UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
1201 NE Lloyd Boulevard, Suite 1100
PORTLAND, OREGON 97232

Refer to NMFS No: WCRO-2019-00174

September 3, 2019

Tawnya Brummett
Acting Forest Supervisor
Payette National Forest
500 North Mission Street
McCall, Idaho 83638

Re: Endangered Species Act Section 7 Formal Consultation and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for the Smith Creek/Hettinger Ranch Hydropower and Irrigation System

Dear Ms. Brummett:

Thank you for your letter of April 3, 2019 requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for ongoing operation of the Smith Creek/Hettinger Ranch Hydropower System and Irrigation Diversion. Your letter included a biological assessment (BA) that analyzed the effects of the proposed action on Snake River Basin steelhead (*Oncorhynchus mykiss*), Snake River spring/summer Chinook salmon (*O. tshawytscha*), designated critical habitat for both species, and essential fish habitat (EFH) for Chinook salmon. Thank you, also, for your request for consultation pursuant to the EFH provisions in section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA)(16 U.S.C. 1855(b)) for this action.

In this biological opinion (Opinion), NMFS concludes that the action, as proposed, is not likely to jeopardize the continued existence of Snake River spring/summer Chinook salmon (Chinook salmon) or Snake River Basin steelhead (steelhead). NMFS also determined the action will not destroy or adversely modify designated critical habitat for Chinook salmon or steelhead. Rationale for our conclusions is provided in the attached Opinion.

As required by section 7 of the ESA, NMFS provides an incidental take statement (ITS) with the Opinion. The ITS describes reasonable and prudent measures (RPM) NMFS considers necessary or appropriate to minimize the impact of incidental take associated with this action. The take statement sets forth nondiscretionary terms and conditions, including reporting requirements, that the Payette National Forest (PNF) and any permittee who performs any portion of the action, must comply with to carry out the RPM. Incidental take from actions that meet these terms and conditions will be exempt from the ESA take prohibition.

This document also includes the results of our analysis of the action's effects on EFH pursuant to section 305(b) of the MSA, and includes one Conservation Recommendation to avoid, minimize, or otherwise offset potential adverse effects on EFH. These Conservation Recommendations are a non-identical set of the ESA Terms and Conditions. Section 305(b)(4)(B) of the MSA requires federal agencies to provide a detailed written response to NMFS within 30 days after receiving these recommendations.

If the response is inconsistent with the EFH Conservation Recommendations, the PNF must explain why the recommendations will not be followed, including the justification for any disagreements over the effects of the action and the recommendations. In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many Conservation Recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, in your statutory reply to the EFH portion of this consultation, NMFS asks that you clearly identify the number of Conservation Recommendations accepted.

Please contact Jim Morrow, Snake River Basin Office at 208-378-5695 or jim.morrow@noaa.gov if you have any questions concerning this consultation, or if you require additional information.

Sincerely,

Michael P. Tehan
Assistant Regional Administrator
Interior Columbia Basin Office

Enclosure

cc: C. Nalder – PNF
S. Blihovde – USFWS
M. Lopez – NPT

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

Smith Creek/Hettinger Ranch Hydropower and Irrigation Diversion – Payette National Forest, Valley County, Idaho, HUC 170602080606

NMFS Consultation Number: WCRO-2019-00174

Action Agencies: United States Forest Service, Payette National Forest

Affected Species and NMFS' Determinations:

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

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

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

Issued By:

Michael P. Tehan
Assistant Regional Administrator

Date: September 3, 2019

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

ACRONYMS

ACRONYM	DEFINITION
BA	Biological Assessment
cfs	cubic feet per second
Chinook Salmon	Snake River spring/summer Chinook salmon
Ditch Bill	Agricultural Irrigation and Livestock Watering System Easement Act
DPS	Distinct Population Segment
DQA	Data Quality Act
Easement	Easement
eDNA	Environmental Deoxyribonucleic Acid
EFH	Essential Fish Habitat
EFSFSR	East Fork South Fork Salmon River
ESA	Endangered Species Act
ESU	Evolutionarily Significant Units
HAPC	Habitat Areas of Particular Concern
ICTRT	Interior Columbia Technical Recovery Team
IDFG	Idaho Department of Fish and Game
ITS	Incidental Take Statement
MPG	Major Population Group
MSA	Magnuson-Stevens Fishery Conservation and Management Act
msl	mean sea level
NMFS	National Marine Fisheries Service
NPT	Nez-Perce Tribe
O&M Plan	Operation and Maintenance Plan
Opinion	Biological Opinion
PBF	Physical and Biological Features
PCE	Primary Constituent Elements
PFMC	Pacific Fisheries Management Council
PNF	Payette National Forest
POD	Points of Diversion
RPM	Reasonable and Prudent Measures
SFSR	South Fork Salmon River
Smith Creek Diversion	Smith Creek/Hettinger Ranch Hydropower and Irrigation Diversion
Spring Diversion	Smith Creek
Steelhead	Snake River Basin steelhead
SUP	Special Use Permit
USFS	U.S. Forest Service
VSP	Viable Salmonid Population

1. INTRODUCTION

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

1.1 Background

The National Marine Fisheries Service (NMFS) prepared the biological opinion (Opinion) and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 U.S.C. 1531 et seq.), and implementing regulations at 50 CFR 402.

We also completed an essential fish habitat (EFH) consultation on the proposed action, in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 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 (DQA) (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). A complete record of this consultation is on file at the Snake Basin Office.

1.2 Consultation History

The Payette National Forest (PNF) proposes authorizing operation and maintenance of a water diversion on a spring tributary of Smith Creek (Spring Diversion) and amending the operation and maintenance plan (O&M Plan) for the Smith Creek/Hettinger Ranch Hydropower and Irrigation Diversion (Smith Creek Diversion) on Smith Creek. The Spring Diversion will be authorized through reissuance of a special use permit (SUP). The Smith Creek Diversion is, and will continue to be authorized under an existing Agricultural Irrigation and Livestock Watering System Easement Act (Ditch Bill) Easement (Easement). The proposed federal action for the Smith Creek Diversion is issuance of the amended O&M Plan for the Easement. The project will affect Snake River spring/summer Chinook salmon (Chinook salmon), Snake River Basin steelhead (steelhead), designated critical habitat for both species, and Chinook salmon EFH. The PNF Level 1 Team recommended finalization of the biological assessment (BA) on March 18, 2019.

Operation and maintenance of the Spring and Smith Creek Diversions are ongoing activities that previously underwent ESA section 7 consultation in 2010 (NMFS Tracking No. WCR-2010-00676). That consultation included reconstruction of the Smith Creek Diversion, issuance of a Federal Energy Regulatory Commission exemption for the Smith Creek Diversion and hydropower facility, issuance of a temporary SUP (until the Easement could be finalized) for the Smith Creek Diversion, issuance of the Easement authorizing operation and maintenance of the Smith Creek Diversion, and issuance of an SUP for operation and maintenance of the Spring Diversion. The 2010 consultation included SUP and Easement terms and conditions designed to minimize the impact of incidental take of ESA-listed species. The Easement was issued on January 26, 2012, but for unknown reasons, not all of the terms and conditions were included in the O&M Plan. However, monitoring indicates that the permittee has complied with the proposed terms and conditions described in the 2010 consultation.

Upon review of the (BA), NMFS determined that the proposed action for the Smith Creek Diversion was not clearly defined and requested additional information in a May 1, 2019, letter to the PNF. After May 1, 2019, NMFS and PNF personnel exchanged a series of e-mails and held one meeting to discuss the proposed action; on May 10, 2019, the PNF sent NMFS a revised proposed action via e-mail. The revised proposed action includes: (1) Revision of the O&M Plan to include most of the terms and conditions described in the 2010 consultation; and (2) limiting diversion of water at the Spring Diversion to 0.03 cubic feet per second (cfs).

This project will likely affect tribal trust resources. Because the action is likely to affect tribal resources, a copy of the draft of the proposed action and terms and conditions was sent to the Nez Perce Tribe (NPT) and Shoshone-Bannock Tribes on August 12, 2019. Neither the Nez Perce Tribe nor the Shoshone-Bannock Tribes provided comments.

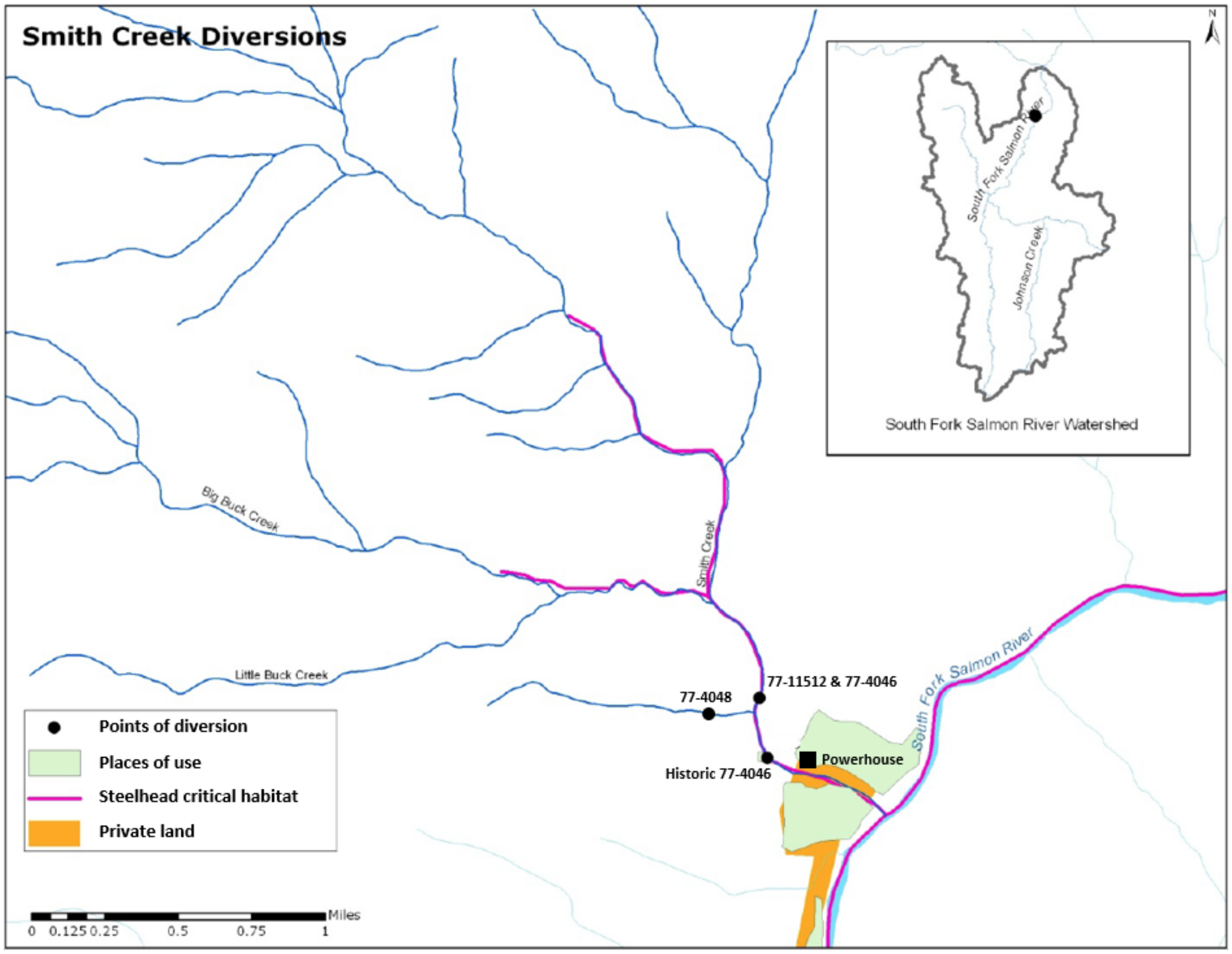
1.3 Proposed Federal Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies (50 CFR 402.02). Under the MSA, "federal action" means any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken by a federal agency (50 CFR 600.910). "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 (50 CFR 402.02).

The proposed action will authorize operation and maintenance of water diversion and transmission facilities on PNF-administered land, in accordance with the terms and conditions of the SUP and Easement. Water diversions on and across PNF-administered land, and use of that water on private land, will presumably not occur without the proposed action, and the effects of that diversion and use will therefore be described in the Analysis of Effects section (Section 2.2).

The federal actions covered by this Opinion are the authorization of ongoing operation and maintenance of the Spring Diversion under an updated SUP and authorization of ongoing operation and maintenance of the Smith Creek Diversion under an updated O&M Plan. Locations of the points of diversion (POD) and places of use are in Figure 1. Descriptions of the water diversion facilities, and management of those facilities under the proposed action, are in Sections 1.3.1 and 1.3.2.

Figure 1. Map of the Smith Creek drainage showing approximate locations of points of diversion and places of use for water rights served by the Spring and Smith Creek Diversions.



1.3.1 Spring Diversion

The POD for this diversion is on a spring approximately 0.5 miles upstream from the confluence of the unnamed spring creek and Smith Creek (Figure 1). The diversion structure consists of a spring box that "taps" the spring. Water is piped a short distance from the spring box to a settling box and is conveyed to the ranch via a 2- to 3-inch pipeline. This diversion serves water right 77-4048 with a maximum diversion rate of 0.23 cfs for stockwater and irrigation of eight acres. Under the proposed action, the water will be used for domestic purposes, including lawn and garden irrigation. The proposed action will authorize maintaining the diversion and conveyance facilities in their current condition and operation of the diversion with withdrawals limited to 0.03 cfs. The SUP term will be 20 years.

1.3.2 Smith Creek Diversion

The Smith Creek diversion serves water right 77-4046, with a maximum diversion rate of 1.9 cfs for irrigation and stockwater; and 77-11512, with a maximum diversion rate of 2.0 cfs for hydropower. The POD for this diversion is on Smith Creek approximately 0.65 miles upstream from the mouth. The diversion consists of a trapezoidal intake box covered by a stainless steel Johnson v-bar screen (Figure 2). The horizontal screen is nearly flush with the streambed and is three feet wide by 5 feet long with 3/32-inch openings that are parallel with the direction of flow. The diversion and screen was designed to allow at least one cfs to remain in the stream. This "bypass" flow also serves as the juvenile bypass system, allowing juvenile salmonids to freely move upstream or downstream past the screen without leaving the stream channel. Precisely testing the bypass flow feature of the diversion would require extensive flow measurements during drought conditions, which has not been done. However, flow measurements taken in 2015 and 2018 suggest that the diversion is operating as designed. Also, water temperature monitoring upstream and downstream from the diversion, conducted since 2012, shows very little warming downstream from the diversion, even during dry years. This suggests that sufficient flow is bypassing the diversion to maintain water quality for rearing salmonids, and that the diversion is likely operating as designed regarding bypass flows during drought conditions.

Figure 2. Point of diversion for the Smith Creek Diversion showing the Johnson Bar screen, the permanent walkway used to clean the screen, and screen cleaning implements (i.e., broom and shovel).

Water diverted at the Smith Creek Diversion enters through the horizontal screen and is conveyed, via a 9-inch steel pipe, a short distance to a 12-inch plastic pipe (penstock) that conveys the water approximately 1,600 feet to the powerhouse. The penstock is equipped with a flow meter capable of continuously measuring amount of water diverted. Water enters the Pelton turbine via the 12-inch penstock and exits via a 16-inch pipe that conveys the water to an energy dissipation structure (water box) with two 12-inch outlets, one that conveys water back to Smith Creek and one that conveys water to the irrigation system. The irrigation water is further divided into two pipes, one each running to the fields north and south of Smith Creek. The irrigation water is pressurized and is distributed via sprinklers, and the system is used to irrigate approximately 82 acres of hay and/or pasture.

Operation and maintenance of the Smith Creek Diversion is authorized under the Ditch Bill Easement that was issued on January 26, 2012. The Easement does not have an expiration date, but it does have a provision to revise or modify the O&M Plan to comply with requirements of the ESA, or other applicable laws. Easement terms and conditions that will be included in the O&M Plan, so as to better comply with the ESA, are described in the following bullets:

- Any ground disturbance due to maintenance of diversion equipment will be mitigated with a high level of erosion control to prevent erosion and subsequent sediment deposition into streams. All maintenance is assumed to be hand maintenance.

- Any leakage due to malfunctioning diversion equipment will be repaired as soon as possible to prevent streambank washout or erosion, and avoid sediment deposition in streams.

- Stream channel conditions at the diversion will be monitored every 3 years by PNF special use administrators and a fisheries biologist and/or hydrologist to determine if changes to the diversion activities are necessary based on conditions found at the site.

- The ranch manager will clean all debris off of the horizontal screen as needed with a stiff bristle nylon barn broom while standing on the catwalk. Collected debris will be placed back into Smith Creek, downstream of the POD.

- The diversion rate will be will be limited to 2.0 cfs when water is being used for irrigation.

- The diversion rate will be limited to 1.5 cfs when water is not being used for irrigation.

- A flow of at least 1.0 cfs will be maintained in Smith Creek below the POD at all times.

The PNF will send the revised draft O&M to NMFS prior to finalization to ensure that all critical elements are included.

<u>1.3.3 Monitoring</u>

Monitoring that will be accomplished by the permittee includes:

- Measure and record the amount of water diverted via the Smith Creek diversion, year-round, and provide the recorded data to the PNF.

- Monitor the screen and bypass system regularly to ensure that the screen is sufficiently free of debris and the bypass system is operating as designed (i.e., bypass flow is present). Notify the PNF immediately if the bypass system is not operating as designed and cannot be fixed to operate as designed within 1-day.

- Note any apparently stressed, stranded, or dead salmonid at or downstream from the Smith Creek Diversion, collect photograph evidence if feasible, and report the sighting to the PNF as soon as feasible.

Monitoring that will be accomplished by the PNF includes:

- Notify NMFS within 1-business day, of the PNF receiving a report of a stressed, stranded, or dead salmonid at or downstream from the Smith Creek Diversion.

- If the PNF is notified by the permittee that the system is not operating as designed, the PNF will in turn notify NMFS within 1-day to determine the next course of action.

- Provide the SUP and easement 5-year inspection report to NMFS by December 31 of the year the inspection is completed. The report will include: Amount of water diverted at the Smith Creek Diversion for the 5-year period; photos of the water diversion and transmission facilities from the inspection site visit; and, any instances of stressed, stranded, or dead salmonids in Smith Creek at and downstream from the POD.

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

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

2.1 Analytical Approach

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

This 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).

The designations of critical habitat for Snake River Basin steelhead and Snake River spring/summer Chinook salmon use the term primary constituent element (PCE) or essential features. The new critical habitat regulations (81 FR 7414) replace this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a ''destruction or adverse modification'' analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this Opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

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

- Identify the rangewide status of the species and critical habitat expected to be adversely affected by the proposed action.
- Describe the environmental baseline in the action area.
- Analyze the effects of the proposed action on both species and their habitat using an "exposure-response-risk" approach.
- Describe any cumulative effects in the action area.
- Integrate 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.
- Reach a conclusion about whether species are jeopardized or critical habitat is adversely modified.
- If necessary, suggest a reasonable and prudent alternative to the proposed action.

2.2 Rangewide Status of the Species and Critical Habitat

This Opinion examines the status of each species that would be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions (Table 1). This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. This Opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds that make up the designated area, and discusses the current function of the PBF that help to form that conservation value.

Table 1. Listing status, status of critical habitat designations and protective regulations, and relevant Federal Register decision notices for ESA-listed species considered in this Opinion.

Species	Listing Status	Critical Habitat	Protective Regulations
Chinook salmon *(Oncorhynchus tshawytscha)*			
Snake River spring/summer-run	T 6/28/05; 70 FR 37160	10/25/99; 64 FR 57399	6/28/05; 70 FR 37160
Steelhead (*O. mykiss*)			
Snake River Basin	T 1/05/06; 71 FR 834	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160

Note: Listing status: 'T' means listed as threatened under the ESA.

2.2.1 Status of the Species

This section describes the present condition of the Snake River spring/summer Chinook salmon evolutionarily significant unit (ESU) and the Snake River Basin steelhead distinct population segment (DPS). NMFS expresses the status of a salmonid ESU or DPS in terms of likelihood of persistence over 100 years (or risk of extinction over 100 years). NMFS uses McElhany et al.'s (2000) description of a viable salmonid population (VSP) that defines "viable" as less than a 5 percent risk of extinction within 100 years and "highly viable" as less than a 1 percent risk of extinction within 100 years. A third category, "maintained," represents a less than 25 percent risk within 100 years (moderate risk of extinction). To be considered viable, an ESU or DPS should have multiple viable populations so that a single catastrophic event is less likely to cause the ESU/DPS to become extinct, and so that the ESU/DPS may function as a metapopulation that can sustain population-level extinction and recolonization processes (ICTRT 2007). The risk level of the ESU/DPS is built up from the aggregate risk levels of the individual populations and major population groups (MPGs) that make up the ESU/DPS.

Attributes associated with a VSP, are: (1) Abundance (number of adult spawners in natural production areas); (2) productivity (adult progeny per parent); (3) spatial structure; and (4) diversity. A VSP needs sufficient levels of these four population attributes in order to: safeguard the genetic diversity of the listed ESU or DPS; enhance its capacity to adapt to various environmental conditions; and allow it to become self-sustaining in the natural environment (ICTRT 2007). These viability attributes are influenced by survival, behavior, and experiences throughout the entire salmonid life cycle, characteristics that are influenced in turn by habitat and other environmental and anthropogenic conditions. The present risk faced by the ESU/DPS informs NMFS' determination of whether additional risk will appreciably reduce the likelihood that the ESU/DPS will survive or recover in the wild.

2.2.1.1 Snake River Spring/Summer Chinook Salmon

The Snake River spring/summer Chinook salmon ESU was listed as threatened on April 22, 1992 (57 FR 14653). This ESU occupies the Snake River basin, which drains portions of southeastern Washington, northeastern Oregon, and north/central Idaho. Several factors led to NMFS' conclusion that Snake River spring/summer Chinook salmon were threatened: (1)

Abundance of naturally produced Snake River spring and summer Chinook salmon runs had dropped to a small fraction of historical levels; (2) short-term projections were for a continued downward trend in abundance; (3) hydroelectric development on the Snake and Columbia Rivers continued to disrupt Chinook salmon runs through altered flow regimes and impacts on estuarine habitats; and (4) habitat degradation existed throughout the region, along with risks associated with the use of outside hatchery stocks in particular areas (Good et al. 2005). On May 26, 2016, in the agency's most recent 5-year review for Pacific salmon and steelhead, NMFS concluded that the species should remain listed as threatened (81 FR 33468).

Life History. Although Snake River spring/summer Chinook salmon are a single ESU, they are subdivided into two runs based on timing of returning adults at Bonneville Dam. Fish migrating over Bonneville Dam prior to June 1 classified as spring run and those migrating from June 1 through July 31 are classified as summer run. Returning spring/summer Chinook salmon adults hold in pools until late summer, when they move out of pools to spawn. Holding pools can be in spawning reaches or in downstream reaches. Fish holding in downstream reaches make a final run to the spawning reaches just prior to spawning. Generally, spring Chinook salmon spawn in higher-elevation reaches in mid- through late August; and summer Chinook salmon spawn in lower in Snake River tributaries in late August and September. However, there is overlap in both spawning areas and timing, and some populations that are classified as a single run type show characteristics of both spring and summer runs.

Eggs are deposited in late summer and early fall, incubate over the winter, and hatch in late winter and early spring of the following year. Spring/summer Chinook salmon typically follow a "stream-type" life history with juveniles rearing through the summer, overwintering in freshwater, and migrating to ocean as age-1 smolts (Healey 1991). However, a small percentage migrate to the ocean in as subyearling smolts and a small percentage rear for an extra year and migrate as 2-year old smolts. Some juveniles complete rearing in the spawning reaches but most move downstream in late-summer or fall and overwinter in larger stream and river reaches. Snake River spring/summer Chinook salmon return from the ocean to spawn primarily as 4- and 5-year-old fish, after 2 to 3 years in the ocean. A small fraction of the fish return as 3-year-old "jacks," heavily predominated by males (Good et al. 2005).

Spatial Structure and Diversity. The Snake River ESU includes all naturally spawning populations of spring/summer Chinook in the mainstem Snake River (below Hells Canyon Dam) and in the Tucannon River, Grande Ronde River, Imnaha River, and Salmon River subbasins (57 FR 23458), as well as the progeny of 15 artificial propagation programs (70 FR 37160). The hatchery programs include the South Fork Salmon River (SFSR) (McCall Hatchery), Johnson Creek, Lemhi River, Pahsimeroi River, East Fork Salmon River, West Fork Yankee Fork Salmon River, Upper Salmon River (Sawtooth Hatchery), Tucannon River (conventional and captive broodstock programs), Lostine River, Catherine Creek, Lookingglass Creek, Upper Grande Ronde River, Imnaha River, and Big Sheep Creek programs. The historical Snake River ESU likely also included populations in the Clearwater River drainage and extended above the Hells Canyon Dam complex.

Within the Snake River ESU, the Interior Columbia Technical Recovery Team (ICTRT) identified 28 extant and four extirpated or functionally extirpated populations of spring/summer-run Chinook salmon, listed in Table 2 (ICTRT 2003; McClure et al. 2005). The ICTRT aggregated these populations into five MPGs: Lower Snake River, Grande Ronde/Imnaha Rivers, SFSR, Middle Fork Salmon River, and Upper Salmon River. For each population, Table 2 shows the current risk ratings that the ICTRT assigned to the four parameters of a VSP (spatial structure, diversity, abundance, and productivity).

Spatial structure risk is low to moderate for most populations in this ESU (NWFSC 2015) and is generally not preventing the recovery of the species. Spring/summer Chinook salmon spawners are distributed throughout the ESU albeit at very low numbers. Diversity risk, on the other hand, is somewhat higher, driving the moderate and high combined spatial structure/diversity risks shown in Table 2 for some populations. Several populations have a high proportion of hatchery-origin spawners—particularly in the Grande Ronde, Lower Snake, and South Fork Salmon MPGs—and diversity risk will need to be lowered in multiple populations in order for the ESU to recover (ICTRT 2007; ICTRT 2010; NWFSC 2015). Diversity risk for the SFSR Chinook salmon population is moderate due to a high proportion of hatchery spawners.

Abundance and Productivity. Historically, the Snake River drainage is thought to have produced more than 1.5 million adult spring/summer Chinook salmon in some years (Matthews and Waples 1991), yet by the mid-1990s counts of wild fish passing Lower Granite Dam dropped to less than 10,000 (IDFG 2007). Wild returns have since increased somewhat but remain a fraction of historic estimates. Between 2005 and 2015, the number of wild adult fish passing Lower Granite Dam annually ranged from 8,808 to 30,338 (IDFG 2016). Natural origin abundance has increased over the last 5 years for most populations in this ESU, but the increases have not been large enough to change population viability ratings for abundance and productivity; all but one population (Chamberlain Creek) remain at high risk of extinction over the next 100 years (NWFSC 2015). Many populations in Table 2 will need to see increases in abundance and productivity in order for the ESU to recover.

Table 2. Summary of viable salmonid population parameter risks and overall current status for each population in the Snake River spring/summer Chinook salmon ESU (NWFSC 2015).

MPG	Population	VSP Risk Parameter: Abundance/ Productivity	VSP Risk Parameter: Spatial Structure/ Diversity	Overall Viability Rating
South Fork Salmon River (Idaho)	Little Salmon River	*Insf. data*	Low	High Risk
	South Fork Salmon River mainstem	High	Moderate	High Risk
	Secesh River	High	Low	High Risk
	East Fork South Fork Salmon River	High	Low	High Risk
Middle Fork Salmon River (Idaho)	Chamberlain Creek	Moderate	Low	Maintained
	Middle Fork Salmon River below Indian Creek	*Insf. data*	Moderate	High Risk
	Big Creek	High	Moderate	High Risk
	Camas Creek	High	Moderate	High Risk
	Loon Creek	High	Moderate	High Risk
	Middle Fork Salmon River above Indian Creek	High	Moderate	High Risk
	Sulphur Creek	High	Moderate	High Risk
	Bear Valley Creek	High	Low	High Risk
	Marsh Creek	High	Low	High Risk
Upper Salmon River (Idaho)	North Fork Salmon River	*Insf. data*	Low	High Risk
	Lemhi River	High	High	High Risk
	Salmon River Lower Mainstem	High	Low	High Risk
	Pahsimeroi River	High	High	High Risk
	East Fork Salmon River	High	High	High Risk
	Yankee Fork Salmon River	High	High	High Risk
	Valley Creek	High	Moderate	High Risk
	Salmon River Upper Mainstem	High	Low	High Risk
	Panther Creek			***Extirpated***
Lower Snake (Washington)	Tucannon River	High	Moderate	High Risk
	Asotin Creek			***Extirpated***
Grande Ronde and Imnaha Rivers (Oregon/ Washington)	Wenaha River	High	Moderate	High Risk
	Lostine/Wallowa River	High	Moderate	High Risk
	Minam River	High	Moderate	High Risk
	Catherine Creek	High	Moderate	High Risk
	Upper Grande Ronde River	High	High	High Risk
	Imnaha River	High	Moderate	High Risk
	Lookingglass Creek			***Extirpated***
	Big Sheep Creek			***Extirpated***

The proposed action will affect individuals in the SFSR Chinook salmon population. Population trend data for most of the Chinook salmon populations in the Idaho portion of the ESU date to 1957, when Idaho Department of Fish and Game (IDFG) started annual Chinook salmon index reach redd counts. Like all of the populations in the ESU, the number of redds in the SFSR Chinook salmon population dropped between 1957 and the mid-1980s. Index reach redd counts for most of the populations in the ESU dropped to dramatically low levels, often fewer than 10 redds, in the early to mid-1990s. In contrast, the lowest count on record for the SFSR population is 97, an order of magnitude higher than the low counts for most of the populations, and the low point for the population (measured as 5-year geomean) occurred in the mid-1980s instead of the mid-1990s (Figure 3). The relative "abundance," compared to other populations in the ESU, is probably due to a combination of extensive hatchery supplementation that began in the mid-1970s, and relatively high quality spawning and rearing habitat (see Section 2.2.2).

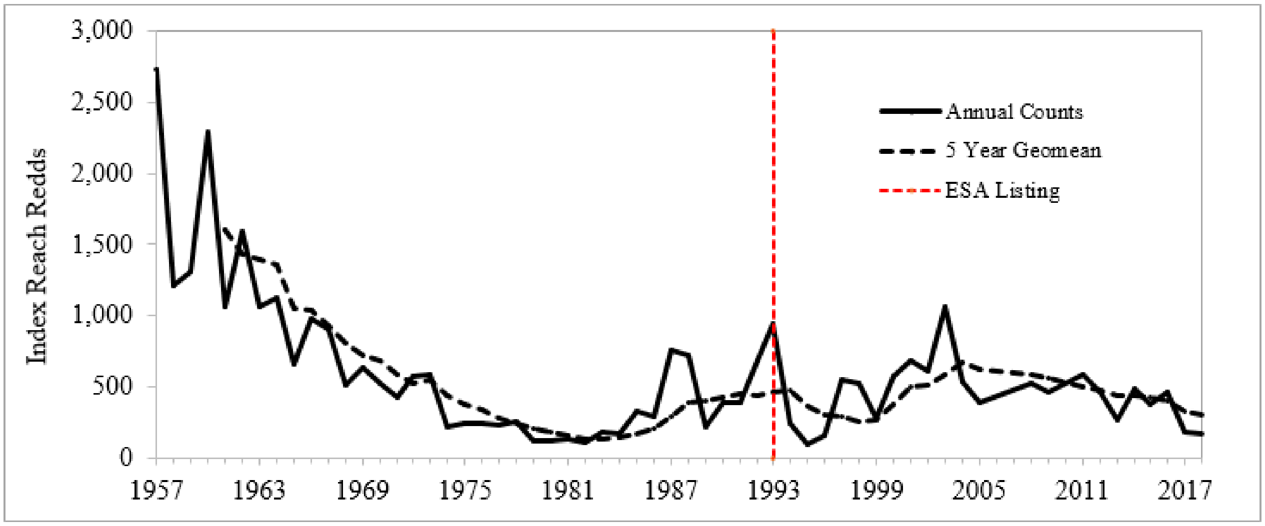


Figure 3. Index reach redds counted in the South Fork Salmon River Chinook salmon population area from 1957 through 2018.

The quality of spawning/rearing habitat is further evidenced by the number of naturally produced SFSR smolts reaching Lower Granite Dam, which during some years, is among the highest in the ESU (Walters et al. 2013). Population productivity is density dependent, measured either as number of juveniles reaching Lower Granite Dam (Walters et al. 2013) or as the proportion of return year redds to stock year redds (Figure 4). The equilibrium population size from Figure 4 is 618 redds and the 20-year geomean population size for return years 1997–2018 is 577 redds. Both of these estimates indicate an average population size of approximately 1,200 returns. Although more abundant than most populations, the SFSR Chinook salmon population continues to be rated as high risk of extinction due to low abundance and productivity.

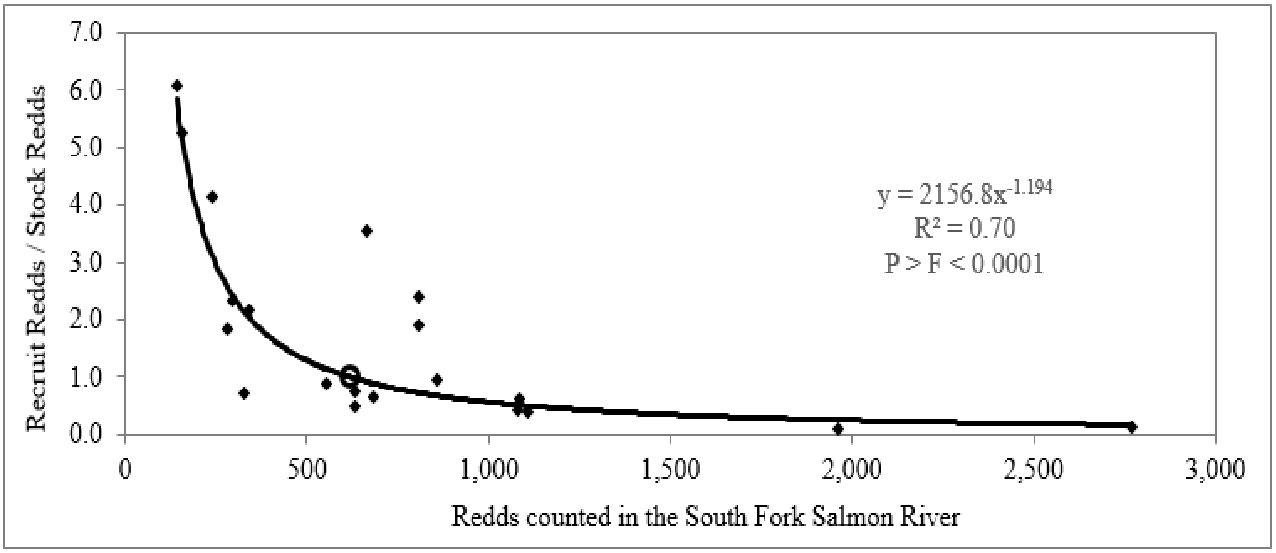


Figure 4. Relationship of whole life cycle productivity and stock year redds for the South Fork Salmon River Chinook salmon population for stock years 1994–2013. The open circle denotes the equilibrium population of 618 redds at a whole life cycle productivity of one.

2.2.1.2 Snake River Basin Steelhead

The Snake River Basin steelhead was listed as a threatened ESU on August 18, 1997 (62 FR 43937), with a revised listing as a DPS on January 5, 2006 (71 FR 834). This DPS occupies the Snake River basin, which drains portions of southeastern Washington, northeastern Oregon, and north/central Idaho. Reasons for the decline of this species include substantial modification of the seaward migration corridor by hydroelectric power development on the mainstem Snake and Columbia Rivers, and widespread habitat degradation and reduced streamflows throughout the Snake River basin (Good et al. 2005). Another major concern for the species is the threat to genetic integrity from past and present hatchery practices, and the high proportion of hatchery fish in the aggregate run of Snake River Basin steelhead over Lower Granite Dam (Good et al. 2005; Ford 2011). On May 26, 2016, in the agency's most recent 5-year review for Pacific salmon and steelhead, NMFS concluded that the species should remain listed as threatened (81 FR 33468).

Life History. Adult Snake River Basin steelhead enter the Columbia River from late June to October to begin their migration inland. After holding over the winter in larger rivers in the Snake River basin, steelhead disperse into smaller tributaries to spawn from March through May. Earlier dispersal occurs at lower elevations and later dispersal occurs at higher elevations. Juveniles emerge from the gravels in 4 to 8 weeks, and move into shallow, low-velocity areas in side channels and along channel margins to escape high velocities and predators (Everest and Chapman 1972). Juvenile steelhead then progressively move toward deeper water as they grow in size (Bjornn and Rieser 1991). Juveniles typically reside in fresh water for 1 to 3 years, although this species displays a wide diversity of life histories. Smolts migrate downstream during spring runoff, which occurs from March to mid-June depending on elevation, and typically spend 1 to 2 years in the ocean.

Spatial Structure and Diversity. This species includes all naturally-spawning steelhead populations below natural and manmade impassable barriers in streams in the Snake River basin of southeast Washington, northeast Oregon, and Idaho, as well as the progeny of six artificial propagation programs (71FR834). The hatchery programs include Dworshak National Fish Hatchery, Lolo Creek, North Fork Clearwater River, East Fork Salmon River, Tucannon River, and the Little Sheep Creek/Imnaha River steelhead hatchery programs. The Snake River Basin steelhead listing does not include resident forms of *O. mykiss* (rainbow trout) co-occurring with steelhead.

The ICTRT identified 24 extant populations within this DPS, organized into five MPGs (ICTRT 2003). The ICTRT also identified a number of potential historical populations associated with watersheds above the Hells Canyon Dam complex on the mainstem Snake River, a barrier to anadromous migration. The five MPGs with extant populations are the Clearwater River, Salmon River, Grande Ronde River, Imnaha River, and Lower Snake River. In the Clearwater River, the historic North Fork population was blocked from accessing spawning and rearing habitat by Dworshak Dam. Current steelhead distribution extends throughout the DPS, such that spatial structure risk is generally low. For each population in the DPS, Table 3 shows the current risk ratings for the parameters of a VSP.

Snake River Basin steelhead exhibit a diversity of life-history strategies, including variations in fresh water and ocean residence times. Traditionally, fisheries managers have classified Snake River Basin steelhead into two groups, A-run and B-run, based on ocean age at return, adult size at return, and migration timing. A-run steelhead predominantly spend 1-year in the ocean; B-run steelhead are larger with most individuals returning after 2 years in the ocean. New information shows that most Snake River populations support a mixture of the two run types, with the highest percentage of B-run fish in the upper Clearwater River and the SFSR; moderate percentages of B-run fish in the Middle Fork Salmon River; and very low percentages of B-run fish in the Upper Salmon River, Grande Ronde River, and Lower Snake River (NWFSC 2015). Maintaining life history diversity is important for the recovery of the species.

Diversity risk for populations in the DPS is either moderate or low. Large numbers of hatchery steelhead are released in the Snake River, and the relative proportion of hatchery adults in natural spawning areas near major hatchery release sites remains uncertain. Moderate diversity risks for some populations are thus driven by the high proportion of hatchery fish on natural spawning grounds and the uncertainty regarding these estimates (NWFSC 2015). Reductions in hatchery-related diversity risks would increase the likelihood of these populations reaching viable status.

The diversity risk for the SFSR steelhead population is low. This population has a relatively large proportion of B-run fish, is well distributed throughout most[1] of the population area, and has never been supplemented with hatchery fish. From a diversity standpoint, the SFSR steelhead population is one of the stronger populations in the DPS.

[1] There are no steelhead in the East Fork South Fork Salmon River upstream from the Stibnite Mine site but essentially all of the other historically accessible habitat is probably occupied.

Table 3. Summary of viable salmonid population parameter risks and overall current status for each population in the Snake River Basin steelhead DPS (NWFSC 2015). Risk ratings with "?" are based on limited or provisional data series.

MPG	Population	VSP Risk Parameter		Overall Viability Rating
		Abundance/ Productivity	Spatial Structure/ Diversity	
Lower Snake River	Tucannon River	High?	Moderate	High Risk?
	Asotin Creek	Moderate?	Moderate	Maintained?
Grande Ronde River	Lower Grande Ronde	N/A	Moderate	Maintained?
	Joseph Creek	Very Low	Low	**Highly Viable**
	Wallowa River	N/A	Low	Maintained?
	Upper Grande Ronde	Low	Moderate	**Viable**
Imnaha River	Imnaha River	Moderate?	Moderate	Maintained?
Clearwater River (Idaho)	Lower Mainstem Clearwater River*	Moderate?	Low	Maintained?
	South Fork Clearwater River	High?	Moderate	High Risk?
	Lolo Creek	High?	Moderate	High Risk?
	Selway River	Moderate?	Low	Maintained?
	Lochsa River	Moderate?	Low	Maintained?
	North Fork Clearwater River			*Extirpated*
Salmon River (Idaho)	Little Salmon River	Moderate?	Moderate	Maintained?
	South Fork Salmon River	Moderate?	Low	Maintained?
	Secesh River	Moderate?	Low	Maintained?
	Chamberlain Creek	Moderate?	Low	Maintained?
	Lower Middle Fork Salmon R.	Moderate?	Low	Maintained?
	Upper Middle Fork Salmon R.	Moderate?	Low	Maintained?
	Panther Creek	Moderate?	High	High Risk?
	North Fork Salmon River	Moderate?	Moderate	Maintained?
	Lemhi River	Moderate?	Moderate	Maintained?
	Pahsimeroi River	Moderate?	Moderate	Maintained?
	East Fork Salmon River	Moderate?	Moderate	Maintained?
	Upper Mainstem Salmon R.	Moderate?	Moderate	Maintained?
Hells Canyon	Hells Canyon Tributaries			*Extirpated*

*Current abundance/productivity estimates for the Lower Clearwater Mainstem population exceed minimum thresholds for viability, but the population is assigned moderate risk for abundance/productivity due to the high uncertainty associated with the estimate.

Abundance and Productivity. Historical estimates of steelhead production for the entire Snake River basin are not available, but the basin is believed to have supported more than half the total steelhead production from the Columbia River basin (Mallet 1974, as cited in Good et al. 2005). Historical estimates of steelhead passing Lewiston Dam (removed in 1973) on the lower Clearwater River were 40,000 to 60,000 adults (Ecovista et al. 2003), and the Salmon River basin likely supported substantial production as well (Good et al. 2005). In contrast, at the time of listing in 1997, the 5-year mean abundance for natural-origin steelhead passing Lower Granite

Dam, which includes all but one population in the DPS, was 11,462 adults (Ford 2011). Counts have increased since then, with between roughly 23,000 and 44,000 adult wild steelhead passing Lower Granite Dam in the most recent 5-year period (2011–2015) (NWFSC 2015).

Population-specific abundance estimates exist for some but not all populations. Of the populations for which we have data, three (Joseph Creek, Upper Grande Ronde, and Lower Clearwater) are meeting minimum abundance/productivity thresholds and several more have likely increased in abundance enough to reach moderate risk. Despite these recent increases in abundance, the status of many of the individual populations remains uncertain, and four out of the five MPGs are not meeting viability objectives (NWFSC 2015). In order for the species to recover, more populations will need to reach viable status through increases in abundance and productivity.

The proposed action would affect individuals in the SFSR steelhead population. The SFSR steelhead population is one of the few that has never been supplemented with hatchery fish and it has the highest proportion of B-run individuals. These two attributes make the SFSR steelhead population very important for recovery of the DPS. Estimates of the number of steelhead spawners returning to the SFSR are available for the 2011–2012 through the 2015–2016 runs and ranged from 602 spawners in 2103–2014, to 1,184 spawners in 2014–2015, with a 5-year geomean of 786 spawners (Copeland et al. 2014; Copeland et al. 2015; Stark et al. 2016; Stark et al. 2017; Stark et al. 2018). These abundance estimates suggest that the tentative abundance/productivity risk ranking of “Moderate?” (Table 3) is likely correct.

2.2.2 Status of Critical Habitat

In evaluating the condition of designated critical habitat, NMFS examines the condition and trends of PBFs which are essential to the conservation of the ESA-listed species because they support one or more life stages of the species. Proper function of these PBFs is necessary to support successful adult and juvenile migration, adult holding, spawning, incubation, rearing, and the growth and development of juvenile fish. Modification of PBFs may affect freshwater spawning, rearing or migration in the action area. Generally speaking, sites required to support one or more life stages of the ESA-listed species (i.e., sites for spawning, rearing, migration, and foraging) contain PBF essential to the conservation of the listed species (e.g., spawning gravels, water quality and quantity, side channels, or food) (Table 4).

Table 5 describes the geographical extent, within the Snake River, of critical habitat for Snake River spring/summer Chinook salmon and Snake River basin steelhead. Critical habitat includes the stream channel and water column with the lateral extent defined by the ordinary high-water line, or the bankfull elevation where the ordinary high-water line is not defined. In addition, critical habitat for Chinook salmon includes the adjacent riparian zone, which is defined as the area within 300 feet of the line of high water of a stream channel or from the shoreline of standing body of water (58 FR 68543). The riparian zone is critical because it provides shade, streambank stability, organic matter input, and regulation of sediment, nutrients, and chemicals.

Table 4. Types of sites, essential physical and biological features, and the species life stage each PBF supports.

Site	Essential Physical and Biological Features	Species Life Stage
Snake River Basin Steelhead[a]		
Freshwater spawning	Water quality, water quantity, and substrate	Spawning, incubation, and larval development
Freshwater rearing	Water quantity & floodplain connectivity to form and maintain physical habitat conditions	Juvenile growth and mobility
	Water quality and forage[b]	Juvenile development
	Natural cover[c]	Juvenile mobility and survival
Freshwater migration	Free of artificial obstructions, water quality and quantity, and natural cover[c]	Juvenile and adult mobility and survival
Snake River Spring/Summer Chinook Salmon		
Spawning & Juvenile Rearing	Spawning gravel, water quality and quantity, cover/shelter (Chinook only), food, riparian vegetation, space (Chinook only), water temperature and access (sockeye only)	Juvenile and adult
Migration	Substrate, water quality and quantity, water temperature, water velocity, cover/shelter, food[d], riparian vegetation, space, safe passage	Juvenile and adult

[a] Additional PBFs pertaining to estuarine, nearshore, and offshore marine areas have also been described for Snake River steelhead and Middle Columbia steelhead. These PBFs will not be affected by the proposed action and have therefore not been described in this Opinion.
[b] Forage includes aquatic invertebrate and fish species that support growth and maturation.
[c] Natural cover includes shade, large wood, log jams, beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.
[d] Food applies to juvenile migration only.

Spawning and rearing habitat quality in tributary streams in the Snake River varies from excellent in wilderness and roadless areas to poor in areas subject to intensive human land uses (NMFS 2015; NMFS 2017). Critical habitat throughout much of the Interior Columbia basin (which includes the Snake River and the Middle Columbia River) has been degraded by intensive agriculture, alteration of stream morphology (i.e., channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining, and urbanization. Reduced summer streamflows, impaired water quality, and reduction of habitat complexity are common problems for critical habitat in non-wilderness areas. Human land use practices throughout the basin have caused streams to become straighter, wider, and shallower, thereby reducing rearing habitat and increasing water temperature fluctuations.

In many stream reaches designated as critical habitat in the Snake River basin, streamflows are substantially reduced by water diversions (NMFS 2015; NMFS 2017). Withdrawal of water, particularly during low-flow periods that commonly overlap with agricultural withdrawals, often increases summer stream temperatures, blocks fish migration, strands fish, and alters sediment transport (Spence et al. 1996). Reduced tributary streamflow has been identified as a major limiting factor for both Snake River spring/summer Chinook salmon and Snake River Basin steelhead (NMFS 2017).

Table 5. Geographical extent of designated critical habitat within the Snake River for ESA-listed salmon and steelhead.

ESU/DPS	Designation	Geographical Extent of Critical Habitat
Snake River spring/summer Chinook salmon	58 FR 68543; December 28, 1993. 64 FR 57399; October 25, 1999.	All Snake River reaches upstream to Hells Canyon Dam; all river reaches presently or historically accessible to Snake River spring/summer Chinook salmon within the Salmon River basin; and all river reaches presently or historically accessible to Snake River spring/summer Chinook salmon within the Hells Canyon, Imnaha, Lower Grande Ronde, Upper Grande Ronde, Lower Snake-Asotin, Lower Snake-Tucannon, and Wallowa subbasins.
Snake River Basin steelhead	70 FR 52630; September 2, 2005	Specific stream reaches are designated within the Lower Snake, Salmon, and Clearwater River basins. Table 21 in the Federal Register details habitat areas within the DPS's geographical range that are excluded from critical habitat designation.

Many stream reaches designated as critical habitat for these species are listed on the Clean Water Act 303(d) list for impaired water quality, such as elevated water temperature (IDEQ 2011). Many areas that were historically suitable rearing and spawning habitat, such as some stream reaches in the Upper Grande Ronde, are now unsuitable due to high summer stream temperatures. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water for agricultural or municipal use all contribute to elevated stream temperatures. Water quality in spawning and rearing areas in the Snake River has also been impaired by high levels of sedimentation and by heavy metal contamination from mine waste (e.g., IDEQ and EPA 2003; IDEQ 2001).

The construction and operation of water storage and hydropower projects in the Columbia River basin, including the run-of-river dams on the mainstem lower Snake and lower Columbia Rivers, have altered biological and physical attributes of the mainstem migration corridor. These alterations have affected juvenile migrants to a much larger extent than adult migrants. However, changing temperature patterns have created passage challenges for summer migrating adults in recent years, requiring new structural and operational solutions (i.e., cold water pumps and exit "showers" for ladders at Lower Granite and Lower Monumental Dams). Actions taken since 1995 that have reduced negative effects of the hydrosystem on juvenile and adult migrants including:

- Minimizing winter drafts (for flood risk management and power generation) to increase flows during peak spring passage;
- Releasing water from storage to increase summer flows;
- Releasing water from Dworshak Dam to reduce peak summer temperatures in the lower Snake River;
- Constructing juvenile bypass systems to divert smolts, steelhead kelts, and adults that fall back over the projects away from turbine units;

- Providing spill at each of the mainstem dams for smolts, steelhead kelts, and adults that fall back over the projects;

- Constructing "surface passage" structures to improve passage for smolts, steelhead kelts, and adults falling back over the projects; and,

- Maintaining and improving adult fishway facilities to improve migration passage for adult salmon and steelhead.

The proposed action will affect designated critical habitat for SFSR populations of Snake River spring/summer Chinook and Snake River Basin steelhead. The SFSR Chinook salmon population is one of three independent Chinook salmon populations in the SFSR drainage. The other two are the East Fork South Fork (EFSFSR) and the Secesh River populations. The SFSR steelhead population is one of two independent steelhead populations in the SFSR drainage, the other one being the Secesh River steelhead population. The SFSR drainage encompasses approximately 850,320 acres, 99 percent of which is administered by the U.S. Forest Service (USFS), 0.16 percent by the Bureau of Land Management, 0.27 percent is owned by the state of Idaho, and approximately 0.62 percent is privately owned.

Habitat in the SFSR drainage has been severely impacted by historic grazing; historic timber harvest; extensive road building, mostly associated with timber harvest; mining, although mostly confined to the EFSFSR drainage; and wildland fire. Also, topography in the drainage is very steep and soils have high levels of decomposed granite, resulting in habitat that is especially vulnerable to grazing, timber harvest, and road building. This vulnerability was obvious by the 1960s and the USFS implemented a timber harvest and road construction moratorium in 1965, and closed most of the grazing allotments before 1970. The USFS also started implementing habitat restoration actions in the mid-1970s and continues to restore habitat throughout the drainage.

With very little water use on state and federal land, and with only 5,300 acres of private land in the SFSR drainage, water use in the SFSR drainage is very light, likely constituting less than 0.6 percent of the water budget. Much of the water use is concentrated around the community of Yellow Pine, Idaho, in the EFSFSR drainage; in the summer home and recreational developments near Warm Lake, in the upper part of the SFSR drainage; and at the remote ranches along the lower SFSR mainstem. Consequential effects on aquatic resources are generally confined to localized reaches of smaller streams. The vast majority of streams in the SFSR drainage have little or no water development and, consequently, have essentially unimpaired flow regimes.

Summer water temperatures in the SFSR drainage are generally indicative of high quality salmonid habitat (Isaak et al. 2018); however, during most years, summer water temperatures in the lower mainstem SFSR reach levels that can stress rearing Chinook salmon and steelhead (Table 6). Tributary streams in the Salmon River drainage are typically colder than the mainstems and can provide important cold water refugia for salmonids rearing in the mainstems (Curet et al. 2009; Flinders et al. 2013). Information from the USFS Rocky Mountain Research Station NorWeST website (https://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html) indicates that mean August water temperatures in lower SFSR tributaries are 4.1°F (2.3°C) to 8.5° F (4.7° C) colder than the mainstem, suggesting that lower SFSR tributaries, and their plumes, should provide important cold water refugia for rearing Chinook salmon and steelhead. Although water temperatures the SFSR and tributaries may have been impacted by past land uses, all of the information that is currently available indicates that cold water refugia in the lower mainstem SFSR is probably functioning appropriately.

Table 6. Water temperature recorded in the South Fork Salmon River mainstem at river mile 10 (i.e., approximately 3 miles downstream from Smith Creek) from the USFS Rocky Mountain Research Station NorWeST database.

Year	Maximum Daily Temperature		Maximum 7-Day Average Maximum Temperature		Mean August Temperature	
	°C	°F	°C	°F	°C	°F
1999	18.3	65.0	17.9	64.2	15.7	60.2
2000	21.4	70.5	20.8	69.4	16.6	61.9
2001	22.4	72.3	21.6	70.9	18.2	64.8
2003	21.3	70.3	20.4	68.7	17.6	63.6
2004	20.5	68.8	19.8	67.6	16.8	62.3

Elevated levels of fine sediment continue to be an issue throughout the drainage. However, approximately 50 years without large scale grazing, timber harvest, and road building; along with 40 years of active habitat restoration, including road obliteration; has facilitated substantial habitat recovery. Also, although wildland fire has caused short-term adverse impacts, the resultant increased recruitment of large woody debris has improved fish habitat quality throughout much of the drainage. The combined effect of all of these factors has resulted in generally good to excellent quality of Chinook salmon designated critical habitat in the SFSR Chinook salmon population area (NMFS 2017). Because the SFSR steelhead population area also includes the EFSFSR, SFSR steelhead designated critical habitat is more affected by legacy effects historic mining than the SFSR Chinook salmon population. However, due to the factors described above, condition of SFSR steelhead designated critical habitat, outside of the EFSFSR drainage is generally good to excellent (NMFS 2017).

2.2.3 Climate Change Implications for ESA-listed Species and their Critical Habitat

Climate change is affecting aquatic habitat and the rangewide status of Snake River spring/summer Chinook salmon and Snake River Basin steelhead. The U. S. Global Change Research Program reports average warming of about 1.3°F from 1895 to 2011, and projects an increase in average annual temperature of 3.3°F to 9.7°F by 2070 to 2099 (CCSP 2014). Climate change has negative implications for ESA listed anadromous fishes and their habitats in the Pacific Northwest (CIG 2004; Scheuerell and Williams 2005; Zabel et al. 2006; ISAB 2007). According to the Independent Science Advisory Board, these effects will cause the following:

- Warmer air temperatures will result in diminished snowpack and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season;

- With a smaller snowpack, watersheds will see their runoff diminished earlier in the season, resulting in lower flows in the June through September period, while more precipitation falling as rain rather than snow will cause higher flows in winter, and possibly higher peak flows; and,

- Water temperatures are expected to rise, especially during the summer months when lower 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 (including steelhead) and their ecosystems (Mote et al. 2003; Crozier et al. 2008a; Martins et al. 2012; 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. Ultimately, the effects of climate change on salmon and steelhead across the Pacific Northwest will be determined by the specific nature, level, and rate of change and the synergy between interconnected terrestrial/freshwater, estuarine, nearshore, and ocean environments.

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

- Direct effects of increased water temperatures on fish physiology;

- Temperature-induced changes to streamflow patterns;

- Alterations to freshwater, estuarine, and marine food webs; and,

- 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 streamflow variation in freshwater, sea-level rise in estuaries, and upwelling in the ocean. How climate change will affect each stock or population of salmon also varies widely depending on the level or extent of change, the rate of change, and the unique life-history characteristics of different natural populations (Crozier et al. 2008b). For example, a few weeks' difference in migration timing can have large differences in the thermal regime experienced by migrating fish (Martins et al. 2011).

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).

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. 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 (the Salmon River basin in Idaho), survival of some Chinook salmon populations was shown to be determined largely by temperature, while in others it was determined by flow (Crozier and Zabel 2006). Certain salmon populations inhabiting regions that are already near or exceeding thermal maxima will be most affected by further increases in temperature and, perhaps, the rate of the increases. The effects of altered flow are less clear and likely to be basin-specific (Crozier et al. 2008b; Beechie et al. 2013). However, flow is already becoming more variable in many rivers, and this increased variability 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 also to other freshwater fish species in the Columbia River basin.

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 water temperature warming (Wainwright and Weitkamp 2013; Limburg et al. 2016). 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; Wainwright and Weitkamp 2013; Limburg et al. 2016). 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 (Verdonck 2006; Lemmen et al. 2016). 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 (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 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. Preliminary data indicate that some Snake River Basin steelhead smolts actively feed and grow as they migrate between Bonneville Dam and the ocean (Beckman 2018), suggesting that estuarine habitat is important for this DPS.

Marine Effects. 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 (Lucey and Nye 2010; Asch 2015; Cheung et al. 2015). 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 (Pearcy 2002; Fisher et al. 2015). For example, recruitment of the introduced European green crab (*Carcinus maenas*) increased in Washington and Oregon waters during winters with warm surface waters, including 2014 (Yamada et al. 2015). Similarly, the Humboldt squid (*Dosidicus gigas*) dramatically expanded its range northward during warm years of 2004–09 (Litz et al. 2011). The frequency of extreme conditions, such as those associated with El Niño events or “blobs” is predicted to increase in the future (Di Lorenzo and Mantua 2016), further altering food webs and 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 current models.

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. 2015; 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 toward food webs with a strong sub-tropical component (Bakun et al. 2015).

Columbia River anadromous fishes also use coastal areas of British Columbia and Alaska and midocean 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 are normally below thermal optima (Gargett 1997). Warm ocean temperatures in the Gulf of Alaska are also associated with intensified downwelling 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 carbon dioxide 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 that it has the greatest effects on invertebrates with calcium-carbonate shells, and has 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 the influence on marine food webs, especially the effects on lower trophic levels (Haigh et al. 2015; Mathis et al. 2015). Marine invertebrates fill a critical gap between freshwater prey and larval and juvenile marine fishes, supporting juvenile salmon growth during the important early-ocean residence period (Daly et al. 2009, 2014).

Uncertainty in Climate Predictions. There is considerable uncertainty in the predicted effects of climate change on the globe as a whole, and on the Pacific Northwest in particular. 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 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, 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. Climate change is expected to impact anadromous fishes during all stages of their complex life cycle. In addition to the direct effects of rising temperatures, indirect effects include alterations in 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. In additional to physical and biological effects, 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).

Summary. Climate change is expected to impact Pacific Northwest anadromous fishes 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. As we continue to deal with a changing climate, management actions may help alleviate some of the potential adverse effects (e.g., hatcheries serving as a genetic reserve and source of abundance for natural populations, increased riparian vegetation to control water temperatures, etc.).

Climate change is expected to make recovery targets for Chinook salmon and steelhead populations more difficult to achieve. Climate change is expected to alter critical habitat by generally increasing temperature and peak flows and decreasing base flows. Although changes will not be spatially homogenous, effects of climate change are expected to decrease the capacity of critical habitat to support successful spawning, rearing, and migration. Habitat action can address the adverse impacts of climate change on Chinook salmon and steelhead. Examples include restoring connections to historical floodplains and freshwater and estuarine habitats to provide fish refugia and areas to store excess floodwaters, protecting and restoring riparian vegetation to ameliorate stream temperature increases, and purchasing or applying easements to lands that provide important cold water habitat and cold water refugia (Battin et al. 2007; ISAB 2007).

The easement for the Smith Creek Diversion is permanent, and the proposed action will therefore likely occur while climate change-related effects are expected to become more evident within the range of the Snake River spring/summer Chinook salmon ESU and the Snake River Basin steelhead DPS. Flow in Smith Creek is largely dependent on high elevation snow which could increase, on average, due to climate change, but could also become more variable, resulting in lower base flow during droughts. Climate change could therefore reduce or exacerbate the effects of the proposed action.

2.3 Action Area

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

The proposed action is authorization of operation and maintenance of water diversions which will result in diversion and use of water for hydropower production and irrigation. Water diversion for hydropower production will affect flows between the POD and the hydropower outfall. Water diverted for irrigation will reduce flows in all stream reaches downstream from the POD. The maximum reduction in flow, due to the proposed action, is 2.03 cfs, which is less than 1 percent of the lowest flows measured in the reach of the SFSR that would be affected (i.e., downstream from Smith Creek).

The reduction in flow, due to the proposed action, will affect fish habitat in Smith Creek from the POD downstream to the mouth. The flow reduction in Smith Creek will also likely affect cold water refugia in the Smith Creek plume within the SFSR[2]. The action area therefore includes Smith Creek from the POD downstream to the mouth, and the Smith Creek plume in the mainstem SFSR. The action area also includes riparian and stream channel habitat near the PODs that may be affected by maintenance activities. Because the flow reduction is less than one percent of the lowest recorded flow in the SFSR, the action area does not include the mainstem SFSR below the downstream extent of the Smith Creek plume (Tehan 2014).

2.4 Environmental Baseline

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 which are contemporaneous with the consultation in process (50 CFR 402.02).

The proposed action would affect a short reach of Smith Creek and a small portion of the mainstem SFSR at the mouth of Smith Creek. Smith Creek is a tributary of the SFSR that flows into the SFSR from the west at river mile 13.25. Smith Creek is a small stream with a drainage of approximately 6,250 acres. The drainage is steep, with a mean slope of 46 percent, elevations ranging from 2,700 feet to 7,800 feet above mean sea level (msl), and a mean basin elevation of 5,920 feet msl. The stream channel in the action area is relatively steep, with limited spawning habitat.

Except for the Hettinger Ranch near the mouth of Smith Creek, the drainage is undeveloped and the only roads in the drainage are those associated with the Ranch. The portion of Smith Creek flowing through the ranch is in a steep sided canyon and, except for one road crossing, the riparian zone is in good condition, in spite of irrigated pasture within 200 feet of the Creek.

All of the water diversions in the Smith Creek drainage are associated with the proposed action, therefore, flow is unimpaired from the standpoint of baseline conditions. There are no streamflow gage data available for the Smith Creek drainage. Measured streamflow data for Smith Creek are limited to four point measurements; three taken in 2015 and one in 2018 (Table 7). Estimated streamflow for ungaged systems are available from the StreamStats website (https://streamstats.usgs.gov/ss/). Streamflow estimated from StreamStats is also in Table 7. A comparison of the measured flows and flows estimated with StreamStats (StreamStats flows) suggests that StreamStats flows are approximately 30 percent too high during the summer/fall baseflow period, and possibly 50 percent too high during spring runoff.

[2] The precise size of the plume is not known, and it varies in size from year to year, but it likely encompasses approximately 7,200 square feet (670 square meters) within the mainstem SFSR (see Section 2.5.1.3).

Table 7. Eighty percent, 50 percent, and 20 percent mean monthly exceedance flow in Smith Creek, from StreamStats, flow measured in Smith Creek, and mean monthly exceedance flow in the South Fork Salmon River at Krassel during the months that flow measurements were taken in Smith Creek.

Month	Estimated Mean Monthly Flow (cfs) From StreamStats			Actual Flow Measurements		Exceedance of Mean Monthly Flow in the SFSR at Krassel During Measurement
	80% Exceedance	50% Exceedance	20% Exceedance	Date	Flow (cfs)	
January	4.47	5.48	7.04			
February	4.57	5.33	6.57			
March	7.7	8.2	14.2			
April	10.9	24.5	45.6	4/15/2015	9.3	53%
May	36.3	63.1	99.0			
June	37.8	61.3	96.5			
July	10.6	16.2	31.2			
August	5.37	7.51	10.8	8/8/2015	3.2	88%
September	4.18	5.93	7.69	9/25/2018	3.0	79%
October	4.21	5.61	7.73	10/1/2015	2.1	85%
November	4.26	5.79	8.17			
December	4.74	6.14	8.31			

Estimated flows in Table 8 were derived by adjusting flows estimated using StreamStats based on actual flow measurements taken in Smith Creek in 2015 and 2018, and on SFSR streamflow gage data. Because these estimates incorporate modeled flows and actual measured flows, they are likely the best available approximation of actual flows in Smith Creek. Table 8 also includes the Tennant (1976) classification of flow quality.

Table 8. Eighty percent, 50 percent, and 20 percent mean monthly exceedance flow in Smith Creek estimated using StreamStats, actually flow measurements in Smith Creek in 2015 and 2018, and streamflow gage data from the SFSR near Krassel gage (USGS 13310700); and quality of flow classified as described in Tenant (1976).

Month	80% Exceedance		50% Exceedance		20% Exceedance	
	cfs	Tennant (1976) classification	cfs	Tennant (1976) classification	cfs	Tennant (1976) classification
January	3.1	Good	3.8	Excellent	4.9	Outstanding
February	3.2	Good	3.7	Excellent	4.6	Outstanding
March	3.9	Excellent	4.1	Excellent	7.1	Optimum
April	5.5	Excellent	12.3	Optimum	22.8	Flushing or max
May	18.2	Optimum	31.6	Flushing or max	49.5	Flushing or max
June	18.9	Optimum	30.7	Flushing or max	48.3	Flushing or max
July	5.3	Good	8.1	Excellent	15.6	Optimum
August	3.8	Fair or degrading	5.3	Good	7.6	Optimum
September	2.9	Poor or minimum	4.2	Fair or degrading	5.4	Good
October	2.9	Good	3.9	Excellent	5.4	Outstanding
November	3.0	Good	4.1	Excellent	5.7	Outstanding
December	3.3	Excellent	4.3	Excellent	5.8	Outstanding
Mean annual discharge			10.9			

Assuming the estimated flows in Table 8 are accurate, unimpaired flow conditions in Smith Creek, described in terms of Tennant (1976) are:

- “Good” or better, during an 80 percent exceedance year, for every month except August and September when they are “Fair or degrading” and “Poor or minimum,” respectively.

- “Excellent” or better, during a 50 percent exceedance year, for every month except August and September when they are “Good” and “Fair or degrading,” respectively.

- “Outstanding” or better during a 20 percent exceedance year, for every month except September when they are “Good.”

Although flow data are limited, the available information suggests that the flow regime in Smith Creek is typical for perennial streams in the SFSR drainage and is sufficient to support year-round occupancy by salmonids.

During 5 years of temperature monitoring in Smith Creek (i.e., 2012, 2013, 2014, 2015, 2018), the maximum temperature recorded was approximately 64°F (18°C) and during 3 of the 5 years, the maximum temperatures recorded were less than 60°F (15.5°C). Unfortunately, these data are in graphical form, making calculation of averages difficult, but, although imprecise, the data indicate that the water temperature regime in lower Smith Creek is near optimal for rearing salmonids and may actually be slightly below optimal during most years. These cool temperatures at the relatively low elevation of lower Smith Creek (i.e., approximately 2,800 feet msl) are probably a result of water flowing from high to low elevation over a relatively short distance, a high degree of shading due to steep topography (i.e., canyon reaches), and shading from a healthy riparian zone.

Mean monthly flow in the lower SFSR ranges from 544 cfs in September to 7,057 cfs in July. The maximum and minimum flows recorded during the period of record (i.e., October 1993 to September 2003) were 21,600 cfs and 139 cfs, respectively (U.S. Geological Survey Gage 13314300). There are approximately 31.5 cfs of water rights in the SFSR drainage, approximately a third of which are for small hydropower facilities that do not result in consumptive use. Assuming that the remainder are used for irrigation, then total impact on the lower mainstem SFSR would be approximately seven cfs, or approximately 1.2 percent of the normal base flow. These data indicate that impacts of water diversion and use on flow within the mainstem SFSR portion of the action area, are very light.

Based on temperature data from nearby reaches upstream and downstream from the action area, summer water temperatures in the mainstem SFSR portion of the action area probably reach levels that stress rearing salmonids (NorWest website[3]). During most years, maximum water temperature exceeds 21°C (70°F) and 7-day average daily maximum temperatures exceed 20°C (68°F) for a period of time during the summer. Although the data are limited, they suggests that water temperatures at the mouth may be slightly cooler than in some upstream reaches. This is possibly due to the effects of lower SFSR tributaries, such as Smith Creek, that typically flow from high to low elevations over a relatively short distance. However, even with this cooling

[3] https://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html

effect, water temperatures in the lower SFSR mainstem regularly reach levels that would prompt rearing salmonid to seek temperature refugia, and the Smith Creek plume may therefore constitute important rearing habitat.

Summary of Baseline Conditions. Habitat in Smith Creek is probably in a near natural condition with flow and water temperatures that are conducive to salmonid rearing. Habitat in the mainstem SFSR portion of the action area is also in a near natural condition although flow has probably been slightly reduced. Summer water temperature in the mainstem SFSR portion of the action area are probably sufficiently warm to prompt rearing salmonids to seek temperature refugia, possibly in Smith Creek and/or in the Smith Creek plume within the mainstem SFSR.

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.

2.5.1 Effects on Listed Species

The proposed actions are: (1) Issuance of an SUP for authorizing O&M of the Spring Diversion; and, (2) issuance of an updated O&M plan for the Smith Creek Diversion. Operation of the Spring Diversion will result in diversion of up to 0.03 cfs during any time of the year. Operation of the Smith Creek Diversion will result in diversion of up to 2.0 cfs during the irrigation season and 1.5 cfs during the remainder of the year. Rearing juvenile steelhead have been documented in Smith Creek via snorkel surveys conducted in 1999, 2015, and 2018, and in an environmental deoxyribonucleic acid (eDNA) sample taken in 2018. Steelhead redd surveys have not been conducted in Smith Creek, but consistent presence of juveniles suggests that Smith Creek could also be used by spawning and migrating adult steelhead. Chinook salmon were not seen during the Smith Creek snorkel surveys and the eDNA sample taken in 2018 was negative for Chinook salmon. Both Chinook salmon and steelhead are present in the mainstem SFSR near the mouth of Smith Creek.

Maintenance of the Diversions will likely result in minor impacts on riparian and stream channel habitat. Failure of the Spring Diversion could result in minor impacts on riparian and stream channel habitat and failure of the Smith Creek Diversion could result in major impacts. Operation of the Diversions will result in reduced flows in Smith Creek and in the mainstem SFSR. Detailed descriptions of the effects of O&M of the Diversions on Chinook salmon and steelhead are in Sections 2.5.1.1–2.5.1.4.

2.5.1.1 Effects on Flow of Operating the Spring and Smith Creek Diversions

Operation of the Spring Diversion will result in diversion of up to 0.03 cfs from a spring that flows into Smith Creek approximately 0.5 miles upstream from the SFSR. The diverted water will be used for domestic purposes, including watering lawns around the ranch buildings, and possibly for watering stock near the ranch buildings. The Diversion will be used year-round, but during most of the year, use will be intermittent and the amount of water diverted will usually be less than 0.03 cfs. However, during the summer months, use will be greater, possibly approaching 0.03 cfs much of the time, due to the need for lawn irrigation. Operating the Spring Diversion will reduce flow in Smith Creek downstream from the POD and will reduce amount of water available for cold water refugia in the SFSR.

Operation of the Smith Creek Diversion will result in diversion of up to 2.0 cfs when the water is being used for irrigation, or up to 1.5 cfs when the water is used for hydropower generation only. Water can be used for irrigation from March 15 through October 31 but past monitoring indicates that irrigation usually does not begin until late April and is usually over by mid-September. The monitoring also indicates that amount of water diverted during irrigation is typically somewhat less than 2.0 cfs, the amount diverted when irrigation is not occurring is approximately 1.0 cfs, and total diversion for the year is less than 930 acre feet[4]. When the water is used for irrigation, operating the Smith Creek Diversion will affect flow in Smith Creek from the Diversion downstream to the mouth (approximately 0.65 miles) and in the SFSR portion of the action area. When water is used for hydropower generation only, flows will be reduced in Smith Creek from the POD downstream to the hydropower outfall (approximately 0.30 miles), but will not be reduced in the lower 0.35 miles of Smith Creek or in the SFSR mainstem.

During the irrigation season, water is transmitted from the Smith Creek Diversion to the powerhouse where a portion of it is used for power generation, then all of it is typically transferred to the irrigation system instead of immediately returning back to Smith Creek. A portion of the water used for irrigation flows back to the streams and a portion is consumptively used and is removed from the water budget. Irrigation of 82 acres of grass hay results in consumptive use of approximately 164 acre feet per year, or 0.42 cfs spread evenly across the irrigation season. The remainder of the diverted water (approximately 1.1 to 1.6 cfs) would eventually return to the system as subsurface flow[5]. Due to the location of the fields adjacent to the SFSR, we assume that the vast majority of diverted water that is not consumptively used would return to the SFSR and not to Smith Creek. Therefore, from late April through mid-September the proposed actions will result in reduction of flow by 1.5 to 2.03 cfs in the lower 0.65 miles of Smith Creek and by approximately 0.42 cfs in the SFSR. This reduction in flow will affect steelhead in Smith Creek and Chinook salmon and steelhead in the Smith Creek plume in the SFSR. From mid-September through late April, the proposed actions will reduce flow in Smith Creek between the Smith Creek Diversion and the hydropower outfall by approximately 1.0 cfs. This reduction in flow will affect steelhead in Smith Creek but will have little or no effect on fish or habitat in the SFSR.

---

[4] One cubic feet per second for 24 hours equals a volume of 1.98 acre feet. Diversion of the maximum allowable rate (i.e., 2.0 cfs during the irrigation season 1.5 cfs outside of the irrigation season) for 1-year would result in a total diversion of 1,315 acre feet. During the four years for which monitoring data are available, volume of water diverted from the Smith Creek Diversion ranged from 822 to 925 acre feet (average = 887).

[5] Irrigation water that is not consumptively used can also return as surface flow; however, due to the high levels of decomposed granitics in the soils characteristic of the SFSR, and because all of the irrigation is via sprinklers, surface flow of unused irrigation water back to Smith Creek or the SFSR is unlikely.

2.5.1.2 Effects on Steelhead in Smith Creek

Maintenance of the Diversions could result in effects on riparian and stream channel habitat, but due to the minimization measures described in the BA, these effects should be very minor. Failure of the Spring Diversion could cause minor effects on riparian habitat and failure of the Smith Creek Diversion could cause major adverse effects, but given adequate maintenance of the water transmission facilities, chance of failure of either diversion should be very small. Operation of the Spring Diversion is not likely to entrain steelhead because steelhead are not likely to be present near the POD. Juvenile steelhead could be entrained in the Smith Creek Diversion. However, this diversion has been screened to NMFS' standards since 2010, it is maintained regularly, there have been no apparent problems, and it does not require fish to go through a bypass system that can delay migration. We therefore do not anticipate entrainment or delay of juvenile steelhead. Also, because the Diversion and screen was designed so as to not impair upstream fish passage, and because adult steelhead migrate when flows are high, we do not anticipate operation of the Smith Creek Diversion to impair upstream migrating adult steelhead.

The proposed actions will reduce flow in Smith Creek. The affected portion of Smith Creek is rearing and migration habitat for juvenile steelhead, is likely migration habitat for adult steelhead, and may be steelhead spawning habitat. Studies have shown that year class strength of salmonid populations is positively related to streamflow (Ricker 1975; Mathews and Olson 1980; Mitro et al. 2003; Elliott et al. 1997; Nislow et al 2004; Arthaud et al. 2010; Beecher et al. 2010). A review of 46 studies found that salmonid demography was usually positively, and was never negatively, related to summer flow (Kovach et al. 2016). Arthaud et al. (2010) determined that streamflow affected year class measured as outmigrating juveniles, which in turn affected number of returning adults, resulting in a relationship of rearing streamflow and whole life cycle productivity. Because of size, the adult life stages of anadromous salmonids are often perceived to be the most limiting with respect to streamflow. However, the available literature indicates that flow during the rearing life stages is often a limiting factor (Mathews and Olson 1980; Mitro et al. 2003; Elliott et al. 1997; Nislow et al 2004; Arthaud et al. 2010; Beecher et al. 2010) and can be the primary limiting factor (Mathews and Olson 1980; Elliott et al. 1997; Arthaud et al. 2010; Beecher et al. 2010).

Snake River Basin steelhead spend the entire juvenile rearing phase of their life cycles in stream habitats and must procure all food needed to survive and grow in that habitat. Food availability for stream dwelling salmonids is generally positively related to streamflow across the entire range of base flows (Harvey et al. 2006; Hayes et al. 2007; Davidson et al. 2010) and this relationship can extend into spring (i.e., higher) flows (Davidson et al. 2010). In addition to base flows, high flow can also be important for stream dwelling salmonids as juveniles grow measurably faster when flows inundate floodplains and promote higher production of invertebrates (Jager 2014). Reducing streamflow, and the resultant reduction in food availability, reduces individual growth (Harvey et al. 2006) and population productivity (Nislow et al. 2004) of stream dwelling salmonids. In addition to food, juvenile stream dwelling anadromous salmonids must have access to instream object cover and in-water escape cover to rear successfully (Hardy et al. 2006); and reducing flow generally reduces access to escape cover (Hardy et al. 2006a). Reduction in streamflow caused by surface water diversions can also result in long-term increases in fine sediments in stream substrates (Baker et al. 2011) and increased summer water temperature (Rothwell and Moulton 2001; Tate et al. 2005; Miller et al. 2007), both of which can adversely affect rearing steelhead.

The available literature, described above, indicates that reducing flow in Smith Creek will reduce quality of steelhead habitat in Smith Creek. In 1999, the IDFG conducted a flow/habitat study in Smith Creek (Reid et al. 2000). This study evaluated flows between one and five cfs based on modeled depth and velocity, and habitat suitability developed using frequency of use data. Flow/habitat studies based on water depth, water velocity, and habitat suitability from frequency of use data, are not typically reliable predictors of salmonid standing stock (Shirvell 1986; Conder and Annear 1987; Bourgeois et al. 1996) or productivity (Irvine et al. 1987; Beecher et al. 2010), nevertheless, the IDFG study indicated that at any flow less than five cfs, a reduction would reduce quality of steelhead habitat. Tennant (1976) introduced a method for qualitatively describing flow conditions for stream dwelling salmonids over the range of flows typically seen in northern Rocky Mountain streams. Flow-related habitat quality in Smith Creek, under the flow regime expected with the proposed action, is in Table 9. A comparison of Table 9 to flow-related habitat quality in Smith Creek without the proposed action (Table 8 in Section 2.4) indicates that the proposed action will affect steelhead through reductions in habitat quality in Smith Creek. The available literature, the IDFG flow/habitat study, and a Tennant (1976) evaluation of flows indicates that the proposed action will affect steelhead by reducing habitat quality in Smith Creek. As described above, the available literature also indicates that flow-related reduction in habitat quality, due to the proposed action, will reduce growth and survival of juvenile steelhead rearing in Smith Creek.

Table 9. Estimated mean monthly flows and Tennant (1976) classification of conditions in Smith Creek between the Diversion and the hydropower outfall (October–March) and between the Diversion and the confluence of Smith Creek and the SFSR (April–September).

Month	80% Exceedance		50% Exceedance		20% Exceedance	
	cfs	Tennant (1976) classification	cfs	Tennant (1976) classification	cfs	Tennant (1976) classification
January	2.1	Fair to degrading	2.8	Good	3.9	Excellent
February	2.2	Good	2.7	Good	3.6	Excellent
March	2.9	Good	3.1	Good	6.1	Outstanding
April	3.5	Fair to degrading	10.3	Optimum	20.8	Optimum
May	16.2	Optimum	29.6	Flushing or max	47.5	Flushing or max
June	16.9	Optimum	28.7	Flushing or max	46.3	Flushing or max
July	3.3	Fair to degrading	6.1	Excellent	13.6	Optimum
August	1.8	Poor or minimum	3.3	Fair to degrading	5.6	Excellent
September	1.0	Severe degradation	2.2	Poor or minimum	3.4	Fair to degrading
October	1.9	Fair to degrading	2.9	Good	4.4	Outstanding
November	2.0	Fair to degrading	3.1	Good	4.7	Outstanding
December	2.3	Good	3.3	Excellent	4.8	Outstanding
Mean annual discharge			10.9			

In one of the few studies of the effects of reducing flow on steelhead biomass and growth in small streams, Harvey et al. (2014) found that a 24 percent reduction in dry season (June–October) flow resulted in a 5 percent to 10 percent (depending on the model) reduction in juvenile steelhead biomass. The average reduction in dry season flow, due to the proposed action, will be 29.5 percent. Assuming that impacts on steelhead are proportional to flow reduction, the proposed action would reduce steelhead biomass in the affected reaches of Smith Creek by 6.1 percent to 12.2 percent, or 9.2 percent, assuming an average of both models.

There have been three snorkel surveys conducted in Smith Creek. The first survey (Reid et al. 2000), conducted in 1999, identified 20 juvenile steelhead and one juvenile cutthroat trout (*O. clarkii*) rearing between the Smith Creek Diversion and the mouth. This survey did not identify any fish in riffle habitat and therefore concentrated on pool habitat. Although it was not clearly stated, the survey may have sampled most of the pools between the Diversion and the mouth. The second survey (Sister Rivers Ranches Co. 2016), conducted in 2015, sampled three sites between the Diversion and the mouth, identified 19 juvenile steelhead, and calculated a density of 5.4 fish per100 square meters. Unfortunately, this study did not state the type of habitat sampled, but we assume that only pool habitat was sampled. The third survey was conducted by the PNF in 2018 and determined that either juvenile steelhead or cutthroat trout were present but did not record size, number, or density of fish. Reid et al. (2000) identified approximately 5,432 square feet (503 square meters) of pool habitat downstream from the Diversion. Assuming 5.4 steelhead per100 square meters, there would be approximately 27 juvenile steelhead rearing in Smith Creek between the Diversion and the mouth. Although it is difficult to compare the studies, a population of 27 rearing steelhead is probably consistent with the findings of Reid et al. (2000). We therefore presume that approximately 27 steelhead rear in Smith Creek between the Diversion and the mouth and that reduction of flow, due to the proposed action, reduces steelhead rearing in this reach by approximately 9.2 percent, or by approximately three juvenile steelhead.

2.5.1.3 Effects on Chinook salmon and Steelhead in the SFSR

Small tributary streams are an important source of invertebrate foods for rearing salmonids (Wipfli and Gregovich 2002; Wipfli et al. 2007; Wipfli and Baxter 2010) and areas below tributary streams may be important for foraging. However, Flinders et al. (2013) determined that salmonid preference for plume habitat was dependent on temperature differential between plume and non-plume mainstem habitat, suggesting that the primary function was as cold water refugia. We therefore assumed that the primary function of Smith Creek tributary plume habitat, for rearing juvenile Chinook salmon and steelhead, is cold water refugia.

Reducing flow in Smith Creek during summer would presumably reduce the amount of cold water refugia available for juvenile rearing Chinook salmon and steelhead. Information needed to precisely quantify impacts of reducing flow on cold water refugia is not available and we therefore relied on a number of assumptions that were based on the information that is available, the best scientific information derived from scientific literature, and our professional expertise. Cold water refugia in tributary plume habitat is related to “surplus” water (i.e., proportion of the water budget that is not consumptively used) (Ebersole et al. 2014). We therefore assumed that reduction in cold water refugia in the Smith Creek plume would be directly proportional to the reduction in “surplus” water.

In the absence of precipitation and snowmelt data for the Smith Creek drainage, we assumed that estimated flow at the mouth of Smith Creek was a reasonable approximation of mean water surplus without the proposed action, and estimated flow minus consumptive use due to the proposed action is a reasonable approximation of water surplus with the proposed action. Under these assumptions, irrigation resulting from the proposed action would reduce water "surplus" in Smith Creek by 9.5 percent during July–September. Assuming that amount of cold water refugia is proportional to water surplus, the proposed action would reduce cold water refugia in the SFSR at the confluence of Smith Creek by 9.5 percent.

Information on density of rearing Chinook salmon and steelhead in tributary plumes in the mainstem SFSR is lacking, but fish density data, derived from snorkel surveys, are available for non-plume habitat in the SFSR and there is one study of salmonid use of tributary plume habitat in the Middle Fork Salmon River (i.e., Flinders et al. 2013). Snorkel survey data collected between 1986 and 2012 at the two sampling sites closest to Smith Creek (i.e., approximately 1.4 miles upstream and 1.95 miles downstream) found average densities of 0.31 Chinook salmon and 0.35 steelhead per 100 square meters. Flinders et al. (2013) found that salmonid density in tributary plume habitat in the lower Middle Fork Salmon River was 1.9 times high as in non-plume habitat. We therefore assume that density of juvenile Chinook salmon and steelhead in the Smith Creek plume is approximately 0.59 per 100 square meters and 0.67 per 100 square meters, respectively. Information on size of the Smith Creek plume is not available, but IDFG snorkeled plume habitat in the upper Salmon River and determined that the plume of a comparable size tributary was 7,143 square feet (665 square meters). Assuming the Smith Creek plume habitat is approximately the same size (i.e., 7,143 square feet [665 square meters]), approximately four juvenile Chinook salmon and five juvenile steelhead would utilize cold water refugia in the Smith Creek plume. Assuming the proposed action reduces cold water refugia in the Smith Creek plume by 9.5 percent, approximately 0.37 Chinook salmon and 0.42 steelhead, an average of one Chinook salmon every 3 years and one steelhead every 2 years, would be displaced from cold water refugia by the proposed action. Fish displaced from cold water refugia may be forced to rear in areas of higher water temperature which could reduce growth and survival. For purposes of this analysis, we assume a worst-case scenario of no survival of fish displaced from cold water refugia.

2.5.1.4 Summary of Effects on Chinook Salmon and Steelhead

Effects of maintaining the Diversions on habitat should be very minor and will not likely result in mortality of Chinook salmon or steelhead. Chance of diversion failure is small and therefore chance of adverse effects due to diversion failure is also small. Operating the Diversions is not likely to entrain Chinook salmon or steelhead or impair upstream passage of adults. Operating the Diversions will reduce flow in steelhead rearing habitat and will reduce cold water refugia for steelhead and Chinook salmon. These flow-related effects will likely result in mortality of an average of three juvenile steelhead annually, and 0.37 juvenile Chinook salmon annually, or one Chinook salmon every 3 years. Based on a smolt to adult return rate of 1.58 percent and 1.1 percent (Tuomikoski et al. 2013), respectively, for steelhead and Chinook salmon, adverse effects due to the proposed action will reduce steelhead and Chinook salmon adult returns by 0.005 and 0.0004, respectively. This reduced production will occur for as long as the Diversions operate.

2.5.2 Effects on Designated Critical Habitat

The entire action area is designated critical habitat for steelhead and Chinook salmon. The SFSR steelhead population is needed for recovery of the Snake River Basin steelhead DPS and the SFSR Chinook salmon population is needed for recovery of the Snake River spring/summer Chinook salmon ESU. Because these populations are necessary for recovery, actions that alter the PBFs essential to their conservation, or that preclude or significantly delay development of such features, may lead to a conclusion that the actions will destroy or adversely modify designated critical habitat.

2.5.2.1 Non-Flow Effects of the Proposed Actions on Riparian and Stream Channel Habitat

Operation and maintenance of the Spring and Smith Creek Diversions could result in physical damage to Chinook salmon and steelhead designated critical habitat in Smith Creek. The following bullets describe effects that could occur:

- Maintenance of the diversions with hand tools or heavy equipment could damage riparian vegetation and streambanks. Damage to riparian vegetation and streambanks could reduce shade and increase water temperature, increase sediment delivery and deposition, and reduce quality and quantity of instream habitat suitable for rearing salmonids.

- Water transmission pipes sometimes fail and, if not immediately addressed, the failure can cause mass wasting into the stream, which would reduce quality and quantity of habitat suitable for rearing salmonids.

Primary impacts on Chinook salmon and steelhead designated critical habitat, resulting from habitat damage described in these bullets, would be due to reduced riparian habitat function and increased sediment delivery/deposition. Reduced riparian habitat function and increased sediment deposition could result in: (1) Wider, shallower stream channels; (2) reduced production of invertebrate foods; and (3) increased water temperatures. These impacts would affect rearing PBFs for Chinook salmon, and spawning and rearing PBFs for steelhead designated critical habitat in Smith Creek.

The SUP and Easement terms and conditions described in the BA require: (1) Any leakage due to malfunctioning diversion equipment will be repaired a soon as possible to prevent streambank washout or erosion and avoid sediment deposition in streams; (2) any ground disturbance due to maintenance of diversion equipment will be mitigated with a high level of erosion control to prevent erosion and subsequent sediment deposition into streams; (3) USFS approval prior to use of heavy equipment; and (4) control of noxious weeds. These terms and conditions will reduce the chance that adverse impacts described above will occur, and will reduce the magnitude of the impacts should any occur. Because both risk and magnitude of adverse impacts due to maintenance of the Diversions or failure of water transmission pipes should be effectively minimized, NMFS anticipates minimal degradation of PBFs due to non-flow related effects of the proposed actions.

2.5.2.2 Flow Effects on Designated Critical Habitat in Smith Creek

The proposed action would reduce flow in Smith Creek between the Smith Creek Diversion POD and the SFSR by up to 2.03 cfs during the irrigation season, and between the Smith Creek Diversion POD and the hydropower outfall by up to 1.5 cfs during the remainder of the year. The primary effect of this reduction in flow would be on water quantity for steelhead rearing, migration, and possibly spawning; and for Chinook salmon rearing. However, because flow influences access to cover, food production, substrate quality, water quality etc., (see Section 2.5.1.2) the secondary effects of reducing flow could potentially affect other PBFs listed in Table 4. Expressed qualitatively in terms of Tennant (1976), the reduction in flow will reduce the time that the affected portion of Smith Creek has “Excellent” or better flows from 75 percent to 44 percent, and will increase the time that it has “Fair or Degrading” flows from 5.5 percent to 19 percent. Expressed quantitatively, based on findings of Harvey et al. (2014), the degradation of steelhead PBFs in Smith Creek will reduce steelhead production by approximately three juveniles annually. Although Chinook salmon have not been documented in Smith Creek, they may occasionally rear, or utilize cold water refugia, in lower Smith Creek. However, because Chinook salmon use of habitat in Smith Creek is likely intermittent, the degradation of habitat quality in Smith Creek, due to the proposed action, will have a very small overall effect on Chinook salmon PBFs.

2.5.2.3 Cold Water Refugia-related Effects of the Proposed Actions on Designated Critical Habitat

The proposed action will affect cold water refugia in the Smith Creek plume in the mainstem SFSR. Summer water temperature in the SFSR portion of the action area is regularly high enough to stress Chinook salmon and steelhead, while water temperature in Smith Creek is near optimum, or possibly even below optimum, for rearing salmonids. This suggests that the Smith Creek plume likely constitutes important cold water refugia for rearing Chinook salmon and steelhead. Cold water refugia is important for rearing anadromous salmonids, facilitating rearing in habitat that may otherwise be unsuitable (Nielsen and Lisle 1994; Belchik 1997). Juvenile Chinook salmon and steelhead rear in the lower SFSR mainstem and likely take advantage of cold water refugia in the Smith Creek plume. The proposed action will reduce summer flow in Smith Creek, which will reduce the amount of cold water refugia in the SFSR at the mouth of Smith Creek by approximately 9.5 percent. This reduction of cold water refugia will degrade the water quality PBFs for juvenile Chinook salmon and steelhead, reducing Chinook salmon and steelhead production by approximately 0.37 and 0.42 juveniles, respectively.

2.5.2.4 Summary of Effects of the Proposed Action on Chinook Salmon and Steelhead Designated Critical Habitat

The SUP and Easement terms and conditions should reduce adverse effects of water diversion maintenance activities to minimal levels and should minimize the chance of adverse effects due to pipe failure. Potential non-flow related effects of the proposed action would therefore not likely reduce the conservation value of Chinook salmon or steelhead designated critical habitat. The reduction of flow in Smith Creek, due to the proposed action, will adversely affect PBFs for steelhead and Chinook salmon, but the overall effect on Chinook salmon designated critical habitat will be very small. The reduction of flow in Smith Creek will reduce the amount of cold water refugia in the SFSR at the mouth of Smith Creek by approximately 9.5 percent, adversely affecting water quality PBFs for rearing steelhead and Chinook salmon.

2.6 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation (50 CFR 402.02). Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA. The entire action area consists of land managed by the PNF and private land owned by the permittee (Hettinger Ranch). Activities on private land that have the most effect on aquatic resources, such as irrigated agriculture and hydropower production, are interrelated and interdependent to the proposed action and the effects of those activities are analyzed in Section 2.5. Activities on private land that are not interrelated and interdependent to federal actions, such as minor road and bridge maintenance, are ongoing, will not likely change appreciably, and therefore are not likely to result in changes to the baseline conditions. Because activities on private land in the action area are largely dependent on federal actions, any changes in those activities that would likely affect ESA-listed species should be interrelated and interdependent to future federal actions and will require separate ESA section 7 consultation.

Some continuing non-federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult if not impossible to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline *vs.* cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline (Section 2.3).

2.7 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's Opinion as to whether the proposed action is likely to: (1) 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 diminishes the value of designated or proposed critical habitat for the conservation of the species.

As previously described, up to an annual average of 0.37 juvenile Chinook salmon and three juvenile steelhead might be killed due to reduced habitat quality in Smith Creek and reduced cold water refugia in the SFSR. This reduction in juvenile abundance translates to an average annual reduction of 0.0004 adult Chinook salmon and 0.005 adult steelhead returns. Compared to typical adult returns of 1,200 Chinook salmon and 768 steelhead, reduction in production due to the proposed action represents less than 0.0001 percent and 0.001 percent of the SFSR

Chinook salmon and SFSR steelhead populations, respectively. This effect will occur for as long as the Diversions are operated.

The SFSR steelhead population is not meeting VSP criteria. Because the potential reduced productivity, due to the proposed action, is very small, it will not likely influence the number of adult steelhead returning to the SFSR for the foreseeable future. Therefore, the proposed action should not influence the abundance, productivity, spatial structure, or genetic diversity of the SFSR steelhead population. Considering the existing condition of the environmental baseline and the lack of potential cumulative effects, NMFS has determined that the loss of no more than three juvenile steelhead per year, due to the proposed action, should not appreciably reduce the likelihood that the SFSR steelhead population will achieve its desired status. Because the effects will not be substantial enough to negatively influence VSP criteria at the population scale, the proposed action would also not likely reduce viability of the Salmon River MPG. For this reason, it will also not likely reduce the likelihood of the survival and recovery of the Snake River Basin steelhead DPS.

The SFSR Chinook salmon population is not meeting VSP criteria. The proposed action could result in mortality of an annual average of 0.37 juvenile Chinook salmon, which would not likely reduce the number of Chinook salmon adult returns for the foreseeable future. Considering the existing condition of the environmental baseline and the lack of potential cumulative effects, NMFS has determined that the displacement of juveniles from cold water refugia, due to the proposed action, should not appreciably reduce the likelihood that the SFSR Chinook salmon population will achieve its desired status. Because the effects will not be substantial enough to negatively influence VSP criteria at the population scale, the proposed action would also not likely reduce viability of the SFSR MPG. For this reason, it will also not likely reduce the likelihood of the survival and recovery of the Snake River spring/summer Chinook salmon ESU.

The proposed action will have adverse effects on all of the Chinook salmon and steelhead freshwater rearing PBFs. However, the adverse effects will be small and will be confined to lower Smith Creek and the Smith Creek plume in the SFSR. The majority of the action area is on land managed by the PNF, and no additional state or private activities are likely to occur on Hettinger Ranch, the only private land in the action area. Coupling the potential effects of the proposed action with the baseline condition and cumulative effects within the action area, NMFS concludes that the proposed action is not likely to appreciably diminish the function and conservation role of the PBFs within the action area. Because the function and conservation value of PBFs will not be appreciably reduced in the action area, they will also not be appreciably reduced at the designation scale.

2.8 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' Opinion that the proposed action is not likely to jeopardize the continued existence of Snake River spring/summer Chinook salmon and Snake River Basin steelhead; and is not likely to destroy or adversely modify Chinook salmon or steelhead designated critical habitat.

2.9 Incidental Take Statement

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

2.9.1 Amount or Extent of Take

The proposed action is reasonably certain to result in incidental take of ESA-listed species. NMFS is reasonably certain that incidental take described here will occur because: (1) The proposed action will reduce flow in the lower 0.65 miles of Smith Creek during the irrigation season and will reduce flow between the Smith Creek Diversion and the hydropower outfall during all other times of the year; (2) the affected reaches of Smith Creek are occupied steelhead rearing habitat; (3) reducing flow in steelhead rearing habitat reduces growth and survival of rearing steelhead; (4) the proposed action will increase consumptive use of water in the Smith Creek drainage, which will reduce cold water refugia in the lower mainstem SFSR; (5) the lower mainstem SFSR is used by rearing Chinook salmon and steelhead year round, including during summer when water temperatures are high enough to stress salmonids.

The take exempted by this ITS is the loss of Snake River Basin steelhead and Snake River spring/summer Chinook salmon from these circumstances. NMFS has quantified an average annual reduction in production, due to the proposed action, of three juvenile steelhead and 0.37 juvenile Chinook salmon. However, changes in production cannot be monitored sufficiently to ensure that amount and extent of take is not exceeded. This is because: (1) Steelhead population estimates are derived from data collected at Lower Granite Dam and lack the precision needed to monitor small production changes; (2) information on number of Chinook salmon are limited to redd counts and screw trap data which lack the precision to detect changes of the scale anticipated due to the proposed action; (3) population density of Chinook salmon and steelhead varies greatly from year to year; and (4) fish harmed due to increased environmental stress caused by the proposed actions would be difficult to distinguish from fish harmed due to environmental stress that normally occurs or that is caused by baseline actions. Even if take that occurred within the action area could be adequately quantified, monitoring total take due to the proposed actions would still not be feasible because some mortality due to effects of the proposed actions in action area is likely to occur during the downstream migration or in the estuary. This is because fish growth is related to streamflow (Harvey et al. 2006; Davidson et al. 2010), so reducing streamflow in rearing habitat likely reduces size of downstream migrating smolts. Smaller smolts have higher mortality outside of the natal tributaries (Zabel and Achord 2004), which results in lower smolt-to-adult return rates.

When take cannot be adequately quantified, NMFS describes the extent of take through the use of surrogate measures of take that would define the limits anticipated in this Opinion. In this case, the extent of take will be described as the amount of water diverted and the amount of water remaining in Smith Creek. These parameters are acceptable surrogates for take due to the proposed action because they can be measured accurately and are directly related to the effect of the proposed action on anadromous salmonids and their habitat.
Because reduction of streamflow is the principal mechanism for take from the proposed actions, and the amount of take cannot be quantified with available information, NMFS uses the causal link established between the activity and a change in habitat conditions affecting the species to represent the extent of take. The extent of take exempted by this ITS will be exceeded if in any given year: (1) Water diverted due to the proposed action exceeds 2.1 cfs during the irrigation season (March 15 through October 31); (2) water diverted due to the proposed action exceeds 1.5 cfs outside of the irrigation season; (3) amount of water diverted during the calendar year exceeds 940 acre feet; or (4) there is any indication that flows immediately downstream from the Smith Creek diversion are less than 1.0 cfs at any time. Numbers 1 and 2 are coextensive with the proposed action but still serve as effective reinitiation triggers because the monitoring requirements will provide adequate opportunities to check through the course of the action whether the surrogates are being exceeded.

2.9.2 Effect of the Take

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

2.9.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" are nondiscretionary measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR 402.02). NMFS believes that full application of conservation measures included as part of the proposed action, together with use of the RPMs described below, are necessary and appropriate to minimize the impact of incidental take of listed species due to implementation of the proposed action.
The PNF and the permittee shall:

1. Minimize chance of entrainment on the Smith Creek Diversion screen.

2. Minimize take due to reducing flow in steelhead and Chinook salmon habitat.

3. Ensure completion of a monitoring and reporting program to confirm that the terms and conditions of this ITS are effective in avoiding and minimizing incidental take from permitted activities and ensure that incidental take is not exceeded.

2.9.4 Terms and Conditions

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

1. The following terms and conditions implement RPM 1 (minimize chance of entrainment):

    a. The permittee will monitor and maintain the screen and all of the diversion and water transmission structures to ensure that they function as designed and have minimal chance of failure.

    b. The permittee will clean debris off of the Smith Creek Diversion screen, as needed[6], to ensure that the screen functions as designed.

    c. The permittee will notify the PNF immediately if any part of the water transmission facilities cannot be maintained in the original condition.

2. The following terms and conditions implement RPM 2 (minimize take due to reducing flow):

    a. The permittee will ensure that amount of water diverted at the Spring Diversion does not exceed 0.03 cfs.

    b. The permittee will ensure that amount of water diverted at the Smith Creek Diversion does not exceed 1.5 cfs when the water is used for hydropower production only.

    c. The permittee will ensure that amount of water diverted at the Smith Creek Diversion does not exceed 2.0 cfs at any time.

    d. The permittee will maintain the Smith Creek Diversion so that it functions as designed with respect to bypass flow.

3. The following terms and conditions implement RPM 3 (monitoring and reporting): The PNF and/or the permittee shall implement and/or require the following:

[6] The fish screen on the Smith Creek diversion requires manual cleaning to operate as designed. Typically, inspection and cleaning should occur daily, although longer intervals will likely occur due to inclement weather or other factors that could potentially affect safety of ranch personnel.

a. Measure flows in Smith Creek immediately upstream from the Smith Creek Diversion at least twice during the summer/fall baseflow period (September 1 – October 15) during a year, or years, in which flow in the SFSR drainage is below average. The PNF will determine the best time to measure flows by monitoring real time gages in the SFSR drainage, with the goal of measuring the lowest flows occurring during the irrigation season of a dry year. These measurements will be taken during 2019-2024 if suitable flows occur during that period, or after 2024 if flows are consistently unsuitable (i.e., higher than average) during 2019-2024.

b. Continuously record amount of water diverted at the Smith Creek Diversion.

c. Continuously monitor water temperature at the two established temperature monitoring sites from July through September.

d. The permittee will notify the PNF within 1-business day of observing evidence that the Smith Creek Diversion bypass is not operating as designed (e. g., unusually low flows bypassing the diversion).

    i. The PNF will notify NMFS within 2 business days of receiving a report that the Smith Creek Diversion bypass is not operating as designed.

e. The permittee will notify the PNF within 1-business day of observing stressed or dead salmonids in Smith Creek at or downstream from the Smith Creek Diversion.

    i. The PNF will notify NMFS within 1-day of receiving a report of a stressed or dead salmonid in Smith Creek at or downstream from the Smith Creek Diversion.

f. The PNF will review the monitoring data each year and will notify NMFS prior to March 31 if: (1) Water diverted due to the proposed action exceeds 2.1 cfs during the irrigation season (March 15 through October 31); (2) water diverted due to the proposed action exceeds 1.5 cfs outside of the irrigation season; (3) amount of water diverted during the calendar year exceeds 940 acre feet; or (4) there is any indication that flows immediately downstream from the Smith Creek diversion are less than 1.0 cfs at any time.

g. The PNF will submit a monitoring report to NMFS by March 31 every fifth year that will include:

    i. Photographic evidence documenting condition of the Spring Diversion, the Smith Creek Diversion and screen, water transmission structures, the hydropower outfall, and condition of riparian and stream channel habitat at the points of diversion and the hydropower outfall.

ii. Amount of water diverted at the Smith Creek Diversion, recorded at least weekly.

iii. Flow measurements in Smith Creek.

h. The PNF shall submit the monitoring report to:

National Marine Fisheries Service
Attention: WCRO-2019-00114
800 East Park Boulevard
Plaza IV, Suite 220
Boise, Idaho 83712-7743

i. NOTICE: If a steelhead or salmon becomes sick, injured, or killed as a result of project-related activities outside the scope of that analyzed in this Opinion, and if the fish would not benefit from rescue, the finder should leave the fish alone, make note of any circumstances likely causing the death or injury, location and number of fish involved, and take photographs, if possible. If the fish in question appears capable of recovering if rescued, photograph the fish (if possible), transport the fish to a suitable location, and record the information described above. Adult fish should generally not be disturbed unless circumstances arise where an adult fish is obviously injured or killed by proposed activities, or some unnatural cause. The finder must contact NMFS Law Enforcement at (206) 526-6133 as soon as possible. The finder may be asked to carry out instructions provided by Law Enforcement to collect specimens or take other measures to ensure that evidence intrinsic to the specimen is preserved.

2.10 Conservation Recommendations

Section 7(a)(1) of the ESA directs federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the 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 or regarding the development of information (50 CFR 402.02).

The PNF and/or the permittee should adopt and implement the following conservation recommendation:

1. Develop solar power resources so as to reduce the need for water diversion from Smith Creek for hydropower.

Please notify NMFS if the PNF or permittee carries out this recommendation so that we will be kept informed of actions that minimize or avoid adverse effects on listed species or their designated critical habitats.

2.11 Reinitiation of Consultation

This concludes formal consultation for the Smith Creek/Hettinger Ranch Hydropower and Irrigation System. As 50 CFR 402.16 states, reinitiation 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 taking specified in the ITS is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this Opinion; (3) the 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 FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT RESPONSE

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 effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH.

This analysis is based, in part, on the EFH assessment provided by the PNF and descriptions of EFH for Pacific Coast salmon (PFMC 2014) contained in the fishery management plans developed by the Pacific Fisheries Management Council (PFMC) and approved by the Secretary of Commerce.

3.1 Essential Fish Habitat Affected by the Project

The proposed action and action area for this consultation are described in Section 1.3 of this document. Juvenile (rearing and migratory) and adult (migratory and spawning) spring/summer Chinook salmon EFH is present in the action area. The action will affect a small portion of the mainstem SFSR by reducing amount of tributary inflow which will reduce amount of available thermal refugia. The affected EFH area is identical to the spring/summer Chinook salmon critical habitat affected and discussed in Section 2.5.1 of the preceding Opinion.

The action area includes areas designated as EFH for spawning, rearing, and migration life-history stages of Chinook salmon. The PFMC (2014) has identified five habitat areas of particular concern (HAPC), which warrant additional focus for conservation efforts due to their high ecological importance. Three of the five HAPC are applicable to freshwater and include:

(1) Complex channels/floodplain habitats; (2) thermal refugia; and (3) spawning habitat. Implementation of the proposed action has the potential to affect the thermal refugia habitat HAPCs.

3.2 Adverse Effects on Essential Fish Habitat

The proposed action will reduce inflow of Smith Creek to the mainstem SFSR which will reduce amount of thermal refugia in approximately 7,143 square feet (665 square meters) of the SFSR. Salmon spawning and rearing habitat exists, and is moderately utilized, in the action area. The effects of the proposed action will reduce utility of thermal refugia which reduce productivity of Chinook salmon rearing habitat in the lower mainstem SFSR. These effects will occur for the duration of the proposed action.

3.3 Essential Fish Habitat Conservation Recommendations

To minimize the adverse effects in Section 3.2, NMFS proposes the following EFH conservation recommendation:

1. Develop solar power resources so as to reduce the need for water diversion from Smith Creek for hydropower.

Fully implementing this EFH conservation recommendation would protect, by avoiding or minimizing the adverse effects described in Section 3.2, approximately 0.16 acres of designated EFH for Pacific Coast salmon.

3.4 Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, the PNF must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS' EFH Conservation Recommendations unless NMFS and the federal agency have agreed to use alternative time frames for the federal agency response. The response must include a description of measures proposed by the agency for avoiding, minimizing, mitigating, or otherwise offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the Conservation Recommendations, the federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects (50 CFR 600.920(k)(1)).

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

3.5 Supplemental Consultation

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

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

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

4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended user of this Opinion is the PNF. Individual copies of this Opinion were provided to the PNF. The format and naming adheres to conventional standards for style.

4.2 Integrity

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

4.3 Objectivity

Information Product Category: Natural Resource Plan

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including NMFS' ESA Consultation Handbook, ESA regulations, 50 CFR 402.01 et seq., and the MSA implementing regulations regarding EFH, 50 CFR 600.

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

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

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

5. REFERENCES

Arthaud, D. L., C. M. Greene, K. Guilbault, and J. V. Morrow Jr. 2010. Contrasting life-cycle impacts of stream flow on two Chinook salmon populations. Hydrobiologia 655:171–188.

Asch, R. 2015. Climate change and decadal shifts in the phenology of larval fishes in the California Current ecosystem. PNAS:E4065-E4074, 7/9/2015.

Baker, D. W., B. P. Bledsoe, C. M. Albano, and N. L. Poff. 2011. Downstream effects of diversion dams on sediment and hydraulic conditions of Rocky Mountain streams. River Research and Applications 27: 388-401.

Bakun, A., B. A. Black, S. J. Bograd, M. García-Reyes, A. J. Miller, R. R. Rykaczewski, and J. Sydeman. 2015. Anticipated Effects of Climate Change on Coastal Upwelling Ecosystems. Current Climate Change Reports 1:85-93. DOI: 10.1007/s40641-015-0008-4, 3/7/2015.

Battin, J., and coauthors. 2007. Projected impacts of climate change on salmon habitat restoration. Proceedings of the National Academy of Sciences of the United States of America 104(16):6720-6725.

Beecher, H. A., B. A. Caldwell, S. B. DeMond, D. Seiler, and S. N. Boessow. 2010. An empirical assessment of PHABSIM using long-term monitoring of coho salmon smolt production in Bingham Creek, Washington. North American Journal of Fisheries Management 30:1529–1543.

Beechie, T., H. Imaki, J. Greene, et al. 2013. Restoring Salmon Habitat for a Changing Climate. River Research and Application 29:939-960.

Beckman, B. 2018. Estuarine growth of yearling Snake River Chinook salmon smolts. Progress report. Northwest Fisheries Science Center, Seattle, Washington, 7/3/2018.

Belchik. 1997. Summer Locations and Salmonid Use of Cool Water Areas in the Klamath River: Iron Gate Dam to Seiad Creek, 1996. Yurok Tribal Fisheries Program, 15900 Hwy. 101N, Klamath, CA 95548. Funded by: National Biological Service Cooperative Agreement. 13 pp.

Bjornn, T. C. and D. W. Reiser. 1991. Habitat requirements of salmonids in streams. Pages 83–138 *in* W.R. Meehan, editor. Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society, Special Publication 19. Bethesda, Maryland.

Black, B., J. Dunham, B. Blundon, J. Brim Box, and A. Tepley. 2015. Long-term growth-increment chronologies reveal diverse influences of climate forcing on freshwater and forest biota in the Pacific Northwest. Global Change Biology 21:594-604. DOI: 10.1111/gcb.12756.

Bograd, S., I. Schroeder, N. Sarkar, X. Qiu, W. J. Sydeman, and F. B. Schwing. 2009. Phenology of coastal upwelling in the California Current. Geophysical Research Letters 36:L01602. DOI: 10.1029/2008GL035933.

Bond, N. A., M. F. Cronin, H. Freeland, and N. Mantua. 2015. Causes and impacts of the 2014 warm anomaly in the NE Pacific. Geophysical Research Letters 42:3414–3420. DOI: 10.1002/2015GL063306.

Bourgeois, G., R. A. Cunjak, and D. Caissie. 1996. A spatial and temporal evaluation of PHABSIM in relation to measured density of juvenile Atlantic salmon in a small stream. North American Journal of Fisheries Management 16:154-199.

Cheung, W., N. Pascal, J. Bell, L. Brander, N. Cyr, L. Hansson, W. Watson-Wright, and D. Allemand. 2015. North and Central Pacific Ocean region. Pages 97-111 in N. Hilmi, D. Allemand, C. Kavanagh, and et al, editors. Bridging the Gap Between Ocean Acidification Impacts and Economic Valuation: Regional Impacts of Ocean Acidification on Fisheries and Aquaculture. DOI: 10.2305/IUCN.CH.2015.03.en.

Climate Change Science Program (CCSP). 2014. Climate Change Impacts in the United States. Third National Climate Assessment. U.S. Global Change Research Program. DOI:10.7930/J0Z31WJ2.

Climate Impacts Group (CIG). 2004. Overview of Climate Change Impacts in the U.S. Pacific Northwest, 7/29/2004.

Conder, A. L., and T. C. Annear. 1987. Test of Weighted Usable Area Estimates Derived from a PHABSIM Model for Instream Flow Studies on Trout Stream. North American Journal of Fisheries Management 7:339-350.

Copeland, T., J. D. Bumgarner, A. Byrne, L. Denny, J. L. Hebdon, M. Johnson, C. A. Peery, S. Rosenberger, E. R. Sedell, G. E. Shippentower, C. Stiefel, and S. P. Yundt. 2014. Reconstruction of the 2011/2012 steelhead spawning run into the Snake River basin. Report to Bonneville Power Administration, Portland, Oregon.

Copeland, T., J. D. Bumgarner, A. Byrne, P. Cleary, L. Denny, J. L. Hebdon, C. A. Peery, S. Rosenberger, E. R. Sedell, G. E. Shippentower, C. Warren, and S. P. Yundt. 2015. Reconstruction of the 2012/2013 steelhead spawning run into the Snake River basin. Report to Bonneville Power Administration, Portland, Oregon.

Crozier, L. and R. W. Zabel. 2006. Climate impacts at multiple scales: evidence for differential population responses in juvenile Chinook salmon. Ecology 75:1100-1109. DOI: 10.1111/j.1365-2656.2006.01130.x.

Crozier, L. G., R. W. Zabel, and A. F. Hamlet. 2008a. Predicting differential effects of climate change at the population level with life-cycle models of spring Chinook salmon. Global Change Biology 14:236-249. DOI: 10.1111/j.1365-2486.2007.01497.x.

Crozier, L. G., A. P. Hendry, P. W. Lawson, T. P. Quinn, et al. 2008b. Potential responses to climate change for organisms with complex life histories: evolution and plasticity in Pacific salmon. Evolutionary Applications 1:252-270. DOI: 10.1111/j.1752-4571.2008.00033.x.

Curet, T., B. Esselman, A. Brimmer, M. White, and M. Green. 2009. Fishery Management Annual Report, Salmon Region, Idaho Department of Fish and Game. IDFG 09-101. 124 pp.

Dalton, M., P. W. Mote, and A. K. Stover. 2013. Climate change in the Northwest: implications for our landscapes, waters and communities. Island Press, Washington, D.C.

Daly, E. A., R. D. Brodeur, and L. A. Weitkamp. 2009. Ontogenetic Shifts in Diets of Juvenile and Subadult Coho and Chinook Salmon in Coastal Marine Waters: Important for Marine Survival? Transactions of the American Fisheries Society 138(6):1420-1438.

Daly, E. A., J. A. Scheurer, R. D. Brodeur, L. A. Weitkamp, B. R. Beckman, and J. A. Miller. 2014. Juvenile Steelhead Distribution, Migration, Feeding, and Growth in the Columbia River Estuary, Plume, and Coastal Waters. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 6(1):62-80.

Davidson, S. R., B. H. Letcher, and K. H. Nislow. 2010. Drivers of growth variation in juvenile Atlantic salmon (Salmo salar): an elasticity analysis approach. Journal of Animal Ecology 79:1113–1121.

Di Lorenzo, E. and N. Mantua. 2016. Multi-year persistence of the 2014/15 North Pacific marine heatwave. Nature Climate Change 1-7. DOI:10.1038/nclimate3082, 7/11/2016.

Ebersole, J. L., P. J. Wigington Jr., S. G. Leibowitz, R. L. Comeleo, and J. Van Sickle. 2014. Predicting the occurrence of cold-water patches at intermittent and ephemeral tributary confluences with warm rivers. Freshwater Science 34: 111-124.

Elliott, J. M., M. A. Hurley, and J. A. Elliott. 1997. Variable effects of droughts on the density of a sea-trout *Salmo trutta* population over 30 years. The Journal of Applied Ecology 34(5):1229-1238.

Ecovista, Nez Perce Tribe Wildlife Division, and Washington State University Center for Environmental Education. 2003. Draft Clearwater Subbasin Assessment, Prepared for Nez Perce Tribe Watersheds Division and Idaho Soil Conservation Commission. 463 p.

Everest, F. H. and D. W. Chapman. 1972. Habitat selection and spatial interaction by juvenile Chinook salmon and steelhead trout in two Idaho streams. Journal of the Fisheries Research Board of Canada 29(1):91-100.

Fisher, J., W. Peterson, and R. Rykaczewski. 2015. The impact of El Niño events on the pelagic food chain in the northern California Current. Global Change Biology 21: 4401-4414. DOI: 10.1111/gcb.13054, 7/1/2015.

Flinders, J., J. Hansen, M. White, B. Beller, and T. Curet. 2013. Fishery management annual report, Salmon Region 2012. Idaho Department of Fish and Game, IDFG # 13-123. 146 pp.

Ford, M. J. (ed.). 2011. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-113, 281 p.

Foreman, M., W. Callendar, D. Masson, J. Morrison, and I. Fine. 2014. A Model Simulation of Future Oceanic Conditions along the British Columbia Continental Shelf. Part II: Results and Analyses. Atmosphere-Ocean 52(1):20-38. DOI: 10.1080/07055900.2013.873014.

Gargett, A. 1997. Physics to Fish: Interactions Between Physics and Biology on a Variety of Scales. Oceanography 10(3):128-131.

Good, T. P., R. S. Waples, and P. Adams (editors). 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC-66, 598 p.

Haigh, R., D. Ianson, C. A. Holt, H. E. Neate, and A. M. Edwards. 2015. Effects of Ocean Acidification on Temperate Coastal Marine Ecosystems and Fisheries in the Northeast Pacific. PLoS ONE 10(2):e0117533. DOI:10.1371/journal.pone.0117533, 2/11/2015.

Hardy, T. B., T. Shaw, R. C. Addley, G. E. Smith, M. Rode, and M. Belchik. 2006. Validation of Chinook fry behavior based escape cover modeling in the Lower Klamath River. International Journal of River Basin Management 4: 1–10.

Hardy, T. B., R. C. Addley, and E. Saraeva. 2006a. Evaluation of Instream Flow Needs in the Lower Klamath River. Phase II, final report prepared for: U.S. Department of the Interior. 229 pp.

Harvey, B. C., R. J. Nakamoto, and J. L. White. 2006. Reduced streamflow lowers dry-season growth of rainbow trout in a small stream. Transactions of the American Fisheries Society 135:998-1005.

Harvey, B. C., J. L.White, and R. J. Nakamoto. 2014. Effects of Streamflow Diversion on a Fish Population: Combining Empirical Data and Individual-Based Models in a Site-Specific Evaluation. North American Journal of Fisheries Management 34:247–257.

Hayes, J. W., N. F. Hughes, and L. H. Kelly. 2007. Process-based modelling of invertebrate drift transport, net energy intake and reach carrying capacity for drift-feeding salmonids. Ecological Modeling 207:171-188

Healey, M. C. 1991. Life history of chinook salmon (*Oncorhynchus tshawytscha*). Pages 80 *in* C. Groot, and L. Margolis, editors. Pacific salmon life histories. University of British Columbia Press, Vancouver, Canada.

Hollowed, A. B., N. A. Bond, T. K. Wilderbuer, W. T. Stockhausen, Z. T. A'mar, R. J. Beamish, J. E. Overland, et al. 2009. A framework for modelling fish and shellfish responses to future climate change. ICES Journal of Marine Science 66:1584-1594. DOI:10.1093/icesjms/fsp057.

Interior Columbia Technical Recovery Team (ICTRT). 2003. Working draft. Independent populations of Chinook, steelhead, and sockeye for listed evolutionarily significant units within the Interior Columbia River domain. NOAA Fisheries. July.

ICTRT. 2007. Viability Criteria for Application to Interior Columbia Basin Salmonid ESUs, Review Draft March 2007. Interior Columbia Basin Technical Recovery Team: Portland, Oregon. 261 pp. Website, https://www.nwfsc.noaa.gov/research/divisions/cb/genetics/trt/trt_documents/ictrt_viability_criteria_reviewdraft_2007_complete.pdf

ICTRT. 2010. Status Summary – Snake River Spring/Summer Chinook Salmon ESU. Interior Columbia Technical Recovery Team: Portland, Oregon.

Idaho Department of Environmental Quality (IDEQ). 2001. Middle Salmon River-Panther Creek Subbasin Assessment and TMDL. IDEQ: Boise, Idaho. 114 p.

IDEQ. 2011. Idaho's 2010 Integrated Report, Final. IDEQ: Boise, Idaho. 776 p.

IDEQ and U.S. Environmental Protection Agency (EPA). 2003. South Fork Clearwater River Subbasin Assessment and Total Maximum Daily Loads. IDEQ: Boise, Idaho. 680 p.

Idaho Department of Fish and Game (IDFG). 2007. Annual returns to Lower Granite Dam, Idaho Department of Fish and Game data provided to NMFS by Peter Hassemer, December 2007. IDFG: Boise, Idaho.

IDFG. 2016. "Hatchery and Wild Chinook Salmon Return to Lower Granite Dam." Follow Idaho Salmon Home (F.I.S.H) website, http://216.206.157.62/idaho/web/apps/MAIN_LGRchinadultreturn_spsu_wild.php, accessed 6-3-16.

Independent Scientific Advisory Board (ISAB). 2007. Climate change impacts on Columbia River Basin fish and wildlife. ISAB Climate Change Report, ISAB 2007-2, Northwest Power and Conservation Council, Portland, Oregon.

Irvine, J. R., I. G. Jowett, and D. Scott. 1987. A test of the instream flow incremental methodology for underyearling rainbow trout, *Salmo gairdnerii*, in experimental New Zealand streams. New Zealand Journal of Marine and Freshwater Research, 21(1): 35-40. DOI: 10.1080/00288330.1987.9516197. https://doi.org/10.1080/00288330.1987.9516197.

Isaak D. J., C. H. Luce, D. L. Horan, G. L. Chandler, S. P. Wollrab, and D. E. Nagel. 2018. Global warming of salmon and trout rivers in the Northwestern U.S.: Road to ruin or path through purgatory? Transactions of the American Fisheries Society 147:566–587.

Jager, H. I. 2014. Thinking outside the channel: Timing pulse flows to benefit salmon via indirect pathways. Ecological Modeling 273: 117-127.

Jones, K. K., T. J. Cornwell, D. L. Bottom, L. A. Campbell, and S. Stein. 2014. The contribution of estuary-resident life histories to the return of adult Oncorhynchus kisutch. Journal of Fish Biology 85:52–80. DOI:10.1111/jfb.12380.

Kennedy, V. S. 1990. Anticipated Effects of Climate Change on Estuarine and Coastal Fisheries. Fisheries 15(6):16-24.

Kirwan, M. L., G. R. Guntenspergen, A. D'Alpaos, J. T. Morris, S. M. Mudd, and S. Temmerman. 2010. Limits on the adaptability of coastal marshes to rising sea level. Geophysical Research Letters 37:L23401. DOI: 10.1029/2010GL045489, 12/1/2010.

Kovach, R. P., C. C. Muhlfeld, R. Al-Chokhachy, J. B. Dunham, B. H. Letcher, and J. L. Kershner. 2016. Impacts of climatic variation on trout: a global synthesis and path forward. Reviews in Fish Biology and Fisheries 26(2):135-151.

Lemmen, D. S., F. J. Warren, T. S. James, and C. S. L. Mercer Clarke (Eds.). 2016. Canada's Marine Coasts in a Changing Climate. Ottawa, ON: Government of Canada.

Limburg, K., R. Brown, R. Johnson, B. Pine, R. Rulifson, D. Secor, K. Timchak, B. Walther, and K. Wilson. 2016. Round-the-Coast: Snapshots of Estuarine Climate Change Effects. Fisheries 41(7):392-394, DOI: 10.1080/03632415.2016.1182506.

Litz, M. N., A. J. Phillips, R. D. Brodeur, and R. L. Emmett. 2011. Seasonal occurrences of Humbolt Squid in the Northern California Current System. CalCOFI Reports 52:97-108.

Lynch, A. J., B. J. E. Myers, C. Chu, L. A. Eby, J. A. Falke, R. P. Kovach, T. J. Krabbenhoft, T. J. Kwak, J. Lyons, C. P. Paukert, and J. E. Whitney. 2016. Climate Change Effects on North American Inland Fish Populations and Assemblages. Fisheries 41(7):346-361. DOI: 10.1080/03632415.2016.1186016, 7/1/2016.

Lucey, S. and J. Nye. 2010. Shifting species assemblages in the Northeast US Continental Shelf Large Marine Ecosystem. Marine Ecology Progress Series, Marine Ecology Progress Series 415:23-33. DOI: 10.3354/meps08743.

Mantua, N. J., S. Hare, Y. Zhang, et al. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society 78:1069-1079, 1/6/1997.

Martins, E. G., S. G. Hinch, D. A. Patterson, M. J. Hague, S. J. Cooke, K. M. Miller, M. F. Lapointe, K. K. English, and A. P. Farrell. 2011. Effects of river temperature and climate warming on stock-specific survival of adult migrating Fraser River sockeye salmon (*Oncorhynchus nerka*). Global Change Biology 17(1):99–114. DOI:10.1111/j.1365-2486.2010.02241.x.

Martins, E. G., S. G. Hinch, D. A. Patterson, M. J. Hague, S. J. Cooke, K. M. Miller, D. Robichaud, K. K. English, and A. P. Farrell. 2012. High river temperature reduces survival of sockeye salmon (*Oncorhynchus nerka*) approaching spawning grounds and exacerbates female mortality. Canadian Journal of Fisheries and Aquatic 69:330–342. DOI: 10.1139/F2011-154.

Mathews, S. B. and F. W. Olson. 1980. Factors affecting Puget Sound coho salmon (*Oncorhynchus kisutch*) runs. Canadian Journal of Fisheries and Aquatic Sciences 37:1373-1378

Mathis, J. T., S. R. Cooley, N. Lucey, S. Colt, J. Ekstrom, T. Hurst, C. Hauri, W. Evans, J. N. Cross, and R. A. Feely. 2015. Ocean acidification risk assessment for Alaska’s fishery sector. Progress in Oceanography 136:71-91.

Matthews, G. M. and R. S. Waples. 1991. Status Review for Snake River Spring and Summer Chinook Salmon. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-F/NWC-200. https://www.nwfsc.noaa.gov/publications/scipubs/techmemos/tm201/

McClure, M., T. Cooney, and ICTRT. 2005. Updated population delineation in the interior Columbia Basin. May 11, 2005 Memorandum to NMFS NW Regional Office, Co-managers, and other interested parties. NMFS: Seattle, Washington. 14 p.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-42, Seattle, Washington, 156 p.

Miller, S. W., D. Wooster, and J. Li. 2007. Resistance and resilience of macroinvertebrates to irrigation water withdrawals. Freshwater Biology 52:2494-2510.

Mitro, M. G., A. V. Zale, and B. A. Rich. 2003. The relation between age-0 rainbow trout (*Oncorhynchus mykiss*) abundance and winter discharge in a regulated river. Canadian Journal of Aquatic Sciences 60:135-139

Morris, J. F. T., M. Trudel, J. Fisher, S. A. Hinton, E. A. Fergusson, J. A. Orsi, and J. Edward V. Farley. 2007. Stock-Specific Migrations of Juvenile Coho Salmon Derived from Coded-Wire Tag Recoveries on the Continental Shelf of Western North America. American Fisheries Society Symposium 57:81-104.

Mote, P. W., E. A. Parson, A. F. Hamlet, et al. 2003. Preparing for Climatic Change: The Water, Salmon, and Forests of the Pacific Northwest. Climatic Change 61:45-88.

Naiman, R. J., J. R. Alldredge, D. A. Beauchamp, P. A. Bisson, J. Congleton, C. J. Henny, N. Huntly, R. Lamberson, C. Levings, E. N. Merrill, W. G. Pearcy, B. E. Rieman, G. T. Ruggerone, D. Scarnecchia, P. E. Smouse, and C. C. Wood. 2012. Developing a broader scientific foundation for river restoration: Columbia River food webs. Proceedings of the National Academy of Sciences of the United States of America 109(52):21201-21207.

National Marine Fisheries Service (NMFS). 2015. ESA Recovery Plan for Snake River Sockeye Salmon (*Oncorhynchus nerka*), June 8, 2015. NOAA Fisheries, West Coast Region. 431 p. http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/domains/interior_columbia/snake/snake_river_sockeye_recovery_plan_june_2015.pdf

NMFS. 2017. ESA Recovery Plan for Snake River Spring/Summer Chinook & Steelhead. NMFS. http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/domains/interior_columbia/snake/Final%20Snake%20Recovery%20Plan%20Docs/final_snake_river_spring-summer_chinook_salmon_and_snake_river_basin_steelhead_recovery_plan.pdf

Nielsen, J. L. and T. E. Lisle. 1994. Thermally stratified pools and their use by steelhead in northern California streams. Transactions of the American Fisheries Society 123:613-626.

Nislow, K. H., A. J. Sepulveda, and C. L. Folt. 2004. Mechanistic linkage of hydrologic regime to summer growth of age-0 Atlantic salmon. Transactions of the American Fisheries Society 133: 79–88.

Northwest Fisheries Science Center (NWFSC). 2015. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. 356 p.

Pacific Fisheries Management Council (PFMC). 2014. Appendix A to the Pacific Coast Salmon Fishery Management Plan, as modified by Amendment 18. Identification and description of essential fish habitat, adverse impacts, and recommended conservation measures for salmon.

Pearcy, W. G. 2002. Marine nekton off Oregon and the 1997–98 El Niño. Progress in Oceanography 54:399–403.

Pearcy, W. G. and S. M. McKinnell. 2007. The Ocean Ecology of Salmon in the Northeast Pacific Ocean-An Abridged History. American Fisheries Society 57:7-30.

Peterson, W., J. Fisher, J. Peterson, C. Morgan, B. Burke, and K. Fresh. 2014. Applied Fisheries Oceanography Ecosystem Indicators of Ocean Condition Inform Fisheries Management in the California Current. Oceanography 27(4):80-89. 10.5670/oceanog.2014.88.

Poesch, M. S., L. Chavarie, C. Chu, S. N. Pandit, and W. Tonn. 2016. Climate Change Impacts on Freshwater Fishes: A Canadian Perspective. Fisheries 41:385-391.

Rehage J. S. and J. R. Blanchard. 2016. What can we expect from climate change for species invasions? Fisheries 41(7):405-407. DOI: 10.1080/03632415.2016.1180287.

Reid, W., C. Robertson, M. Beucler, C. E. Corsi, G. Servheen, S. Grunder, D. Parrish, H. J. Hansen, and R. C. Martin. 2000. Idaho Department of Fish and Game, Statewide Technical Asstance, Job Performance Report Project FW-7-R-6. 82 pp.

Ricker, W. S. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin Fisheries Research Board of Canada 191: 382.

Rothwell, E. and M. Moulton. 2001. Influence to stream temperatures from diversions. Monitoring 2001, Sawtooth National Recreation Area. 14 pp.

Rykaczewski, R., J. P. Dunne, W. J. Sydeman, et al. 2015. Poleward displacement of coastal upwelling-favorable winds in the ocean's eastern boundary currents through the 21st century. Geophysical Research Letters 42:6424-6431. DOI:10.1002/2015GL064694.

Scheuerell, M. D. and J. G. WIlliams. 2005. Forecasting climate-induced changes in the survival of Snake River spring/summer Chinook salmon (Oncorhynchus tshawytscha). Fisheries Oceanography 14(6):448–457.

Shirvell, C. S. 1986. Pitfalls of physical habitat simulation in the instream flow incremental methodology. Department of Fisheries and Oceans Fisheries Research Branch, Prince Rupert, British Columbia V8J 1G8. 68 pp.

Sisters River Ranches Company. 2016. 2015 South Fork Ranch Hydro Monitoring Report. Monitoring report to the Payette National Forest. 11 pp.

Spence, B., G. Lomnicky, R. Hughes, and R. P. Novitski. 1996. An ecosystem approach to salmonid conservation. TR-4501-96-6057. ManTech Environmental Research Services Corp.: Corvallis, Oregon.

Stark, E. J., C. Bretz, A. Byrne, P. Cleary, T. Copeland, L. Denny, R. Engle, T. Miller, S. Rosenberger, E. R. Sedell, G. E. Shippentower, and C. Warren. 2016. Snake River basin steelhead 2013/2014 run reconstruction. Report to Bonneville Power Administration, Portland, Oregon.

Stark, E. J., A. Byrne, P. J. Cleary, T. Copeland, L. Denny, R. Engle, T. Miller, D. Nemeth, S. Rosenberger, E. R. Sedell, G. E. Shippentower, and C. Warren. 2017. Snake River basin steelhead 2014/2015 run reconstruction. Report to Bonneville Power Administration, Portland, Oregon.

Stark, E. J., A. Byrne, P. J. Cleary, J. Ebel, T. Miller, D. Nemeth, S. Rosenberger, E. R. Sedell, and C. Warren. 2018. Snake River Basin 2015-2016 steelhead run reconstruction. Report to Bonneville Power Administration, Portland, Oregon.

Sykes, G. E., C. J. Johnson, and J. M. Shrimpton. 2009. Temperature and Flow Effects on Migration Timing of Chinook Salmon Smolts. Transactions of the American Fisheries Society 138:1252-1265.

Tate, K.W., D.F. Lile, D.L. Lancaster, M.L. Porath, J.A. Morrison, and Y. Sado. 2005. Statistical analysis of monitoring data aids in prediction of stream temperature. California Agriculture 59(3):161-167.

Tehan, M. 2014. May, 13, 2014, Memorandum from Michael Tehan, assistant regional administrator for the National Marine Fisheries Service, West Coast Region (WCR), Columbia Basin Office to the WCR Columbia River Office.

Tennant, D. L. 1976. Instream flow regimes for fish, wildlife, recreation, and related environmental resources. Pages 359-373 in J. F. Osborn and C. H. Allman, eds. Instream Flow Needs, Volume II. American Fisheries Society, Bethesda, USA.

Tuomikoski, J., J. McCann, B. Chockley, H. Schaller, S. Haeseker, J. Fryer, R. Lessard, C. Petrosky, E. Tinus, T. Dalton, and R. Ehlke. 2013. Comparative Survival Study of PIT-tagged Spring/Summer/Fall Chinook, Summer Steelhead, and Sockeye. 2013 Annual Report, BPA Contract #19960200. 47 pp. Appendices.

Verdonck, D. 2006. Contemporary vertical crustal deformation in Cascadia. Tectonophysics 417(3):221-230. DOI: 10.1016/j.tecto.2006.01.006.

Wainwright, T. C. and L. A. Weitkamp. 2013. Effects of Climate Change on Oregon Coast Coho Salmon: Habitat and Life-Cycle Interactions. Northwest Science 87(3):219-242.

Walters, A. W., T. Copeland, and D. A. Venditti. 2013. The density dilemma: limitations on juvenile productions in threatened salmon populations. Ecology of Freshwater Fish 22(4):508-519.

Ward, E. J., J. H. Anderson, T. J. Beechie, G. R. Pess, and M. J. Ford. 2015. Increasing hydrologic variability threatens depleted anadromous fish populations. Global Change Biology 21(7):2500-2509.

Whitney, J. E., R. Al-Chokhachy, D. B. Bunnell, C. A. Caldwell, et al. 2016. Physiological Basis of Climate Change Impacts on North American Inland Fishes. Fisheries 41(7):332-345. DOI: 10.1080/03632415.2016.1186656.

Wipfli, M.S. and D.P. Gregovich. 2002. Export of Invertebrates and Detritus from Fishless Headwater Streams in Southeastern Alaska: Implications for Downstream Salmonid Production. Freshwater Biology 47:957-969.

Wipfli, M.S., J.S. Richardson, and R.J. Naiman. 2007. Ecological linkages between headwaters and downstream ecosystems: transport of organic matter, invertebrates, and wood down headwater channels. Journal of the American Water Resources Association 43(1):72-85.

Wipfli, M.S. and C.V. Baxter. 2010. Linking ecosystems, food webs, and fish production: subsidies in Salmonid watersheds. Fisheries: 35(8): 373-387.

Yamada, S., W. T. Peterson, and P. M. Kosro. 2015. Biological and physical ocean indicators predict the success of an invasive crab, Carcinus maenas, in the northern California Current. Marine Ecology Progress Series 537:175-189. DOI: 10.3354/meps11431.

Zabel, R.W. and S. Achord. 2004. Relating size of juveniles to survival within and among populations of Chinook salmon. Ecology 85:795–806.

Zabel, R. W., M. D. Scheuerell, M. M. McClure, et al. 2006. The Interplay Between Climate Variability and Density Dependence in the Population Viability of Chinook Salmon. Conservation Biology 20(1):190-200, 2/1/2006.