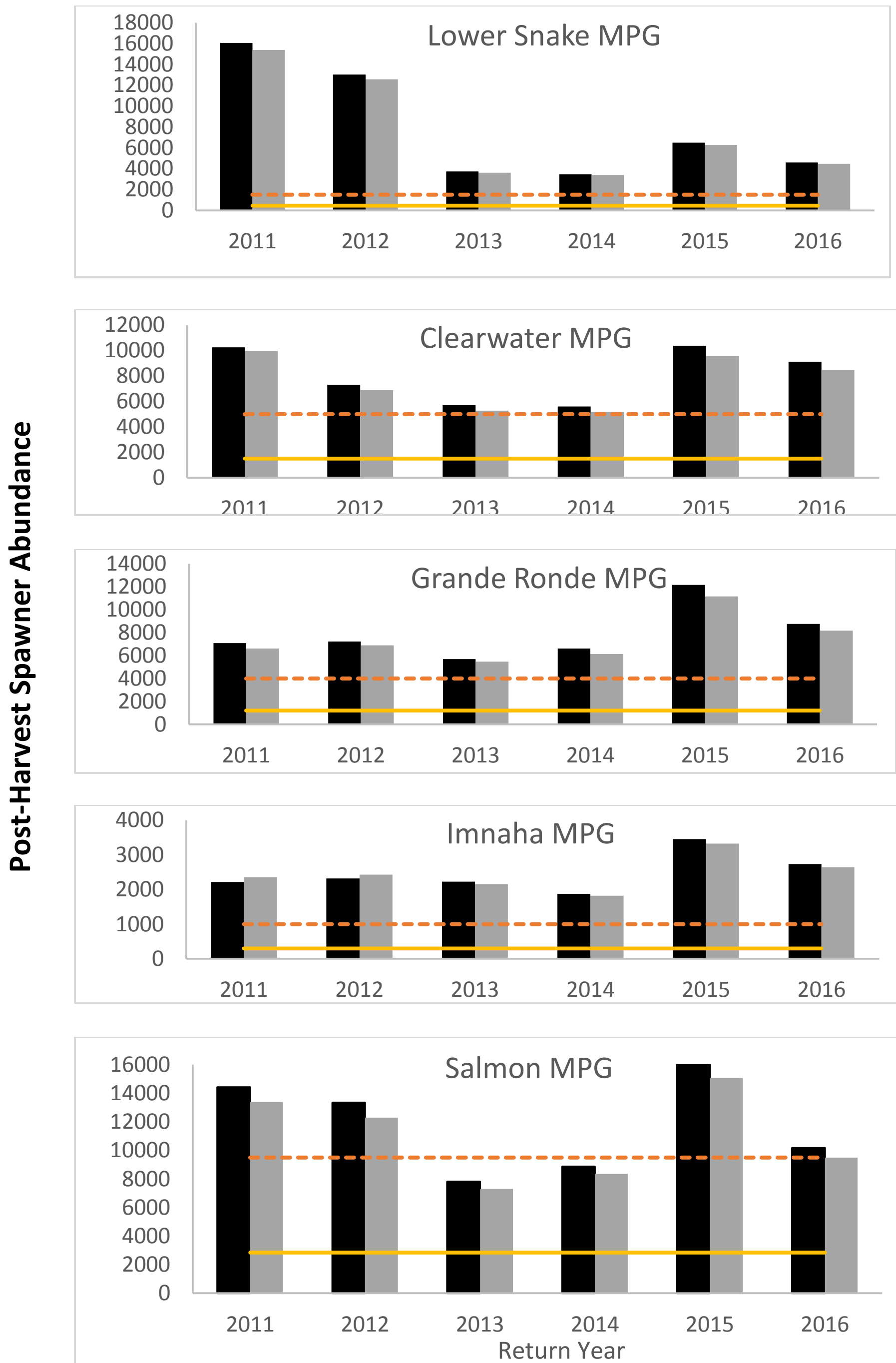

Figure 12. Estimated current (black bar) and proposed (gray bar) impacts on natural-origin Snake River steelhead by MPG from Snake River Basin fisheries relative to MAT (dashed line), and CAT (solid line) values.

2.5.1.5. Evaluating hatchery fish harvest

Unclipped hatchery-origin steelhead are encountered in steelhead fisheries. No unclipped hatchery fish originate within the Grande Ronde and Imnaha MPGs (with the exception of a few missed clipped from the hatchery programs within the geography of those MPGs). Thus, mortality of unclipped hatchery fish occurs only within the remaining three MPGs, with the highest rate occurring in the Clearwater (Table 19). In addition, in three of the six years from 2011-2016, a single fish from the Mid-Columbia Steelhead DPS was caught in Snake River Basin steelhead fisheries, based on the Steelhead Run Reconstruction Model (Stark 2018b). Because hatchery-origin steelhead are not essential to recovery, NMFS considered the impacts on hatchery-origin steelhead, but these effects are not a key factor in our determination for natural-origin steelhead. Since there is no way to differentiate these fish from natural-origin fish during the fishery, fishing regulations designed to remain within natural-origin harvest impacts are likely to limit harvest of unclipped hatchery fish as well. It is anticipated that the rates in Table 19 will increase as tribal treaty fisheries for steelhead expand by MPG as much as four times the current rate for unclipped hatchery-origin steelhead. In addition, the harvest of unclipped hatchery-origin steelhead from the mid-Columbia River will be no more than 20 fish annually.

Table 19. Estimated loss of unclipped hatchery-origin fish from three of the five Major Population Groups (MPG) in which they are released.

MPG	Year	Total Lost	# return to Ice Harbor Dam	Estimated MPG % Loss
Lower Snake	2011	7	763	0.9
	2012	7	578	1.2
	2013	7	852	0.8
	2014	8	508	1.6
	2015	9	937	1.0
	2016	5	511	1.0
Clearwater	2011	780	9049	8.6
	2012	266	3876	6.9
	2013	233	6366	3.7
	2014	155	3785	4.1
	2015	215	5503	3.9
	2016	123	2823	4.4
Salmon	2011	597	13446	4.4
	2012	215	6578	3.3
	2013	200	3442	5.8
	2014	160	3065	5.2
	2015	116	3570	3.2
	2016	86	2014	4.3

Source: (Stark 2018a)

Harvest of listed hatchery-origin adipose-clipped fish is exempt from take prohibitions under the salmon and steelhead 4(d) Rule. This harvest is summarized in Table 20 to provide context for the proposed natural-origin impact rates, and may increase into the future with the overall higher proposed impact rate on natural-origin fish. This may be a benefit to natural-origin fish on the spawning grounds as there may be fewer hatchery fish spawning in natural areas resulting in a potential decrease in genetic and ecological effects over the current level.

Table 20. Harvest of adipose-clipped, hatchery-origin steelhead from 2011-2016 destined for each major population group; ICH = Ice Harbor Dam.

MPG	Average Annual Harvest	Average ICH Return	Average % Harvested
Lower Snake	1216	3916	32
Clearwater	18798	23291	79
Grande Ronde	10156	18938	56
Salmon	36727	54454	68
Imnaha	1108	3367	32
Hells Canyon*	4674	10747	46

Source: (Stark 2018a)
*There are no extant natural-origin steelhead populations within this MPG

2.5.2. Fall Chinook salmon

Only a few reports are available that provide empirical evidence describing catch and release mortality rates for Chinook salmon in freshwater recreational fisheries. ODFW estimates a per-capture hook-and-release mortality for wild spring Chinook in Willamette River fisheries of 8.6% (Schroeder et al. 2000 in Lindsay et al. 2004), which is similar to a mortality of 7.6% reported by Bendock and Alexandersdottir (1993) in the Kenai River, Alaska. Although a more recent study by Lindsay et al. (2004) found that for wild Willamette spring Chinook salmon hooking mortality was 12.2%, the temperatures in the Willamette during the spring fishery are likely warmer than for a fall fishery in the Snake River; and studies have shown that hooking mortality increases with warmer water temperatures (Muoneke and Childress 1994). Based on the above information, state fishery managers use a 10 percent rate when evaluating impacts of proposed recreational fisheries.

Fall Chinook salmon adults occur in the mainstem of the Snake River and the lower reaches of the major tributaries primarily in September through November. For IDFG's steelhead fisheries, impacts to natural-origin fall Chinook salmon have been < 1% (Table 21). For WDFW's steelhead and fall Chinook fisheries (these cannot be separated) these impacts have been ~1% (Table 22). For NPT fisheries impacts cannot be separated by species-specific fisheries, and were greatest during the 2016-2017 fishing season with 3.8% of the natural-origin run at Lower Granite Dam caught (Table 23). Data was unavailable for ODFW, but is likely to be small, < 0.2% of the natural-origin run at Lower Granite Dam.

This impact rate would result in a small decrease in the abundance and possibly productivity of the ESU, but recent returns of this ESU well above the MAT value of 4,200 natural-origin fall Chinook salmon indicate that this level of impact is not expected to appreciably reduce the likelihood of survival and recovery of Snake River fall Chinook salmon. Furthermore, recent data suggests that the numbers of hatchery-origin adults, may be limiting the productivity of the natural-origin component of the population (Perry et al. 2017). In addition, the recent changes in hatchery management to begin releasing fall Chinook salmon into the Salmon River Basin will increase population spatial structure and may lead to increased productivity (NMFS 2018a).

Table 21. Incidental mortality of natural-origin fall Chinook salmon in Idaho's state recreational steelhead fisheries: LGR; Lower Granite Dam.

Year	Natural-origin fall Chinook salmon over LGR	Incidental mortality (%)
2007	2,816	0.7
2008	2,995	0.4
2009	4,273	0.2
2010	7,347	0.2
2011	8,072	0.4
2012	11,306	0.2
2013	20,132	0.5
2014	11,899	0.3
2015	15,034	0.3
2016	8,762	0.2

Source: (Kozfkay 2018)

Table 22. Incidental mortality of natural-origin fall Chinook salmon in Washington's recreational steelhead and fall Chinook salmon fisheries above and below Lower Granite Dam (LGR; creel is for both fisheries and cannot be separated).

Year	Total fall Chinook salmon caught and released	Proportion natural-origin fall Chinook salmon over LGR	Number natural-origin fall Chinook salmon over LGR	Number natural-origin fall Chinook salmon caught and released[1]	Incidental mortality (%)
2010	3,000	0.18	7,347	540	0.7
2011	1,919	0.34	8,072	652	0.8
2012	2,058	0.37	11,306	761	0.7
2013	6,157	0.39	20,132	2401	1.2
2014	3,563	0.24	11,899	855	0.7
2015	5,678	0.29	15,034	1647	1.1
2016	2,281	0.27	8,762	616	0.7

Source: Jeremy Trump, WDFW, Personal Communication, August 31, 2018

[1] Estimates are a combination of Idaho creel in CRC area 650 (WA/ID Stateline to upstream to Oregon Stateline) and Washington Creel in Areas 640-648 (mouth to WA/ID State Line. Washington Estimates are expected to over-estimate the impact because it includes harvest and release of natural-origin fish downstream of Lower Granite Dam, but it uses the natural-origin adult estimates at Lower Granite Dam instead of the total within the mainstem Snake River.

Table 23. Mortality of natural-origin fall Chinook salmon in Nez Perce Tribal Treaty fisheries: LGR; Lower Granite Dam.

Season	Natural-origin fall Chinook salmon over LGR	Number natural-origin fall Chinook salmon caught	Mortality (%)
2010-2011	7,347	110	1.5
2011-2012	8,072	108	1.3
2012-2013	11,306	139	1.2
2013-2014	20,132	458	2.3
2014-2015	11,899	435	3.7
2015-2016	15,034	522	3.5
2016-2017	8,762	333	3.8

Sources: (Kozfkay 2018; Oatman 2017)

2.5.3. Snake River Spring/Summer Chinook Salmon

The fisheries in the proposed action that target hatchery-origin adult steelhead are conducted from July through March and there is a very short period of overlap with spring/summer Chinook fisheries in the month of July. The earliest spring/summer Chinook salmon first enter the lower reaches of the main-stem rivers in April and most have left the mainstem by the opening of the other fisheries in July. The time and area separation of the runs and spawning areas effectively eliminates overlap with adult spring/summer Chinook salmon. Thus, we anticipate that no more than 40 adult Chinook salmon are likely to be affected by the Proposed Action distributed across 28 extant populations in the ESU. This level of mortality is unlikely to result in any detectable changes in abundance or productivity of the populations or the ESU.

2.5.4. Sockeye Salmon

Because sockeye salmon adults typically return to the Snake River Basin from July through September, and Snake River mainstem and Salmon River Basin steelhead fisheries open August 1 and close in April and mid-May, there may be some overlap with migrating sockeye salmon. However, steelhead fisheries do not occur in the Stanley Basin when sockeye salmon return to spawn. Thus, a small number of sockeye salmon (~10) may be encountered in steelhead fisheries. An estimated 10 percent catch-and-release mortality rate, as is used for Chinook salmon since no rate is available for sockeye salmon, means that potentially one sockeye salmon is killed annually in Snake Basin steelhead fisheries. A single fish is unlikely to result in any detectable changes in sockeye population productivity.

2.5.5. Demographics

Fisheries can affect the demographics of the target fish species over time if they select for certain sizes or run times, but it is unknown how quickly the change occurs, if it is genetically based, and if the change is reversible (Hard et al. 2008). Hook-and-line fisheries are size selective by generally targeting larger fish and can be selective for time if regulations are crafted to target certain portions of the run. Gillnets are selective for body shape and migration timing, while purses seines are generally not size selective, but could select for migration timing and for certain behaviors such as schooling (Hard et al. 2008).

Fisheries that are not size selective can still affect the maturation timing of fish if fish spawn earlier to compensate for fishing pressure. Salmon and steelhead fisheries in terminal areas are less likely than non-terminal fisheries to affect maturation timing because fish in terminal areas have already made the decision to spawn. Fishing on mature individuals could affect other life history aspects such as fecundity and/or egg size (Hard et al. 2008).

Even though Hard (et al. 2008) found that direct evidence for evolutionary responses of salmon and steelhead populations due to fishing did not exist, the authors recommended ensuring some larger/older individuals escape to spawn to prevent fisheries from affecting demographics. In Oregon, Washington, and Idaho, adult steelhead are defined as those over 20 inches in length (to differentiate from rainbow trout), but there is no maximum size limit[8] in rivers. For a fishery to exert selection effects, it needs to substantially affect spawners. This is more likely to occur when harvest rates are high (Hard et al. 2008), but relatively low fishing pressure over many years can also affect population demographics. Because steelhead fisheries have been in effect for many years, there is the potential that the demographics of the DPS have been affected. However, low harvest rates also allow many fish to escape fisheries, and because the Snake River Basin steelhead fisheries occur in a terminal area where most, if not all, fish have matured, the proposed steelhead fisheries are not likely to change the maturation timing of steelhead in the Snake River DPS.

2.5.6. Illegal Harvest

Illegal harvest in recreational fisheries has not been identified as an important cause of the decline of listed species (62 FR 43937, August 18, 1997). Tribal law enforcement patrols areas of high fishing activity during the treaty fishery. State law enforcement officers patrol open fishing waters and utilize check stations and undercover patrols in areas of high activity. Although illegal harvest does occur, and incidents are cited every year (Table 24), it is difficult to quantify the number of fish illegally harvested. However, fewer than two percent of the licenses checked result in an enforcement citation. Furthermore, only a subset of those citations were for possession of fish without a healed adipose scar, suggesting fish had an intact adipose fin and may have been of natural-origin.

Table 24. Enforcement citations issued in IDFG's recreational steelhead fisheries.

Year	Number of licenses checked	Possession of fish without a healed adipose scar	Fishing during a closed season	Failure to record harvest	% of license checks resulting in a citation
2014	3009	4	0	22	0.86
2015	2835	3	4	25	1.12
2016	2790	1	14	14	1.04
2017	1817	1	0	8	0.50

[8] Idaho fishing regulations, Oregon fishing regulations, Washington fishing regulations

Sources: (IDFG 2014; IDFG 2016; IDFG 2017)

2.5.7. Interrelated and Interdependent Effects

Angler wading can harm trout eggs that are buried at shallow depths in small gravel, but is not likely to harm salmon eggs that are buried deeply in large gravel and cobble. Briggs (in Healey 1991) reports Chinook eggs buried 20 to 36 cm deep (average 28 cm), while other studies reported eggs buried 10 to 80 cm depending on substrate and intergravel flows. Bell (1990) suggests 3/4 to 4 inch gravel (18 mm to 100 mm) as preferable for most salmon spawning. Healey (1991) suggests that cleaning the gravel of finer particles and sorting the larger gravel into the egg deposition area provides larger interstices that improve intergravel water flows to irrigate the incubating eggs, and creates more stability than uniformly graded gravel. These factors should make the eggs of naturally spawning salmon less susceptible to disturbance or crushing by wading anglers than trout eggs.

Furthermore, angler access to spawning areas for listed salmon and steelhead is likely limited. Spring/summer Chinook salmon spawn in late summer and the spawning rivers are frozen during much of the incubation period. Steelhead spawn in the spring at the start of spring runoff and most of the egg incubation takes place in high flows. In addition, the most important spawning and rearing areas where natural-origin, ESA-listed salmon and steelhead spawn are outside the proposed fishery areas. Thus, it is unlikely that angler access and wading will result in any measureable adverse effects on listed salmon and steelhead.

Boat operation can cause local displacement of juvenile salmon and can cause direct mortality of eggs and alevins when power boats are operated in shallow water. Quantifying the effects of boat operation depends on motor type, traveling speed, bottom structure of the water body, and slope of the shoreline (Lewin et al. 2006), and thus is difficult to do at any scale. Eggs and developing alevins may be killed, displaced, or buried in fine sediment caused by the turbulence of passing power boats (Horton 1994). These impacts were at depths < 44 cm for propeller driven boats and < 36 cm for jet-driven boats for sockeye salmon with small substrate (1-50 mm in diameter). Impacts on egg survival decreased rapidly on either side of the center line of the boat.

The sublethal effects of boat traffic on survival, stress, habitat choice and susceptibility to predation of juvenile salmonids was studied on the Rogue and Chetco rivers in Oregon (Satterthwaite 1995). Stress indicators increased when power boats were passed through side channels, but not in the main channels where most boat traffic usually occurs. Some juvenile salmonids were displaced by boats passing directly overhead, but few fish showed behavioral response to boats passing at a lateral distance of 5m or more. The juvenile salmon were more likely to show a behavioral response to an oar powered drift boat or kayak than power boats, but the reaction responses were more pronounced among fish displaced by power boats passing directly overhead.

Although powerboat use can disturb fish or eggs in shallow water, powerboat use for fishing does not occur in shallow waters where steelhead and spring Chinook spawn. Fall Chinook spawn in areas where powerboats are used, but fall Chinook spawn in deeper water and larger substrate.

Float boat use in shallow water may displace fish, but does no lethal harm to fish and eggs. Harassment of fish and destruction of fish or eggs is prohibited by state law and regulations. Therefore, NMFS concludes that powerboat use is not likely to result in effects beyond normal fish avoidance reactions to a disturbance for listed salmon and steelhead.

2.5.8. Effects on Critical Habitat

The Proposed Action is likely to have direct effects on adult migration conditions (through interception of adult fish as they are migrating) and indirect effects on substrate (due to wading and boating), riparian vegetation, and juvenile migration conditions (due to presence of fishers on the banks and in or on the water). By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine-derived nutrients to spawning and rearing areas to a small extent. Effects on water quality will be due to garbage or hazardous materials spilled from fishing boats or left on the banks (Lewin et al. 2006). All of these effects, however, are expected to be small in magnitude and transitory in time frame, and therefore are not likely to reduce the capacity of those features to meet the conservation needs of the affected ESUs and DPSs.

2.6. Cumulative Effects

“Cumulative effects” are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). For the purpose of this analysis, the action area is that part of the Columbia River Basin described in Section 2.3. To the extent ongoing activities have occurred in the past and are currently occurring, their effects are included in the baseline (whether they are Federal, state, tribal or private). To the extent those same activities are reasonably certain to occur in the future (and are tribal, state or private), their future effects are included in the cumulative effects analysis. This is the case even if the ongoing tribal, state or private activities may become the subject of a section 10 permit or section 4(d) determination in the future until an opinion for the permit or 4(d) plan has been completed.

Future Tribal, state, and local government actions will likely be in the form of legislation, administrative rules, or policy initiatives. Government and private actions may include changes in land and water uses, including ownership and intensity, any of which could impact ESA-listed species or their habitat. Government actions are subject to political, legislative, and fiscal uncertainties. These realities, added to the geographic scope of the action area that encompasses numerous government entities exercising various authorities and the many private landholdings, make any analysis of cumulative effects difficult. This section identifies representative actions that, based on currently available information, are reasonably certain to occur. It also identifies some goals, objectives, and proposed plans by government entities. However, NMFS is unable to determine at this point in time whether any proposals will in fact result in specific actions.

Habitat

In the Snake Basin, each state administers the allocation of water resources within its borders, and each tribe administers allocation of tribal water rights within their reservations. Most streams in the basin are over appropriated, except in the Salmon and Clearwater Subbasins, even though water resource development has slowed in recent years. The state and tribal governments are cooperating with each other and other governments to increase environmental protections, including better habitat restoration. NMFS cooperates with the state and tribal water resource management agencies in assessing water resource needs in the Snake River Basin, and in developing flow requirements that will benefit ESA-listed fish.

In NMFS' 2014 opinion (NMFS 2014g) on the FCRPS, we described information provided by the states of Idaho, Oregon, and Washington for ongoing, future, or expected projects that were reasonably certain to occur and that were expected to benefit recovery efforts in the Interior Columbia Basin. Here we briefly update that in the relevant sections below.

State of Idaho – ESA Section 6 Cooperative Agreement

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

State of Oregon – Oregon Plan for Salmon and Watersheds

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

State of Washington – Governor's Salmon Recovery Office

The Governor's Salmon Recovery Office arose from Washington's Salmon Recovery Act, and it includes the Salmon Recovery Funding Board (SRFB). SRFB has helped finance more than 900 salmon recovery projects focused on habitat protection and restoration. SRFB administers two grant programs (general salmon recovery grants and Puget Sound Acquisition and Restoration grants). Municipalities, tribal governments, state agency non-profit organizations, regional fisheries enhancement groups, and private landowners may apply for these grants. Lower Columbia Conservation and Sustainable Fisheries Plan (CSF Plan) (WDFW and LCFRB 2015) provides the framework for implementing recovery plan hatchery and harvest actions in the LCR. The goal of the CSF Plan is to: 1) support efforts to recover salmon and steelhead populations to healthy, harvestable levels; and, 2) sustain important fisheries. The CSF Plan encompasses the tenets of the recovery plan, and acknowledges that an "all H" (Habitat, Hatcheries, Harvest, Hydro) approach to recovery is necessary.

Non-Federal habitat and hydropower actions are supported by state, and local agencies; tribes; environmental organizations; and private communities. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives. These projects address the protection of adequately functioning habitat, and the restoration of degraded fish habitat, including improvements to instream flows, water quality, fish passage and access, pollution reduction, and watershed or floodplain conditions that affect downstream habitat. These projects also support probable hydropower improvement efforts that are likely to continue to improve fish survival through hydropower systems.

Significant actions and programs contributing to these benefits include growth management programs (planning and regulation); a variety of stream and riparian habitat projects; watershed planning and implementation; acquisition of water rights for instream purposes and sensitive areas; instream flow rules; storm water and discharge regulation; TMDL implementation to achieve water quality standards; hydraulic project permitting; and increased spill and bypass operations at hydropower facilities. NMFS determined that many of these actions would have positive effects on the viability (abundance, productivity, spatial structure, and/or diversity) of listed salmon and steelhead populations and the functioning of PCEs in designated critical habitat. These activities are likely to have beneficial cumulative effects that will significantly improve conditions for the salmon and steelhead, though at this time NMFS is not attributing specific benefits to those actions.

NMFS also noted that some types of human activities, such as development, contribute to cumulative effects and are generally expected to have adverse effects on populations and PBFs. Many of these effects are activities that occurred in the recent past and were included in the environmental baseline. Some of these activities are considered reasonably certain to occur in the future because they occurred frequently in the recent past (especially if authorizations or permits have not yet expired), and are addressed as cumulative effects. Within the action area non-Federal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. All of these activities can contaminate local or larger areas with hydrocarbon-based materials.

Tribal governments will continue to participate in cooperative efforts involving watershed and basin planning designed to improve fish habitat. The results from changes in tribal forest and agriculture practices, in water resource allocations, and in changes to land uses are difficult to assess for the same reasons discussed under state and local actions. The earlier discussions related to growth impacts apply also to tribal government actions. Tribal governments will need to apply comprehensive and beneficial natural resource programs to areas under their jurisdiction to produce measurable positive effects for ESA-listed species and their habitat.

The effects of private actions are the most uncertain. Private landowners may convert current use of their lands, or they may intensify or diminish current uses. Individual landowners may voluntarily initiate actions to improve environmental conditions, or they may abandon or resist any improvement efforts. Their actions may be compelled by new laws, or may result from growth and economic pressures. Changes in ownership patterns will have unknown impacts. Whether any of these private actions will occur and their resulting effects is highly unpredictable.

Hatcheries

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

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

Harvest

The proposed fishery activities in the Snake River Basin are designed with a mandate for sustainable resource use under both Federal and State law and policy. Because the allowable impacts on listed species follow a maximum allowable incidental impact rate, if other conservation measures are unsuccessful in returning fish to the area, fishery impacts would be constrained. The Snake River Basin is a terminal harvest area, but harvest on the DPSs and ESUs considered here does occur in other fisheries outside of the Snake Basin, in the mainstem Columbia River (NMFS 2018b). Although fish from the Snake River are not specifically targeted because of the mixed-stock nature of mainstem fisheries, they are impacted. However, these mainstem Columbia River fisheries have been ongoing for decades and their effects have already been realized before the remainder of each ESU and DPS passes dams in the Snake River, and are accounted for in the status of each species and before harvest in the Snake River Basin occurs.

Within the action area, there are expected to be beneficial effects on the biological and human environments associated with fishery management (e.g., reduction is naturally-spawning hatchery fish and local economies). Conservative management of recreational and tribal treaty fishing is only one element of a large suite of regulations and environmental factors that may influence the overall status of listed salmon populations and their habitat. The recreational fishing program is coordinated with monitoring and adaptive management measures so that fishery managers can respond to changes in the status of affected listed salmon and ensure that the affected ESUs are adequately protected.

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

Climate Change

The cumulative effect of climate change on ESA-listed salmon and steelhead are difficult to predict, but are assumed in the status of the ESA-listed species affected by the Proposed Action. The Proposed Action addresses climate change effects by aligning harvest operations with recovery, primarily by ensuring that natural populations are capable of improving in productivity, abundance, and diversity, which will allow them to adapt to changing environments. Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life history types that will be successful in the future are neither static nor predictable; therefore, maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations.

Summary

Overall, we anticipate that projects to restore and protect habitat, restore access and recolonize the former range of salmon and steelhead, and improve fish survival through hydropower sites will result in a beneficial effect on salmon and steelhead compared to the current conditions. We also expect that future harvest and development activities will continue to have adverse effects on listed species in the action area; however, while we cannot attribute specific benefits at this time, we anticipate these activities will be mindful of ESA-listed species and will perhaps be less harmful than would have otherwise occurred in the absence of the current body of scientific work that has been established for anadromous fish. In general, we think the level of adverse effects will be lower than those in the recent past, and much lower than those in the more distant past. NMFS anticipates that available scientific information will continue to grow and tribal, public, and private support for salmon recovery will remain high. This will continue to fuel state and local habitat restoration and protection actions as well as hatchery, harvest, and other reforms that are likely to result in improvements in fish survival.

2.7. Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the Proposed Action. In this section, NMFS adds the effects of the Proposed Action (Section 1.3) to the environmental baseline (Section 2.4) and to cumulative effects (Section 2.6) to formulate the agency's opinion as to whether the Proposed Action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat for the conservation of the species.

In assessing the overall risk of the Proposed Action on each species, NMFS considers the risks of each factor discussed in Section 2.5.1 above, in combination, considering their potential additive effects with each other and with other actions in the area (environmental baseline and cumulative effects). This combination serves to translate the positive and negative effects posed by the Proposed Action into a determination as to whether the Proposed Action as a whole would appreciable reduce the likelihood of survival and recovery of the listed species and how their designated critical habitat would be affected.

Our environmental baseline analysis considers the effects of hydropower, changes in habitat (both beneficial and adverse), fisheries, and hatcheries on this ESU. Although all may have contributed to the listing of the ESU, all factors have also seen improvements in the way they are managed/operated. In addition, the management of these factors may be further adjusted in the future and alleviate some of the potentially adverse effects of climate change (e.g., hatcheries serving a genetic reserve for natural populations).

2.7.1. Snake River Fall Chinook Salmon

Best available information indicates that the Snake River Fall Chinook Salmon ESU is at moderate risk and remains threatened (NWFSC 2015). The steelhead fisheries proposed in the Snake River Basin are not anticipated to result in more than ~6% mortality of the Snake River Fall Chinook Salmon ESU as measured at Lower Granite Dam. This would result in a small decrease in the abundance and possibly productivity of the ESU, but recent returns of this ESU well above MAT indicate that this level of impact is not expected to appreciably reduce the likelihood of survival and recovery of Snake River fall Chinook salmon. The Proposed Action is unlikely to have a measureable effect on spatial structure and diversity because over 90% percent of the ESU spawners will escape to spawn and fisheries are in place throughout all major spawning aggregates of the ESU. In addition, the recent changes in hatchery management to begin releasing fall Chinook salmon into the Salmon River Basin will increase population spatial structure and may lead to increased productivity.

Added to the Species' Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the

Action Area. The recovery plans for each ESU describe the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed salmon. Such actions are improving habitat conditions, and hatchery and harvest practices to protect listed salmon ESUs. For the Snake River Fall Chinook Salmon ESU, NMFS expects this trend to continue and could lead to increases in abundance, productivity, spatial structure and diversity. However, the degree of improvement is likely to be limited to some degree by climate change and development necessary to cope with human population growth.

After considering the current viability status of these species, the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the small effects of the Proposed Action on abundance, productivity, spatial structure, and diversity, added to other ongoing and anticipated actions, will not appreciably reduce the likelihood of survival and recovery of this ESA-listed ESU.

2.7.2. Snake River Spring/Summer Chinook Salmon

Best available information indicates that the Snake River Spring/Summer Chinook Salmon ESU is at high risk and remains threatened. Our environmental baseline analysis considers the effects of hydropower, changes in habitat (both beneficial and adverse), fisheries, and hatcheries on this ESU. Although all may have contributed to the listing of this ESU, all factors have also seen improvements in the way they are managed/operated. In addition, the management of these factors may be further adjusted in the future and alleviate some of the potentially adverse effects of climate change (e.g., hatcheries serving as a genetic reserve for natural populations).

The steelhead fisheries proposed to be implemented in the Snake River Basin are not expected to appreciably reduce the likelihood of survival and recovery of Snake River spring/summer Chinook salmon. The time and area separation of the two fisheries nearly eliminates impacts on spring/summer Chinook salmon, although we cannot rule out slight decreases in adult abundance and potentially productivity. As stated earlier, we anticipate that 40 adults could be impacted in the steelhead fishery. However, this number of fish distributed across the 28 extant populations in the ESU is unlikely to have any measureable effect on the abundance or productivity of the ESU.

Added to the Species' Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area. The recovery plans for the ESU describe the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed salmon. Such actions are improving habitat conditions, and hatchery and harvest practices to protect listed salmon ESUs. NMFS expects this trend to continue and could lead to increases in abundance, productivity, spatial structure and diversity. However, the degree of improvement is likely to be limited to some degree by climate change and development necessary to cope with human population growth.

After considering the current viability status of these species, the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the small effects of the Proposed Action on abundance, productivity, spatial structure, and diversity, added to other ongoing and anticipated actions, will not appreciably reduce the likelihood of survival and recovery of this ESA-listed ESU.

2.7.3. Snake River Steelhead

Best available information indicates that the Snake River Steelhead DPS is at high risk and remains at threatened status (NWFSC 2015). However, in NMFS' most recent status review (NWFSC 2015)for populations where estimates of the status of abundance, productivity, spatial structure and diversity exist, abundances are close to or exceed MAT, and productivity is well over replacement (i.e., at least 1 progeny is produced on average for each parent). Although, the last few years of steelhead abundance have been low, this may be because of a warm-water "blob" that formed in the Pacific Ocean off the coast of the Pacific Northwest in 2014. As a result of the blob, there has been poor survival of young salmon and steelhead while in the ocean over the last several years, which has impacted the number of adults returning to spawn. However, recent data from scientists at NMFS' Northwest Fisheries Science Center have indicated that marine conditions are improving, and the intrinsic productivity of Snake River steelhead is expected to provide resilience to the effects of short-term perturbations in marine survival.

Snake River steelhead listed under the ESA may be affected by the proposed fisheries in several ways and at several different life stages. The primary impact is mortality of listed, adult, natural-origin steelhead incidental to fisheries targeting hatchery-origin steelhead. But, catch-and-release fishing, combined with fishing gear restrictions, sanctuary areas, and time and area closures, allows harvest of hatchery-origin steelhead in recreational fisheries while reducing the impact on natural-origin fish. The proposed fisheries are expected to kill no more than 10 percent of the portion of the Snake River steelhead DPS that escape to the Snake River Basin, and a much lower percentage if calculated based on the number of Snake River steelhead that return to the mouth of the Columbia River. This is the amount by which abundance would be reduced; this could also reduce productivity of the DPS, but not to levels that NMFS believes pose a threat to DPS survival or recovery because each MPG is still predicted to be above or close to aggregated CAT values with this level of impact (Figure 12). The most recent average ten years of steelhead abundance are also well above CAT for all MPGs. Thus, although abundances may be low in a few recent years, considering a longer time frame is important for evaluating affects to the species. Furthermore, if abundances fall below the critical abundance threshold, fishery managers, along with NMFS, will determine what fishery modifications will be implemented to reduce impacts on natural-origin steelhead. The Proposed Action is unlikely to have a measureable effect on spatial structure and diversity because MATs considered spatial structure and diversity when they were established and fisheries are dispersed throughout all extant MPGs of the DPS.

Added to the Species' Status, Environmental Baseline, and effects of the Proposed Action are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area. The recovery plan for this DPS describes the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed steelhead. Such actions include improving habitat conditions, and hatchery and harvest practices to protect listed steelhead DPSs, and NMFS expects this trend to continue, and could lead to increases in abundance, productivity, spatial structure, and diversity. However, the degree of improvement is likely to be limited to some degree by climate change and development necessary to cope with human population growth.

After considering the current viability status of these species, the environmental baseline, and other pertinent cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the effects of the Proposed Action, added to other ongoing and anticipated actions, will not appreciably reduce the likelihood of survival and recovery of this ESA-listed DPS in the wild.

2.7.4. Snake River Sockeye Salmon

Best available information indicates that the Snake River Sockeye Salmon ESU is at high risk and remains endangered (NWFSC 2015). The steelhead fisheries proposed in the Snake River Basin are not anticipated to result in more than 10 encounters and 1 mortality of sockeye salmon adults. This would result in a small decrease in the abundance and possibly productivity of the ESU, but this level of impact is not expected to appreciably reduce the likelihood of survival and recovery of Snake River sockeye salmon.

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

After considering the current viability status of these species, the Environmental Baseline, and other pertinent cumulative effects, including any anticipated Federal, state, or private projects, NMFS concludes that the small effects of the Proposed Action on abundance, productivity, spatial structure, and diversity, added to other ongoing and anticipated actions, will not appreciably reduce the likelihood of survival and recovery of this ESA-listed ESU.

2.7.5. Middle Columbia Steelhead

Best available information indicates that the MCR Steelhead DPS is at high risk and remains at threatened status (NWFSC 2015). The Proposed Action is not expected to have any effects on the abundance and productivity of natural-origin steelhead. However, hatchery-origin steelhead may be intercepted in the fishery, but they are not essential to DPS recovery, and thus the effect of the Proposed Action will not reduce the likelihood of survival and recovery of the DPS.

2.7.6. Critical Habitat

The direct effects through interception of adult fish as they are migrating and indirect effects on substrate, riparian vegetation, and juvenile migration are expected to be small in magnitude and transitory in time frame. By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas. Effects on water quality are likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks.

Added to the effects of the Proposed Action, are the effects of future state, private, or tribal activities, not involving Federal activities, within the Action Area. The recovery plans for the ESUs and DPSs describes the on-going and proposed state, tribal, and local government actions that are targeted to reduce known threats to ESA-listed steelhead. Such actions include improving habitat conditions, and hatchery and harvest practices to protect listed steelhead DPSs, and NMFS expects this trend to continue. Therefore, these effects are not likely to reduce the capacity of those features to meet the conservation needs of the affected ESUs and DPSs.

2.8. Conclusion

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

2.9. Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibits the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns, including breeding, feeding, or sheltering. Harass is defined as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns that include, but are not limited to, breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

2.9.1. Amount or Extent of Take Anticipated

The proposed 4(d) authorization is for activities to be conducted indefinitely. Harvest of clipped hatchery-origin fish is considered direct take and is not listed in this ITS. NMFS determined that incidental take is reasonably certain to occur as follows:

2.9.1.1. Steelhead

The rates of lethal take by incidental capture and release detailed in Table 2 are the maximum authorized annually for all fishery managers, and for all fisheries in the Snake River Basin that may take natural-origin adult Snake River steelhead. As discussed earlier in this Opinion, NMFS cannot reliably attribute certain proportions of the incidental mortality from capture, handling and release to various fisheries by target species. Take of steelhead may be attributable to anglers solely targeting steelhead, Chinook or other species, or anglers targeting multiple species at once. Thus, while NMFS cannot reliably estimate the amount of incidental take attributable specifically to this proposed action, we may regard and rely on the incidental capture and release limits for all fisheries in Table 2 as a surrogate measure of the lethal incidental take of Snake River steelhead resulting from the proposed action. This is a reasonable surrogate because it is rationally connected to the amount of take attributable to the proposed action, which is a subset of the total amount from all fisheries. Moreover, it can be reliably monitored by in-season, and post-season assessments of PIT tag conversion data, GSI data dam counts, and angler surveys.

Take also occurs in the form of non-lethal capture, handling and release of natural-origin steelhead. This form of take cannot be reliably quantified. Therefore, NMFS will rely on a surrogate measure of this incidental take, in the form of lethal take by incidental capture and release, detailed in Table 2.

The amount of lethal take incidental mortality is a separate provision of this Statement. However, its use as a surrogate for non-lethal take is appropriate because the amount of lethal take by the same actions (incidental capture, handling and release) bears a rational connection to the non-lethal take that occurs as a result of the proposed action. A rise in incidental mortality indicates a potential increase in capture, handling and release with both lethal and non-lethal outcomes. The lethal form of incidental capture, handling and release can be reasonably monitored by in-season, and post-season assessments of PIT tag conversion data, GSI data dam counts, and angler surveys.

Unclipped hatchery-origin steelhead from the Snake River steelhead DPS are also likely to be taken lethally by incidental capture and release by the proposed fisheries at up to the following rates:

- Lower Snake MPG: 6.4%
- Clearwater MPG: 34.4%
- Salmon MPG: 23.2%

Because some unclipped hatchery-origin steelhead from the mid-Columbia River Steelhead DPS can be detected above ICH, up to 20 steelhead from this DPS may also be taken lethally by incidental capture and release annually in Snake River steelhead fisheries.

2.9.1.2. Fall Chinook Salmon

Up to 6% of the adult natural-origin fall Chinook salmon estimated to return to Lower Granite Dam may be taken lethally through incidental capture and release in recreational and tribal treaty steelhead fisheries. As with the take of steelhead, NMFS cannot reliably attribute certain proportions of the incidental mortality from capture, handling and release to various fisheries by target species. Take of steelhead may be attributable to anglers solely targeting steelhead, Chinook or other species, or anglers targeting multiple species at once. Thus, while NMFS cannot reliably estimate the amount of incidental take attributable specifically to this proposed action, we may regard and rely on the incidental capture and release limits of 6% of natural-origin fall Chinook attributable to all fisheries as the surrogate measure of the lethal incidental take resulting from the proposed action. This is a reasonable surrogate because it is rationally connected to the amount of take attributable to the proposed action, which is a subset of the total amount of take from all fisheries. Moreover, it can be reliably monitored by in-season, and post-season assessments of PIT tag conversion data, GSI data dam counts, and angler surveys.

Take also occurs in the form of non-lethal capture, handling and release of natural-origin fall Chinook salmon. This form of take cannot be reliably quantified. Therefore, NMFS will rely on a surrogate measure of this incidental take, in the form of a 6% lethal take by incidental capture and release.

The amount of lethal take Incidental mortality is a separate provision of this Statement. However, its use as a surrogate for non-lethal take is appropriate because the amount of lethal take by the same actions (incidental capture, handling and release) bears a rational connection to the non-lethal take that occurs as a result of the proposed action. A rise in incidental mortality indicates a potential increase in capture, handling and release with both lethal and non-lethal outcomes. The lethal form of incidental capture, handling and release can be reasonably monitored by in-season, and post-season assessments of PIT tag conversion data, GSI data dam counts, and angler surveys.

2.9.1.3. Spring/Summer Chinook Salmon

Take in the form of non-lethal encounters (e.g. capture and handling) are expected to be no more than 40 adults, with 4 mortalities, annually, for recreational and tribal treaty steelhead fisheries.

2.9.1.4. Sockeye Salmon

Take in the form of non-lethal encounters (capture, handling) are expected to be no more than 10 adults, with 1 mortality, annually, for recreational and tribal treaty steelhead fisheries.

2.9.2. Effect of the Take

In the biological opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the Proposed Action, is not likely to jeopardize the continued existence of the Snake River Spring/Summer Chinook Salmon ESU, Snake River Fall Chinook

Salmon ESU, Snake River Steelhead DPS, or Mid-Columbia River Steelhead DPS, or result in the destruction or adverse modification of their designated critical habitat.

2.9.3. Reasonable and Prudent Measures

"Reasonable and prudent measures" are nondiscretionary measures to minimize the amount or extent of incidental take (50 CFR 402.02). NMFS concludes that the following reasonable and prudent measures are necessary and appropriate to minimize incidental take. NMFS shall:

1. Ensure that state applicants minimize adverse effects on ESA-listed salmon and steelhead in state-managed steelhead fisheries by requiring live release of all non-target fish and application of the FMEPs as described.
2. Ensure all fishery managers to coordinate annually on allocation and harvest impacts on Snake River steelhead and to ensure total allowable take is not exceeded.
3. Ensure an annual post-season fishery report be submitted to NMFS.
4. Ensure a review of the Proposed Action every five years to verify validity of assumptions, identify new information gaps, discuss any changes to the harvest regime, and review requested information.

2.9.4. Terms and Conditions

The terms and conditions described below are non-discretionary, and NMFS or any applicant must comply with them in order to implement the RPMs (50 CFR 402.14). NMFS or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this ITS (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse.

1. NMFS shall ensure that state applicants minimize adverse effects on ESA-listed salmon and steelhead in state-managed steelhead fisheries by requiring live release of all non-target fish and implementation of the FMEPs as described.
2. NMFS shall ensure all fishery managers to coordinate annually on allocation and harvest impacts on Snake River steelhead to ensure take is not exceeded. The fishery managers shall be required to:
    a. Submit a pre-season steelhead fishery plan that includes the projected natural-origin run size and impact rate, and fishery season structure (e.g., open areas, bag limits).
    b. Notify NMFS of steelhead impacts that exceed those in the ITS in-season and post-season as soon as possible.
3. NMFS shall ensure all fishery managers share data for the annual post-season fishery report (i.e., Steelhead Run Reconstruction), and ensure the report is submitted to NMFS.
    a. The report shall include encounter and mortality of ESA-listed natural-origin steelhead by MPG, and any fishery season structure changes due to Snake River steelhead abundances that are below the critical abundance thresholds in Table 3.

   b. This can be tables embedded within the Steelhead Run Reconstruction Report assembled by the fishery managers, similar to Table 17 and Table 19.

   c. Fishery managers shall submit data by January 31 following the year the fishery ends to allow for modeling of total impact rates for natural-origin steelhead.

   d. Fishery managers shall submit the preliminary report to NMFS by March 15 following the year after the fishery ends, and the final report by December 31 following the year after the fishery ends.

4. NMFS shall conduct a review of the Proposed Action every five years to verify validity of assumptions, identify new information gaps, discuss any changes to the harvest regime, and review requested information. However, because the fishery managers are managing under a new framework, the initial review will take place three years after opinion signature.
   a. IDFG shall share data on their steelhead catch-and-release mortality study as soon as it is available, and at least within three years of opinion signature

2.9.5. Conservation Recommendations

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

NMFS has identified four conservation recommendations appropriate to the Proposed Action:

1. Evaluate the concept of self-regulation of fisheries, where angler effort is correlated with fish abundance; if abundance is low, will angler effort decrease compared to a year of higher fish abundance and will this result in lower impact rates to natural-origin adults? Estimates of natural encounter rates may be needed for this analysis.

2. Continue to collect and analyze data that will better inform and allow development of stock-recruit models for individual steelhead populations, which typically require at least 10-20 years of data. Investigate improvements to GSI to improve resolution among reporting groups. Once these methods are developed, the fishery managers may be able to begin managing fishery impacts at the population scale.

3. As tribes potentially expand their fisheries across their Usual and Accustomed (U&A) areas, NMFS recommends monitoring (e.g., expanded creel or other appropriate survey methods) of natural-origin impacts to more accurately assess combined impacts at the MPG and DPS levels from all fishery managers.

4. Evaluate whether catch and release mortality rate calculation should vary over the timeframe of the fishery to account for changes in river temperature. Evidence suggests that warmer temperatures could lead to higher levels of catch and release mortality.

2.10. Reinitiation of Consultation

This concludes formal consultation on the approval and implementation of steelhead fisheries in the Snake Basin. As 50 CFR 402.16 states, re-initiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and if: (1) The amount or extent of incidental take specified in the ITS is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

3. MAGNUSON-STEVENS ACT ESSENTIAL FISH HABITAT CONSULTATION

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

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

3.1. Essential Fish Habitat Affected By The Project

The Proposed Action is the implementation of Snake River steelhead fisheries, as described in Section 1.3. The action area (Section 2.3) of the Proposed Action includes habitat described as EFH for Chinook and coho salmon (PFMC 2003) within the Snake River Basin. Because the PFMC does not have fishery management plans for steelhead or sockeye salmon, EFH has not been described for these species. Therefore, the analysis is restricted to the effects of the Proposed Action on EFH for Chinook and coho salmon. For Chinook salmon, EFH encompasses all available watersheds within the Snake River Basin. For coho salmon, EFH in Idaho occurs in the Lower Salmon River, and throughout the Clearwater Subbasin with the exception of the Lochsa and Lower North Fork Clearwater Rivers (PFMC 2014).

As described by PFMC (2003), the freshwater EFH for Chinook and coho salmon has five habitat areas of particular concern (HAPCs): (1) complex channels and floodplain habitat; (2) thermal refugia; (3) spawning habitat; (4) estuaries; and (5) marine and estuarine submerged aquatic vegetation. The aspects of EFH that might be affected by the Proposed Action include effects on natural-origin Chinook and coho salmon in spawning and rearing areas (primarily addressing HAPC 3).

3.2. Effects of the Proposed Action

EFH may be affected by fisheries through interception of adult fish as they are migrating and indirect effects on substrate, riparian vegetation, and juvenile migration. However, these effects are expected to be small in magnitude and transitory in time frame. For example, it is anticipated that less than 10 and 6 percent of listed natural-origin steelhead and fall Chinook salmon that escape to Ice Harbor Dam, respectively, will be incidentally killed in recreational fisheries targeting hatchery fish. By removing adults that would otherwise return to spawning areas, harvest could also affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, but only to a small extent, based on the relatively small proportion of natural fish expected to be killed in the fisheries. Effects on water quality as a result of the presence of the fisheries themselves are also likely to be minor; these will be due to garbage or hazardous materials spilled from fishing boats or left on the banks in small discrete areas and water flow would quickly dissipate these materials.

NMFS concludes that the Proposed Action would not adversely affect designated EFH for Chinook or coho salmon.

3.3. EFH Conservation Recommendation

Because NMFS did not identify any potential adverse effects by the Proposed Action on EFH for Chinook and coho salmon, NMFS has no conservation recommendations specifically for Chinook and coho salmon EFH.

3.4. Statutory Response Requirement

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

Because NMFS has determined that the proposed action is not likely to adversely affect EFH for Pacific salmon, no statutory response is required at this time.

3.5. Supplemental Consultation

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

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

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

4.1. Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion are the IDFG, ODFW, WDFW, NPT, CTUIR, and SBT. These ESA section 7 on the proposed action determined that the proposed action will not jeopardize the affected ESUs/DPSs or destroy or adversely modify their critical habitat; the MSA consultation determined that the proposed action would not adversely affect designated EFH for Pacific salmon. Therefore, NMFS can issue an incidental take permit. The scientific community, resource managers, and the stakeholders benefit from the consultation. Individual copies of this opinion were provided to the IDFG, ODFW, WDFW, NPT, CTUIR, and SBT. This opinion will be posted on the Public Consultation Tracking System website. The format and naming adheres to conventional standards for style.

4.2. Integrity

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

4.3. Objectivity

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

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

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

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

5. APPENDIX A: FACTORS CONSIDERED WHEN ANALYZING HATCHERY EFFECTS

NMFS' analysis of the Proposed Action is in terms of effects the Proposed Action would be expected to have on ESA-listed species and on designated critical habitat, based on the best scientific information available. The effects, positive and negative, for the two categories of hatchery programs are summarized in Table 25. Generally speaking, effects range from beneficial to negative when programs use local fish[9] for hatchery broodstock, and from negligible to negative when programs do not use local fish for broodstock[10]. Hatchery programs can benefit population viability, but only if they use genetic resources that represent the ecological and genetic diversity of the target or affected natural population(s). When hatchery programs use genetic resources that do not represent the ecological and genetic diversity of the target or affected natural population(s), NMFS is particularly interested in how effective the program will be at isolating hatchery fish and at avoiding co-occurrence and effects that potentially disadvantage fish from natural populations. NMFS applies available scientific information, identifies the types of circumstances and conditions that are unique to individual hatchery programs, then refines the range in effects for a specific hatchery program. Analysis of a Proposed Action for its effects on ESA-listed species and on designated critical habitat depends on six factors. These factors are:

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

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

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

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

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

Table 25. An overview of the range of effects on natural population viability parameters from the two categories of hatchery programs.

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

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

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

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

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

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

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

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

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

5.2.1. Genetic effects

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

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

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

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

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

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

The proportion of hatchery fish (pHOS)[11] among natural spawners is often used as a surrogate measure of gene flow. Appropriate cautions and qualifications should be considered when using this proportion to analyze outbreeding effects. Adult salmon may wander on their return migration, entering and then leaving tributary streams before spawning (Pastor 2004). These “dip-in” fish may be detected and counted as strays, but may eventually spawn in other areas, resulting in an overestimate of the number of strays that potentially interbreed with the natural population (Keefer et al. 2008). Caution must also be taken in assuming that strays contribute genetically in proportion to their abundance. Several studies demonstrate little genetic impact from straying despite a considerable presence of strays in the spawning population (Blankenship et al. 2007; Saisa et al. 2003). The causative factors for poorer breeding success of strays are likely similar to

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

those identified as responsible for reduced productivity of hatchery-origin fish in general, e.g., differences in run and spawn timing, spawning in less productive habitats, and reduced survival of their progeny (Leider et al. 1990; Reisenbichler and McIntyre 1977; Williamson et al. 2010).

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

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

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

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

Critical information for analysis of hatchery-induced selection includes the number, location, and timing of naturally spawning hatchery fish, the estimated level of gene flow between hatchery-origin and natural-origin fish, the origin of the hatchery stock (the more distant the origin compared to the affected natural population, the greater the threat), the level and intensity of hatchery selection and the number of years the operation has been run in this way. Efforts to control and evaluate the risk of hatchery-influenced selection are currently largely focused on gene flow between natural-origin and hatchery-origin fish[12]. The Interior Columbia Technical Recovery Team (ICTRT) developed guidelines based on the proportion of spawners in the wild consisting of hatchery-origin fish (pHOS) (Figure 13).

More recently, the Hatchery Scientific Review Group (HSRG) developed gene-flow guidelines based on mathematical models developed by (Ford 2002) and by(Lynch and O'Hely 2001). Guidelines for isolated programs are based on pHOS, but guidelines for integrated programs are based also on a metric called proportionate natural influence (PNI), which is a function of pHOS and the proportion of natural-origin fish in the broodstock (pNOB)[13]. PNI is, in theory, a reflection of the relative strength of selection in the hatchery and natural environments; a PNI value greater than 0.5 indicates dominance of natural selective forces. The HSRG guidelines vary according to type of program and conservation importance of the population. When the underlying natural population is of high conservation importance, the guidelines are a pHOS of no greater than 5 percent for isolated programs. For integrated programs, the guidelines are a pHOS no greater than 30 percent and PNI of at least 67 percent for integrated programs (HSRG 2009). Higher levels of hatchery influence are acceptable, however, when a population is at high risk or very high risk of extinction due to low abundance and the hatchery program is being used to conserve the population and reduce extinction risk in the short-term. (HSRG 2004)offered additional guidance regarding isolated programs, stating that risk increases dramatically as the level of divergence increases, especially if the hatchery stock has been selected directly or indirectly for characteristics that differ from the natural population. The HSRG recently produced an update report (HSRG 2014) that stated that the guidelines for isolated programs may not provide as much protection from fitness loss as the corresponding guidelines for integrated programs.

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

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

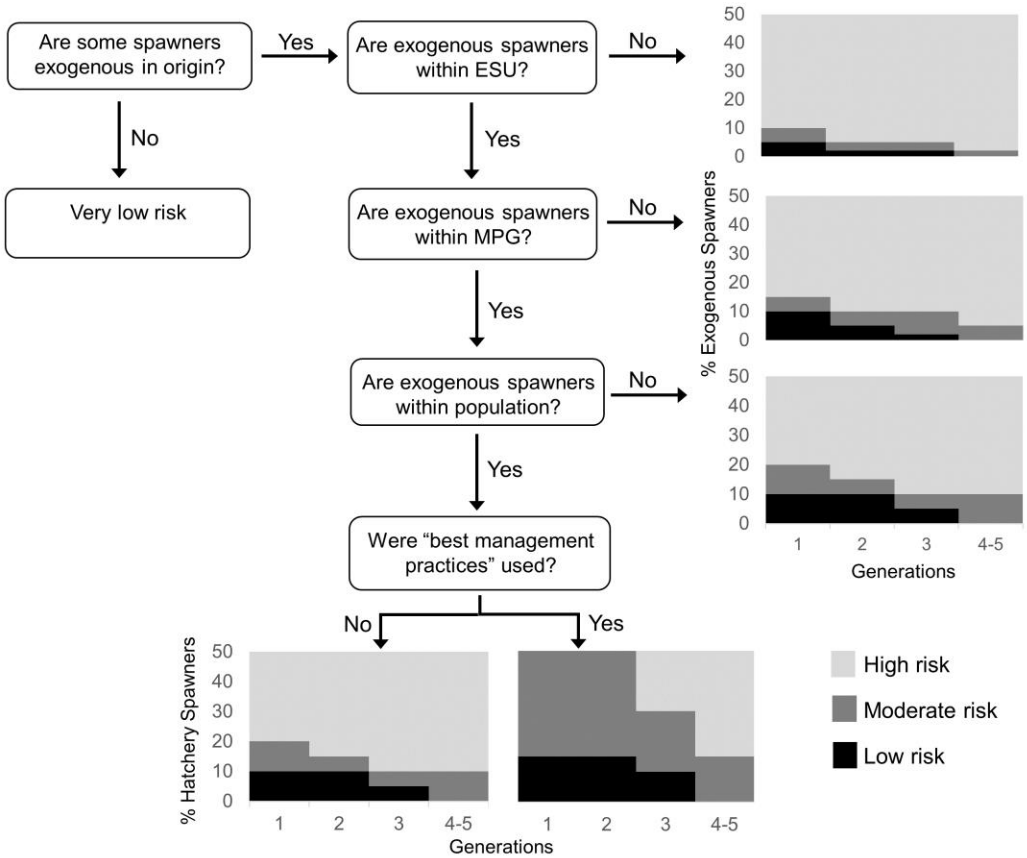

Figure 13. ICTRT (2007b) risk criteria associated with spawner composition for viability assessment of exogenous spawners on maintaining natural patterns of gene flow. Exogenous fish are considered to be all fish hatchery origin, and non-normative strays of natural origin.

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

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

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

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

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

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

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

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

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

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

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

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

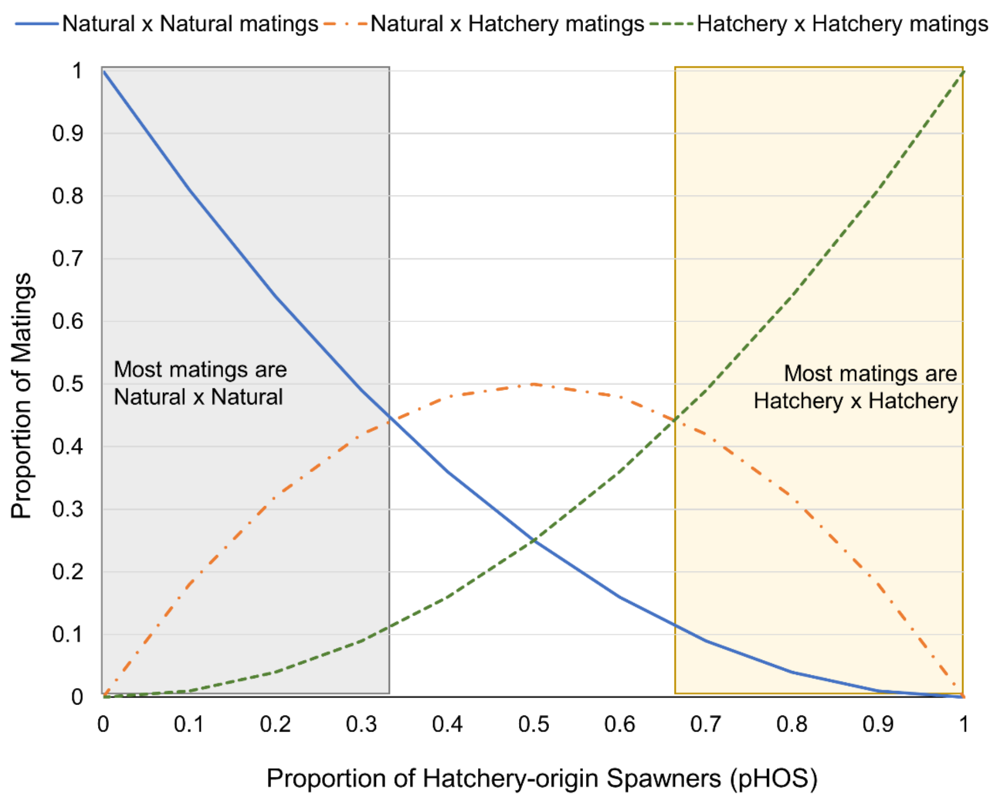

Figure 14. Relative proportions of types of matings as a function of proportion of hatchery-origin fish on the spawning grounds (pHOS).

5.2.2. Ecological effects

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

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

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

5.2.3. Adult Collection Facilities

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

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

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

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

5.3.1. Competition

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

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

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

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

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

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

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

Critical to analyzing competition risk is information on the quality and quantity of spawning and rearing habitat in the action area,[15] including the distribution of spawning and rearing habitat by quality and best estimates for spawning and rearing habitat capacity. Additional important information includes the abundance, distribution, and timing for naturally spawning hatchery fish and natural-origin fish; the timing of emergence; the distribution and estimated abundance for progeny from both hatchery and natural-origin natural spawners; the abundance, size, distribution, and timing for juvenile hatchery fish in the action area; and the size of hatchery fish relative to co-occurring natural-origin fish.

5.3.2. Predation

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

15 “Action area” means all areas to be affected directly or indirectly by the action in which the effects of the action can be meaningfully detected and evaluated.

more prolonged period, as discussed above. The progeny of naturally spawning hatchery fish also can prey on fish from a natural population and pose a threat. In general, the threat from predation is greatest when natural populations of salmon and steelhead are at low abundance, when spatial structure is already reduced, when habitat, particularly refuge habitat, is limited, and when environmental conditions favor high visibility.

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

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

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

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

- Releasing all hatchery fish as actively migrating smolts through volitional release practices so that the fish migrate quickly seaward, limiting the duration of interaction with any co-occurring natural-origin fish downstream of the release site.
- Ensuring that a high proportion of the population have physiologically achieved full smolt status. Juvenile salmon tend to migrate seaward rapidly when fully smolted, limiting the duration of interaction between hatchery fish and naturally produced fish present within, and downstream of, release areas.
- Releasing hatchery smolts in lower river areas near river mouths and below upstream areas used for stream-rearing young-of-the-year naturally produced salmon fry, thereby reducing the likelihood for interaction between the hatchery and naturally produced fish.
- Operating hatchery programs and releases to minimize the potential for residualism.

5.3.3. Disease

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

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

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

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

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

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

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

5.3.4. Acclimation

One factor the can affect hatchery fish distribution and the potential to spatially overlap with natural-origin spawners, and thus the potential for genetic and ecological impacts, is the acclimation (the process of allowing fish to adjust to the environment in which they will be released) of hatchery juveniles before release. Acclimation of hatchery juvenile before release increases the probability that hatchery adults will home back to the release location, reducing their potential to stray into natural spawning areas. Acclimating fish for a period of time also allows them to recover from the stress caused by the transportation of the fish to the release location and by handling. (Dittman and Quinn 2008) provide an extensive literature review and introduction to homing of Pacific salmon. They note that, as early as the 19th century, marking studies had shown that salmonids would home to the stream, or even the specific reach, where they originated. The ability to home to their home or "natal" stream is thought to be due to odors to which the juvenile salmonids were exposed while living in the stream (olfactory imprinting) and migrating from it years earlier (Dittman and Quinn 2008; Keefer and Caudill 2014). Fisheries managers use this innate ability of salmon and steelhead to home to specific streams by using acclimation ponds to support the reintroduction of species into newly accessible habitat or into areas where they have been extirpated (Dunnigan 1999; Quinn 1997; YKFP 2008).

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

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

- The timing of the acclimation, such that a majority of the hatchery juveniles are going through the parr-smolt transformation during acclimation

- A water source unique enough to attract returning adults
- Whether or not the hatchery fish can access the stream reach where they were released
- Whether or not the water quantity and quality is such that returning hatchery fish will hold in that area before removal and/or their harvest in fisheries.

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

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

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

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

5.4.1. Observing/Harassing

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

5.4.2. Capturing/handling

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

5.4.3. Fin clipping and tagging

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

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

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

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

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

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

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

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

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

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

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

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

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

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